EFFECTS OF 5 AND 10 MINUTE BOUTS OF FOAM ROLLING ON PEAK TORQUE IN THE QUADRICEPS AND HAMSTRINGS

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Abstract

Background: Acute bouts of self-myofascial release (SMR) have shown to increase joint ROM without causing a decrease in muscular force production. The effects of longer bouts of SMR using a foam roller prior to strength performance remains unclear. **Aim:** The purpose of this study was to determine the effect of longer bouts of SMR via foam roller application on knee extension and flexion peak torque. **Methods:** Four males and six females participated in two trials of hamstrings and quadriceps foam rolling (5 minutes- 1 minute set, 30 seconds rest) (10 minutes- 1 minute set, 30 second rest). Maximal voluntary contraction (MVC) force was measured after each intervention. Quadricep and hamstring ROM were measured using a manual goniometer and pain was measured before and after each session of rolling. **Results:** Quadriceps peak torque decreased significantly after 5 minutes of foam rolling. There were no significant effects on ROM. **Conclusion:** Bouts of foam rolling for 5 to 10 minutes on the quadriceps prior to strength based exercise can alter viscoelastic properties of the muscles and potentially cause damage to the sarcomeres resulting in a reduction in muscular force Furthermore, there appears to be no ROM benefit for foam rolling sessions lasting 5 to 10 minutes prior to exercise.

Introduction

Repeated exercise can lead to small increments of muscle damage called micro trauma, resulting in tears, dehydration and decreased flexibility of fascia (Barnes, 1997). The damaged fascia constructs fibrous adhesions to the muscle which can result in impaired range of motion (ROM), strength, endurance, structure and coordination (Barnes, 1997). Myofascial release (MFR), otherwise known as self-myofascial release (SMR) has been thought to aid in the reduction of the adhesions by the individual using bodyweight with a tool, such as a foam roller to apply tension to the soft tissue. A foam roller is a dense columnar foam tool with which an individual rolls a specific region of their body, using weight as the force, as a method of self massage.

SMR is soft tissue therapy for treatment of skeletal muscle apathy and discomfort. The therapy relaxes contracted muscles and improves blood flow to the muscle and surrounding ligaments/tendons, thereby stimulating the stretch reflex in the muscles (Barnes, 1997). The abrasions between the soft tissue and the foam roller creates heat tension that returns the fascia to a moldable consistency and cleaving the adhesions from the soft tissue (Barnes, 1997). The process of foam rolling has been utilized by physical therapists and athletic trainers as a means of recovery, soft tissue restoration, improved muscular function and performance and ROM; ultimately, a

manual therapy for retaining force, correcting muscular imbalances and relieving muscle soreness (MacDonald et al, 2013).

The similarities between static stretching and SMR remain unclear. While static stretching has been associated with a decline in strength for up to an hour post stretching, it has also shown to have the benefits of increasing ROM and flexibility prior to exercise (Fowles et al, 2007). In contrast, it is unknown whether SMR would increase ROM prior to exercise without performance impairments. Sullivan et al, (13) researched the acute effects of a custom made roller device on hamstring ROM and muscle performance using 1 and 2 sets of 5 and 10 second durations. A 4.3% increase in ROM was found in 17 subjects with no significant differences in isometric knee flexion peak torque. It was also found that ten seconds increased ROM 2.3% more than 5 seconds ($p=0.069$). Although effective in increasing range of motion with no decrease in muscular force, the customized rolling device is not a practical tool. A high density foam roller is more accessible, less costly and easily transportable. A foam roller could possibly achieve the same ROM and peak torque results with longer application durations.

A study by MacDonald et al, (13) investigated the effect of an acute bout of myofascial release on knee extensor force, muscle activation and knee ROM. Eleven physically active males were measured for knee extensor force during a 4.5 seconds isometric MVC and knee joint ROM. The subjects were measured before, 2 minutes, and ten minutes after two conditions; 1 minute trials of SMR via foam rolling of the quadriceps and 2 trials with no intervention. There was a 12.7% and 10.3% increase in quadriceps flexibility 2 and 10 minutes after foam rolling with no subsequent decrease in muscle force (MacDonald et al, 2013). It remains unclear whether longer bouts of foam rolling will provide greater benefits to ROM and without a decrease in muscle force.

