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Acute Effects of Two Different Foam Rollers on Range of Motion

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Acute Effects of Two Different Foam Rollers on Range of Motion

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Isaac Henry

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Acute Effects of Two Different Foam Rollers on Range of Motion

Abstract

The aim of this study was to determine if differences existed between the effects two different foam rollers had on hip and shoulder ROM. Ten college students participated in a random cross over design study. Participants' hip and shoulder ROM were measured with a goniometer pre and post three different conditions: control, Supernova (SN), and Grid. The first session consisted of taking pre ROM measurements followed by 10 minutes of rest and post ROM measurements (control). Then the participants were familiarized with the foam rolling procedures that were used for the next two sessions. During the next two sessions the control trial procedures were repeated, except instead of resting between pre and post testing the participants foam rolled using one of the foam rollers. Repeated measures ANOVA followed by protected dependent *t* tests revealed that significant (p<.05) differences existed between control and SN, control and Grid, but not between SN and Grid (p>.05). Effect sizes revealed that when comparing mean differences from pre to post for SN and Grid: a large effect was seen for shoulder extension (d = -.80) in favor of SN, moderate effects were observed for shoulder flexion (d = -.50) in favor of SN, hip flexion (d = -.62) in favor of SN, and hip abduction (d = .57) in favor of Grid. When compared to control, both foam rollers acutely improved hip and shoulder ROM to a greater extent, and both foam rollers yielded similar improvements to ROM.

Chapter One: Introduction

Significance

The benefits of exercise for fitness and performance are well documented (Garber et al., 2011). However, over time exercise can cause micro-trauma which may cause the myofascial tissue to solidify and develop adhesions (Barnes, 1997). These adhesions cause muscular dysfunctions like decreased range of motion (ROM), reduced strength, and diminished contractile potential (Barnes, 1997). Massages are thought to relieve these adhesions and acutely improve athletic performance and ROM, but the research analyzing acute effects of massage on performance and ROM is inconclusive. In fact, stretching was far superior at increasing range of motion in the lower extremities when compared to massage (Weerapong, Hume, & Kolt, 2005).

Despite the lack of empirical evidence supporting the acute benefits of massage on muscular performance and ROM, a new method has been popularized in recent years that mimics the myofascial release aspect of massage. “Myofascial release is a massage technique that focuses on soft tissue that is tight or in spasm. The source of the tightness can be muscle spasm, soft tissue adhesions, scar tissue, and/or excessive release of acetylcholine (Paolini, J., 2009).” The new method, known as foam rolling, is based on the concept of self-myofascial release (SMR), which simply means using one’s own body weight to achieve myofascial release.

ROM is the degree of movement that a joint can achieve as measured by static or dynamic flexibility. Several different factors can effect ROM such as: joint structure, age, sex, elasticity and plasticity of connective tissue, resistance training methods, muscle bulk, and activity level (Baechle & Earle, 2008, Chapter 13). Soft tissue’s contribution to a joint’s ROM can be broken down into the following: joint capsule-47%, muscle and its fascia-41%, tendons and ligaments-10%, and skin-2% (Heyward, 2010, Chapter 10). Consequently, it is reasonable to think SMR via foam rolling would effectively improve ROM since SMR targets the muscle and its fascia, yet there appears to be no clear link between foam rolling and muscular performance (i.e. force output, power output, muscle activation, etc.).

Men’s Fitness claims that performing SMR via foam rolling can increase strength and ROM if done just before squatting (Tuthill, 2016). Claims such as these can be found everywhere in laymen’s literature, but it is difficult to find peer-reviewed research to support them. The existence of these claims are prevalent possibly due to the documented benefits of increased ROM during physical activity such as maximizing the benefits of certain exercises (Baechle & Earle, 2008, Chapter 14). Additionally, limited ROM can lead to injury, meaning ROM should be improved before participating in physical activity (Halperin, Aboodarda, Button, Andersen, & Behm, 2014). Consequently, investigating the acute effects of SMR via foam rolling on ROM and muscular performance has been the focus of research done on foam rolling thus far.

The research on SMR via foam rolling at this point has shown that significant acute improvements to ROM are possible, but that muscular performance will not acutely improve to a significant extent (MacDonald et al., 2013; Sullivan, Silvey, Button, & Behm, 2013). Since acutely improving ROM to a significant extent is possible via foam rolling, the benefits of increased ROM should be identified. Performing resistance training exercises through a fuller/larger ROM yield significantly superior chronic benefits (i.e. hypertrophy, strength gains, and muscle function) when compared to partial/shorter ROM (MacDonald et al., 2013; Sullivan et al., 2013). If foam rolling can acutely improve ROM and resistance training through fuller/larger ROM lead to superior chronic effects of resistance training, investigating whether a particular foam roller is better at acutely increasing ROM compared to another would be a valuable endeavor.

Currently only one study has compared foam rollers to one another, but not their effects to muscular performance or ROM. Curran, Fiore, and Crisco (2008) compared the difference in the pressure applied by two different foam rollers. The researchers argued that applying a higher concentrated pressure and having an isolated contact area while foam rolling would improve the effectiveness by allowing an individual to access deeper soft tissues. This was achieved to a greater extent using a foam roller similar to The Grid Foam Roller by Trigger Point Performance, hence why it was used for this study. Studies investigating foam rollers have not all used the exact same foam roller, instead various types of foam rollers have been utilized. For example, Sullivan et al. (2013) and Halperin et al. (2014) used a rolling pin like device; whereas, MacDonald et al. (2013) and Healey, Hatfield, Blanpied, Dorfman, & Riebe (2014) studied a cylinder shaped like device about five inches in diameter.

The creators of the MobilityWOD Supernova argue that SMR can be more successfully achieved using their device. More effectively reaching deeper tissue, the ability to "grip and shear" the muscle fibers, and allowing for more pressure tolerance whilst creating more isolated pressure are a few of the reasons described by the creators for why their device is superior to all others. The MobilityWOD Supernova was therefore the other SMR device used for this study.

Purpose/Hypothesis

The aim of this study was to investigate the differences between the acute effects two different foam rollers had on hip and shoulder ROM among college aged students. It was hypothesized that the MobilityWOD Supernova would be superior at acutely increasing hip and shoulder ROM when compared to The Grid Foam Roller by Trigger Point Performance. This was mainly due to the fact that the Supernova appeared to more easily access small crevices and deeper tissues when compared to the Grid, plus it seemed to create more pressure on treated areas, which should improve the effectiveness of SMR (Curran et al., 2008). Five measurements at the shoulder and six at the hip were taken in order to fully analyze ROM at each joint.

Limitations and Delimitations

The delimitations of this study are that participants must be at least 18 years of age and taken or enrolled in KINS 5423 or KINS 4263 at the University of Central Oklahoma. A limitation of this study is not being able to control the amount of pressure each participant exerts while foam rolling, which might change the effectiveness of the foam rolling (Curran et al., 2008). Secondly, factors that affect ROM such as: age, training status, activity level, and muscle bulk are not being controlled for in this study. However, the study has a random cross over design to minimize the impact of these factors.

Definitions

- *Acute Effects:* immediately after treatment in terms of minutes.
- *Fascia:* fibrous connective tissues that surround organs, bones, muscles, and much more (Baechle & Earle, 2008, p. 107). It is composed of collagen, elastin, and ground substance (Paolini, 2009).
- *Muscular Performance*: for this study, muscular performance will refer to such things as: force output, muscle activation, hypertrophy, and power output. Range of motion will be considered separate from muscular performance.
- *Myofascia:* fascia that surrounds muscles, tendons, and ligaments.
- *Myofascial Release:* “Myofascial release is a massage technique that focuses on soft tissue that is tight or in spasm (Paolini, 2009).

Chapter Two: Literature Review

The literature review will first focus on the studies that have examined the acute effects of SMR via foam rolling or roller massage on muscular performance and ROM. Then, the studies that have investigated the benefits of increased ROM during resistance training will be analyzed.

Foam Rolling, Muscular Performance, and ROM

Sullivan et al. (2013) aimed to evaluate the acute effects a roller-massager had on lower extremity ROM and hamstring force output. Seventeen (10 females, 7 males) individuals completed a pre and post sit-and-reach and hamstring maximal voluntary contraction (MVC) force for four different roller massage treatments, but only nine participants (6 females, 3 males) completed a control treatment that consisted of resting for five minutes prior to post testing. Two treatments were conducted per session, separated by 30-45 minutes. Roller massage treatments consisted of rolling the hamstrings for either: one set for five seconds, two sets for five seconds, one set for 10 seconds, or two sets for 10 seconds with a constant pressure roller apparatus (CPRA). The CPRA kept a constant pressure of 13 kg and a constant speed of 120 beats per minute.

A 2x3x3 (time x rolling duration x sets of rolling) repeated measures ANOVA was used to analyze the data, with a Bonferroni (Dunn's) post hoc test being ran if significance was found. All roller massage treatments significantly (p = 0.0001) increased hamstring ROM (pre: 31.32 ± 2.10 cm to post: 32.68 ± 2.06 cm) by 4.3%, but 10 seconds (32.37 ± 2.09 cm) showed almost significantly superior results, irrespective of set number, when compared to five seconds (31.63 ± 2.08 cm), p=0.069. There was no significant change in hamstring MVC force after using the roller massager. The authors concluded that the use of a roller massager can acutely increase hamstring ROM significantly, especially if used for longer durations, with no subsequent changes in MVC force (Sullivan et al., 2013).

