ACUTE EFFECTS OF SELF-MYOFASCIAL RELEASE WITH A FOAM ROLLER ON SUBSEQUENT 30-METER SPRINT PERFORMANCE

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by

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January 2016

CERTIFICATION OF APPROVAL

I certify that I have read Acute effects of self-myofascial release with a foam roller on subsequent 30-meter sprint performance by Anna Lee McGregor, 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.

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Self-myofascial release (SMR) has become an increasingly common practice among athletes in preparation for physical activity; however, research on the effects of SMR prior to athletic performance is limited. The aim of this study was to look at the acute effects of SMR with a foam roller on sprint performance in a group of experienced sprinters. The study was a randomized balanced cross-over design in which 12 participants performed a 10-minute foam roller intervention or control intervention with 30-m sprint time and hamstring flexibility measured pre- and post-intervention. A 2x2 (time x condition) analysis of variance revealed that there was no significant difference in 30-m sprint time between conditions, however, a paired t-test showed a significant increase in 30-m sprint time for the control condition. Hamstring flexibility increased significantly for the foam-roller condition compared to the control. In conclusion, SMR with a foam roller was effective at improving hamstring flexibility without adversely affecting performance.

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

[signature] 12/10/15

Chair, Thesis Committee Date

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INTRODUCTION

Within the past decade, self-myofascial release (SMR) has become a popular technique used by athletes both in preparation for and following physical activity. Myofascial release is a technique designed to treat the fibrous adhesions or restrictions that develop between layers of fascia through the application of mechanical pressure along muscles (Barnes, J. F., 2004; MacDonald et al., 2013). The damage to muscles that occurs with regular exercise can lead to restrictions in the fascia that surrounds muscles, resulting in decreased strength, endurance, and motor coordination (Barnes, M. F., 1997). Anecdotal literature claims that SMR performed prior to exercise can improve athletic performance through the breakdown of these restrictions and restoration of the length-tension relationship in muscle (Clark, M. & Russell, A., 2014). However, the optimal length-tension relationship for injury-free performance is not known (Butler, R. J., 2003; Goodwin et al., 2007). The primary tools used in performing SMR are a foam roller or a roller-massager. A foam roller is a solid foam cylinder of varying densities and lengths marketed as a tool to help improve athletic performance by rolling it along muscles prior to physical activity (Boyle, M. F., 2014; Clark & Russell, 2014). A stick massager is a plastic, cylindrical tool that is also used for SMR.

These products were marketed as having properties that improve athletic performance before any scientific evidence existed to support this claim. The majority of research shows that foam rolling had no significant acute effects on measures of force, power, or agility (MacDonald et al., 2013; Healey et al., 2014; Janot et al., 2013) and improved flexibility and range of motion (MacDonald et al., 2013; Sullivan et al., 2013). Similarly, the use of roller massagers has been shown to have no significant effect on most measures of performance including sprint speed, strength, vertical jump (Mikesky et al. 2002), muscle contractile force, and muscle activation (Sullivan et al., 2013), but a decrease in evoked twitch force and an increase in range of motion has been observed (Sullivan et al., 2013). The exception to this trend is a study by Peacock et al. (2014) who found foam rolling in conjunction with a dynamic warm-up improved subsequent power, agility, speed, and strength performance compared to a dynamic warm-up alone and no improvement in flexibility was observed. A study by Healey et al. (2014) is the only study to measured perceived fatigue with SMR and found that the increase in fatigue following performance was significantly less for the foam rolling condition compared to the control (Healey et al., 2013). For all of the studies looking at the effects of SMR on performance, the duration of the SMR intervention ranges from as little as 5 and 10 seconds (Sullivan et al., 2013) to a maximum of 2 minutes (MacDonald et al., 2013; Mikesky et al., 2002). Massage is a technique similar to SMR that has been more extensively studied than SMR and with longer durations of treatment (15 to 30 minutes).

The large majority of studies relating massage to subsequent athletic performance have shown it to decrease performance in vertical jump (Arazi et al., 2012; Arabaci R., 2008; Hunter et al., 2006), agility (Arazi et al., 2012), short sprints (Arazi et al., 2012; Fletcher et al., 2010; Arabaci., 2008) and force production (Hunter et al., 2006; Wiktorrson-Moller et al., 1983). Massage has also been shown to improve flexibility

(Arabaci, 2008; Arazi et al., 2012; McKechnie et al., 2007) and decrease fatigue (Weerapong et al., 2005). Exceptions to these trends include a study by McKechnie et al. (2007) who found no significant change in force or power with 6 minutes of massage to the plantar flexors and Goodwin et al. (2007) who found a non-significant trend toward slower sprint times with 15 minutes of massage performed prior to warm-up.

Purpose

The aim of this study was to examine the acute effects of a 10 minute SMR intervention on subsequent sprint performance in experienced sprint athletes. The experimental intervention consisted of foam rolling the hamstrings, quadriceps, calves, IT band, and gluteal muscles for 2 minutes per muscle group and the control intervention was mock-foam rolling by similarly supporting the body in the same 5 positions as during the foam roller intervention. Time to complete a 30-meter sprint was measured pre- and post-intervention. Secondary outcome measures included hamstring flexibility, perceived fatigue, and perceived pain during the intervention.

Hypotheses

The design of the present study is most similar to those described by Arabaci (2008) and Arazi et al. (2012) in the duration of the intervention, the timing of the intervention with respect to the performance tests, and the control condition. Based on the apparent relationship presented in the literature between massage and performance decrements (Arabaci, 2008; Arazi et al., 2012), it was hypothesized that a decrease in sprint performance would be observed following 10 minutes of SMR treatment and this decrease would not be observed under the control condition. It was also predicted that there would be a greater improvement in hamstring flexibility following the SMR intervention compared to the control. Based on previous research on fatigue following SMR (Healey et al., 2013) and massage treatment (Weerapong et al., 2005) it was hypothesized that the SMR intervention would correspond to reduced perceived fatigue relative to the control intervention.

Significance

The findings of this study inform sprint athletes of the costs and benefits of SMR with respect to sprint performance, flexibility, and fatigue. The effects on sprint performance have implications about the effects of foam rolling on power performance in general, and flexibility measures provide valuable information relating to injury prevention. The optimal timing and duration of SMR before performance can lower the risk of injury without performance impairments.

Terms

SMR	(Self Myofascial Release) A method of relieving restrictions in soft tissue by compression using a tool such as a foam roller or stick massager.
Fascia	Connective tissue that branches throughout the body and provides support and stabilization of bone and muscle (Sullivan et al., 2013)
Warm-up	A method of preparing the body for physical activity through a series of exercises that heats up muscles.
Foam rolling	An SMR technique which utilizes the pressure from one's own body weight against a foam cylinder to massage a muscle group.