Although we did not aim to investigate the effects of SMR after exercise, previous research showed that longer bouts of FR immediately following heavy eccentric loading provided an increase in ROM with a decrease in pain associated with delayed onset muscle soreness (MacDonald et al 2014). MacDonald et al, (14) investigated the effects of 20 minutes foam rolling on the quadriceps as a recovery tool. Measurements included ROM, muscle soreness, MVC during knee extension (three 3- to 5-s MVC, separated by 2 min each) and force placed on the foam roller. The main results of the study concluded that FR improved passive and dynamic ROM in the quadriceps and hamstrings, especially when performed 24-48 hours post exercise. Muscle soreness showed a substantial decrease with implementation of foam rolling, with 24, 48, and 72 hour time frames post intervention; having a decreased likeliness of soreness by 85%, 97%, and 98%, respectively (MacDonald, et al, 2014). McDonald's work displays the benefit of increased ROM with implementation of long bouts of foam rolling post

exercise, but there is limited research on ROM and muscle soreness when foam rolling is utilized before heavy eccentric loading.

Although studies showed no decrease in force production after the implementation of MFR, the absence of significant change may be due to length of rolling bouts. Changing the length of the muscle alters the degree of the actin-myosin interaction, influencing the tension development during contraction. Maximal contractile tension (i.e., force, power, and contraction velocity) decreases with increases in the velocity of muscle shortening (Thorstensson et al, 1976). It remains unclear as to whether SMR is a way of altering the soft tissue or whether the effects can be attributed to the excitation or inhibition of CNS.

The purpose of this study was to determine the ROM and peak torque of the quadriceps and hamstrings of active individuals after longer bouts of SMR application. It was hypothesized that ROM would increase and peak torque would decrease in the hamstrings and quadriceps with the implementation of 5 and 10 minute application of SMR via high density foam roller.

Methods

Subjects

Ten, habitually active for the past year subjects with no previous injuries or foam rolling experience participated in the study. Six females and four males (means ± SD; Age 23 ±2 .6 years; self reported weight 68.13±16.3 kg; self reported height 1.7± 0.1 m; BMI 23.4±3.8 kg/m). Subjects were verbally informed of the purposes of the study, associated risks, filled out a medical history questionnaire and gave written informed consent (Sullivan et al, 2013). This study was approved by California State University San Marcos Review Board.

Exercise Protocol

Three laboratory testing sessions were separated by at least 72 hours and occurred at the same time of day for each individual participant. During each session, subjects were given standardized instructions and measurements were taken by the same researcher. Subject's were instructed to refrain from heavy exercise and caffeine, unless habitually consumed caffeine, 24 hours before testing (Healey et al, 2013).

Day 1 consisted of baseline testing using the dominant leg and familiarization using the nondominant leg. Subjects were asked which leg was dominant. If they were unsure, a researcher rolled a ball and whichever leg kicked the ball was considered dominant. Day 2 and 3 consisted of randomized experimental testing on the dominant leg. On the first day, participants reviewed quadriceps and hamstrings ROM protocol, foam rolling technique and performed two unilateral MVC, 30 degrees per second. After

a 5 minute warm up on the cycle ergometer (Monark Ergomedic 839E), subjects completed two all-out bouts of 5 repetitions of knee extension and flexion. Similar to MacDonald et al, 2013, strong verbal encouragement was provided during MVC. Subjects received their recordings of peak torque, power and total work for both leg extension and flexion immediately after each trial.

Upon arrival into the lab on day 2 and 3, participant's ROM was immediately measured and they performed either 5 minutes or 10 minutes of foam rolling on both their quadriceps, then their hamstrings. After completing the MVC, ROM was measured again. Throughout each testing session, participant's quadricep and hamstring pain was recorded before testing, during their last bout of foam rolling for each muscle group and after the strength assessment. Subject's pain scale was also recorded 24 hours later.