Halperin et al. (2014) also studied the acute effects a roller massager had on ROM and MVC force; however, the participants used a roller massager to self-massage (SM) the calf muscles with the ankle ROM and MVC force of the plantar flexors being the main outcome measurements. Specifically, the acute effects of SM with a roller massager compared to static stretching (SS) on ankle ROM, plantar flexor MVC force, and single limb balance were assessed. Fourteen (12 males, 2 females) individuals who were physically active two days a week on average volunteered for this randomized cross-over study. Participants attended two different sessions separated by three to six days. Each session began with a 10 heel raise warm-up followed by two pretests, separated by 10 minutes. After the second pretest, participants were assigned to either 30 seconds of SS or 30 seconds of SM, each performed for three sets, before re-testing at one and 10 minutes post intervention.

A two way repeated measures ANOVA (2 conditions x 3 time intervals) was ran to compare the differences between the two interventions, with Cohen's *d* effect size (ES) and percent change (%Δ) being calculated if there was significance. Self-massage produced significantly greater force output at 10 minutes post intervention compared to SS, $p = 0.005$, ES =1.23, %Δ = 8.2%. Both SM (p =0.004, ES = 0.24, %Δ = 3.6%) and SS (p = 0.001, ES = 0.27, %Δ = 5.4%) significantly improved dorsiflexion ROM immediately after the intervention. It was concluded that SM with a roller massager was superior at increasing MVC force while producing similar ROM improvements compared to SS at 10 minutes post-intervention (Halperin et al., 2014).

"The Stick", a semi rigid rod that is used manually to massage muscles, is the device that was mentioned in the previous two studies as a roller massager. Mikesky, Bahamonde, Stanton, Alvey, & Fitton (2002) studied The Sticks' effect on muscular: strength, power, and flexibility. Thirty (7 males, 20 females) collegiate athletes performed two minutes of either visualization, placebo electric stimulation, or massage via The Stick before each test. Then hamstring flexibility, vertical jump, flying-start 20-yard dash, and muscular strength of the knee extensors were tested. The Stick had no significant acute impact on any of the measurements, $p>0.05$. Although there was no significant effect on any of the measures, the authors mentioned that The Stick's impact on sprint time (2.74 ± 0.03 s vs. 2.76 ± 0.03 s in the control group) was trending to significance, $p=0.08$. It was argued that at high levels of competition even the slightest of competitive edge matters (Mikesky et al., 2002).

Finally, a study that evaluates self-myofascial release (SMR) via foam rolling was done by MacDonald et al. (2013). The researchers wanted to determine if SMR with a foam roller could increase range of motion (ROM) at the knee, without decreasing muscular function in the quadriceps. It was hypothesized that ROM would increase and muscular force output would decrease. Eleven healthy and currently active college aged males volunteered for the study. The participants attended four different sessions, separated by 24-48 hours each. During sessions one and two ROM and force output were measured, respectively. Force output and ROM were measured again during sessions three and four, respectively; however, two 1-minute sets of foam rolling on the quadriceps were completed prior to testing. Participants were instructed to place as much pressure on the quadriceps of the right leg as they rolled slowly, using kneading-like motions, from the hip to the knee and quickly back up.

Measurements were taken pre, two minutes post intervention, and 10 minutes post intervention. Goniometers were used to measure the knee ROM and a knee extensor machine was used to measure knee extensor MVC force. A 2-way analysis with repeated measures was used to analyze the data. There was a significant increase in ROM by10º and 8º degrees at 2 and 10 minutes, respectively, after foam rolling, $p<0.001$. After foam rolling the significant ($p<0.01$) negative relationship with ROM and force output no longer existed at both 2 and 10 minutes post intervention. The authors concluded that SMR via foam rolling can acutely increase ROM at the knee with no significant effect on muscle force or activation (MacDonald et al., 2013).

Unlike Macdonald et al. (2013), Peacock, Krein, Silver, Sanders, & Von Carlowitz (2014) were able to report significant improvements to athletic performance after using foam rolling in conjunction with a dynamic warm-up. The aim of this study was to determine if an acute bout of foam rolling plus a dynamic warm-up could improve athletic performance to a greater extent than a dynamic warm-up alone. Eleven male college athletes completed six performance test: sit-and-reach, vertical jump, standing long jump, pro-agility drill, estimated one repetition max bench press, and a 37m sprint after completing one of two warm-up conditions. A crossover design was used in which participants completed a dynamic warm-up protocol (DYN) or a full-body foam rolling protocol plus a dynamic warm-up (SMR) on two different occasions. Paired samples *t* tests revealed that SMR more significantly ($p < .05$) improved all test scores except sit-and-reach when compared to DYN (Peacock et al., 2014)

Likewise, Healey et al. (2014) studied the effects SMR with a foam roller had on athletic performance compared to planking. The authors hypothesized that benefits from foam rolling were due to a “warming-up” effect that was similar to performing a plank. Muscle soreness, fatigue, and exertion before and after testing was also examined. Twenty-six healthy (13 male, 13 female) college-aged individuals volunteered for the study, all of which had performed three to four days of physical activity per week for the past six months. A randomized crossover study design with one session of familiarization and two sessions of testing was used. Each participant performed either planking or SMR before a battery of athletic tests (vertical jump height and power, isometric power, and agility). The participants foam rolled the entire length of the quadriceps, hamstring, IT band, calves, latissimus dorsi, and rhomboid muscles for 30 seconds. A plank position was held for 30 seconds that mimicked the body position of each muscle group that was foam rolled.

A 2x2 (trial x gender) analysis of variance with repeated measures was used to assess the results. No significant differences were found between SMR and planking for any of the athletic outcome measures, $p>0.05$. There was a significantly lower reported fatigue post exercise after foam rolling when compared to planking, $p<0.05$. The authors concluded that foam rolling had no effect on acute athletic performance, but that the perceived lowering of fatigue after foam rolling may help athletes train harder (Healey et al., 2014).

Janot et al. (2013) decided to look at a slightly different measure of muscular performance by comparing the differences that SS and myofascial release (MFR) had on anaerobic power as measured by a 30 second cycling Wingate test. A randomized cross-over design was used, in which young healthy volunteers (14 females, 9 males) performed testing after three different treatments: control, SS, and MFR separated by exactly a week each. The same seven muscle groups were treated for 30 seconds, three sets in a specific order for both SS and MFR interventions: quadriceps, hamstrings, IT band, adductors, gluteus, hip flexors, and calf muscles. Peak power output (PPO) and percent power drop (PPD) were the major outcome measures of the Wingate test.

A repeated measures ANOVA was used to analyze the difference between interventions, with a Tukey's HSD post-hoc test being ran if significance was found. No significant interactions were found when the entire sample size was analyzed, but when the sample was split into gender there were significant findings. Absolute PPO was significantly ($p<0.05$) increased after SS (881.1 ± 169.3 W) and MFR (891.1 ± 202.4 W) among males when compared to the control (850.6 ± 165.4 W) treatment, but absolute PPO significantly dropped after SS (508.3 ± 67.1 w) compared to the control (536.9 ± 69.1 W) in females, with no significant effect resulting from MFR, $p>0.05$. Surprisingly, PPD was significantly ($p<0.05$) decreased for both interventions when compared to the control treatment (control: 44.9 ± 5.3%; SS: 40. 6 ± 6.7%; MFR: 41.5 ± 6.0%) among females; however, in males PPD significantly ($p<0.05$) increased after MFR (48.9 ± 8.3%) when compared to the control (44.7 ± 7.7%) treatment. The authors reasoned that MFR may be slightly superior to SS when acute increases to PPO are desired for a short time (i.e. weightlifting, shot put, discus, long jump, high jump) among males but not females. Additionally, MFR may help females acutely increase muscle power endurance while maintaining PPO (Janot et al., 2013).

Determining if foam rolling in conjunction with static stretching (SS) was better at improving passive hip flexion ROM compared to foam rolling or SS alone was the aim of Mohr, Long, and Goad (2014). Forty individuals with less than 90° of hip flexion were randomly assigned to one of four treatments: foam rolling, SS, foam rolling plus SS, or control. Those who were in the SS group received three passive stretches held for one minute each, those in the foam rolling group completed three sets of one minute repetitions of SMR for the hamstrings, and the SS plus foam rolling group did both while the control group just rested. A bubble inclinometer was used to measure pre and post intervention passive hip flexion ROM during all six sessions. The foam rolling plus SS group more significantly improve ROM compared to SS (*p* = .04), foam rolling (*p* = .006), and control (*p* = .001) groups (Mohr et al., 2014). Škarabot, Beardsley, and Štirn (2015) reported similar results in a random cross-over design that investigated the differences between foam rolling (FR), SS, and FR + SS acute effects on passive ankle dorsiflexion ROM. Foam rolling and SS consisted of three sets of 30s repetitions for the planter flexor muscles, and the FR + SS simply combined these protocol. Pairwise *t* tests revealed that FR + SS was superior at improving dorsiflexion ROM when compared to FR ($p \leq .05$). The authors concluded that FR + SS would be better at acutely improving dorsiflexion ROM than FR alone (Škarabot et al., 2015).

In summary, studies show that the use of SMR via foam rolling improve ROM with no subsequent positive or negative effect to muscular performance, the possible exception being anaerobic power as displayed by Janot et al. (2013). Conversely, Peacock et al. (2013) showed significant improvements to muscular performance after foam rolling plus a dynamic warm-up, but these results may have been due to foam rolling acting as a further “warming-up” effect and reduced perceived fatigue as evident by Healey et al. (2014). Halperin et al. (2014) provided evidence that SMR yielded similar acute improvements to ROM when compared to SS. However, combining SMR via foam rolling with SS will lead to superior ROM improvement when compared to foam rolling alone (Mohr et al., 2014; Škarabot et al., 2015). Mikesky et al. (2002) may have shed light on an acute dose response to SMR. The dose response being two minutes of consecutive SMR on the same muscle resulting in no significant effect to ROM; whereas, the majority of the literature, including MacDonald et al. (2013) and Sullivan et al. (2013), showed acute increases in ROM after 30s to one minute of SMR on the same muscle, even after multiple sets.