Stick Massager	A plastic cylindrical tool which is used to perform SMR by rolling it against a muscle group.
Swiss massage	A set of massage techniques including petrissage, tapotement, friction, effleurage, and vibration (defined by: Weerapong et al., 2005).
Swedish Massage	Same techniques as Swiss Massage.
Petrissage	A massage of deep muscle tissue using a kneading motion with hands to improve circulation and venous return.
Tapotement	A massage technique involving stimulation of the tissues through application of rapid hand striking.
Effleurage	A massage technique involving smooth, sliding motions along the muscle.
Friction	A massage technique in which pinpoint pressure is applied to muscles through fingertips.
Vibration	A massage technique involving quick, rhythmic shaking.
Isometric	A motion in which force varies but muscle length is unchanged.
Isokinetic	A motion in which muscle length changes but force exerted is unchanged.
MVC	Maximum Voluntary Contraction; a direct measure of maximum concentric (muscle shortening) force for a given muscle group.
ROM	Range of Motion; the degree of movement about a joint.
30-meter sprint	A common measure of power performance; the time required for an individual at a stationary, standing start to run through 30 meters in a straight line.

Assumptions

- There will be a change in performance from pre to post test.
- The change in performance measures from pre- to post-test can be attributed to the intervention.
- Subjects performed at maximum effort for each 30-meter sprint trial.
- Randomization of which intervention is performed first accounted for any effects the order of tests may have.
- Participants fit the specified criteria and followed all pre-testing instructions
- Sprint time was not influenced by the sit-and-reach test.

Limitations

- Self-massage of subjects allowed for inconsistency between subjects in the pressure applied against the foam roller but this was minimized with standard instructions for all subjects.
- Sprint time was affected by reaction time to start signal, weather conditions, and daily variations in the subjects' abilities.
- The researcher timing the 30-m sprints was not blinded to the treatment.
- Since foam rollers vary in firmness, the findings of the study are only applicable to the type of foam roller used.
- The degree of muscle tension and restrictions in the subjects was not determined, as a result, the benefits and impairments caused by the foam roller varied between subjects.
- This study does not examine the mechanism by which foam rolling affects performance.

METHODS

Research Design

This study implemented a randomized balanced crossover design completed on three non-consecutive days within one week. Subjects had a familiarization day in which they came to the facility, learned how to perform the foam roller intervention, and became acquainted with the performance measure. Subjects were not required to perform the sprint test on the familiarization day as it has been shown that reliability in sprint performance can be achieved without a familiarization session (Moir et al., 2004; Glaister et al., 2006). Following the familiarization day, subjects were randomly assigned to perform either the foam roller intervention or the control. On the third day, subjects performed the intervention they did not perform on the first day. Testing was conducted on an all-weather outdoor track. Subjects completed a 30-meter sprint both prior to and following intervention.

The thirty-meter sprint pre-test was performed 5 minutes following warm-up to allow adequate time for recovery following warm-up. The 30-meter sprint post-test was performed within two minutes following the intervention. Flexibility and fatigue measures were completed immediately prior to 30-meter sprints. The experimental protocol is summarized in figure 1.

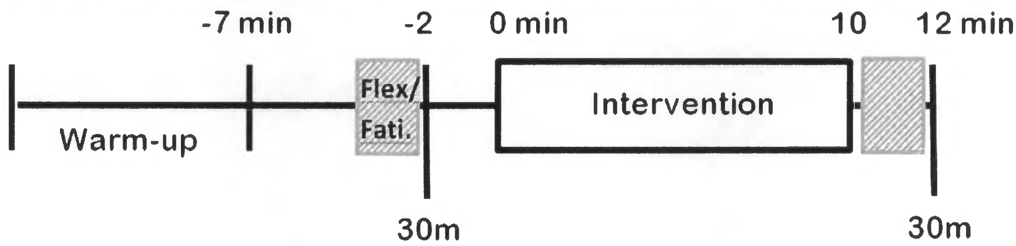

Figure 1. Experimental Protocol Timeline

Participant Criteria

Twelve sprint athletes (ages 24 to 38 years) were recruited for this study. Participants' characteristics are summarized in Table 1. During recruitment, prospective participants were informed of the purpose and significance of the study as well as testing procedures and intervention. Athletes who volunteered to participate signed an informed consent and filled out a health screening questionnaire. To meet the criteria for participation in this study, subjects must have participated in regular training for a sprint event at the collegiate level, did not have any current injuries or health problems, and had 1 or more years of experience as a sprint athlete. Subjects were asked to refrain from exercise, massage, and SMR the day before and day of testing. Subjects were asked to follow their normal eating routines and get at least 8 hours of sleep each night during the week of testing.

Table 1. Demographic characteristics for total group, females, and males reported as means (SD).

	Total (N = 12)	Females (N = 7)	Males (N = 5)
Age (yrs)	28.4 (5.2)	27.1 (4.9)	30.2 (5.6)
Height (in)	70.0 (4.5)	66.7 (2.3)	74.1 (2.7)
Weight (lbs)	160.1 (33.7)	131.6 (13.1)	188.6 (18.6)

Procedures

Warm-up: The subjects followed a warm-up protocol similar to that described by Arabaci (2008) including a jog, stretches, and a series of short sprints that gradually increased in intensity. The subjects jogged for 800 meters around a 400-m track for approximately 5 minutes. Immediately following the warm-up jog, subjects stretched the following muscle groups:

- *Quadriceps*: standing on one leg and holding the opposite foot behind the body
- *Hamstring*: standing with one leg forward and knee extended, flex at hips, reaching toward the foot of the extended front leg
- *Hip flexors*: Standing in a lunge position with front knee bent and hips pressing forward
- *Hip extensors*: Standing on one leg with opposite knee pulled to chest
- *Calves*: Stand with toes on a 3 inch step and lower heels off step

Subjects performed 2 sets of 10 repetitions of each stretch and held each stretch for 3-4 seconds. It is widely accepted among track and field athletes and coaches that this kind of dynamic stretching will prepare the body for exercise without significant performance decrements. Following stretching, subjects ran 3 sets of 50-meters at 60%, 70%, and 80% of maximal running pace, and 2 sets of 20-m at 90 and 100% of maximal running pace. Subjects had 1 minute of rest in between each warm-up sprint.

Foam Roller Interventions: Subjects performed 10 minutes of foam rolling of the lower body including the hamstrings, calves, quadriceps, gluteals, and IT band. Two minutes of foam rolling was allotted to each of these 5 muscle groups. The foam roller was 36 inches in length, 6 inches in diameter, and medium density. The subjects supported their upper body with their arms and had the target muscle against the foam roller. Subjects rolled the target muscle from distal to proximal end and back on the foam roller using their body weight to maintain a uniform pressure. Each muscle group was rolled simultaneously on both legs with the exception of the IT band and gluteal muscles which were rolled out individually for each leg. Subjects were asked to foam roll at a pain level between 6 and 7 on a scale of 0 to 11. Two minutes following the 10-minute intervention, subjects proceeded to do their post-intervention 30-m sprint trial.