ROM

One researcher throughout the study measured ROM with a standard manual goniometer (accurate to 1◦) (MacDonald et al, 2013). ROM was measured pre and post foam roll and post MVC. Two ROM measurements were averaged.

To assess quadriceps ROM subjects were instructed to perform a lunge as deep as they could while maintaining an upright torso and placing their front knee over their ankle.The landmark the goniometer was placed on was the lateral side of the knee bone on subject's dominant leg. While an arm was placed against the subject's chest to ensure no further hip flexion, an investigator passively flexed the subject's knee until they reported discomfort. Similar to MacDonald et al, 2013, The ROM measurement was the change in angle at the knee.

To determine hamstring ROM, subjects were instructed to lay on their back and an investigator lifted subject's leg toward their body until the subject reported discomfort. The manual goniometer was placed on the landmark, vastus lateralis, of the dominant leg and the angle to which the hip was stretched was the ROM measurement.

Intervention

Five and ten minute FR sessions were completed on both the quadriceps and hamstrings. The high density foam roller was used because it is standard for what is found in most sporting goods stores. Much like MacDonald et al, (13), subjects were instructed to place as much of their body weight onto the foam roller. To roll the quadriceps, subjects began in a low plank position on their forearms with legs crossed and moved in an undulating motion, proximal to distal, starting at the hip and ending just above the knee. Once they reached the knee, they quickly rolled the FR back to the starting position. For the hamstrings, subjects were instructed to begin on their ischial tuberosity with their hands on the floor behind them and end at the back of the knee.

Again, quickly rolling back up to the proximal portion to begin another cycle. They completed 2-3 sets in 1 minute and rested for 30 seconds, similar to MacDonald et al, (13). Subjects were instructed to remove pressure during the rest period.Subjects were monitored and adjusted throughout the FR protocol. An interval timer (GYMBOSS, MI) was used to help subjects time their FR sets. The five minute trial took 14 minutes and the ten minute trial took 28 minutes.

MVC

In order to determine dominant leg force production, similar to MacDonald et al, 2013, the subject's were seated in a chair with their hip and knee flexed at 90 degrees. The backrest was adjusted and subject's were strapped into the chair. Straps were placed across the subjects trunk, waist and thigh. Their calf was placed on a padded surface and then restrained with another strap. Once the subject restraints were secure, they were asked to fully extend and flex their leg to make sure there was no medial or lateral pulling of the knee. The chair measurements were recorded to ensure consistency for each trial. The subject was then instructed to extend and flex their leg until they felt comfortable and once they were ready, they fully flexed their leg which starts the MVC. With verbal encouragement they completed 5 full leg extensions and flexions at 30 degrees per second.

Muscle Pain

The Borg (1982) 0-10 category ratio scale was explained to each subject during the familiarization trial to acquaint the subject with their given pain throughout testing. Instructions were repeated before subsequent trials. Immediately post-testing and 24 hours following, subjects were notified to identify any muscular pain via phone call or text message.

Data Analysis

Initially, a 1 way analysis of variance (ANOVA) with repeated measures (duration) was performed to determine if there were any extensor and flexor force effects due to rolling duration. ROM data was analyzed with a 2-way ANOVA with repeated measures. The two factors (2x2) included intervention FR-5 and FR-10 and time (precondition and postcondition) to determine ROM effects due to duration. All data was analyzed using SPSS software Version 18.0 (SPSS, IL) Data were considered statistically significant using alpha level $p<0.05$.