Range of Motion and Resistance Training

The effects of training through a larger ROM verses a shorter ROM is a concern most fitness and performance professionals are concerned with. McMahon, Morse, Burden, Winwood, and Onambele (2014) aimed to identify the effects exercising through a longer verses a shorter ROM had on resistance training adaptations and detraining. Twenty-six (14 males, 12 females) young healthy adults were randomly split into three groups: longer ROM (LR), shorter ROM (SR), or control. The LR (0-90º knee flexion) and SR (0-50º knee flexion) groups resistance trained three times per week for eight weeks at 80% one repetition max (1RM), followed by four weeks of detraining. Squat, leg press, and leg extension were the exercises performed during the eight week training program. Resistance training adaptations were measured pre and post intervention (weeks 0, 8, 10, 12) including muscular: size, architecture, strength, and subcutaneous fat. Muscular strength (torque measured in $N \cdot m$) was measured with a dynamometer, while muscle architecture (measured in mm), muscle size (measured in mm), and subcutaneous fat (measured in mm) were measured using a real-time ultrasonography.

A repeated measures ANOVA with Bonferroni correction post hoc test were used to analyze the data. The LR group showed significantly ($p<0.05$) better improvements in all outcome measures when compared to the SR group: strength (18 ± 2% vs. 4 ± 2%), distal anatomical cross-sectional area (59 ± 15% vs. 16 ± 10%), fascicle length (23 ± 5% vs. 10 ± 2%), and subcutaneous fat (22 ± 8% vs. 5 ± 2%). Strength diminished significantly ($p<0.05$) faster in the SR group then it did in the LR group. The authors stated that when increases to muscular strength and size are the goals of resistance training, LR is better than SR (McMahon et al., 2014).

A similar study was conducted by Pinto et al. (2012), but different ROM exercises were observed in the upper body instead of the lower body. Comparing the effects between partial ROM versus full ROM upper body resistance training on strength and muscle thickness (MT) among young men was the aim of this study. Forty men were randomly assigned into three groups: full ROM (FULL, 0-130º), partial ROM (PART, 50-100º), or control. Participants completed a supervised 10 week progressive resistance training program, in which they performed a preacher curl twice a week. The participants' preacher curl 1RM and elbow flexor's MT, measured by ultrasound, were assessed pre and post intervention.

Repeated measures ANOVA revealed a significant ($p<0.05$) increase in elbow flexion 1RM for both FULL (25.7 ± 9.6 %) and PART (16 ± 6.7 %) but not the control. Effect sizes showed that the FULL (1.89) group had a moderate to large change in strength; whereas, the PART (0.87) had a small change in strength. Average elbow flexor MT significantly ($p<0.05$) increased for both FULL (9.65 ± 4.4 %) and PART (7.37 ± 4.9 %), but the effect sizes showed that FULL (1.09) had more favorable change when compared to PART (0.57). It was concluded that performing elbow flexion through a full ROM during resistance training versus partial ROM may lead to superior strength gains among untrained men (Pinto et al., 2012).

Bloomquist et al. (2013) investigate the effects of full range of motion verses partial range of motion in a multi joint movement. The purpose of this study was to compare the results of a deep squat (DS) and shallow squat (SS) on knee extensor muscle size and function. Seventeen male college aged students were randomly placed into a DS (0-120º of knee flexion) group or SS (0-60º of knee flexion) group. Participants were supervised as they strength trained with barbell free weights three times per week for 12 weeks, based on a progressive periodized program. The main outcome measures included: cross sectional area (CSA), squat jump performance, DS and SS 1RM, and isometric strength.

A paired *t* test was used to analyze the change over time, and an unpaired *t* test was used to analyze the differences between groups. Both groups significantly ($p<0.05$) increased each of the squatting depth's 1RM. However, DS (4-7 %) training increased front thigh muscle CSA more significantly ($p<0.05$) than the SS training. Also, a superior increase in isometric knee extension strength at 75º (6 ± 2 %) and 105º (8 ± 1 %) knee flexion was observed for DS versus SS, $p<0.05$. Lastly, squat-jump performance was more significantly increased for DS (15 ± 3 %) when compared to SS, $p<0.05$. In conclusion, the authors stated that DS training was superior to SS training at improving knee extensor muscle size and function among males (Bloomquist et al., 2013).

Performing resistance training exercises through a longer ROM versus a shorter ROM yield greater increases to muscular strength and size in the lower body (McMahon, Morse, Burden, Winwood, & Onambele, 2013). Likewise, Bloomquist et al. (2013) showed that better improvements to muscle size and function were achieved through deep squats when compared to shallow squats. Lastly, Pinto et al. (2012) revealed that greater strength gains may be attained if bicep curls are completed through a full ROM when compared to a partial ROM. It can be concluded that performing resistance training exercises through a larger/fuller ROM result in superior muscular performance outcomes.

Conclusion

It is evident that acutely improving muscular performance will not be achieved to a significant degree through SMR via foam rolling; nevertheless, SMR via foam rolling can acutely improve ROM to a significant extent, without a detriment to muscular performance

(MacDonald et al., 2013; Sullivan et al., 2013). Although acutely improving muscular performance by executing SMR via foam rolling is unlikely, the acute effects SMR via foam rolling have on ROM may help improve the benefits of resistance training in the long run. Performing exercises through a larger/fuller ROM can help improve the chronic benefits of resistance training (Bloomquist et al., 2013). The literature has not defined a precise methodology for performing SMR via foam rolling; however, a few commonalities and guidelines have emerged (i.e. sufficient pressure exerted, duration, and sets). Whether a particular foam roller is superior to another has not been determined or investigated, and the effect foam rolling has on different ROM measurements at the same joint for an upper and lower body joint has not been investigated. Consequently, the current study examined the acute effects two different foam rollers had on several ROM measurements at the hip and shoulder, in order to discover possible differences.

Chapter Three: Methodology

The purpose of this study was to compare the acute effects two different foam rollers had on hip and shoulder ROM among college aged students. It is hypothesized that the MobilityWOD Supernova will improve hip and shoulder ROM to a greater extent than The Grid Foam Roller by Trigger Point Performance.

Participants

Students who were enrolled in KINS 5423 or KIN 4263 at the University of Central Oklahoma during the spring semester of 2016 were asked to participate in this study. Introduction to basic foam rolling techniques were taught in these classes, meaning the participants would have some experience foam rolling. Thus the results of this study only apply to college aged individuals. Participants had to be free from injury for at least the last 6 months. The primary researcher attended each class to read an approved recruitment script (Appendix C) or sent an approved recruitment email (Appendix D). Once the students who were interested in participating emailed the primary researcher, appointments were set for testing at the UCO Wellness Center Lab. Based on previous research by MacDonald et al. (2013), univariate effect size for change in ROM was estimated to be (d=1.62) requiring a sample size of six participants to find statistical significance, $\alpha = .05$, $1 - \beta = .80$ (Cohen, 1992).

Instruments

Curran, Fiore, and Crisco (2008) determined that a multilevel rigid roller (MRR), a non-uniform cylinder consisting of a hollow polyvinyl chloride inner core, more effectively applied isolated pressure compared to a bio-foam roller (BFR), a uniform polystyrene foam cylinder, when performing SMR via foam rolling. It was argued that applying a higher concentrated pressure and having an isolated contact area while foam rolling would improve the effectiveness by allowing an individual to access deeper soft tissues, which was achieved to a greater extent using an MRR. Therefore, The Grid Foam Roller by Trigger Point Performance, which matches the device used by Curran et al. (2008), was one of the SMR devices used in this study.

Dr. Kelly Starrett, creator of MobilityWOD.com, is a leader in the field of mobility, which involves SMR via foam rolling. He and his associates have created a revolutionary foam rolling like device called the MobilityWOD Supernova. They argue that it is superior to any other foam rolling device at performing SMR. Dr. Starrett explains in a video found on therxreview.com that the Supernova: is able to “grip and shear” the muscle more effectively, it allows for more pressure tolerance due to better diffusion, it can reach deeper tissue more effectively, it allows tissue fluid to move around more effectively due to creating high and low pressure areas, it is much more mobile (able to roll in several directions), and it is easier to transport. The MobilityWOD Supernova was therefore the other SMR device used for this study.

According the ACSM’s Guidelines for Exercise Testing and Prescription 9th ed. (2013), a goniometer is a more precise tool for measuring joint ROM compared to other field tests. Thus a plastic True-Angle Goniometer was used to measure the participants hip and shoulder ROM.

Procedures

A randomized cross-over design was used, with three different conditions: Supernova (SN), Grid, and a control trial which received no treatment. Participants arrived at the lab and signed an informed consent. Next their age, height, and weight were measured and recorded. Then the participant’s hip and shoulder ROM were measured with a goniometer (Appendix F), followed by a 10 minute rest, after which hip and shoulder ROM were measured again (control treatment). The primary researcher took all the measurements on the participant’s dominant side. Once the measurements were complete, the tester introduced the participants to the Supernova and Grid, explaining, demonstrating, and allowing the participants to practice the techniques that would be used during the next two conditions (Appendix E). At the next two sessions, participants were randomly assigned to the Supernova or Grid conditions. Hip and shoulder ROM were measured first, followed by lower body SMR and post hip ROM testing. Upper body SMR was then performed prior to post shoulder ROM testing. Visual and verbal directions were given during both conditions by the instructor. Each session was separated by at least 48 hours and took about an hour. This study was approved by the University of Central Oklahoma Institutional Review Board.