Control Intervention: Participants matched the 5 positions for each foam roller exercise and distributed their body weight between their arms, feet, and the target muscle, intermittently sliding forward and backward as in foam rolling. Participants were instructed not to stretch their muscles and not to massage there lower body against the ground during the control.

Measures

Thirty-meter Sprint: Sprint performance was measured as the time it took the subjects to sprint 30-meters from a stationary standing start. The subjects were prompted to start using three auditory signals and the start time was synchronous with the beginning of the auditory start signal. The standing start has been shown to have high reliability in measurements of sprint time (Duthie et al., 2006). Sprint time was measured using a video and audio recording of the start signal and the participant crossing the finish line. Sprint time was calculated as time from the beginning of the auditory "go" signal to the moment the participant's chest reached the finish line. Sprint times were also measured with a handheld chronometer, consistent with Arazi et al. (2012). The reliability of measures of sprint time recorded with a handheld stopwatch does not differ significantly from that of electronic timing (Hetzler et al., 2008). The researcher timing the sprint was not blinded to the conditions and all participants were timed by the same researcher.

Flexibility: Hamstring flexibility was assessed in between warm-up and pre-intervention sprint and then again immediately following the intervention. A YMCA sit-and-reach test was performed as described in the ACSM's Guidelines for Exercise Testing and Prescription (Pescatello, L. S. & ACSM, 2014).

Perceived Fatigue: Fatigue was measured immediately before each 30-m sprint by asking subjects to respond to the question: "What is your overall level of physical fatigue right now?" Subjects responded using a 7-point Likert scale with 1 corresponding to no fatigue, 2 to very light fatigue, 3 to light fatigue, 4 to moderate fatigue, 5 to strong fatigue, 6 to very strong fatigue, and 7 to maximal fatigue. The 7-point Likert scale has been shown to have higher reliability than scales with <7 response categories and is faster and easier to use than scales with >7 categories (Preston, C. C. & Colman, A. M., 2000).

Perceived Pain: Perceived pain for each muscle group was measured 30 seconds into each 2 minute foam roller exercise or control position using a 0 to 10 scale with 0 corresponding to no pain and 10 corresponding to worst possible pain. This measure is consistent with that implemented by MacDonald et al. (2014).

Data Analysis

Data was analyzed using SPSS software. 2x2 (time x condition) analyses of variance (ANOVA) tested for differences between groups. Follow-up paired t-tests were performed to look for significant differences between pre-intervention and post-intervention measures.

RESULTS

Table 2 presents the mean values for hamstring flexibility, perceived fatigue, and 30-meter sprint time. A two-way ANOVA revealed that the interaction of time and condition had no significant effect on 30-m sprint time ($F = 0.364$; $p = 0.558$). There was a main effect of time such that 30-meter sprint times increased from pre- to post-intervention independent of condition ($F = 30.291$; $p = 0.000$). Paired t-tests revealed that there was no significant change in 30-m sprint for the foam roller condition ($t = 1.617$; $p < 0.10$) but there was a significant increase in 30-m sprint time for the control condition ($t = 4.678$; $p < 0.0005$). Figure 2 compares mean pre-intervention and post-intervention values for 30-meter sprint time.

Table 2. Raw Data Presented as Mean (SD)

	Pre-Intervention	Post-Intervention
Foam-Roller		
Flexibility	**16.43** (6.27)	***17.48** (6.07)
Fatigue	2.46 (1.34)	2.46 (1.12)
30-m Sprint	4.91 (0.27)	4.99 (0.26)
Control		
Flexibility	17.17 (6.73)	17.49 (6.70)
Fatigue	2.33 (0.98)	2.33 (1.30)
30-m Sprint	**4.93** (0.26)	***5.04** (0.26)

*Significantly different from pre-intervention of same condition.

The two-way ANOVA revealed that there was a significant difference in hamstring flexibility between groups ($F = 6.329$, $p = 0.029$). There was also a significant increase in flexibility from pre- to post-intervention independent of condition. Follow up paired t-tests revealed that there was a significant increase in hamstring flexibility from pre- to post-intervention for the foam rolling condition ($t = 4.05$; $p < 0.005$). An increase in mean hamstring flexibility was observed for the control condition but this increase was not statistically significant ($t = 1.27$; $p > 0.10$). Figure 3 compares mean pre-intervention and post-intervention values for hamstring flexibility.

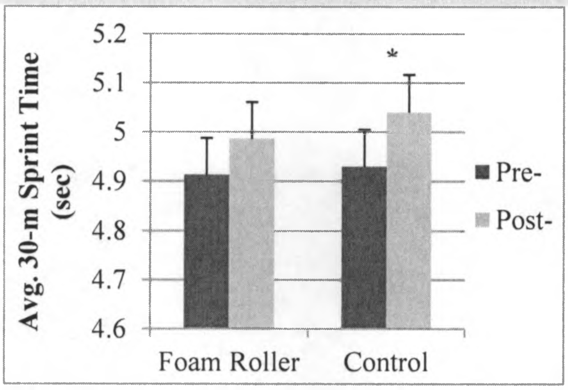

Figure 2. Average Sprint Time pre- and post-intervention for both conditions.

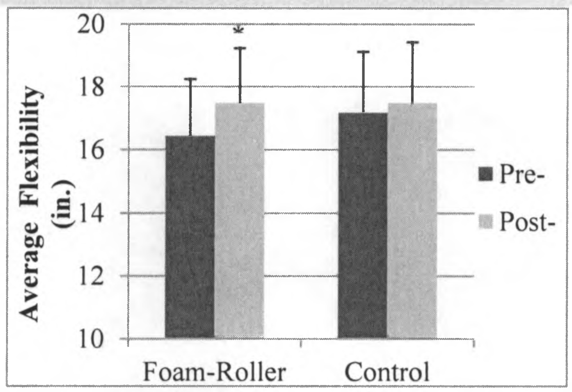

Figure 3. Average Hamstring Flexibility pre- and post-intervention for both conditions.

* Significantly different from pre-intervention of same condition.

There was a significant difference in perceived pain between the control and foam roller conditions ($t = -8.343$; $p = 0.000$) as shown in figure 4. Mean pain throughout the control was 1.01 ± 0.68 and mean pain during foam-rolling was 4.43 ± 1.25. There was no correlation between perceived pain foam rolling and perceived pain during the control. Mean values for perceived fatigue are shown in table 2. There were no significant differences in fatigue between groups (Figure 5).