Results

Maximum Velocity Contraction (MVC)

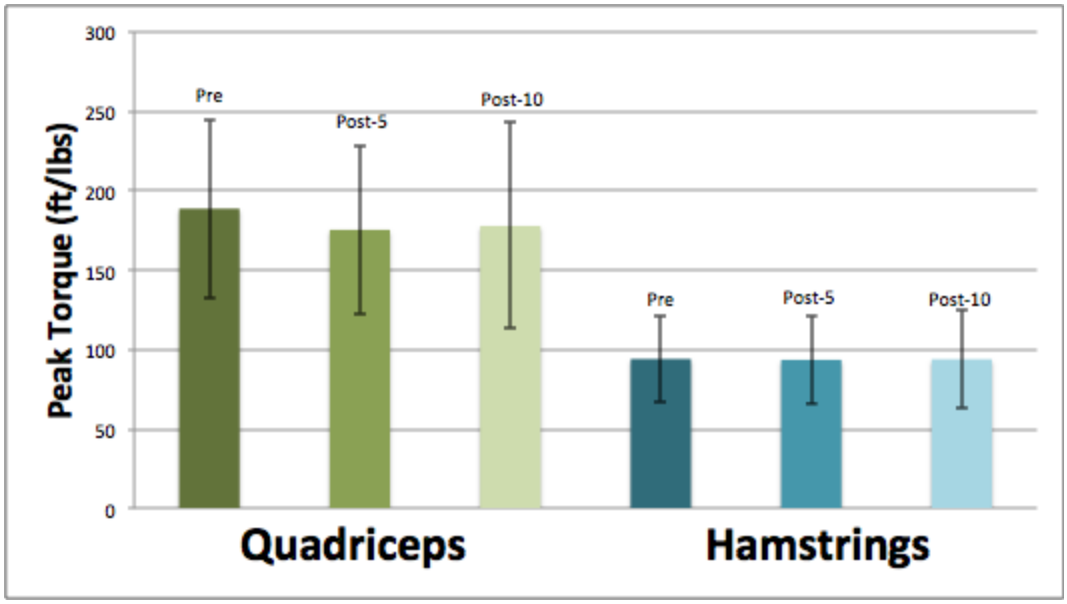
There was a significant main effect for duration with a decrease in quadriceps peak torque from baseline to post-5 to post-10 (alpha p <0.05, p=.048) (see Table 1. for details). A post hoc 1- way ANOVA (2 levels) analysis revealed that compared with baseline, post-5 significantly (p=.012) decreased peak torque by 7.34% (Figure 1.) There was no significant difference between post-5 and post-10 quadriceps force production(p=.768). Although not significant, there was 5.95% decrease in peak torque post-10 (p=.211). There was no change in peak torque in the hamstrings p=.911 for either FR session. No significant difference was found between 5 and 10 minute baseline hamstrings peak torque (P=.865).

Table 1. Raw MVC data from pre to post intervention durations

	Baseline hamstrings (ft/lbs)	**Post-5 minutes hamstrings (ft/lbs)**	**POST-10 minutes hamstrings (ft/lbs)**	**Baseline-quadriceps ft//lbs)**	**POST-5 minute quadriceps (ft/lbs)**	**POST-10 minute quadriceps (ft/lbs)**
Mean ± SD	**94.1± 27.7**	**93.52 ± 27.7**	**93.88 ± 31.2**	**188.77± 54.4**	**175.4 ± 53.4***	**177.86 ± 64.9**

* Represents a significant (p<0.05) main effect between foam rolling and baseline values.

