SELF-MYOFASCIAL RELEASE FOAM ROLLING VS. COMPRESSION GARMENTS: WHICH IS MORE EFFECTIVE AT REDUCING DOMS?

A thesis submitted to the faculty of
San Francisco State University
In partial fulfillment of
the requirements for
the Degree

Master of Science

In

Kinesiology: Exercise Physiology

by

Griffin Edward Maloon

San Francisco, California

May 2017

CERTIFICATION OF APPROVAL

I certify that I have read Self-myofascial release foam rolling vs. compression garments: which is more effective at reducing DOMS? by Griffin Edward Maloon, and that in my opinion this work meets the criteria for approving a thesis submitted in partial fulfillment of the requirement for the degree Master of Science in Kinesiology: Exercise Physiology at San Francisco State University.

Nicole Bolter, Ph.D.
Professor

Matthew Lee, Ph.D.
Professor

Marialice Kern, Ph.D.
Professor

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Griffin Edward Maloon
San Francisco, California
2017

Strenuous resistance exercise can result in exercise induced muscle damage (EIMD) which leads to delayed onset muscle soreness (DOMS). DOMS can impair an individual's ability to perform at a high level in subsequent exercise bouts if not treated. Studies done on self-myofascial release (SMR) foam rolling and compression garments have found positive effects on reducing perceived muscle soreness after high intensity exercise, although no such study has compared head-to-head effectiveness of each modality. The proposed study investigated which technique is most effective in mitigating perceived muscle soreness and attenuating loss of dynamic power after exercise. The participants were randomly assigned to one of three treatment conditions after their initial visit for exercise testing where they performed a vertical jump test as a dynamic power assessment, and single-leg extensions using a leg extension machine. The three conditions were SMR foam rolling (FR), compression garment (CG), and a control condition (CON). Participants engaged in the assigned treatment condition while also reporting levels of perceived muscle soreness, until they return for a second visit for a posttest assessment of vertical jump 72 hours later. The results showed significantly lower muscle soreness in CG and FR groups when compared to CON 48 and 72 hours postexercise, with FR also experiencing the smallest decrement in dynamic power amongst the groups. CG and FR were equal in terms of reducing perceived muscle soreness, but FR took much less time using the modality to reap the benefits, making it a more practical option for reducing DOMS.

Keywords: compression garment, self-myofascial release, delayed onset muscle soreness, foam rolling

I certify that the Abstract is a correct representation of the content of this thesis.

Dr. Matthew Lee

5/10/17
Date

PREFACE AND/OR ACKNOWLEDGEMENTS

I would like to start off by thanking all of the individuals who participated in the study. I would also like to thank all of my professors who have imparted a great wealth of knowledge upon me during my time at San Francisco State University. A special thanks goes to my committee, Dr. Lee, Dr. Bolter, and Dr. Kern, your guidance and help throughout this process has been invaluable. Finally, I would like to thank my friends and family for their continued encouragement and support, none of this would be possible without you.

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Introduction

From marathon runners who spend long portions of their days covering vast distances in training, or weightlifters that put maximal effort into moving heavy loads, all avid exercise enthusiasts must face the problem of recovery from strenuous exercise. Muscle damage and soreness is common among individuals who engage in high-intensity exercise sessions. Delayed onset muscle soreness (DOMS) is a circumstance that can result from this high-intensity exercise, and lengthen the recovery process by persisting for several days. DOMS can negatively affect performance by changing muscle function and joint mechanics resulting from skeletal muscle and connective tissue structural damage along with muscle soreness (Pearcey et al., 2015). Many individuals are looking for something to attenuate this muscle soreness, so they can shorten recovery time between exercise bouts. The answer may lie in two relatively new methods of reducing muscle soreness: compression garments and self-myofascial release with a foam roller.

The use of clothing with specific compression qualities, also known as compression garments, has become increasingly popular in the exercise world (Periera et al., 2014). They are a cost-effective and safe way to attenuate strength loss, decrease subjective muscle soreness, and aid in the removal of markers of muscle damage in both elite athletes and beginning exercisers (Davies, Thompson, & Cooper, 2009). Garments come in a variety of different ways from whole body compression suits to isolated sleeves for the upper limbs, and stockings and socks for the lower limbs. The rationale behind compression garments is to create a pressure gradient that limits the available space for swelling hemorrhage and hematoma formation in damaged muscle (Davies et al., 2009). The structure of the garment also provides mechanical support to the applied area, reducing the amount of movement and oscillation and facilitating straight-line tissue repair to the muscles (Davies et al., 2009; Kraemer et al., 2010).

Self-myofascial release (SMR) has been shown to attenuate DOMS in a wide array of different populations and fitness levels, using various tools, the most common being the foam roller (Cheatham et al., 2015; Pearcey et al., 2015). Proponents of foam rolling believe it can alleviate muscular imbalances, reduce perceived muscle soreness and joint stress, and enhance ROM and the efficiency of the neuromuscular system (MacDonald et al., 2013). When using a foam roller, the objective is to exert pressure on the soft tissue target area by use the weight of your body on the foam roller (Pearcey et al., 2015). The pressure exerted on the soft tissue will be both precise and broad as the individual rolls from the top of the area to the bottom, generating friction along the way (Pearcey et al., 2015). In this way, foam rolling is akin to massage done by oneself due to the fact that the foam roller applies a pressure to the soft tissue that is similar to pressure applied to soft tissue by way of manual manipulation by a sport massage therapist (Pearcey et al., 2015). This type of self-massage is an advantageous technique to improve muscular recovery for athletes and beginning exercisers because it is cheap, simple, and relatively quick (Pearcey et al., 2015).

Although it is widely accepted that foam rolling and compression garments are effective methods to mitigate effects of muscle soreness, to my knowledge there are no studies comparing the effectiveness of each modality against each other. Both modalities are readily available to the public and at a reasonable cost. Therefore, the purpose of the present study was to evaluate which method (self-myofascial release using a foam roller vs. wearing compression garments) is more proficient at alleviating symptoms of DOMS induced by high-intensity resistance exercise. It was hypothesized that groups using either compression garments or foam rollers would experience lower levels of perceived muscle soreness compared to the control group using static stretching as a treatment intervention. Also, it was hypothesized that the group using foam rollers would have lower perceived muscle soreness and less of a decrement in muscular performance, when compared to groups wearing compression garments

Methodology

<u>Participants:</u> The study population consisted of 30 healthy young adults (22-30 years old), both male (*n*=20) and female (*n*=10), from San Francisco State University and the surrounding Bay Area. Inclusion criteria for participants included being physically active and engaging in an aerobic or strength training regimen 2-3 times per week. All participants filled out a Physical Activity Readiness Questionnaire (PAR-Q) (see Appendix D) as well as The ACSM Risk Stratification Screening Questionnaire (see Appendix E) before enrolling in the study. Each individual was informed of the risks,

benefits, experimental protocols, and parameters of the study and was required to give written informed consent. All procedures were approved by the San Francisco State University's IRB prior to any recruitment of subjects. Individuals with any form of cardiovascular, pulmonary, or metabolic disease were excluded from the study, along with those with any musculoskeletal injury or deficit. Participants were instructed to abstain from vigorous exercise for at least 24 hours prior to testing.