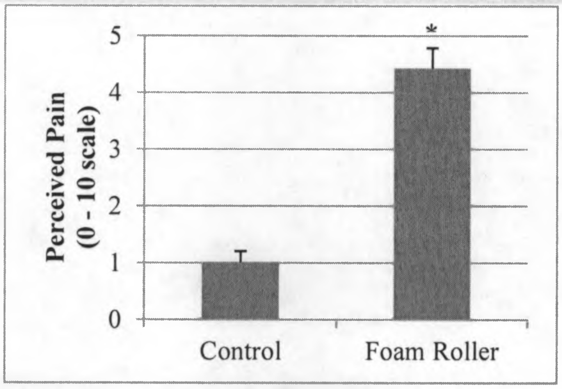

Figure 4. Average Perceived Pain during both conditions

* Significantly different from control

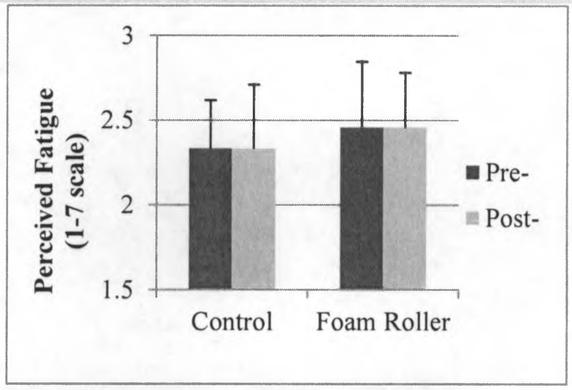

Figure 5. Average Perceived Fatigue pre- and post-intervention for both conditions.

DISCUSSION

It has become an increasingly popular trend in athletics to incorporate self-myofascial release with a foam-roller into warm-up routines. The findings of previous studies regarding the effects of foam-rolling on performance have been mixed. Some research has observed that relatively short duration (≤ 2 min) self-myofascial release with a foam-roller does not affect performance (MacDonald et al., 2013; Janot et al., 2013; Healey et al., 2014), while more recent research has found improvements in performance with the incorporation of foam-rolling into warm-up (Peacock et al., 2014). Although foam-rolling and massage are similar treatments, the majority of research on pre-exercise massage has shown the opposite effect on performance. Relatively long duration (15-30 min) massage has corresponded to decrements in strength (Hunter et al. 2006), power, agility, and speed (Arazi et al., 2012; Arabaci, 2008). It was hypothesized that 10 minutes of self-myofascial release with a foam roller would improve hamstring flexibility and worsen 30-meter sprint performance. The main findings of this study are that 10 minutes of foam-rolling of the lower body corresponded to reduced decrements in 30-meter sprint performance compared to control condition and a significant increase in hamstring flexibility.

Thirty-Meter Sprint

Contrary to the hypothesis, foam rolling was found to have no effect on 30-meter sprint performance and a significant worsening of performance was observed for the control condition. Ten minutes of foam rolling did not have the same effect on performance as 15 to 30 minutes of massage. Massage is thought to reduce muscular power and strength by creating a non-optimal muscle length-tension relationship. The stretch applied during massage can cause sarcomere lengthening to a point that decreases myosin cross-bridges (Arabaci, 2008). Perhaps the pressure applied during foam-rolling was not sufficient to cause lengthening to the same extent as that in massage studies. It is possible that the sprint athletes in this study had a higher than optimal muscle tension at during their pre-intervention sprint. Sarcomere lengthening can also be beneficial for power production if the starting length is shorter than optimal.

The findings of the present study are consistent with most previous SMR research which observed no effect of foam rolling on performance measures such as cycle ergometer power output (Janot et al., 2013), isometric knee extension force (MacDonald et al., 2013), squat force, vertical jump, and agility (Healey et al., 2014). The only study to find improvements in performance with foam rolling was that by Peacock et al. (2014)

who found a decrease in 37-m sprint time following foam-rolling of the upper and lower body for 30 seconds per muscle group as well as improvements in agility, bench press, vertical jump, and standing long jump measures. Although no studies have yet looked at the mechanisms by which foam rolling affects performance, Peacock et al. (2014) suggest that foam rolling improved performance through physiological improvements, improved motor unit recruitment patterns, and firing rates. Contrary to this theory, massage treatment has been shown to reduce alpha motoneuron excitability and cause acute depressions in the H-reflex (Sullivan et al., 1991).

This is the only study to observe a decrease in performance from pre- to post-intervention for the control condition. The control for this study was to match the five foam rolling positions while intermittently supporting the body using the arms and feet as done during foam rolling. The control conditions for previous research studies relating foam rolling to performance have been rest (Janot et al., 2013; MacDonald et al., 2013), isometric holds in the form of planking (Healey et al., 2014), and continuous warm-up with the absence of foam-rolling (Peacock et al., 2014). The long duration of the intervention in this study is one potential explanation for the decrease in performance. Participants started their pre-intervention sprint 5 minutes after the end of the warm-up and started their post-intervention sprint 19 minutes after the end of the warm-up. The finding that 30-m sprint performance did not worsen significantly after foam-rolling indicates that foam rolling reduced the decrement in performance that occurred with time following the warm-up. A possible explanation for this observation is that the friction created from foam rolling may act to heat the muscles, (Sullivan et al., 2013) better preparing them for performance.

The only study to find improvements in performance following foam rolling was that by Peacock et al. (2014) who found improvements in bench press, vertical jump, horizontal jump, agility, and speed. The time gap between foam rolling and each performance test was not explicitly stated but the design included either a foam roller intervention or no intervention, followed by a general dynamic warm-up, and 5 performance tests each preceded by a 4 minute rest period and an exercise-specific warm-up. The difference in results between this study and that by Peacock et al. (2014) indicates that the timing of foam rolling in relation to the warm-up and the performance measure may be crucial in determining the effects it will have on performance. Under both conditions, 30-meter sprint time worsened from pre-intervention to post-intervention, indicating that a greater length of time between warm-up and performance results in slower sprint times. Perceived fatigue did not differ significantly before the pre-intervention and post-intervention 30-m sprint; therefore the worsening of performance cannot be attributed to fatigue.

Hamstring Flexibility

Hamstring flexibility increased significantly from pre- to post-intervention for the foam rolling condition and no significant effect was observed for the control condition. These results are consistent with the findings of MacDonald et al. (2013) who found a significant increase in ROM following 2 minutes of foam rolling of the quadriceps muscle. Mikesky et al. (2002) and Sullivan et al. (2013) also found improvements in flexibility and range of motion with SMR using a roller massager. Contrary to these findings, are the results of the study by Peacock et al. (2014) who found no difference in hamstring flexibility when foam rolling was performed prior to a dynamic warm-up.