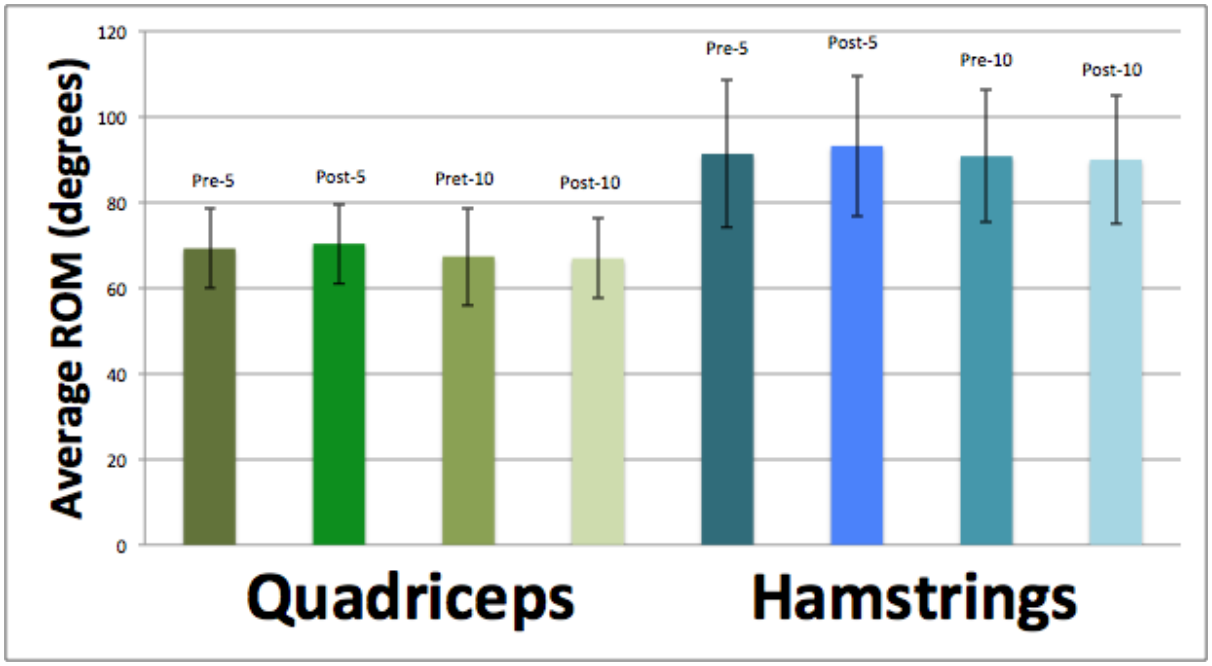
Figure 1. Peak torque (ft/lbs) in hamstrings and quadriceps pre and post two conditions.



Range of Motion (ROM)

A 2-way ANOVA with repeated measures (pre to post x duration) revealed no significant ROM effects on hamstrings or quadriceps post 5 or 10 (Figure 2). Post-5 hamstrings showed a 2% increase from pre testing (p=.405). Post-10 hamstrings there was even less of an increase in ROM (.34%, p=.905). Post-5 quadriceps showed a 1.6% (p=.415) increase from the pre test, while post-10 only showed .08% increase (p=.397). When comparing both pre trial days for each muscle and intervention, there was no statistical difference in ROM (quadriceps p=.344, hamstrings p=.499).

Figure 2. Average ROM in degrees in hamstrings and quadriceps from pre to post foam roll intervention.



Discussion

The purpose of this study was to to determine the ROM and peak torque of the quadriceps and hamstrings in active individuals after longer bouts of SMR application. It was hypothesized that ROM would increase and peak torque would decrease in the hamstrings and quadriceps with the implementation of 5 and 10 minute application of SMR via high density foam roller. The most important findings are as follows: (1) There was a significant decrease in peak torque in the quadriceps from baseline to FR5 to FR10. Peak torque in the quadriceps decreased by 7.34% and 5.95% after 5 minutes FR and 10 minutes FR respectively (2) No changes occurred in hamstring peak torque production after 5 minutes FR or 10 minutes FR (3) There were no changes in range of motion in the quadriceps or hamstrings after 5 minutes FR or 10 minutes FR. Our results suggest that long bouts of foam rolling (5 minutes-10 minutes) may lead to a decrease in force production in the quadriceps while having no effect on range of motion in either the quadriceps or hamstrings.

Foam rolling for 5 minutes and 10 minutes resulted in a subsequent decrease in force production of the quadriceps by 7.34% and 5.95% respectively. One potential theory to explain the decrease in force production of the quadriceps is that foam rolling sessions lasting for 5 minutes to 10 minutes may be sufficient in duration to produce negative effects on the muscle, similar to static stretching. Static stretching for 15-30 seconds, has shown to improve ROM without having a significant effect on MVC. Longer durations of static stretching, 60 seconds or more, have been shown to affect the viscoelastic properties of the musculotendinous units by making them more

compliant. An increase in compliance of the musculotendinous units has been correlated with a decrease in MVC in the hamstrings (Ogura et al, 2007).