Statistical Analysis

The null hypothesis states that there is no difference in the acute effects two different foam rollers have on ROM. The research hypothesis was that the Supernova would be better at improving hip and shoulder ROM compared to the Grid. Time (pre and post) and condition (Supernova, Grid, and control) were the independent variables; whereas, the 11 measures of ROM were dependent variables and are listed below:

- Shoulder Flexion (SF)
- Shoulder Extension (SE)
- Shoulder Abduction (SAb)
- Shoulder Internal Rotation (SIR)
- Shoulder External Rotation (SER)
- Hip Flexion (HF)
- Hip Extension (HE)
- Hip Abduction (HAb)

- Hip Adduction (HAd)
- Hip Internal Rotation (HIR)
- Hip External Rotation (HER)

Statistical Package for the Social Sciences (SPSS) 21.0 was used to analyze all collected data. In order to compare the acute effects each foam roller had on ROM, the mean difference scores (pre – post) for each condition was calculated first. Then, repeated measures ANOVA's were ran. A Mauchly's Test of Sphericity was ran for all dependent variables to confirm the variance of the differences between conditions were equal. Sphericity was assumed if the test yielded an alpha level greater than .05, and if Sphericity was violated, the alpha level for Greenhouse-Geisser was used to determine if there were significant differences between conditions. If significance was found, protected dependent *t* tests were ran to determine between which conditions the significant differences occurred. The alpha level was set at 0.05, which means that there was an increase in type one error due to the number of repeated measures ANOVA test ran. Having a small sample size and this study being the first of its kind, were the reasons why an increase in type one error, by not adjusting the alpha level, was accepted

Univariate effect size and percent change (%Δ) were calculated to help define the magnitude of any differences between conditions. Effect size and percent change were calculated using the mean difference scores (pre – post) for each condition. When calculating effect size between the foam rolling conditions, the Grid mean differences were subtracted from the SN mean differences, so a positive number means that Grid was more effective and a negative number means SN was more effective. A pooled standard deviation was used to calculate all effect sizes.

Chapter Four: Results

Purpose

Increased ROM during physical activity can lower the risk of injury and maximize the benefits of certain exercises (Baechle & Earle, 2008, Chapters 13 and 14). Performing SMR via foam rolling can acutely increase ROM with no significant effect on muscle force or activation (MacDonald et al., 2013). Therefore, the purpose of this study was to compare the acute effects two different foam rollers had on hip and shoulder ROM among college aged students in order to discover if one foam roller was superior to the other. A complete explanation for the statistical analyses of this study will be provided in this section.

Participant Demographics

There were a total of 10 participants (5 males, 5 females) in this research study. The mean age was 24 ± 5.23 years, the mean height was 66.43 ± 3.35 in, and the mean weight was 157.2 ± 45.26 lbs.

Repeated Measures Analysis of Variance

It was hypothesized that hip and shoulder ROM would be more significantly improved utilizing the Supernova versus the Grid. Participants were tested for three different conditions: control, Supernova (SN), and Grid. Repeated measures ANOVA with follow up protected dependent t tests were ran to analyze the differences between the conditions. Additionally effect sizes and percent change were calculated to express the magnitude and direction of the differences.

Shoulder Flexion. Repeated-measures ANOVA was utilized to compare the participants' mean difference scores for three different conditions: control, SN, and Grid. A significant effect was found, $F(2,18) = 4.85$, $p = .021$. Follow-up protected dependent *t* tests revealed that mean difference scores were significantly different between control v SN (0.1 ± 1.85 v -4.3 ± 4.60, respectively, p = .017), but not between control v Grid (0.1 ± 1.85 v -2.3 ± 3.37, respectively, p = .089) and SN v Grid (-4.3 ± 4.60 v -2.3 ± 3.37, respectively, p = .206). When compared to the control condition (%Δ= 0.06%), Cohen's effect size and percent change show that SN (d = 1.26, %Δ = 2.67%) had a slightly larger effect than Grid (d = .88, %Δ = 1.40%), and when both foam rolling conditions were compared to each other a moderate effect (d = -.50) in favor of SN was observed.

Shoulder Extension. Repeated-measures ANOVA was utilized to compare the participants' mean difference scores for three different conditions: control, SN, and Grid. A significant effect was found, F(2,18) = 6.87, p = .006. Follow-up protected dependent t tests revealed that mean difference scores were significantly different between control v SN (0.6 ± 1.58 v -4.6 ± 3.98, respectively, p = .004), but not between control v Grid (0.6 ± 1.58 v -1.6 ± 3.53, respectively, p = .139) and SN v Grid (-4.6 ± 3.98 v -1.6 ± 3.53, respectively, p = .074). Although there was no significant difference between control v Grid or SN v Grid, Cohen's effect size show that there was a large effect (d = .80) observed when comparing control v Grid with a percent change of 1.88% v 4.92%, respectively, and a large effect (d = .80) was observed when comparing SN v Grid. A large effect (d = 1.72) was seen for control v SN and a percent change of 1.88% v 10.38%, respectively.

Shoulder Abduction. Repeated-measures ANOVA was utilized to compare the participants' mean difference scores for three different conditions: control, SN, and Grid. A significant effect was found, F(2,18) = 7.67, p = .004. Follow-up protected dependent t tests revealed that mean difference scores were significantly different between control v SN (0.7 ± 2.00 v -5.5 ± 6.83, respectively, p = .007) and control v Grid (0.7 ± 2.00 v -5.6 ± 4.77, respectively, p = .001), but not for SN v Grid (-5.5 ± 6.84 v -5.6 ± 4.77, respectively, p = .967). When compared to the control condition (%Δ= .42%), Cohen's effect size show that Grid (d = 1.72, %Δ = 3.33%) had a slightly larger effect than SN (d = 1.23, %Δ = 3.55%), and when both foam rolling conditions were compared to each other close to no effect (d = .02) was observed.

Shoulder Internal Rotation. Repeated-measures ANOVA was utilized to compare the participants' mean difference scores for three different conditions: control, SN, and Grid. A significant effect was found, $F(1.29,11.64) = 7.49$, p = .014. Follow-up protected dependent t tests revealed that mean difference scores were significantly different between control v SN (1.3 ± 2.26 v -3.7 ± 4.19, respectively, p = .000) and control v Grid (1.3 ± 2.26 v -2.6 ± 4.50, respectively, p = .015), but not for SN v Grid (-3.7 ± 4.19 v -2.6 ± 4.50, respectively, p = .548). When compared to the control condition (%Δ= 2.19%), Cohen's effect size and percent change show that SN (d = 1.48, %Δ = 6.23%) had a slightly larger effect than Grid (d = 1.09, %Δ = 4.39%), and when both foam rolling conditions were compared to each other a near small effect (d = -.25) in favor of SN was observed.

Shoulder External Rotation. Repeated-measures ANOVA was utilized to compare the participants' mean difference scores for three different conditions: control, SN, and Grid. A significant effect was found, $F(2,18) = 6.74$, p = .007. Follow-up protected dependent t tests revealed that mean difference scores were significantly different between control v SN (0.8 ± 2.49 v -4.5 ± 4.33, respectively, p = .011) and control v Grid (0.8 ± 2.49 v -7.0 ± 6.29, respectively, p = .012), but not for SN v Grid (-4.5 ± 4.33 v -7.0 ± 6.29, respectively, p = .302). When compared to the control condition (%Δ= .97%), Cohen's effect size and percent change show that Grid (d = 1.63, %Δ = 8.45%) had a slightly larger effect than SN (d = 1.50, %Δ =

5.39%), and when both foam rolling conditions were compared to each other a small effect (*d* = .46) in favor of SN was observed.

Hip Flexion. Repeated-measures ANOVA was utilized to compare the participants' mean difference scores for three different conditions: control, SN, and Grid. A significant effect was found, F(2,18) = 10.28, *p* = .001. Follow-up protected dependent *t* tests revealed that mean difference scores were significantly different between control v SN (0.7 ± 2.00 v -6.3 ± 4.95, respectively, *p* = .004) and control v Grid (0.7 ± 2.00 v -3.8 ± 2.78, respectively, *p* = .007), but not for SN v Grid (-6.3 ± 4.95 v -3.8 ± 2.78, respectively, *p* = .132). When compared to the control condition (%Δ= .65%), Cohen's effect size and percent change show that SN (*d* = 1.86, %Δ = 5.59%) had virtually the same large effect as Grid (*d* = 1.86, %Δ = 3.42%), and when both foam rolling conditions were compared to each other a moderate effect (*d* = -.62) in favor of SN was observed.

Hip Extension. Repeated-measures ANOVA was utilized to compare the participants' mean difference scores for three different conditions: control, SN, and Grid. A significant effect was found, F(2,18) = 6.18, *p* = .009. Follow-up protected dependent *t* tests revealed that mean difference scores were significantly different between control v SN (0.8 ± 2.15 v -3.5 ± 3.75, respectively, *p* = .008) and control v Grid (0.8 ± 2.15 v -3.1 ± 2.89, respectively, *p* = .012), but not for SN v Grid (-3.5 ± 2.15 v -3.1 ± 2.89, respectively, *p* = .799). When compared to the control condition, Cohen's effect size show that Grid (*d* = 1.53) had a slightly larger effect than SN (*d* = 1.41) but a smaller percent change (15.12% v 18.32%, respectively), and when both foam rolling conditions were compared to each other almost no effect (*d* = -.12) was observed.

Hip Abduction. Repeated-measures ANOVA was utilized to compare the participants' mean difference scores for three different conditions: control, SN, and Grid. A significant effect was found, $F(2,18) = 4.95$, $p = .019$. Follow-up protected dependent *t* tests revealed that mean difference scores were significantly different between and control v Grid (0.5 ± 2.07 v -4.0 ± 3.43, respectively, $p = .001$), but not for control v SN (0.5 ± 2.07 v -2.0 ± 3.62, respectively, $p = .125$) and SN v Grid (-2.0 ± 2.07 v -4.0 ± 3.43, respectively, $p = .291$). Although there was no significant difference between control v SN or SN v Grid, Cohen's effect size show that there was a large effect ($d = .85$) observed when comparing control v SN with a percent change of 1.61% v 6.10%, respectively. A moderate effect ($d = .57$) was observed when comparing SN v Grid. A large effect ($d = 1.59$) was seen for control v Grid with a percent change of 1.61% v 12.38%, respectively.