Experimental Design: The study used a randomized control design in which each participant was randomly assigned to 1 of 3 different intervention conditions: foam rolling (FR), compression garment (CG), and a control condition (CON). A randomized control design was used rather than a crossover design to eliminate the incidence of a training effect occurring after multiple trials of exercise testing. After exercise testing each participant was randomly assigned to one of the three intervention groups.

Experimental Protocol for Visit 1: Participants came into the Strength and Conditioning Room (GYM 148) in the Gymnasium building at San Francisco State University for testing procedures a total of 2 times throughout the course of the study. During Visit 1 the participants were asked which modality they believe is the best in reducing perceived muscle soreness: foam rolling, compression garments, or static stretching (see Appendix F). The participant was instructed on how to foam roll the quadriceps femoris, and also on how to properly perform a single-leg standing quadriceps static stretch in accordance with ACSM guidelines (ACSM, 2014). Each participant completed a warm-up of 2x10 body weight lunges and 2x10 squat jumps. After the warm-up the participant performed a vertical jump test as a pretest assessment of dynamic power. They were given 3 attempts at the vertical jump test, with the highest score being used for data entry. The test was used as a baseline measurement for muscular performance, and was repeated during Visit 2 (Davies, Thompson, & Cooper, 2009). After the vertical jump test the participant performed a warm-up set of single leg extension on the leg extension machine. They then had 3 tries to set their 1 repetition max (1RM) for single-leg extension on the leg extension machine. This determined how much resistance they worked against in the experimental trials. This test ensured that individuals were working against a percentage of their own 1RM instead of a set resistance that could result in higher variability in muscle soreness. The intensity during the exercise was 65% of their 1RM, in accordance with previous studies (MacDonald et al., 2014; Pearcey et al., 2015; Goto & Morishima, 2014). The non-dominant leg was used for this study instead of randomizing which leg to use in order to eliminate the chance that a participant used his/her dominant leg, which could have enhanced adaptations to preventing soreness. The participant then performed 10x10 single-leg extensions at 65% 1RM, with 1-minute rest in between sets. This high-volume, high-intensity protocol has been used in previous studies to induce muscle soreness (Davies, Thompson, & Cooper, 2009). In the case that the participant was not able to fully complete all 10 repetitions per set, the researcher was there to spot the participant and help aid in lifting the weight so the participant could finish all 10 repetitions per set.

Foam Rolling Condition: Participants who were randomly assigned to the FR group then performed 20x60 sec. of foam rolling on the non-dominant quadriceps muscle, with 1 minute of rest in between sets, during the 24-hour period following exercise testing. The participant had the option to perform the 20 minutes of foam rolling and 20 minutes of rest all at once or split it up into different sessions throughout the day. If the participant chose to split up the sessions they were limited to a minimum of 5x60 sec. per session. The intensity of foam rolling was subjectively measured using the BS-11 Numeric Pain Rating Scale (see Figure 2) of 0-10, 0 being no pain at all and 10 being the worst pain ever experienced. The foam rolling trials were performed at an intensity of 3-4 on the BS-11 Numeric Pain Rating Scale, indicating just below moderate pain. The foam roller used in this study was a ProSource high-density foam roller. Previous research has shown that a foam roller with high-density like the one used in this study allows for more pressure to be applied to the target area when compared to foam rollers that are low in density (Curran, Fiore, & Crisco, 2008; MacDonald et al., 2014 MacDonald et al., 2013). The participants took the foam roller home with them and complete 20x60 sec. of foam rolling 3 times for a total of 60 minutes of foam rolling, limiting 20 minutes per 24-hour period.

Compression Garment Condition: Participants randomly assigned to the compression garment condition were instructed to put on the single leg quadriceps compression sleeve immediately postexercise testing. If the participant was assigned to the CG group circumference measurements were taken of the midthigh in accordance with American College of Sports Medicine (ACSM) guidelines on circumference measurements (halfway between the inguinal crease and the patella on the proximal border) (ACSM, 2014). This procedure was used to determine the sizing for appropriate compression when using the compression quadriceps sleeve. The compression garment that was used is a McDavid Thigh Sleeve. After completion of exercise testing during Visit 1, the participant put on the thigh sleeve and had the researcher check for correct placement. The participant was instructed to wear the compression sleeve at all times until they came back for Visit 2 72 hours postexercise. In order to assure correct pressure was being applied at all times, the researcher made a small mark with a sharpie on the participant's skin at the anterior midline of the top and bottom of the thigh sleeve. The participant was able to line the compression garment up with these two markers if for some reason it moved from correct placement. The participants were allowed to take the compression sleeve off to bathe, but told to put it back on immediately after. Participants were instructed to abstain from any vigorous exercise or modality to enhance recovery during the 72-hour testing period.

<u>Control Condition:</u> Participants randomly assigned to the control condition at Visit 1 performed static stretching of the non-dominant quadriceps muscle in accordance with ACSM guidelines for static stretching. The participants performed 10x60 sec. of static stretching on the non-dominant quadriceps using a standing single-leg quadriceps stretch,

per 24-hour period. The participants were allowed to rest 30 seconds between each set, but were required to complete the 10 total minutes of static stretching in one session as was instructed by ACSM guidelines (ACSM, 2014).

Experimental Protocol for Visit 2: After 72 hours the participants returned to the exercise physiology lab for Visit 2 and another vertical jump test, which was compared to the vertical jump test completed during Visit 1. The vertical jump test was used as the dependent variable used to measure changes in muscular performance over time. The participant also reported perceived muscle soreness of the quadriceps 24, 48, and 72 hours after Visit 1 by telephone call or text initiated by the researcher. The researcher measured perceived muscle soreness of the non-dominant quadriceps using a chair stand to sit test. The participant was instructed to sit down in a chair then rise from the chair and then sit back down. After completing this test, the researcher asked the participant to rate their perceived muscle soreness using the BS-11 Numerical Rating. The participant was instructed to abstain from any vigorous exercise or modality to enhance recovery during the 72-hour testing period.

Data Analysis: IBM SPSS Version 24 was the primary software used to analyze all data. A one-way ANCOVA was used to determine if there were any differences in vertical jump scores between pre and posttest for each participant and between different intervention groups (CG, FR, CON). A Bonferroni *post hoc* was used in addition to the ANCOVA to determine significance, with a statistical significance of $p < 0.05$. A 3x3 mixed between-within subjects repeated measures ANCOVA was used to determine if there were any difference in perceived muscle soreness between different time points (24, 48, 72 hours post exercise) for each participant and between different intervention groups (CG, FR, CON) for the same participant. Opinion on which of the 3 modalities was best at reducing DOMS was used as a covariate for this analysis to determine whether it had any effect on perceived muscle soreness amongst the different treatment groups. A Tukey *post hoc* was used in addition to the ANCOVA to determine significance. All data were reported as mean ± SD.

Results

The study population consisted of 20 male subjects and 10 female subjects. The average age of the subjects was 25 years old ($M = 25.1$, $SD = 1.8$). All participants engaged in an exercise regimen at least twice per week, with an average of 4 days of exercise per week ($M = 4.5$, $SD = 1.3$).