The results in the study are in agreement with Arroya-Moraes et al, (01) who investigated the effects of massage on isokinetic torque, possibly due to a decreased motor unit activation due to excessive parasympathetic input. Furthermore, Sullivan et al, (13) suggested that a lengthened muscle could cause mechanical damage to the sarcomeres, resulting in less than optimal actin-myosin cross-bridge linking according to the length tension relationship. These results are in contrast with McDonald et al (2013) which, demonstrated an increase in ROM without a significant effect on MVC in the quadriceps, although foam rolling sessions were brief, consisting of 2, 1 minute foam rolling sessions.

The increase in ROM after foam rolling was similar to previous studies using SMR. Post-5 quadriceps and hamstrings ROM increased 1.6% and 2.0% respectively. Foam rolling for 10 minutes also resulted in an increase, although not significant, in the quadriceps and hamstrings ROM of 0.08% and 0.34% respectively. Sullivan et al (2013) showed a 2.3% increase in hamstring ROM, however, foam rolling sessions of 10 seconds were used rather than 5 minute and 10 minute sessions used in the present study. Another study conducted by McDonald et al, (13) showed that 2, 1 minute foam rolling sessions significantly improved ROM 12.7% and 10.3% in the quadriceps post foam rolling at 2 minutes and 10 minutes respectively. The significant increase in ROM observed in the McDonald study was not observed in the current study for either FR condition.

In the present study, the data revealed the positive ROM effects from FR do not last beyond 7 minutes. During the 10 minute trial, there was a 14 minute rest period for the quadriceps while the hamstring was rolled, unlike the 5 minute trial, where the quadriceps only had 7 minute rest. This finding is not in agreement with Macdonald et al, (13) who stated a statistically significant ROM increase 2 and 10 minutes post FR.

A small sample size limited our results. Sullivan, MacDonald and Healey organized studies with sample sizes of 17, 11 and 26 subjects respectively, but there was little data that had significance. With a larger sample population, post-10 quadriceps peak torque and ROM results, likely would have been significant.

Another potential limitation in the study was the difficulty determining whether the subject properly executed the techniques of foam rolling. Each participant was given individual, standardized guidance on the foam rolling protocol. They were allowed as much time as they needed to feel comfortable to complete the task and were monitored and adjusted throughout the FR trials. Without a custom made machine or force plate to measure pressure placed onto the foam roller, there was no way to determine the amount of force being placed on the muscles. The average body weight was 68.13±

16.3 kg, so we had to assume this was the mean pressure exerted on the FR (Sullivan et al, 2013).

Finally, there was a possibility that subjects lost motivation due to their expressed dislike of the task of foam rolling. This could have resulted in a distracted mentality and a lower level of performance when it came time to do the exercises. In order to combat the possibility of bias, only subjects who had no experience with foam rolling were chosen (Healey 2014).

Conclusion

In conclusion, foam rolling for bouts of 5 and 10 minutes resulted in a decrease in force production in the quadriceps, while there was no change in ROM or force in the hamstrings. Based on the findings in the present study, future research may investigate peak torque 24 hours or more, after longer bouts of foam rolling to determine it's effects. Furthermore, the foam rolling took place immediately prior to MVC. It would be interesting to determine any positive effects due to foam rolling days in advance prior to muscular strength performance. Also, in order to see if there is any change in the range of motion, an additional criteria for future subject groups would be to gather subjects with limited ROM (Macdonald 2013). As Macdonald has discussed, if subjects already had range of motion in knee flexion to get their foot to their buttocks, then there is difficult to see improvements after intervention.

Based on the results, it would not be wise to use foam rolling prior to exercise in a clinical setting, as it has no significant impact on range of motion and causes a decrease in force production. Furthermore, based on the findings in the present study, we rejected the hypothesis due to the lack of significant ROM increase and the insignificant decrease in peak torque in the hamstrings. Five to ten minute SMR bouts via foam roller in healthy individuals provides little ROM benefits while decreasing force production in the quadriceps.

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