Hip Adduction. Repeated-measures ANOVA was utilized to compare the participants' mean difference scores for three different conditions: control, SN, and Grid. No significant effect was found, $F(2,18) = .633$, $p = .543$. Cohen's effect size revealed that there was a small effect ($d = .31$) between control and SN with a percent change of 2.17% v 5.80%, respectively. Near no effect ($d = -.09$) between control v Grid was observed with a percent change of 2.17% v 1.34%, respectively, and a small effect ($d = -.39$) between SN v Grid was seen.

Hip Internal Rotation. Repeated-measures ANOVA was utilized to compare the participants' mean difference scores for three different conditions: control, SN, and Grid. A significant effect was found, $F(2,18) = 9.11$, $p = .002$. Follow-up protected dependent *t* tests revealed that mean difference scores were significantly different between control v SN (1.2 ± 2.15 v -3.2 ± 2.53, respectively, $p = .002$) and control v Grid (1.2 ± 2.15 v -3.5 ± 3.06, respectively, $p = .011$), but not for SN v Grid (-3.2 ± 2.53 v -3.5 ± 3.06, respectively, $p = .803$). When compared to the control condition ($\%\Delta = 3.61\%$), Cohen's effect size show that SN ($d = 1.87$) had a slightly larger effect than Grid ($d = 1.78$) but a smaller percent change (9.50% v

10.67%, respectively), and when both foam rolling conditions were compared to each other almost no effect (*d* = .11) was observed.

Hip External Rotation. Repeated-measures ANOVA was utilized to compare the participants' mean difference scores for three different conditions: control, SN, and Grid. No significant effect was found, F(2,18) = .481, *p* = .626. Cohen's effect size showed a small effect (d = .41) for control v Grid with a percent change of 0.74% v2.75%, respectively, but close to no effect (*d* = .09) for control v SN with a percent change of 0.74% v 0%, respectively. When both foam rolling conditions were compared to each other a close to small effect (*d* = .27) was observed.

Summary

The researcher accepted the null hypothesis due to no significant differences found between the foam rolling conditions (Table 7). Nevertheless, when compared to control, SN significantly ($p<.05$) improved all variables except HAb, HAd, and HER; Grid significantly ($p<.05$) improved all variables except SF, SE, HAd, and HER (Tables 6 & 7). Furthermore, effect sizes revealed that both moderate and large effects were achieved for a few of the dependent variables when comparing SN to Grid (Table 3). Effect sizes further revealed that when compared to control, both SN and Grid had a large effect on all variables except HAd and HER (Tables 4 & 5).

When analyzing the scores from pre to post for SN and Grid, effect sizes show that the changes are trivial to small for all upper body variables except SER (SN: *d* = -.82; Grid: *d* = -1.20). Scores from pre to post for SN and Grid in the lower body on the other hand displayed that small to large effects were achieved for the majority of the variables (Table 2). In summary, among college aged students both SN and Grid acutely improved all ROM variables significantly more than the control condition, except HAd and HER. Yet, among college aged students SN and Grid did not significantly differ from each other; although, small to large effects sizes were calculated between the mean difference scores of SN and Grid for most of the ROM variables (Table 3). Lastly, using effect sizes to compare changes from pre to post for both SN and Grid it is evident that changes to upper body ROM were mostly trivial; whereas, changes to lower body ROM for the most part were moderately effective.

Chapter Five: Discussion

Purpose/Hypothesis

The aim of this study was to investigate the differences between the acute effects two different foam rollers had on hip and shoulder ROM among college aged students. It was hypothesized that the MobilityWOD Supernova would be superior at acutely increasing hip and shoulder ROM when compared to The Grid Foam Roller by Trigger Point Performance.

Significance

Exercise is immensely important in order to improve or maintain health, fitness, and performance (Garber et al., 2011). Micro-trauma caused by exercise my lead to the myofascial tissue solidifying and developing adhesions though; adhesions cause muscular dysfunctions like reduced strength, diminished contractile potential, and decreased ROM (Barnes, 1997). Additionally, literature supports the concept of chronic resistance training through larger/fuller ranges of motion in order to improve muscular performance outcomes (Bloomquist et al., 2013). Therefore, researchers studied the acute effects SMR via foam rolling had on muscular performance and ROM, which has shown that muscular performance is not acutely improved via foam rolling but ROM may be (Halperin et al., 2014). However, it is unknown whether certain foam rollers are superior to others. The current study examined the acute effects two different foam rollers had on hip and shoulder ROM among college aged students.

Restatement of Results

Both foam rolling conditions (SN and Grid) significantly ($p < .05$) improved shoulder and hip ROM compared to control, with the exception of HAb and HER (Table 6). On the contrary, there were no significant differences found for any dependent variables when SN and Grid were compared (Table 7). Cohen’s effect size calculations may provide meaningful results when comparing the two different foam rollers' effect on shoulder and hip ROM (Table 3). In short, a large effect was seen for SE (*d* = -.80), moderate effects were observed for SF (*d* = -.50), HF (*d* = -.62), and HAb (*d* = .57), and small effects were found for SER (*d* = .46) and HAd (*d* = -.39) when comparing SN to Grid. The changes from pre to post for SN and Grid were trivial to small in the upper body, except SER, and small to large in the lower body as evident by effect sizes (Tables 1 & 2).

Comparison of Literature

To the primary researcher's knowledge the current study is unique in that it is the first to compare the acute effects to ROM between two different foam rollers. The current study is also the first to assess several different measures of ROM at the same joint for an upper and lower body joint (hip and shoulder). Although the current study did not find significant differences between foam rollers, acute improvements to ROM were significantly different compared to control for both foam rollers. These results support the findings of similar studies such as Halperin et al. (2014), Sullivan et al. (2013), and MacDonald et al. (2013). For example, Sullivan et al. (2014) observed that SMR with a roller massager can significantly ($p = .0001$) improve sit-and-reach scores. Secondly, MacDonald et al. (2013) indicated that knee flexion ROM can be significantly ($p < .001$) improved immediately after foam rolling. Lastly, Halperin et al. (2014) showed that SMR yielded similar results in ROM improvements when compared to SS, both of which significantly improved dorsiflexion ROM.

Limitations

The amount of pressure each participant put on the foam roller was not controlled for in this study; more pressure could lead to better benefits of SMR (Curran et al., 2008). However, each participant was asked to exert as much pressure on the foam roller as possible, but whether the participants put efficient pressure is unknown. Secondly, factors that affect ROM such as: age, training status, activity level, and muscle bulk were not controlled for in this study. A small sample size of only college aged students may have limited the results of this study, especially considering moderate and large effect sizes were calculated for differences between foam rollers. Familiarization of the foam rolling procedures, especially the Supernova, was simplistic. If a longer familiarization period was employed for this study, participants may have learned the complexity of the Supernova and become accustomed to such things as pain and discovery of trigger points, which may have made the foam rolling more effective. The results of this study may have been different if the tester was blinded to which condition the participant performed prior to testing.

Strengths

Providing a true control condition was a strength of this study, as it allowed the researcher to compare changes created by foam rolling to a baseline. Secondly, joints move in several directions, which is accomplished by different muscles working in unison. Therefore, several muscles around a muscle should be foam rolled to improve overall ROM at that joint. Measuring several different ranges of motion at each joint allowed the researcher to more specifically define the effects SMR via foam rolling have on a joint's flexibility. Additionally, examining a lower and upper body joint better demonstrates SMR via foam rolling's ability to effect ROM.

Future Directions

Researchers looking to investigate differences between the acute effects to ROM different foam rollers have should consider controlling for activity level, muscle bulk, ROM restriction, hypermobility, and current training status. If studying the Supernova, one should incorporate different foam rolling procedures that would better utilize the Supernova's strengths (i.e. grip and shear). Additionally, it would be a good idea for studies to be done on the chronic effects that SMR via foam rolling have on ROM and muscular performance since the current literature focuses on only the acute effects. Foam rolling as a tool for recovery has also been popularized, but few studies have been done to examine the effects foam rolling have on recovery. Pearcey et al. (2015) concluded that foam rolling was successful at reducing symptoms of delayed onset muscle soreness (DOMS), d = .59 to .84, and the subsequent negative effect DOMS has on sprint time (d = .68 to .77) and power (d = .48 to .87). Future studies should aim to replicate these results and examine the mechanisms behind such results. The mechanisms for increasing ROM via foam rolling should also be further studied.

Practical Implications

Based on the results of this study and the literature as a whole, SMR via foam rolling is an effective method for acutely improving ROM. Increased range of motion can lead to improved chronic benefits of resistance training (Bloomquist et al., 2013). Therefore, foam rolling can be implemented by those wanting to acutely improve ROM just before resistance training specifically or any other physical activity, as it will not negatively impact muscular performance (MacDonald et al., 2013). The results of this study suggest that the specific foam roller used will not significantly affect ROM improvement outcomes, but should be considered according to preference and ease of implementation. Additional consideration for which muscle or group of muscles an individual is foam rolling should be taken into account, as the right tool for the job may vary, meaning using different foam rollers for different muscles may be ideal.