Tables 1 and 2 show the values for change in vertical jump scores (in.) from pretest to posttest. During pretest evaluations, each participant was asked which modality they believed was best at reducing DOMS: static stretching (1); foam rolling (2); or compression garments (3). A one-way ANCOVA investigated if the treatment group or opinion on recovery modalities impacted the change in vertical jump scores from pretest to posttest, and if there was an interaction between treatment group and opinion that may have affected change in vertical jump scores. The analysis revealed a main effect for the treatment group [F (2,24) = 6.55, p = 0.005], but no opinion effect or interaction. Therefore, indicating preexisting opinion on which recovery modality is best at reducing DOMS had no effect on change in vertical jump scores, even if the subject was randomly assigned to the treatment group they indicated was best at reducing DOMS [F (1,24) = 0.27, p = 0.61]. The treatment group effect size was rather large (partial eta squared = 0.35), indicating that 35% of the change in vertical jump scores can be attributed to the treatment group. A Bonferroni *post-hoc* comparison revealed that the mean score for the foam rolling group (M = -0.025, SD = 0.75, p = 0.004) was significantly different from the control group (M = -1.85, SD = 0.54). Pairwise comparisons indicated a mean difference of 1.8 in. when comparing change in vertical jump scores between the foam rolling group and the control group. In other words, participants in the control condition saw a significantly larger decrease in their posttest vertical jump when compared to their pretest vertical jump than the foam rolling condition did. There was no significant difference between the change in vertical jump scores for when the compression garment group (M = -0.98, SD = 1.54) was compared to the control group, as well as the compression garment group being compared to the foam rolling group.

Table 3 shows the mean values of perceived muscle soreness scores for the three treatment groups at different time points following exercise testing. A 3x3 mixed between-within subjects repeated measures ANCOVA was conducted to assess the impact of three different treatment conditions (CON, FR, CG) on perceived muscle soreness scores across three time points (24 hours, 48 hours, and 72 hours postexercise testing). An interaction effect was observed for time x treatment, Wilks' Lambda = 0.62, F (4,52) = 3.57, p = 0.012, partial eta squared = 0.22. This indicates that 22% of the change in perceived muscle soreness can be attributed to the interaction between time and treatment group, which is rather large effect size. A Tukey *post hoc* analysis found that at 48 hours postexercise there was a significant difference in perceived muscle soreness between CON vs. FR (Mean Difference = 2.30, SD = 0.72, p = 0.004), and CON vs. CG (Mean Difference = 2.10, SD = 0.72, p = 0.007). The *post hoc* analysis also showed that there was a significant difference in perceived muscle soreness at 72 hours postexercise between CON vs. FR (Mean Difference = 3.00, SD = 0.51, p = 0.00), and CON vs. CG (Mean Difference = 2.80, SD = 0.510, p = 0.00). Interestingly, at both 48 and 72 hours postexercise both the FR and CG groups showed significantly lower perceived muscle soreness scores when compared to the CON group. It should be noted that at all three time points perceived muscle soreness did not significantly differ between CG and FR groups.

There was a significant main effect for time, Wilks' Lambda = 0.16, F (2,26) = 67.71, p = 0.000, partial eta squared 0.84. This indicated that 84% of the change in perceived muscle soreness can be attributed to time. A Tukey *post hoc* analysis revealed that the mean difference in muscle soreness differed across all time points: 24 h vs. 48 h (Mean Difference = 1.2, SD = 0.28, p = 0.001); 48 h vs. 72 h (Mean Difference = 1.57, *SD* = 0.21, *p* = 0.000); 24 h vs. 72 h (Mean Difference = 2.77, *SD* = 0.26, *p* = 0.000). Perceived muscle soreness was found to decrease at every time point, regardless of treatment group.

There was also a significant main effect for treatment, F (2,27) = 8.87, p = 0.001, partial eta squared = 0.39. Indicating that 39% of change in perceived muscle soreness scores was due to the treatment group, regardless of time. A Tukey *post hoc* analysis revealed a significant difference in perceived muscle soreness scores between CON vs. FR (Mean Difference = 2.0, *SD* = 0.53, *p* = 0.003), and CON vs. CG (Mean Difference = 1.87, *SD* = 0.53, *p* = 0.005). However, there was no significant difference in perceived muscle soreness scores between FR vs. CG (Mean Difference = -0.13, *SD* = 0.53, *p* = 1.00). Although both the CG and FR groups saw lower perceived muscle soreness than the CON group, the perceived muscle soreness between the CG and FR group remained equal.

A majority of the participants indicated they believed static stretching (*N* = 15) was the most effective method of reducing DOMS when compared to FR (*N* = 13) and CG (*N* = 2). The ANCOVA found that the covariate of opinion for which modality was best at reducing DOMS was not significant. The analysis revealed that regardless of whether the participant was assigned to the treatment condition they thought was best at reducing DOMS, it had no effect on perceived muscle soreness [F (1,26) = 0.05, p = 0.98].

Discussion

Recovering from an intense bout of exercise can be tough for individual, regardless of fitness level. DOMS is one of the greatest factors that can hinder recovery after intense exercise, but there are different modalities that can mitigate the symptoms of DOMS. The present study investigated the application of three different recovery modalities (static stretching, foam rolling, and compression garments) after a 10x10 single-leg extension protocol. Results of the study support the first hypothesis, being that the FR group and the CG group experienced significantly lower perceived muscle soreness during the recovery period. This finding indicates that the use of CG and FR both enhanced recovery from DOMS in the individuals who used each separate modality. However, the hypothesis that both the FR and CG groups would experience a mitigation of dynamic power loss compared to the CON group was not true. Although the CG did have a smaller change in vertical jump scores when compared to the CON group, it was not statistically significant. Individuals in the FR group benefitted most from the recovery modality, as they were able to maintain dynamic power to the greatest extent amongst the groups, with their posttest vertical jump being only approximately 0.03 in. shorter than their pretest vertical jump.

The second hypothesis being that the FR group would experience a greater attenuation of perceived muscle soreness than the CG group was not supported, as the results showed the perceived muscle soreness for the CG and FR group did not differ throughout the study. These findings suggest that both modalities are equal in terms of their ability to aid in the reduction of DOMS when compared to a static stretching regimen. It also indicates that in and of itself, the use of CG and FR are effective methods to mitigate perceived muscle soreness as the mean values of both groups at 72 hours postexercise were under a score of 1, indicating almost no pain whatsoever (see Table 3).

Several studies examining the effects of foam rolling on DOMS have found it imparts benefits on dynamic movements, such as vertical jump (Pearcey et al., 2015; MacDonald et al., 2013). One theory on why foam rolling can impart beneficial effects on dynamic movements is its ability to change the properties of the muscle fascia (MacDonald et al., 2013). DOMS can cause crosslinks in the muscle fascia, which makes it less compliant and can result in limited ability to produce power and force (Barnes, 2005; Stone, 2000). Using a FR can act to warm the fascia, making it more fluid like which allows for the atypical crosslinks to be destroyed and muscle elasticity to be restored (MacDonald et al., 2013). This phenomenon along with FR ability to improve ROM can explain why the FR group saw the smallest decrement in vertical jump in the face of DOMS. The results of this study are in line with previous studies, which found that wearing a CG for 24-72 hours postexercise did not have an effect on dynamic power assessments, such as vertical jump (Davies, Thompson, & Cooper, 2009).