Perceived Fatigue

There was no significant difference in fatigue from pre-intervention to post-intervention. The only other study to measure the effects of foam rolling on perceived fatigue before and after performance tests found fatigue to be significantly higher after control trials compared to foam-rolling trials (Healey et al., 2014). The control implemented by Healey et al. (2014) was 30-second planks in positions that matched those performed during the foam-rolling condition. In the present study, participants supported their body weight on their feet and elbows intermittently and were allowed to support part of their weight with their lower body as they would during foam-rolling. This difference in the control condition may explain the discrepancy in findings between this study and that by Healey et al. (2014).

Limitations

The implications of this study are limited in that the results only apply to this specific population and this density of foam roller. The amount of pressure applied to the muscle during foam-rolling was self-selected and participants were varied in the amount of pressure used as indicated by the different levels of pain perceived. Differing levels of muscle tension also likely contributed to the difference in pain level reached by the participants. Experienced sprinters were recruited in order to minimize variation in sprint time due to inconsistency in effort and reaction time but these factors likely played a role in the variation in sprint times. Another potential limitation of this study is that performance may have been affected by the weather and temperature which varied between trials and even within trials. Finally, the sample size for this study was too small to allow for comparisons between age groups and genders.

Future Research

To address some of these limitations, future studies should be conducted indoors to control environmental conditions. Future studies may also recruit a larger sample and look for differences between age groups and genders. This study might also be improved by repeating part or all of the warm-up after the intervention to avoid a drop in performance.

Practical Applications

The results of this study indicate that foam rolling does not impair 30-meter sprint performance under these conditions and is, in fact, less harmful than the mock-foam-rolling control. The significant increase in hamstring flexibility for the foam-roller condition indicates that foam-rolling may be helpful in preventing injury due to excessive muscle tension. As hamstring strains are the most common injury in sprint athletes, foam-rolling may be an effective technique for reducing the incidence of injury without hurting performance.

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APPENDIX 1: REVIEW OF LITERATURE

Fascial Changes in Response to Trauma

Fascia is essentially connective tissue composed of collagen, elastin, and ground substance. These three components provide the structures they surround with support, flexibility, and cushion, respectively (Barnes, M. F., 1997). In response to trauma, fascial components become restricted and create excessive tension throughout the body (Barnes, 1997). Strenuous physical activity is one source of trauma that can result in muscle damage and cause a buildup of scar tissue in fascia (Curran et al., 2008; Healey et al., 2014). Restrictions in fascia result from a combination of solidification of the ground substance, a loss of resiliency in the elastic component, and denser, more fibrous collagen (Barnes, 1997). Athletes with fascial restrictions are less able to absorb impact during physical activity which makes them more susceptible to injury and more likely to experience pain (Barnes, 2004).

The Physiological Effects of Myofascial Release

Myofascial release (MR) refers to the application of mechanical pressure along muscles and is thought to break apart the restrictions in fascia. Performing MR after exercise is thought to expedite recovery from a workout and reduce pain and discomfort (Sullivan et al., 2013). MR prior to exercise has been shown to improve ROM and flexibility (MacDonald et al., 2013; Sullivan et al., 2013; Mikesky et al. 2002), supposedly through the stretching of the muscles and reduction of fascial restrictions. It has also been proposed that MR can better prepare the body for physical activity through a warm-up effect generated from the friction along the muscles during MR (Sullivan et al., 2013). There has been no research to determine the mechanism by which MR affects ROM and flexibility, however, it has been suggested that massage can induce changes in muscle temperature (Drust el al., 2003), increases in parasympathetic activity (Delaney et al., 2002), decreases in stress hormone levels (Barlow et al., 2004), and decreases in neuromuscular excitability (Sullivan et al., 1991). If MR release induces a response similar to that of massage, these mechanisms could explain changes observed in performance following MR. Self-myofascial release (SMR) using a foam roller is a relatively new form of MR which is claimed to have all the benefits associated with MR and function by way of the same mechanism as MR (Healey et al., 2014; MacDonald et al., 2013). In recent years, there have been many anecdotal claims that SMR with a foam roller will improve athletic performance (Boyle, M., 2014; Clark & Russell, 2014). These are often vague statements based on the assumption that decreased muscle tension and improved flexibility will undeniably translate into improved performance.

Tools for Performing Self-Myofascial Release

A foam roller is a common tool used to perform self-myofascial release. A foam roller is a solid, foam cylinder that can vary in length and firmness. A foam roller is 6 inches (15cm) in diameter, and between 12 and 36 inches (30.5 – 91 cm) in length. The density of the foam material is variable and affects the level of firmness and pressure it can produce. To perform SMR on the lower body using a foam roller the individual supports their upper body with their arms as in a plank position and their lower body supported on top of the roller. The individual then rolls along the entire muscle from the proximal to distal end and back again multiple times with the target muscle as relaxed as possible. The pressure of the person's body weight on the roller performs myofascial release (Healey et al., 2014; Curran et al., 2008).

Another common tool used to perform self-myofascial release is a roller massager or "stick" massager. A roller massager is a plastic cylinder approximately 1 inch in diameter and 17 inches (43 cm) to 24 inches (61 cm) in length. It has handles on both ends and the middle segment is covered with hollow plastic cylinders that rotate freely around the base. Massage is performed by rolling the stick along the muscle and pressure is applied using force produced from the user's arms (Sullivan et al., 2013) as opposed to body weight as with the foam roller.

SMR and Performance

To date, there have been only four studies which have looked at the acute effects of SMR with a foam roller on athletic performance, and two additional studies using hand-held roller massagers as the tool for implementing SMR (Sullivan et al., 2013; Mikesky et al., 2002). The studies looking at the effects of foam rolling on performance are all fairly recent, being published between 2013 and 2014. However, the first study to investigate the effects of SMR on exercise tests used a stick roller massager (Mikesky et al., 2002). The study conducted by Mikesky and colleagues (2002) is one of two studies to look at the effects of SMR on subsequent sprint performance. The participants included 30 collegiate athletes from soccer, volleyball, and basketball teams. Sprint performance was measured as the time to complete the last 20 yards of a 30-yard sprint which the authors refer to as a flying 20-yd. Also measured in this study were vertical jump, isokinetic knee extension, and hamstring flexibility. Prior to the flying 20-yd and the vertical jump, 2 minutes of SMR was performed on the hamstrings, gluteals, quadriceps, and calves. The results obtained were not statistically significant; however, the decrease in sprint time from pretest to posttest was greatest for the stick intervention compared to two control conditions. The stick treatment also showed the greatest improvements in strength, flexibility, and vertical jump but the difference in results between this treatment and control was not statistically significant. The authors note that even though the sprint times were not statistically significant, races are often won by hundredths or even thousandths of a second and these improvements observed in this study are worth exploring.