Conclusion

Although there were no statistically significant differences between the acute effects two different foam rollers had on ROM, both foam rollers were effective at improving shoulder and hip ROM compared to the control trial among college aged students. It may be added that meaningful effect sizes were calculated when comparing the two different foam rolling conditions; however, even the effect sizes could not paint a clear picture of which foam roller was better overall. Effect sizes did reveal that both foam rollers' influence on changes to upper body ROM were primarily trivial and that changes to lower body ROM were mostly moderate. In conclusion, among college aged students with various body types, training statuses, and mobility capacities both foam rollers were more effective at acutely improving hip and shoulder ROM when compared to doing nothing. Though, the improvements from pre to post for both foam rollers were trivial for upper body ROM and moderate for lower body ROM.

Considering the growing body of literature over foam rolling, it can be recommended to foam roll just before physical activity in order to significantly increase ROM without jeopardizing muscular performance, and the current study suggests that different foam rollers will yield similar results to ROM among college aged students. Additionally, this study suggest that foam rolling may be more effective for improving hip ROM compared to shoulder ROM among college aged students. However, further research should be done to better understand the impact both foam rollers have on acutely and chronically improving ROM and other health parameters. Based on effect sizes from this study, the debatably meaningful acute effects foam rolling have on ROM would appear to apply more effectively to athletes who desire even the smallest improvement. The use of a specific foam roller may depend on: what muscle is being treated, familiarity of the specific foam roller, familiarity of the exercise being performed with the foam roller, and personal preference. The MobilityWod Supernova and The Grid Foam Roller both have potential to significantly impact people’s ROM but should be further researched.

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Tables

Table 1

Descriptive Statistics, Effect Size, and Percent Change of Shoulder Range of Motion

			Pre	Post			
		N	Mean ± SD	Mean ± SD	Mean Diff	ES	%Δ
Control							
	SF	10	163.00±27.99	162.9±28.48	0.10	0.00	0.06%
	SE	10	31.90±9.64	31.3±9.73	0.60	0.06	1.88%
	SAb	10	166.90±39.16	166.2±37.98	0.70	0.02	0.42%
	SIR	10	59.30±17.71	58±17.71	1.30	0.07	2.19%
	SER	10	82.40±8.25	81.6±8.26	0.80	0.10	0.97%
SN							
	SF	10	161.20±26.41	165.5±28.23	-4.30	-0.16	2.67%
	SE	10	44.30±49.18	48.9±47.26	-4.60	-0.09	10.38%
	SAb	10	155.10±54.10	160.6±52.06	-5.50	-0.10	3.55%
	SIR	10	59.40±14.92	63.1±15.17	-3.70	-0.25	6.23%
	SER	10	83.50±5.52	88±4.81	-4.50	-0.82	5.39%
Grid							
	SF	10	164.10±23.25	166.4±24.51	-2.30	-0.10	1.40%
	SE	10	32.50±8.52	34.1±9.86	-1.60	-0.19	4.92%
	SAb	10	168.00±36.37	173.6±35.88	-5.60	-0.15	3.33%
	SIR	10	59.20±13.51	61.8±14.76	2.60	-0.19	4.39%
	SER	10	82.80±5.83	89.8±6.03	-7.00	-1.20	8.45%

Note. SN = supernova, SF = shoulder flexion, SE = shoulder extension, SAb = shoulder abduction, SIR = shoulder internal rotation, SER = shoulder external rotation

Table 2

Descriptive Statistics, Effect Size, and Percent Change of Hip Range of Motion

			Pre	Post			
		N	Mean ± SD	Mean ± SD	Mean Diff	ES	%Δ
Control							
	HF	10	108.40±9.70	107.70±10.19	0.70	0.07	0.65%
	HE	10	22.50±6.59	21.70±7.10	0.80	0.12	3.56%
	HAb	10	31.10±7.14	30.60±7.46	0.50	0.07	1.61%
	HAd	10	23.00±4.03	23.50±4.81	-0.50	-0.12	2.17%
	HIR	10	33.20±8.15	32.00±7.87	1.20	0.15	3.61%
	HER	10	26.90±8.23	26.70±8.99	0.20	0.02	0.74%
SN							
	HF	10	112.70±8.03	119.00±8.15	-6.30	-0.78	5.59%
	HE	10	19.10±5.26	22.60±4.60	-3.50	-0.67	18.32%
	HAb	10	32.80±5.25	34.80±5.12	-2.00	-0.38	6.10%
	HAd	10	20.70±3.09	21.90±4.53	-1.20	-0.39	5.80%
	HIR	10	33.70±9.49	36.90±10.16	-3.20	-0.34	9.50%
	HER	10	27.00±7.47	27.00±9.09	0.00	0.00	0.00%
Grid							
	HF	10	111.20±8.30	115.00±7.33	-3.80	-0.46	3.42%
	HE	10	20.50±4.79	23.60±5.40	-3.10	-0.65	15.12%
	HAb	10	32.30±5.58	36.30±6.18	-4.00	-0.72	12.38%
	HAd	10	22.40±4.48	22.70±5.38	-0.30	-0.07	1.34%
	HIR	10	32.80±8.28	36.30±8.72	-3.50	-0.42	10.67%
	HER	10	25.50±6.31	26.20±7.53	-0.70	-0.11	2.75%

Note. SN = supernova, HF = hip flexion, HE = hip extension, HAb = hip abduction, HAd = hip adduction, HIR = hip internal rotation, HER = hip external rotation

Table 3

Descriptive Statistics and Effect Size for Supernova vs. Grid

		SN	Grid	
	N	Mean Difference ± SD	Mean Difference ± SD	ES
SF	10	-4.30±4.60	-2.30±3.37	-0.50
SE	10	-4.60±3.98	-1.60±3.53	-0.80
SAb	10	-5.50±6.84	-5.60±4.77	0.02
SIR	10	-3.70±4.19	-2.60±4.50	-0.25
SER	10	-4.50±4.33	-7.00±6.29	0.46
HF	10	-6.30±4.95	-3.80±2.78	-0.62
HE	10	-3.50±3.75	-3.10±2.89	-0.12
HAb	10	-2.00±3.62	-4.00±3.43	0.57
HAd	10	-1.20±2.44	-0.30±2.16	-0.39
HIR	10	-3.20±2.53	-3.50±3.06	0.11
HER	10	0.00±2.63	-0.70±2.50	0.27

Note. SN = supernova, SF = shoulder flexion, SE = shoulder extension, SAb = shoulder abduction, SIR = shoulder internal rotation, SER = shoulder external rotation, HF = hip flexion, HE = hip extension, HAb = hip abduction, HAd = hip adduction, HIR = hip internal rotation, HER = hip external rotation

*significant difference (p<.05)

Table 4

Descriptive Statistics and Effect Size for Control vs. Supernova

		Control	SN	
	N	Mean Difference ± SD	Mean Difference ± SD	ES
SF	10	0.10±1.85	-4.30±4.60	1.26*
SE	10	0.60±1.58	-4.60±3.98	1.72*
SAb	10	0.70±2.00	-5.50±6.84	1.23*
SIR	10	1.30±2.26	-3.70±4.19	1.48*
SER	10	0.80±2.49	-4.50±4.33	1.50*
HF	10	0.70±2.00	-6.30±4.95	1.86*
HE	10	0.80±2.15	-3.50±3.75	1.41*
HAb	10	0.50±2.07	-2.00±3.62	0.85*
HAd	10	-0.50±2.07	-1.20±2.44	0.31
HIR	10	1.20±2.15	-3.20±2.53	1.87*
HER	10	0.20±1.81	0.00±2.63	0.09

Note. SN = supernova, SF = shoulder flexion, SE = shoulder extension, SAb = shoulder abduction, SIR = shoulder internal rotation, SER = shoulder external rotation, HF = hip flexion, HE = hip extension, HAb = hip abduction, HAd = hip adduction, HIR = hip internal rotation, HER = hip external rotation

*significant difference (p<.05)

Table 5

Descriptive Statistics and Effect Sizes for Control vs. Grid

		Control	Grid	
	N	Mean Difference ± SD	Mean Difference ± SD	ES
SF	10	0.10±1.85	-2.30±3.37	0.88*
SE	10	0.60±1.58	-1.60±3.53	0.80*
SAb	10	0.70±2.00	-5.60±4.77	1.72*
SIR	10	1.30±2.26	-2.60±4.50	1.09*
SER	10	0.80±2.49	-7.00±6.29	1.63*
HF	10	0.70±2.00	-3.80±2.78	1.86*
HE	10	0.80±2.15	-3.10±2.89	1.53*
HAb	10	0.50±2.07	-4.00±3.43	1.59*
HAd	10	-0.50±2.07	-0.30±2.16	-0.09
HIR	10	1.20±2.15	-3.50±3.06	1.78*
HER	10	0.20±1.81	-0.70±2.50	0.41

Note. SN = supernova, SF = shoulder flexion, SE = shoulder extension, SAb = shoulder abduction, SIR = shoulder internal rotation, SER = shoulder external rotation, HF = hip flexion, HE = hip extension, HAb = hip abduction, HAd = hip adduction, HIR = hip internal rotation, HER = hip external rotation

*significant difference (p<.05)

Table 6

Results of Repeated Measures Analysis of Variance: Within Subjects Effects

		df	F	p
SF				
	Condition	2	4.846	0.021
	Error	18		
SE				
	Condition	2	6.874	0.006
	Error	18		
SAb				
	Condition	2	7.672	0.004
	Error	18		
SIR				
	Condition	1.293[a]	7.489	0.014[a]
	Error	11.638[a]		
SER				
	Condition	2	6.744	0.007
	Error	18		
HF				
	Condition	2	10.280	0.001
	Error	18		
HE				
	Condition	2	6.176	0.009
	Error	18		
HAb				
	Condition	2	4.946	0.019
	Error	18		
HAd				
	Condition	2	0.633	0.543
	Error	18		
HIR				
	Condition	2	9.105	0.002
	Error	18		
HER				
	Condition	2	0.481	0.626
	Error	18		

Note. SF = shoulder flexion, SE = shoulder extension, SAb = shoulder abduction, SIR = shoulder internal rotation, SER = shoulder external rotation, HF = hip flexion, HE = hip extension, HAb = hip abduction, HAd = hip adduction, HIR = hip internal rotation, HER = hip external rotation.
[a]Sphercity was violated, so Greenhouse-Geisser is reported.