The continued use of the foam rolling and compression garment modalities seemed to speed recovery by reducing perceived muscle soreness. Although initially (24 hours postexercise), all groups' perceived muscle soreness was equal, the use of the CG and FR significantly reduced perceived muscle soreness at the later time points in the study (48 and 72 hours postexercise). Previous studies have postulated that the main benefit from FR and CG involves their ability to remove biological markers of muscle damage such as blood lactate and creatine kinase, while also brining a greater volume of blood, and thereby oxygen, to the affected muscle (Pearcey et al., 2015; Cheatham et al., 2015; Davies, Thompson, & Cooper, 2009). The fact that the CG and FR groups both experienced lower perceived muscle soreness, indicative of enhanced recovery, could be due to the fact that these modalities helped improve blood flow to the quadriceps femoris to a greater extent when compared to the CON group who completed a static stretching regimen. The actual pressure applied to the area by the FR or CG seems to be a greater stimulus than stretching of the muscle when it comes to enhanced blood flow and recovery. The results seem to indicate that FR and CG use have an inverse relationship with perceived muscle soreness: as the time the modality is used increases, perceived muscle soreness decreases. This is indicated by perceived muscle soreness being equal for all groups at 24 hours postexercise, but then seeing significantly lower perceived muscle soreness for CG and FR groups 48 and 72 hours postexercise when compared to the CON group. Several studies support the notion that CG and FR must be used continuously over several days to impart substantial benefits on recovery and reduce DOMS (MacDonald et al., 2013; Kraemer et al., 2015; Pearcey et al., 2015).

The fact that the preexisting opinion on which modality is best at reducing DOMS had no effect on performance assessment (vertical jump) or perceived muscle soreness indicates somewhat of a reverse placebo effect, in the sense that the study showed that modalities such as FR and CG both significantly reduced DOMS when compared to CON, even if the subject believed static stretching was a more effective modality. In other words, those recovery modalities work whether a person believes they will or not. It is interesting though that a large proportion of the participants thought that static stretching was the best modality out of the three in order to reduce DOMS. Half the participants ($N = 15$) indicated before the study that static stretching was the most effective modality of the three in terms of reducing DOMS. This could be due to the fact that research on CG and FR is still relatively new with information still emerging about the benefits of each. Numerous studies suggest that information regarding CG and FR has not yet reached the collective social consciousness, and some of the mechanisms by which it acts upon the body are still not fully understood (Pearcey et al., 2015; Chetham et al., 2015; Davies, Thomspson, & Cooper, 2009; MacDonald et al., 2013). On the other hand, static stretching practices have been taught in the fitness and physical education world for many years. That fact that static stretching is a more commonly understood practice may explain why more participants indicated they believed it was the most effective modality of the three at reducing DOMS.

Limitations: Although all subjects reported that they completed all the required work with their specified recovery modality, there still in lies the chance that they may have either skipped a FR or stretching session, or may have taken off the compression garment for some reason other than to bathe and told the researcher otherwise. The study did not have access to equipment used to measure blood variables, thereby not allowing any measurements of blood biomarkers of muscle damage like creatine kinase and lactate dehydrogenase, which are more sensitive indicators of muscle damage and DOMS.

All participants were told to refrain from any sort of vigorous exercise or recovery modality (other than the one they were assigned) that may help aid in recovery during the 72-hour recovery period. Although all participants reported to have complied with this request, it is possible that participants may have engaged in some sort of exercise during that time period, especially due to the fact that the study population was relatively active and regularly engaged in an exercise regimen. Moreover, some of the participants may have had a preexisting adaptation to reducing DOMS. If they were engaged in a high-intensity resistance training program, they may have experienced diminished perceived muscle soreness from the exercise protocol. For example, an individual who has been resistance training 5 days per week for the past 6 months is more accustomed high-intensity strength exercise than an individual who may only engage in resistance training

2 days per week. The individual who is exercising 5 days per week may have developed adaptations to shorten recovery time, facilitate muscle repair, and maintain a higher threshold to perceived muscle soreness when compared to the individual who exercises 2 days per week. Random assignment into the treatment groups was used to try and attenuate this phenomenon from occurring.

Future Research: Future research in the field should focus on comparing different amounts of time needed to see benefits from CG and FR. It would be interesting to investigate whether 10 minutes of FR or 12 hours of wearing a CG per day would still have a beneficial effect on reducing DOMS. The present study used a protocol of 20 minutes of FR and 24 hours of CG per day. This shortened protocol could shed light on whether using the modality 50% less than the present study would still impart the same benefits. Also, timing could be an interesting variable to examine as well, whether different times of the day (i.e. morning vs. night) or splitting up the modality use throughout the day would have any sort of beneficial effect on limiting DOMS.

A future research design could use a randomized crossover design so each participant tries each recovery modality. The design would have to alter exercise protocol for each exercise testing session so the participant does not develop a training effect to the exercise induced muscle damage. This study has shown the beneficial effects of CG and FR on the quadriceps femoris muscle, but future research could examine if the same positive effects on DOMS would be seen if the CG and FR were applied to a different area such as calf, gluteus maximus, or pectoralis major. Finally, it would be interesting to compare the effectiveness of CG and FR in terms of reducing DOMS to other popular recovery modalities today such as deep tissue massage, cryotherapy, heat therapy (i.e. sauna).

Practical Applications: Although the FR and CG groups did not differ in perceived muscle soreness throughout the study, it is interesting to note that this phenomenon occurred with these two groups using their respective modalities for differing amounts of time. The FR group used a foam roller for 20 minutes a day for 3 days, for a total of 60 minutes during the study. The CG group wore the compression garment for all 72 hours of the study, only removing it for bathing purposes. So essentially, an individual could get the same beneficial effects of reducing perceived muscle soreness and mitigating DOMS by just using a FR for 20 minutes a day rather than a CG for 24 hours. This study also offers beneficial information for anyone trying to find a cost-effective and easy way to reduce DOMS, as the foam roller used in this study was only $8, while the compression garments were over twice that amount. Although the popularity of foam rollers and compression garments is growing, it is still startling how many individuals do not know the beneficial effects of these recovery modalities, including those in the fitness profession. The information provided in this study shows that both these modalities are more effective at reducing DOMS when compared to static stretching, which many participants in this study indicated they still believed was best at reducing DOMS. It is important for those in the fitness profession to take this information and integrate it into exercise program for clients, who could see marked improvements in recovery by the use of compression garments and foam rollers.

Conclusion: From the present findings, it can be postulated that FR and CG impart significant benefits on reducing DOMS. Additionally, FR also is a useful tool in terms of maintaining dynamic power performance after high-intensity exercise causing DOMS. Although there appears to be no difference between the effects that CG and FR have on perceived muscle soreness 72 hours postexercise, it should be noted that FR requires substantially less time spent using the modality to reap these enhanced recovery benefits.