The next study to examine the effects of SMR with a stick roller massager prior to performance measured ROM, involuntary activation, and maximum voluntary contraction (MVC) of the hamstring (Sullivan et al., 2013). There were 4 separate interventions with the roller massager; 1 set of 5 seconds, 1 set of 10 seconds, 2 sets of 5 seconds, and 2 sets of 10 seconds. Researchers found a significant increase in ROM (as measured by a sit-and-reach test) for all subjects in the roller massager group and a trend towards a greater increase in ROM with longer duration of roller massage intervention. No significant differences were found for MVC force or muscle activation from pre- to post-intervention compared to the control condition. Evoked twitch force (ETF) yielded significant decreases from pre- to post-rolling. A significant interaction was observed between duration and change in ETF. A decrease in ETF was observed when duration increased from 5 to 10 seconds and only one set was performed, but the opposite trend was observed between ETF and duration when 2 sets were performed. That is, an increase in twitch force for 2 sets of 10 seconds when compared to 2 sets of 5 seconds. A limitation of this study was the experimental group consisted of only 7 subjects and the control group was a separate group of 9 subjects. The small sample size may explain the inconsistent trends observed between ETF and duration. The subjects were physically active but were not athletes and thus, may not have had many fascial restrictions. This may have limited the amount of improvement seen in ROM for the subjects. The researchers concluded that using the roller massager increased ROM without a subsequent decrease in voluntary contraction force.

In 2013, McDonald et al. published a study investigating the acute effects of SMR with a foam roller on isometric knee extension, range of motion (ROM), and EMG activity in the quadriceps of a group of 11 male recreational resistance trainers (MacDonald et al., 2013). The SMR treatment was 1 minute of foam rolling of the quadriceps, a 30 second rest, and then another 1 minute of foam rolling. The duration of SMR implemented by MacDonald et al. (2013) was relatively long compared to the studies using a stick massager because the 2 minutes of treatment was applied to only one muscle group. Similar to the findings by Mikesky et al. (2002), the results for this study showed no significant change in force production with SMR. MacDonald et al. (2013)

did show a significant increase in ROM of the knee joint following SMR treatment. The results obtained by MacDonald et al. (2013) indicate that 2 minutes of SMR can increase ROM without a decrease in muscle activation, muscular force, or rate of force development.

A study by Janot et al. (2013) measured Peak Power Output (PPO) and Percent Power Decrease (PPD) during 5 second sprints on a cycle ergometer within 30 seconds following an SMR intervention with a foam roller. Twenty-three participants performed 20 minutes of SMR divided between 7 muscle groups of the lower body. Each SMR exercise was performed for 30 seconds and repeated 3 times for a total of 90 seconds per muscle group. There were found to be no significant differences in measures of power between the control and SMR interventions when the overall group was considered. Interestingly, when the group was divided by gender there was a significant increase in PPO in males following SMR and a trend toward a decrease in PPO in females following SMR compared to the control. Similarly, there was a significant drop in PPD for females and a significant increase in PPD for males following SMR treatment. The increase in PPD for men following SMR indicates greater fatigability of the muscle compared to the control condition. The authors suggest there is a "trade-off" between increasing power output and increasing fatigability with regard to the use of SMR.

Healey et al., (2014) investigated the acute effects of foam rolling on vertical jump, isometric squat force, and agility. Twenty-six physically active college students performed both the control condition as well as foam rolling of the quadriceps, hamstrings, IT band, calves, latissimus dorsi, and rhomboids for 30 seconds per muscle group. The researchers found that foam rolling had no effect on performance but did result in significantly lower perceived fatigue as rated on a 10 point Likert scale. Healey and colleagues (2014) suggested that the reduction in fatigue may be due to increased blood flow and removal of lactate. Increased circulation would theoretically increase the clearance of lactic acid and H^+ ions and positively impact action potential conduction velocity, allowing for greater contractile force (Bigland-Ritchie et al., 1981). It should be noted, however, that the control for this study was to maintain a plank position which is more fatiguing than the rest condition commonly used as a control for other studies (Peacock et al., 2014; MacDonald et al., 2013; Janot et al., 2013).

The most recent study relating foam rolling to performance recruited 11 athletically trained male participants and measured agility, strength, power, and speed following the control condition of a 5 minute dynamic warm-up and the experimental condition of SMR followed by the same dynamic warm-up (Peacock et al., 2014). The SMR treatment targeted muscle groups of both the upper and lower body. Thirty seconds of foam rolling was performed on each muscle group. Significant improvements were found for vertical jump, standing long jump, agility, 1 RM bench press, and 37-meter sprint. There was no significant improvement in hamstring flexibility as measured by a sit-and-reach test. The study by Peacock et al. (2014) was the first to observe significant improvements in power, strength, and agility performance following SMR. One limitation of this study was that there was no control condition. The control session differed from the experimental session only in that foam rolling was removed from the protocol. Another limitation is that the 37-meter sprint was the last in a series of six performance tests, and the authors did not specify exactly how much time passed in between the intervention and the 37-meter sprint.

Massage and Performance

While research on the effects of SMR on athletic performance is a relatively new and understudied topic, there have been several studies looking at the relationship between massage and sprint performance. The majority of research has shown that 15 to 30 minutes of massage caused a reduction in sprint performance or had no significant effect. There is no evidence that massage can enhance subsequent athletic performance.

A study investigating the effect of lower limb Swedish massage on performance in 30-meter sprint and vertical jump found a worsening of both performances from pre-massage to post-massage compared to the rest control (Arabaci, 2008). The duration of this massage was 5 minutes on the anterior lower limb and 10 minutes on the posterior lower body. The only improvement seen was in hamstring flexibility assessed with a sit-and-reach test. The researchers looked at the components of the 30-meter sprint separately and found that the first 10-meter acceleration was slower as well as the reaction time. The limitations of this study were that the subjects were not athletes but a group of 24 physically active white males in their early 20s.

A similar study was conducted by Arazi et al. (2012) on 20 male collegiate athletes. Five minutes of Swiss massage was performed on the anterior thigh and 10 minutes on the hamstrings and calf muscles. Arazi et al. (2012) observed a decrease in vertical jump, agility, and 30 meter sprint performance and an improvement in hamstring flexibility with massage treatment. The 30-meter sprint was broken down into the first 10-meter and first 20-m for comparison and a greater decrease in performance was also observed for these measures in comparison to the control intervention. A limitation of this study is that there were only 7 subjects in the massage group and 6 in the control group. In addition, the athletes were all from different sport types. The authors conclude that massage should not be recommended for warm-up prior to an explosive event.