Table 7

Results of Dependent t Tests

		t	df	Significance
Control v SN				
	SF	2.920	9	0.017
	SE	3.766	9	0.004
	SAb	3.444	9	0.007
	SIR	5.752	9	0.000
	SER	3.179	9	0.011
	HF	3.809	9	0.004
	HE	3.352	9	0.008
	HAb	1.692	9	0.125
	HIR	4.390	9	0.002
Control v Grid				
	SF	1.908	9	0.089
	SE	1.622	9	0.139
	SAb	5.281	9	0.001
	SIR	3.012	9	0.015
	SER	3.151	9	0.012
	HF	3.457	9	0.007
	HE	3.162	9	0.012
	HAb	5.014	9	0.001
	HIR	3.168	9	0.011
SN v Grid				
	SF	-1.362	9	0.206
	SE	-2.023	9	0.074
	SAb	0.043	9	0.967
	SIR	-0.625	9	0.548
	SER	1.096	9	0.302
	HF	-1.658	9	0.132
	HE	-0.263	9	0.799
	HAb	1.122	9	0.291
	HIR	0.258	9	0.803

Note. SF = shoulder flexion, SE = shoulder extension, SAb = shoulder abduction, SIR = shoulder internal rotation, SER = shoulder external rotation, HF = hip flexion, HE = hip extension, HAb = hip abduction, HIR = hip internal rotation.

Appendix A

Institutional Review Board Approval Email

April 16, 2015 IRB Application #: 15079

Proposal Title: Acute Effects of Two Different Foam Rollers on Range of Motion

Type of Review: Initial-Expedited

Investigator(s):
Mr. Isaac Henry
Dr. Jacilyn Olson
Department of Kinesiology and Health Sciences
College of Education and Professional Studies
Campus Box 189
University of Central Oklahoma
Edmond, OK 73034

Dear Mr. Henry and Dr. Olson:

Re: Application for IRB Review of Research Involving Human Subjects

We have received your materials for your application. The UCO IRB has determined that the above named application is APPROVED BY EXPEDITED REVIEW. The Board has provided expedited review under 45 CFR 46.110, for research involving no more that minimal risk and research category 7.

Date of Approval: 4/16/2015
Date of Approval Expiration: 4/15/2016

If applicable, informed consent (and HIPAA authorization) must be obtained from subjects or their legally authorized representatives and documented prior to research involvement. A stamped, approved copy of the informed consent form will be sent to you via campus mail. The IRB-approved consent form and process must be used. While this project is approved for the period noted above, any modification to the procedures and/or consent form must be approved prior to incorporation into the study. A written request is needed to initiate the amendment process. You will be contacted in writing prior to the approval expiration to determine if a continuing review is needed, which must be obtained before the anniversary date. Notification of the completion of the project must be sent to the IRB office in writing and all records must be retained and available for audit for at least 3 years after the research has ended.

It is the responsibility of the investigators to promptly report to the IRB any serious or unexpected adverse events or unanticipated problems that may be a risk to the subjects.

On behalf of the UCO IRB, I wish you the best of luck with your research project. If our office can be of any further assistance, please do not hesitate to contact us.

Sincerely,

Robert Mather, Ph.D.
Chair, Institutional Review Board
NUC 341, Campus Box 132
University of Central Oklahoma
Edmond, OK 73034
405-974-5479
irb@uco.edu

Appendix B

Informed Consent Form

UNIVERSITY OF Central Oklahoma

UCO IRB Number 15079
For Office Use Only

UNIVERSITY OF CENTRAL OKLAHOMA
INFORMED CONSENT FORM

This is a template including all of the necessary elements of an Informed Consent Form. It is not necessary to use this form. In some cases, you may need another format, i.e. an online survey, a participant letter, etc. See Informed Consent Guidelines on our website for more information.

Research Project Title: Acute Effects of Two Different Foam Rollers on Range of Motion

Researcher (s): Mr. Isaac Henry and Dr. Jacilyn Olson

A. **Purpose of this research:** The benefits of exercise for fitness and performance are well documented (Garber et al., 2011). However, over time exercise can cause micro-trauma which may cause the myofascial tissue to solidify and cause the muscles to knot up (Barnes, 1997). Muscles that have become knotted up may experience decreased flexibility and strength (Barnes, 1997). A new method, known as foam rolling, is widely excepted as a way to break up knots and restore normal mucle function. Simply put, foam rolling mimics a deep tissue message that can be self-administered. Investigating the immediate effects of foam rolling on flexibility and muscular performance has been the focus of research done on foam rolling thus far. Due to the well-known benefits of increasing flexibility regardless of muscular performance, the current study will focus on the effects of foam rolling on flexibility. The purpose of this study is to compare the immediate effects of two different foam rollers on hip and shoulder flexibility.
B. **Procedures/treatments involved** A randomized cross-over design will be used, with three different treatments: foam roller A, foam roller B, and a control trial which will receive no treatment. In other words each participant will randomly perform each treatment on separate days. Participants will arrive at the lab and sign an informed consent. Next their age, height, and weight will be recorded. Then the participant's hip and shoulder ROM will be measured with a goniometer, followed by a 10 minute rest, after which hip and shoulder flexibility will be measured again (control treatment). All measurements will be taken by the same tester to ensure reliability. Once the measurements are complete, the tester will introduce the participants to the two different foam rollers and the techniques that will be used. At the next two sessions, participants will randomly be assigned to one of the two foam rolling treatments. Hip and shoulder flexibility will be measured, followed by lower body foam rolling and post hip flexibility testing. Upper body foam rolling will then be performed prior to post shoulder flexibility testing. Visual and verbal directions will be given at both sessions by the instructor. Each session will be separated by at least 48 hours. The sessions will last about an hour each.
C. **Expected length of participation:** One hour on 3 non consecutive days.
D. **Potential benefits:** You will receive your results and have them explained. This will show you if your shoulder and hip all within recommended ranges of motion. No

UNIVERSITY OF Central Oklahoma

UCO IRB Number 15079
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other benefits, including compensation (e.g. money or extra credit), will be awarded for participation.

E. **Potential risks or discomforts:** The physical exertion that you will be doing (foam rolling) is performed at a very low intensity. You might feel a mild discomfort while foam rolling simular to what you would feel while stretching. A small chance of slight soreness simular to the feeling after a deep tissue message is possible.
F. **Medical/mental health contact information (if required):** The UCO student counseling center is located on the fourth floor of the Nigh University Center in suite 402. The hours are 8am - 5pm and they can be reached at 974-2215. Mercy Health Center at University of Central Oklahoma. Telephone number: 974-2317.
G. **Contact information for researchers:** Mr. Isaac Henry 405-243-6007 and Dr. Jacilyn Olson 974-5681
H. **Contact information for UCO IRB:** UCO IRB: irb@uco.edu, 974-5497
I. **Explanation of confidentiality and privacy:** The collected data will only be disseminated as aggregate data. The paper data will be shredded and the electronic data will be erased off of the flash drive and emptied into the computers recycle bin, where it will then be deleted off of the hard drive completely. The data will be kept for three years following completion of the study. All data will be destroyed at this time.
J. **Assurance of voluntary participation:** Participants will be given complete information about the program, the inherent risks, the potential benefits, and will be left to make their decision to participate voluntary. You are free to withdraw from this research study at any time. Your choice to leave the study will not affect your relationship with this institution. You have the right to refuse to answer any questions or stop the questionnaire at any time without consequence.

AFFIRMATION BY RESEARCH SUBJECT

I hereby voluntarily agree to participate in the above listed research project and further understand the above listed explanations and descriptions of the research project. I also understand that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at any time without penalty. I acknowledge that I am at least 18 years old. I have read and fully understand this Informed Consent Form. I sign it freely and voluntarily. I acknowledge that a copy of this

Informed Consent Form has been given to me to keep.

Research Subject's Name: _______

Signature:

Date: _______

APPROVED
APR 16 2015
UCO IRB

APPROVAL
APR 15 2016
EXPIRES

Appendix C

In Class Recruitment Script

Hi, my name is Isaac Henry. I am a student from the Department of Kinesiology and Health Studies. I am currently looking for participants for a research study. You must be 18 years or older and currently have no known health problems. The study is designed to investigate the immediate effects two different foam rollers have on shoulder and hip flexibility. Testing will take place on three non-consecutive days and will take about an hour each time. No direct benefits, including compensation (e.g. money or extra credit), will be awarded for participation; however, an indirect benefit is finding out if your shoulder and hip flexibility scores fall within recommended ranges. I will pass around note cards and if you would like to participate please sign-up with your name and email address. You may also contact me at 405-243-6007 or ihenry@uco.edu with any questions. Your participation is completely anonymous, voluntary, and very appreciated.

Appendix D

Recruitment Email

Dear ______

My name is Isaac Henry. I am a student from the Department of Kinesiology and Health Studies. I am currently looking for participants for a research study. You must be 18 years or older and currently have no known health problems. The study is designed to investigate the immediate effects two different foam rollers have on shoulder and hip flexibility. Testing will take place on three non-consecutive days and will take about an hour each time. No direct benefits, including compensation (e.g. money or extra credit), will be awarded for participation; however, an indirect benefit is finding out if your shoulder and hip flexibility scores fall within recommended ranges. If you would like to participate please reply to this email with your availability. You may also contact me at 405-243-6007 or ihenry@uco.edu with any questions. Your participation is completely anonymous, voluntary, and very appreciated.