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Table 1 Mean ± SD vertical jump test results

Treatment Group	Pretest Vertical Jump (in.)	Posttest Vertical Jump (in.)	Δ Vertical Jump (in.)	Which modality is best at reducing DOMS?
CON (N = 10)	16.56 ± 3.06	14.73 ± 3.14	-1.85 ± 0.54	15
FR (N = 10)	16.20 ± 2.66	16.18 ± 2.41	**-0.03 ± 0.75***	13
CG (N = 10)	20.30 ± 4.82	19.28 ± 4.04	-0.98 ± 1.54	2
Total (N = 30)	17.69 ± 3.98	16.73 ± 3.69	-0.95 ± 1.26	30

* = $p < 0.05$ vs. CON

Table 2 Mean ± SD for change in vertical jump test score (in.) with regards to opinion for best recovery modality

Treatment Group	Opinion	Δ Vertical Jump (in.)	N
CON	Yes	-1.96 ± 0.51	6
	No	-1.69 ± 0.63	4
	Total	-1.85 ± 0.54	10
FR	Yes	0.00 ± 0.93	6
	No	-0.063 ± 0.47	4
	Total	**-0.03 ± 0.75** *	10
CG	Yes	-1.50 ± 0	1
	No	-0.92 ± 1.63	9
	Total	-0.98 ± 1.54	10
Total	Yes	-1.02 ± 1.21	13
	No	-0.90 ± 1.33	17
	Total	-0.95 ± 1.26	30

* = $p < 0.05$ vs. CON

Opinion meaning the subject was randomly assigned to the treatment group they had indicated they believe was best at reducing DOMS before testing (1=Yes), or the subject was randomly assigned to a treatment group that was different from what they indicated they believed was best at reducing DOMS (2=No).

Table 3 Mean ± SD changes in perceived muscle soreness (0-10) over recovery period

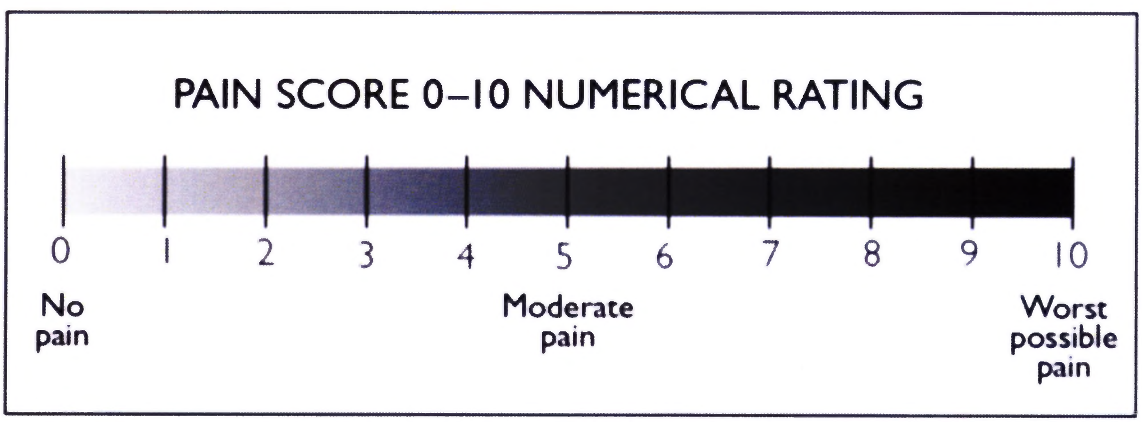
Time Postexercise	Treatment Group	Perceived Muscle Soreness
24 h	CON	5.00 ± 1.05
	FR	4.30 ± 1.42
	CG	4.30 ± 1.89
	Total	4.53 ± 1.48
48 h	CON	4.80 ± 0.63
	FR	**2.50 ± 2.07** *
	CG	**2.70 ± 1.77** *
	Total	3.33 ± 1.88
72 h	CON	3.70 ± 0.82
	FR	**0.70 ± 1.25** *
	CG	**0.90 ± 1.28** *
	Total	1.77 ± 1.78

* = $p < 0.05$ vs. CON

Figure 1 Change in mean ± SD perceived muscle soreness throughout 72 hours

* = $p < 0.05$ vs. CON

Figure 2 BS-11 Numeric Pain Rating Scale



Appendix A

Mechanisms of DOMS: Delayed onset muscle soreness (DOMS) is a consequence of exercise-induced muscle damage (EIMD) that can occur in novice exercisers to elite athletes after an intense exercise session (MacDonald et al., 2014). Muscle soreness, swelling of the muscle, transient muscle damage, and attenuation of strength and ROM are all typical signs of EIMD (MacDonald et al., 2014). EIMD can also have an effect on the neuromuscular systems of the body. Uncommon stress is placed on ligaments and tendons due to a reduction in shock attenuation caused by recruitment patterns and sequencing being altered by EIMD (MacDonald et al., 2014). Treatments such as compression garments, cryotherapy, and submax exercise have shown to impart positive effects on some symptoms of EIMD, but no single therapy has been proven to alleviate all the symptoms of EIMD (MacDonald et al., 2014). In a study done by MacDonald et al., the use of foam rollers is hypothesized to be a beneficial therapy to alleviate the symptoms of EIMD and DOMS (MacDonald et al., 2014). Nevertheless, further research is needed to fully understand the physiological mechanisms by which symptoms of EIMD and DOMS can be attenuated.

Characteristics of DOMS are dependent upon the intensity, duration, and mode of exercise performed, as well as the individual themselves (Pearcey et al., 2015). Normally, the intensity of DOMS is greatest 24 to 72 hours post exercise (Pearcey et al., 2015). After hour 72 DOMS will typically start to diminish and eventually dissipate approximately 7 days postexercise (Pearcey et al., 2015). Some individuals may only experience minor stiffness in the muscle that can be alleviated by everyday activities, while others may experience intense pain and soreness that limits their ability to do any sort of activity or movement (Pearcey et al., 2015). Common performance detriments that are accompanied by DOMS include: reduced production of force, diminished joint proprioception, limited ROM, muscle stiffness, accelerated resting metabolic rate, depreciated power output, realignment of recruitment pattern networks, and increased chance of muscle damage (Pearcey et al., 2015; Weerapong et al., 2005). These performance detriments can lead to impaired joint and muscle function, which in turn causes individuals to seek out different movement patterns with less resistance. Performance is often diminished as a result (Pearcey et al., 2015).

Although there is still debate as to what physiological mechanism causes decreased performance with DOMS, Pearcey et al. postulates that several circumstances may contribute to the issue (Pearcey et al., 2015). One theory is that the intense action of exercise actually ruptures the Z-lines of the sarcomere. With this injury at the physiological level comes inflammation and fatiguing of the muscle. As a result, there is a drastic drop in ability to produce strength, along with severe pain (Pearcey et al., 2015). Cheung, Hume & Maxwell support the notion sarcomere damage is one of the principle physiological causes of DOMS (Cheung, Hume & Maxwell, 2003). Their theory is that receptors for pain in the body, such as nociceptors, become hypersensitive due to build-up of calcium, increase in osmotic pressure, sarcomere injury, and protein deterioration following intense exercise. When these receptors become sensitized the result is the muscle pain of DOMS (Cheung, Hume & Maxwell, 2003).