Hunter et al. (2006) tested muscle strength and power in ten physically active young males. There was a greater decline in isokinetic knee extension force following a 30 minute leg massage compared to the control. This decline in force was statistically significant at one of four contraction velocities. At the other three velocities there was a non-significant trend toward force reduction following massage. No significant change in vertical jump height was observed but there was a trend towards a greater decrease in performance following the massage intervention. These authors concluded that lower limb massage reduces concentric force of the knee extensors and proposed that alteration of the length-tension relation in the muscles was the likely mechanism for this reduction.

Fletcher et al. (2010) examined the effects of massage and warm-up on 20-m sprint performance in 20 physically active male college students and found that sprint times were slower under the massage only condition compared to when subjects performed a warm-up and massage or a traditional warm-up only. There was no significant difference in sprint time when comparing massage accompanying warm-up to the warm-up only condition. Fletcher et al. (2010) do not recommend massage prior to competition because it appears to have no greater benefit than a traditional warm-up. One difference between this study by Fletcher et al. (2010) and other studies on massage and sprint performance is the use of a fast, superficial massage technique (Fletcher et al., 2010) compared to more intense, deep penetrating Swiss (Arazi et al., 2012) and Swedish massage techniques (Arabaci, 2008).

Consistent with the findings of Fletcher et al. (2010), a study by Goodwin et al. (2007) found no significant differences in 30 meter sprint times following traditional warm-up compared to a warm-up preceded by 15 minutes of massage. There was a trend toward faster sprint times for the control group but the difference was not statistically significant. The research design implemented by Goodwin et al. (2010) is unique in that massage was performed prior to warm-up as opposed to after warm-up as in other studies (Arazi et al., 2012; Arabaci, 2008).

Harmer et al. (1991) found no significant change in the mean stride frequency following 30 minutes of whole body Swedish massage including effleurage, tapotement, and petrissage. Data was obtained from 14 sprint athletes performing 30-meter sprints. A flaw in this study was that stride frequency is only informative of overall sprint performance when combined with stride length. Another aspect of this study that separates it from most others is that the massage was performed on the whole body rather than just the lower limb. From this it can be assumed that the lower body received significantly less than 30 minutes of massage.

Short Duration Massage and Performance

The entirety of research relating massage to sprint performance indicates that 15 to 30 minutes of massage is not effective in improving sprint or any power performance and may even cause reductions in sprint performance, power, strength, and agility. No study has yet looked at shorter durations of massage on sprint performance but some studies have investigated the relationship between shorter durations of massage and other measures of strength and power.

McKechnie et al. (2007) found that 6 minutes of massage (3 minutes each leg of petrissage and tapotement) had no significant effect on power performance as measured by a drop jump and no effect on concentric calve raise. There was a significant increase in flexibility of the plantar flexors following massage. This study by McKechnie et al. (2007) focused on a smaller muscle group than some of the other studies that did find changes in power and strength performance. The lack of a significant decline in performance could be attributed to the size of the muscle group or potentially to the shorter duration of massage. The effects of shorter duration massage on a larger muscle area could be very informative for athletes. A study by Wiktorsson-Moller et al. (1983) found decreases in isokinetic quadriceps and hamstring strength with 6 to 15 minutes of petrissage massage of all major muscle of the leg. Stretching was much more effective at increasing flexibility than massage. The only significant increase in ROM observed for the massage group was in dorsiflexion of the ankle whereas static stretching increased ROM about the hip, knee, and ankle.

Overall, research on the effects of SMR on athletic performance is inconsistent but in favor of there being no significant effect on performance with short duration SMR and an increase in flexibility (Sullivan et al. 2013; Mikesky et al., 2002; MacDonald et al., 2013). Relatively long duration massage appears to reduce athletic performance while increasing flexibility (Arabaci, 2008; Arazi et al., 2012; Hunter et al., 2006). When treatment precedes warm-up, foam-rolling has been shown to improve performance (Peacock et al., 2014) with no change in flexibility, and massage has had no significant effect on performance (Goodwin et al., 2007).

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APPENDIX 2: INFORMED CONSENT

San Francisco State University

Informed Consent to Participate in a Research Study
Acute Effects of Self-Myofascial Release with a Foam Roller on Subsequent 30-m sprint Performance

A. PURPOSE AND BACKGROUND

The purpose of this study is to determine the immediate effects of foam rolling on sprint performance, flexibility, and fatigue. The researcher, Anna McGregor is a graduate student at San Francisco State University. You are being asked to join this study because you are between the ages of 18 and 34, you competed in a sprint event in the past year, and you do not have any current injuries or medical conditions that could affect your ability to exercise.

B. PROCEDURES

If you agree to participate in this research study, you will be asked to make 3 visits to Cox Stadium on the SFSU campus at 1600 Holloway Ave, San Francisco, CA 94132.

On visit one: *(~56 minutes)*

- You will be asked to fill out a health history questionnaire *(~10 minutes)*
- You will be asked to read and sign the informed consent document *(~10 minutes)*
- You will then perform a standardized warm-up *(~18 minutes)*
    - You will be asked to jog 2 laps around the track totaling 0.5 miles
    - You will then be asked to stretch the muscles of your lower body by holding 5 positions for 3-4 seconds. Each stretch will be repeated 10 times. The 5 stretches include:
        1) Standing on one leg and holding the opposite foot behind your body
        2) Reaching towards feet with legs straight
        3) Holding a lunge position
        4) Standing on one leg and using your arms to pull the opposite knee against your chest
        5) Positioning your feet halfway off a step and lowering your heels toward the ground.
    - You will then be asked to run three 50-meter sprints at gradually faster speeds separated by 2 minutes of rest.

  - You will be asked to run a 20-meter sprint at a pace slightly slower than your top speed and another 20-meter sprint at top speed 2 minutes after the first.
- You will be instructed on how to use a foam roller on 5 areas of your lower body *(~3 min)*
- You will be asked to perform 2 minutes of foam rolling on each of these areas. You will support your upper body with your arms and your lower body will be against the foam roller. You will massage your legs by rolling the foam roller between the ground and your legs. *(~10 min)*
- During foam rolling, you will be asked to keep your level of pain between 6 and 7 on a scale of 0 to 10. You will be shown a pain scale and be asked to rate your level of pain during foam rolling.
- You will be instructed on how to perform a sit-and-reach test, you will be shown an example of a one-question fatigue survey that you will fill out in your next 2 visits and the instructor will demonstrate the procedures for a 30-meter sprint that you will perform in the next 2 visits. *(~5 min)*