Appendix E

Foam Rolling Procedures and Pictures

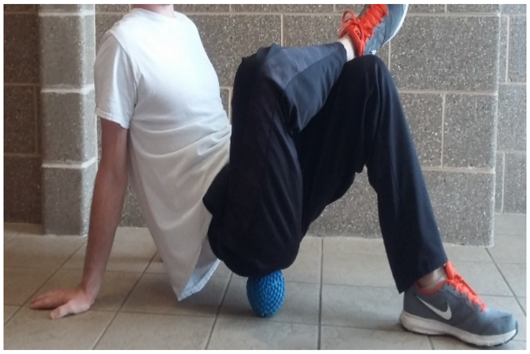
Foam Rolling Procedures

The participants were instructed to complete 10 repetitions for each muscle; a repetition will be considered rolling from origin to insertion. It was instructed to perform slow kneading-like movements and to place as much pressure on the muscle being treated as possible. If a knot/hot spot is found, the participant sat on that spot for 10 seconds then continued with full repetitions. A specific muscle order was used during each session:

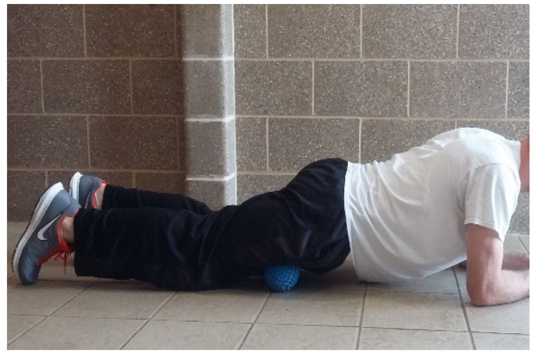
- Gluteus
- Hamstrings
- IT Band
- Quadriceps
- Adductors
- Hip Flexors
- Spine
- Latissimus/Serratus Anterior
- Triceps
- Pectoralis
- Front Deltoid
- Rear Deltoid

When foam rolling the hamstrings and quadriceps, the repetitions were split into: three repetitions with the femur internally rotated, four repetitions with the femur in a neutral position, and three repetitions with the femur externally rotated (10 total repetitions). The primary researcher demonstrated the proper technique first, then monitored the participants as they foam rolled, giving verbal cues when necessary.

Supernova Hip Pictures

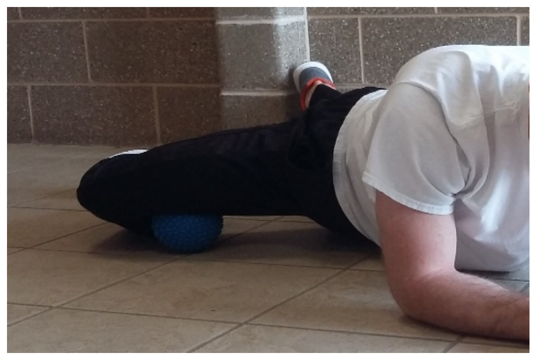


Gluteus

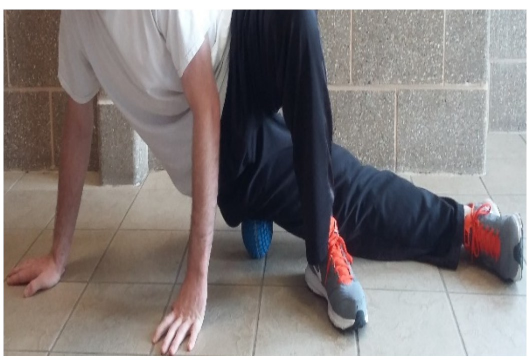


Quadriceps

Hamstrings



Adductors

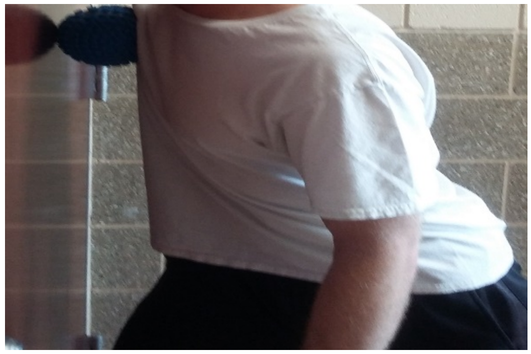


IT Band

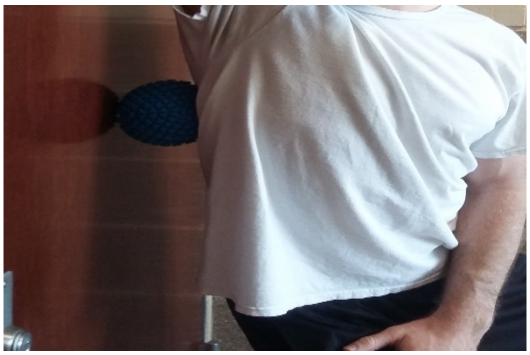
Hip Flexors

Supernova Shoulder Pictures

Spine



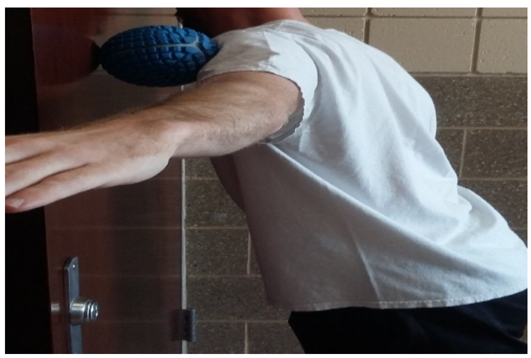
Pectoralis



Lats/Serratus Anterior

Rear Deltoid

Triceps

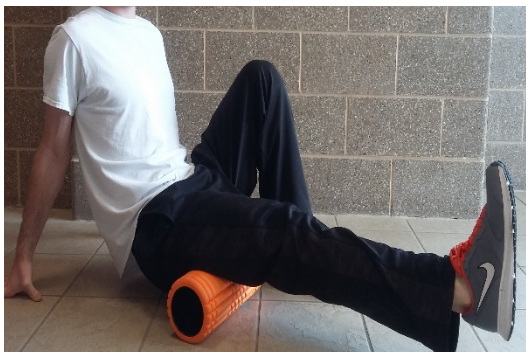


Front Deltoid

Grid Hip Pictures

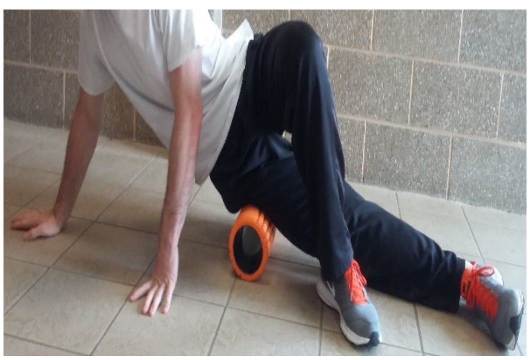
Glutes

Quadriceps

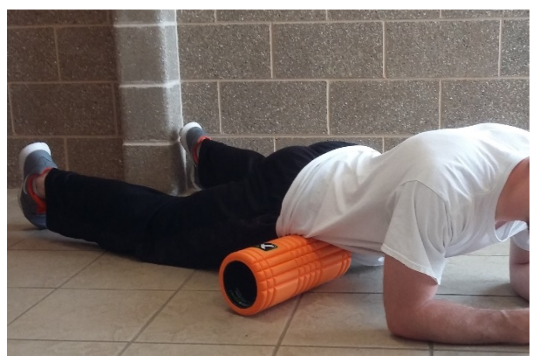


Hamstrings

Adductors



IT Band

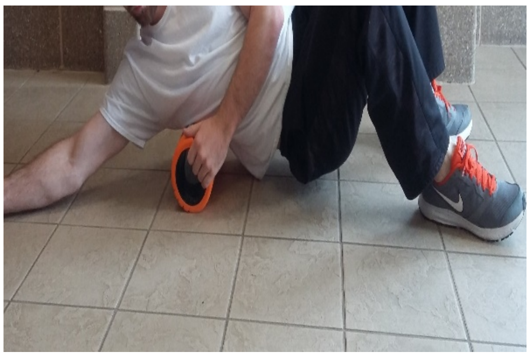


Hip Flexors

Grid Shoulder Pictures

Spine

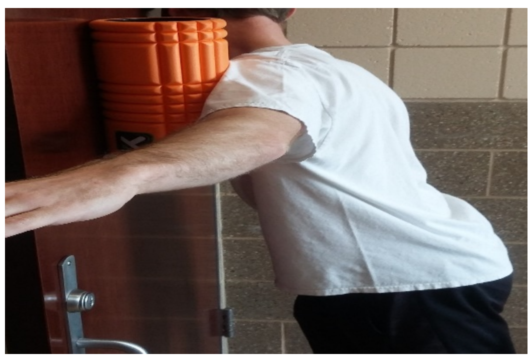
Pectoralis



Lats/Serratus Anterior

Rear Deltoid

Triceps



Front Deltoid

Appendix F

Goniometer Measurement Protocol

Goniometer Measurement Protocol

Every measurement was taken by the primary researcher to ensure reliability, and each measurement was taken twice. If the first two measurements differ five degrees or more, a third measurement was taken. A plastic True-Angle Goniometer was used to measure ROM at the shoulder and hip. Eleven measurements were taken (five for the shoulder and 6 for the hip) and were as follows:

- Shoulder Flexion
- Shoulder Extension
- Shoulder Abduction
- Shoulder Internal Rotation
- Shoulder External Rotation
- Hip Flexion
- Hip Extension
- Hip Abduction
- Hip Adduction
- Hip Internal Rotation
- Hip External Rotation

Universal goniometer measurement procedures will be followed as described in *Advanced fitness assessment and exercise prescription 6th ed.* found on pages 269-270.