Damage to connective and muscle tissue during primarily eccentric movements is thought to be due to immense stress placed upon the myofibrils (Torres et al., 2012; Komi et al., 1972). The sensation of soreness arises because of this damage and generates inflammation in the damaged area (Torres et al., 2012). An influx of inflammatory cells, edema, and calcium ions into the intracellular space contribute to the cell losing homeostasis and signaling pain receptors (Torres et al., 2012; Crane et al., 2012; Weerapong, Hume & Kolt, 2005; Hilbert, Sforzo & Swensen, 2003). The injury to the sarcoplasmic reticulum of the muscle cell can open up intracellular calcium channels (Weerapong, Hume & Kolt, 2005). As calcium enters the cell it activates Calpain, a protease which takes part in degrading structural proteins in the muscle cell (Clarkson & Sayers, 1999; Hilbert, Sforzo & Swensen, 2003). The muscle sends out an inflammatory response triggering an influx of cells and fluid to the injured area. The inflammatory response also attracts macrophages and neutrophils to the area, where they act in the healing of the cell as well as the damage processes (Weerapong, Hume & Kolt, 2005). In some cases, the neutrophils can unintentionally degrade healthy muscle tissue resulting in further damage (Hilbert, Sforzo & Swensen, 2003). Further research is needed to identify the precise physiological processes as to why it takes hours for soreness to fully develop, as it still is not fully comprehended (Weerapong, Hume & Kolt, 2005).

A study done by MacDonald et al. said that while injury to the muscle cell is associated with DOMS, the injury to the cell does not specifically result in DOMS (MacDonald et al., 2014). The reasoning behind this theory being that muscle enzyme outflow and myofibrillar injury are not associated with the feeling of being sore (MacDonald et al., 2014). To this point it may be more likely that injury to connective tissue may play a larger role in the development of DOMS, with the myotendionous junction being reported as the primary location of soreness (MacDonald et al., 2014; Jones et al., 1987). Further research is needed in this area as the literature on connective tissue damage and DOMS is limited.

Appendix B

Mechanisms of compression garments: There have been several research studies investigating the use of compression garments as a mediator of muscle damage and soreness after high-intensity exercise. One study done by Duffield found that the compression garment led to an increase in intramuscular pressure, which was hypothesized to attenuate the extent of muscle damage from high-intensity plyometric and sprint exercises (Duffield, 2009). He went on to add that while the use of compression garments may not act directly to shorten recovery time, it aids in the attenuation of self-perceived muscle soreness (Duffield, 2009). Several studies looked at the extent of reduced muscle vibration in the working muscles, which may also contribute to the alleviation of muscle damage (Duffield, 2009; Martorelli et al., 2015). More specifically, Doan et al., observed a reduction in muscle oscillation on landing from vertical jumps which coincided with a higher reduction in muscle soreness in the compression garment group when compared to the control group (Doan et al., 2003). The ability of the compression garment to reduce muscle damage is likely due to an enhancement in soft tissue repair (Kraemer et al., 2001). In a study done by Kraemer et al., they presented the theory of dynamic casting, which acts to reduce soft tissue damage by compressing the affected muscle and limiting extra movements (Kraemer et al., 2001). Significant results are limited by the heterogeneity of the subjects used in several studies. In studies done by Kraemer et al., and Martorelli et al., the study population consisted of well-trained athletes (Kraemer et al., 2001; Martorelli et al., 2015). The attenuated muscle soreness seen after exercise could possibly be due to training adaptations in these athletes rather than the compression garment itself (Kraemer et al. 2001).

One of the most widely agreed upon benefits of wearing compression garments is their effect on perceived muscle soreness. Several studies have demonstrated a significant reduction in muscle soreness in individuals who use compression garments compared to those in a control group (Davies, Thompson, & Cooper, 2009; Goto & Morishima, 2014). One study found perceived muscle soreness was greatly attenuated 48 hours after repetitive maximal drop jumps, which can cause a high amount of eccentric loading on the muscles (Davies, Thompson, & Cooper, 2009). The eccentric loading of this exercise can result in damage to the cytoskeleton and disrupt myofibrillar material, so compression garments can be crucial in limiting these factors. Another study done by

Goto & Morishima, demonstrated decreased muscle soreness and fatigue after a whole body exercise protocol when the participants wore the compression garment in recovery (Goto & Miorishima, 2014). The compression garment trial also showed a rapid performance recovery when performing 1RM chest press and MVC for knee extension (Goto & Morishima, 2014). The participants were found to have attenuated swelling in both the lower and upper limbs when wearing the compression garment after exercise (Goto & Morishima, 2014). Previous studies have shown localized swelling can result in muscle soreness after exercise (Cleak & Eston, 1992). Since the subjects in the study done by Goto & Morishima put on the compression garment immediately after their exercise protocol, they were protected from secondary muscle damage and delayed-onset muscle soreness (Goto & Morishima, 2014). Goto & Morishima, explained a possible limitation of the study being a placebo effect of the compression garments (Goto & Morishima, 2014). The compression garment worn during recovery exerted pressure on the muscle that could have resulted in a lower perceived muscle soreness even when physiological variables were unchanged (Goto & Morishima, 2014).

The neuromuscular and metabolic effects that compression garments have on the body are a rapidly growing area of research over the past 10-15 years. Numerous studies have shown that compression garments facilitate enhanced blood flow and may increase venous return (Duffield, 2009; Chauveau, 1999; Davies, Thompson & Cooper, 2009; Driller & Halson, 2012). A study done by Driller & Halson found that compression garments reduced transmural pressure on arterioles by applying pressure on underlying tissues (Driller & Halson, 2012). This direct pressure was hypothesized to cause the arterioles to dilate, thereby increasing blood flow (Driller & Halson, 2012). The study went on to state that the compression garment further aided in an increase in blood returning to the heart by redistributing blood to the deep venous system from the periphery (Driller & Halson, 2012). Davies et al., supported this claim in their study adding that a combination of compression on superficial veins along with enhanced capillary filtration led to a greater blood volume being redirected towards the deep veins (Davies, Thompson, & Cooper, 2009). Two separate studies done by Chauveau, and Bringard et al. cited specifically that the compression garment enhances the muscle pump action which assists in the accelerated blood flow and increase in venous return (Chauveau, 1999; Bringard, Perrey, & Belluye, 2006). This increase in blood flow has also been shown to aid in the clearance of exercise-induced metabolites (Duffield, 2009; Goto & Morishima, 2014; Bringard, Perrey, & Belluye, 2006; Davies, Thompson, & Cooper, 2009). The increased blood flow seen in the study done by Davies et al. was hypothesized to work similar to the idea of active recovery, in that it aided in the removal of exercise-induced metabolites and allowed blood gases to return to normal levels (Davies, Thompson, & Cooper, 2009).