<u>On visit two:</u> *(~43 minutes)*

- You will be asked to jog 2 laps around the track totaling 0.5 miles *(~5 min)*
- You will then be asked to stretch the muscles of your lower body by holding 5 positions for 3-4 seconds. Each stretch will be repeated 10 times. *(~5 min)*
- You will then be asked to run three 50-meter sprints at gradually faster speeds separated by 2 minutes of rest *(~5 min)*
- You will be asked to run a 20-meter sprint at a pace slightly slower than your top speed and another 20-meter sprint at top speed 2 minutes after the first. *(~3 min)*
- Five minutes after the last 20-meter sprint, you will be asked to perform a sit-and-reach flexibility test. You will sit with your legs straight in front of you and will reach forward with your hands together as far as you can with your hands sliding along a meter stick to measure how far you reach. You will hold your hands at the farthest point for 2 seconds and then slowly sit back and relax. The better of two attempts will be recorded. *(~7 min)*
- You will then be asked to rate you level of fatigue by indicating how tired you are on a scale of 1 to 7. *(<1 min)*
- You will be asked to run a 30-meter sprint at your top speed. The instructor will say "Ready, set, go" and begin timing you on "go." *(<1 min)*
- 2 minutes after the start of the 30-meter sprint, you will either foam roll while rating your level of pain for the same areas of your legs as you did in your first visit or you will sit for ten minutes in various positions matching those performed during foam rolling. *(~12 min)*
- You will then be asked to perform the sit-and-reach test again and rate your level of fatigue on a scale of 1 to 7. *(~2 min)*
- Immediately after this you will run another 30-meter sprint at top speed. *(<1 min)*
- You will then be advised to either rest or jog an easy 1 lap cool down around the track. *(3 min)*

<u>On visit three:</u> *(~43 minutes)*

- You will complete the same warm-up that you did on visit 1 including the 2 lap jog, the 5 stretches, and the 5 sprints. *(~18 minutes)*
- You will be asked to perform a sit-and-reach test and rate your level of fatigue on a scale of 1 to 7. *(~7 min)*
- You will run a 30-meter sprint as fast as you can. *(<1 min)*
- You will then be asked to either sit in various positions for 10 minutes or foam roll for 10 minutes. You will perform whichever task you did not do in visit 2. *(~12 min)*
- You will perform another sit-and-reach test, fatigue rating, and 30-meter sprint, in that order *(~2 min)*
- You will finish visit 3 will a 1 lap jog around the track to cool down. *(~3 min)*

The total time commitment will be about **2.5 hours**.

C. <u>RISKS</u>

The sprint exercises will expose you to the risk of muscular and joint injury. This risk will be minimized by the warm-up jog, stretches, and gradual progression of sprint speed in the warm-up drills. If at any point you do not wish to continue, the testing will be stopped upon your request. You are obligated to tell the researcher of any pain or discomfort you feel throughout the study. You will only be included for this study if you are uninjured and deemed to be at "low-risk" for any cardiovascular event as indicated by your answers on the health history questionnaire distributed at the beginning of the study. You are obligated to answer honestly to all of the questions in the Health History questionnaire. This will minimize the risks of participating in this study. There is a risk that you will experience discomfort in performing the foam roller exercises. This risk will be minimized by instruction of proper technique on how to distribute your body weight between your arms and legs, and reduce the amount of force being applied to your leg muscles. If you sustain an injury, you will seek a medical referral at your own expense. You are free to withdraw from this study at any time without penalty. There is a risk of potential loss of privacy. This risk will be minimized by keeping participants' names separate from their data and excluding names from any publication of this research. All research data will be kept in a secure location and only the researcher will have access to the data.

D. <u>CONFIDENTIALITY</u>

There is a risk of potential loss of privacy. In order to minimize this risk, all research data will be stored in a device with full disk encryption and password-protection. All data will be stored in Dr. Lee's office at San Francisco State University in Gym 131. Only the researcher and the researcher's advisor will have access to the data. The names or identities of the participants will not be used in any published reports of the research. The data for each individual will be assigned a code and information relating the participants' identities to the corresponding code will be kept separate from the data in a secure location.

E. <u>DIRECT BENEFITS</u>

There are no direct benefits for you as a participant in this research.

F. <u>COSTS</u>

The only cost to you will be transportation to the research site.

G. <u>COMPENSATION</u>

There will be no compensation for participating in this research.

H. <u>ALTERNATIVES</u>

The alternative is not to participate in the research.

I. <u>QUESTIONS</u>

You have spoken with Anna McGregor about this study and have had your questions answered. If you have any further questions about the study, you may contact the researcher by email at almcg@mail.sfsu.edu or by phone at (619) 987-2662.

Questions about your rights as a study participant, or comments or complaints about the study, may also be addressed to the Office for the Protection of Human Subjects at 415: 338-1093 or protocol@sfsu.edu.

J. CONSENT

You have been given a copy of this consent form to keep.

PARTICIPATION IN THIS RESEARCH IS VOLUNTARY. You are free to decline to participate in this research study, or to withdraw your participation at any point, without penalty. Your decision whether or not to participate in this research study will have no influence on your present or future status at San Francisco State University.

Signature ______________________________ Date: _________

Research Participant

Signature ______________________________ Date: _________

Researcher

APPENDIX 3: PRE-PARTICIPATION QUESTIONNAIRE

Pre-participation Screening Questionnaire

Directions: Write "Yes" next to any true statements below. Otherwise, leave it blank.

If you answer "yes" to any of the questions below, you will not be able to participate in the study.

___ Have you ever had a heart attack, heart surgery, stroke or any other cardiovascular event?

___ Have you ever experienced any abnormal events during physical exertion (example: fainting, chest pain, unreasonable breathlessness)?

___ Do you have joint or musculoskeletal problems that limit your physical activity?

___ Have you ever been prescribed heart or blood pressure medications?

___ Have you ever been told by a medical professional that you have diabetes?

___ Have you ever been told by a medical professional that you have asthma or other lung disease?

___ Have you ever been told by a medical professional that you have high blood pressure?

___ Have you ever been told by a medical professional that you have high cholesterol?

___ Are you physically inactive (i.e., you get less than 30 min. of physical activity on at least 3 days per week)?

___ Do you have a close blood relative who had a heart attack before age 55 (father or brother) or age 65 (mother or sister)?

___ Do you know of any reason that you could not safely engage in exercise?

Participant's name (print): ________________________

Participant's signature: ___________________________

Researcher's name: _____________________________

Researcher's signature: __________________________

APPENDIX 4: PAIN AND FATIGUE ASSESSMENT SCALES

FATIGUE ASSESSMENT

Please respond to the following question by **circling** the response that best describes how you feel in this moment.

*What is your level of **overall physical fatigue** right now?*

1	2	3	4	5	6	7
No Fatigue	Very weak Fatigue	Weak Fatigue	Moderate Fatigue	Strong Fatigue	Very Strong Fatigue	Maximal Fatigue

PAIN ASSESSMENT

Please respond to the following question by **circling** the response that best describes how you feel in this moment.

What is your level of pain right now?

0	1	2	3	4	5	6	7	8	9	10
No Pain					Moderate pain					Worst Possible pain