Biological markers of muscle damage, creatine kinase (CK) and lactate dehydrogenase (LDH), are the two most commonly measured exercise-induced metabolites that seem to be affected by the use of compression garments. Several studies have shown significantly decreased levels of CK and LDH after exercise when compression garments are worn (Kraemer et al., 2001; Kraemer et al., 2010; Davies Thompson, & Cooper, 2009). Kraemer et al., found that after a heavy resistance training exercise session, the individuals wearing compression garments showed significantly lower CK and LDH concentrations 24 hours postexercise (Kraemer et al., 2010). These reduced levels of CK and LDH demonstrated the ability of the compression garment to enhance repair of musculature, even at lower levels of soft tissue damage (Kraemer et al., 2010). In a previous study done by Kraemer et al., they hypothesized that two possible mechanisms as to why there was a decrease in CK concentration in the group wearing the compression garments after eccentric exercise: 1) the compression treatment acts to attenuate the release of damage markers, such as CK; and 2) The compression garment facilitates a more rapid clearance and removal of damaged myofibrillar proteins (Kraemer et al., 2001). Along with these reduced levels of CK and LDH came a significant reduction in perceived muscle soreness in the group wearing the compression sleeve 5 days post exercise, when compared to a control group (Kraemer et al., 2001).

Still, several studies have found inconclusive results relating performance recovery to blood parameters (Goto & Morishima, 2014). A study done by Goto & Morishima found no difference in CK, Interleukin 6 (IL-6), Insulin Growth Factor-1 (IGF-1), or serum free testosterone when comparing the compression garment group to the control group after heavy resistance training exercise (Goto & Morishima, 2014). Another study found an improved recovery of jump performance after 100 plyometric drop jumps in the group wearing the compression garment, but did not see any effect on plasma CK concentrations (Jakeman et al., 2010). Using direct measures of blood biomarkers of muscle damage such as magnetic resonance imaging has been thought to produce a more accurate method (Goto & Morishima, 2014). This is an area of future research to test the sensitivity of this instrumentation in measuring blood biomarkers of exercise-induced muscle damage.

Appendix C

Mechanisms of self-myofascial release with a foam roller: Foam rolling has become a common practice that massage therapists use to help hasten recovery and attenuate DOMS (Pearcey et al., 2015). DOMS has a tendency to limit dynamic movements such as those involving multiple joints or sport-specific maneuvers. SMR using foam rolling techniques can positively affect the recovery of these movements, not unlike massage therapy (Pearcey et al., 2015). Massage therapy has shown a positive effect on EIMD by reducing perceived muscle soreness, inflammation and stress on a cellular level, and also increasing blood flow to the affected area, and production of mitochondria (MacDonald et al., 2014). One study done by Nguyen et al., found that individuals who used a massage therapist after high-intensity exercise were shown to have decreased concentration of neutrophils in the muscle bed, and an attenuation of plasma creatine kinase concentration (Nguyen et al., 2009). A study done by Weerapong et al., also saw an increase in neutrophil concentration 24 hours postexercise in a massage group, which coincided with reductions in perceived muscle soreness and inflammation (Weerapong et al., 2005). Another study done by Crane et al., looked at biochemical factors after inducing EIMD of the quadriceps in 11 young men (Crane et al., 2012). The group that received massage therapy after the EIMD saw an increase in the mechanosensory sensors that lead to the production of new mitochondria by the transcription of COX7B and ND1, when compared to the control group (Crane et al., 2012). The mitochondria that arise from this process are hypothesized to increase the rate of muscle repair (Crane et al., 2012). The massage group also was shown to have decreased levels of heat-shock proteins and cytokines, which are indicators of inflammation and stress at a cellular level (Crane et al., 2012). Zainuddin et al., postulated that massage to sore areas of soft tissue may cause low-threshold sensory fibers to discharge and briefly stop pain from soreness (Zainuddin et al., 2005). The study also supported the claim that massage has positive effects on decreasing DOMS as seen by decreased swelling and a reduction in creatine kinase levels in massaged areas after EIMD has occurred (Zainuddin et al., 2005). It was hypothesized that massage can have a positive effect on the transport of creatine kinase in the sore muscle to blood circulation in the body (Zainuddin et al., 2005). The massage also can enhance creatine kinase removal by improving the blood flow (Zainuddin et al., 2005). One study looked at how a 30-minute massage on a single leg affected symptoms of DOMS after a downhill running exercise session for 2 hours (Farr et al., 2002). The researchers found that the experimental massage leg had significant reductions in perceived muscle soreness when compared to the contralateral control leg (Farr et al., 2002). A study done by Hilbert, Sforzo & Swensen, speculated that effects of massage may be more in the psychological realm than physiological (Hilbert, Sforzo & Swensen, 2003). The researchers postulated that things such as increased levels of serotonin and endorphins, enhanced patterns of sleep, and reductions in stress hormones may be the cause for why these decreases in muscle soreness were seen in massage groups after high-intensity exercise (Hilbert, Sforzo & Swensen, 2003).

Although the mechanisms by which DOMS works are still unclear, it has been hypothesized that the primary cause of DOMS is due to the properties of connective tissues being altered by unaccustomed movements or high-intensity exercise (Cheatham et al., 2015). In a study done by Cheatham et al., he postulated that foam rolling may be effective for alleviating DOMS because it is acting upon the altered connective tissue, rather than the skeletal muscle (Cheatham et al., 2015). It is hypothesized that this phenomenon may be why there is attenuation in perceived muscle soreness, while there is no decrease in muscular performance (Cheatham et al., 2015). A study done by MacDonald et al., further supported this point by showing that the primary location for EIMD pain is in the connective tissue, and the group that foam rolled showed significantly lower pain scores throughout the study when compared to the control group. This lead the researchers to conclude that foam rolling can be an effective way to aid in the connective tissue recovery (MacDonald et al., 2014).

Several studies have indicated that self-myofascial release (SMR) not only can increase blood lactate removal by increasing the flow of blood to the massaged area, it also is thought to reduce edema concentration, and facilitate the delivery of oxygen to affected muscle (Cheatham et al., 2015; Weerapong, Hume, Kolt, 2005; Pearcey et al., 2015; Crane et al., 2012). Increased levels of blood lactate and edema have been shown to indicate muscle damage and often go hand in hand with perceived muscle soreness (Cheatham et al., 2015). In a study done by Pearcey et al., it was hypothesized that increase in blood flow to the affected area was responsible for the positive benefits on improving recovery and decreasing muscle soreness (Pearcey et al., 2015). The increase blood flow results in improved delivery of oxygen to the muscles, which promotes adenosine triphosphate (ATP) to be resynthesized in the mitochondria and calcium to be transported into the sarcoplasmic reticulum (Pearcey et al., 2015). These physiological mechanisms are thought to result in enhanced recovery of the musculature and decreased perceptions of muscle soreness (Pearcey et al., 2015).

In a study done by Barnes, it was hypothesized that fascia can change levels of viscosity due to atypical crosslinks that form (Barnes, 2005). These crosslink, along with scar tissue, form from the muscle being over exerted or from idleness (Stone, 2000). When the fascia is in a more solid state it is less compliant, and can cause decrements in muscular force and limited movement patterns (Barnes, 2005; Stone, 2000). A study done by MacDonald et al., explains how foam rolling can fix this problem. The friction that is created between the body and the foam roller creates a warming of the fascia (MacDonald et al., 2013). When this happens the fascia becomes more like a fluid, which allows the destruction of fibrous adhesions in the different sections of the fascia and soft-tissue elasticity to be reestablished (MacDonald et al., 2012).

Foam rolling immediately after exercise is crucial for jump-starting the recovery process. A study done by Cheatham et al. found that using a foam roller for 10-20 minutes post-exercise results in attenuation of perceived muscle soreness, while also mitigating any performance decrement to lower body musculature (Cheatham et al., 2015). In addition, foam rolling in the 3 days following high-intensity exercise for approximately 20 minutes/day resulted in further reductions in perceived muscle soreness (Cheatham et al., 2015). Another study done by Pearcey et al., found similar results indicating that just a 20-minute foam rolling session following high-intensity exercise and once every 24 hours for 4 days postexercise led to a reduction in perceived muscle soreness and an ability to perform dynamic multi-jointed movements which are commonly hindered by DOMS (Pearcey et al., 2015). The group that used foam rollers after exercise found higher scores in: pressure-pain threshold, sprint speed, and power output at all post-exercise time points of outcome measures when compared to a control group (Pearcey et al., 2015). These results indicated that foam rolling is an effective method to attenuate DOMS while also avoiding curtailment of performance (Pearcey et al., 2015).

One of the most pronounced benefits of foam rolling is its effect on perceived muscle soreness. A study done by MacDonald et al., looked at perceived muscle soreness ratings for individuals that had DOMS by engaging in high-intensity eccentric exercise (MacDonald et al., 2014). The group that used a foam roller 24 and 48 hours post exercise showed significantly reduced perceived muscle soreness scores when compared to the control group (MacDonald et al., 2014). This finding was further supported by the fact that there was no significant change in between the force generated on the foam roller by the individual at 24 and 48 hours postexercise, but there was a significant decrease in pain perception 24 hours to 48 hours postexercise in the foam rolling group (MacDonald et al., 2014). It was posturized that the foam rolling group was able to mitigate the decrements shown by the control group due to healthy connective tissue being maintained, which resulted in reduced neural inhibition and attenuation of DOMS (MacDonald et al., 2014). The attenuation of DOMS allowed for proper afferent feedback by both sensory and mechanical receptors in the connective tissue, which in turn gave the foam rolling group the ability to control muscle activation (MacDonald et al., 2014). There were also more pronounced benefits in attenuating decrements from dynamic movements as opposed to isometric movements in the foam rolling group (MacDonald et al., 2014).

Appendix D

Physical Activity Readiness Questionnaire - PAR-Q (revised 2002)

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO		
☐	☐	1.	**Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?**
☐	☐	2.	**Do you feel pain in your chest when you do physical activity?**
☐	☐	3.	**In the past month, have you had chest pain when you were not doing physical activity?**
☐	☐	4.	**Do you lose your balance because of dizziness or do you ever lose consciousness?**
☐	☐	5.	**Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?**
☐	☐	6.	**Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?**
☐	☐	7.	**Do you know of any other reason why you should not do physical activity?**

If you answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- if you are or may be pregnant – talk to your doctor before you start becoming more active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME ____

SIGNATURE ____________________________ DATE ____________________

SIGNATURE OF PARENT or GUARDIAN (for participants under the age of majority) ____________________ WITNESS ____________________

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

continued on other side...

Appendix E

Your Prescription for Health
Exercise is Medicine®

HEALTHCARE PROVIDERS' ACTION GUIDE

1 HOW TO USE THE ACTION GUIDE
2 PROMOTING PHYSICAL ACTIVITY IN YOUR CLINIC
3 ASSESSING PHYSICAL ACTIVITY
4 PRESCRIBING PHYSICAL ACTIVITY
5 PROVIDING PHYSICAL ACTIVITY REFERRALS
6 BEING A CHAMPION IN YOUR HEALTH SYSTEM

Appendix D - ACSM Risk Stratification Screening Questionnaire

Assess your health by marking all true statements.

You have had:

___ a heart attack
___ heart failure
___ cardiac arrhythmia
___ known heart murmur
___ congenital heart disease
___ any heart surgery
___ coronary angioplasty
___ heart palpitations

You have:

___ experienced chest pain with mild exertion
___ experienced dizziness, fainting, or blackouts with mild exertion
___ experienced unusual fatigue or shortness of breath during usual activities
___ been prescribed heart medications (please indicate):

Check all that apply:

___ you are a man older than 45 years
___ you smoke
___ your blood pressure is greater than 140/90
___ you take blood pressure medication
___ you are completely physically inactive
___ you currently have bone/joint problems
___ you have had a recent injury/surgery
___ you are a diabetic or take medicine to control your blood sugar
___ you have been diagnosed with high cholesterol >200 (or HDL is less than 35 mg/dL or LDL is greater than 169 mg/dL)
___ you have a close blood relative who had a heart attack before age 55 (father/brother) or age 65 (mother/sister)

___ Other (specify) ______________________________

Use the following risk stratification scoring table (page 17) to sum the total number of risk factors present in your patient in determining their current level of cardiovascular disease risk.

Your Prescription for Health
Exercise is Medicine®

Risk Stratification Scoring

Positive Risk Factors	Defining Criteria	Points
Age	Men ≥ 45 years, Women ≥ 55 years	+1
Family History	Myocardial infarction, coronary revascularization, or sudden death before 55 years of age in father of other 1st degree male relative or before 65 years of age in mother or other 1st degree female relative	+1
Cigarette Smoking	Current cigarette smoker or those who quit within the previous six months, or exposure to environmental tobacco smoke (i.e., secondhand smoke)	+1
Sedentary Lifestyle	Not participating in at least 30 minutes of moderate-intensity physical activity on at least three days/week for at least three months	+1
Obesity	Body mass index ≥30 kg/m^2 or waist girth >102 cm (40 inches) for men >88 cm (35 inches) for men	+1
Dyslipidemia	Low-density lipoprotein (LDL) cholesterol ≥ 130mg/dL (3.37 mmol/L) or high-density lipoprotein (HDL) cholesterol <40mg/dL (1.04mmol/L) or currently on lipid-lowering medication; If total serum cholesterol is all that is available, use serum cholesterol >200 mg/dL (5.18mmol/L)	+1
Prediabetes	Fasting plasma glucose ≥100 mg/dL (5.50 mmmol/L) but <126 mg/dL (6.93 mmol/L) or impaired glucoe tolerance (IGT) where a two-hour oral glucose tolerance test (OGTT) value is ≥140 mg/dL (7.70 mmol/L), but <200 mg/dL (11.00mmol/L)	+1
Negative Risk Factors	**Defining Criteria**	**Points**
High HDL Cholesterol	≥60 mg/dL (1.55 mmol/L)	-1

Total CVD Risk Score: ___________

* See Appendix E for Risk Categories and related recommendations for Screening, Clinical Testing, and Exercise Recommendations.

Appendix F

SMR Foam Rolling vs. Compression Garments: Which is Most Effective at Reducing DOMS?

Name:____

Date:____

Phone:____

How many days per week do you engage in any kind of exercise or physical activity?

____

Which modality do you believe is best at reducing symptoms of Delayed-Onset Muscle Soreness (DOMS)? Please circle ONE answer

Compression Garments **Foam Rolling** **Static Stretching**