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Graduate Studies

THE TRAINING EFFECT OF FOAM ROLLING ON RANGE OF MOTION, FLEXIBILITY, AGILITY AND VERTICAL JUMP HEIGHT

A Manuscript Style Thesis Submitted in Partial Fulfillment of the Requirements for the Master of Science in Clinical Exercise Physiology

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THE TRAINING EFFECT OF FOAM ROLLING ON RANGE OF MOTION, FLEXIBILITY, AGILITY, AND VERTICAL JUMP HEIGHT

By Olivia J. Stovern

We recommend acceptance of this thesis in partial fulfillment of the candidate's requirements for the degree of Master of Science in Clinical Exercise Physiology

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ABSTRACT

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This study was designed to evaluate the training effects of foam-rolling on ankle and knee range of motion, flexibility, agility, and vertical jump height. Twenty subjects (8 male, 12 female) completed 6 weeks of foam rolling, which was held three days per week. Fourteen volunteers (6 males 8 females) with similar characteristics served as a control group. Pre and post-testing evaluation included ankle dorsiflexion and knee flexion range of motion, T-test, and vertical jump height. No significant differences were found in knee range of motion, vertical jump height, or T-test time. Lower back and hamstring flexibility, as measured by the sit-and-reach test did improve significantly consequent to foam rolling. Ankle range of motion increased for both the foam rolling and the control groups. Results indicate that 6 weeks of foam rolling had a positive training effect on lower back and hamstring flexibility and did not negatively affect agility or vertical jump height.

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INTRODUCTION

Self-myofascial release (SMR) has become more widely used by athletes and fitness enthusiasts in the last decade. It has become so popular that it was listed as the 14th most popular worldwide fitness trend in 2019 (Thompson, 2018). Fascia is a dense, irregular connective tissue that surrounds and connects every muscle and organ in the body. Therapeutic treatments on fascia claim to alter either the density, tonus, viscosity, or arrangement of individual fibers through manual pressure (Schleip & Müller, 2013). It is hypothesized that the changes to fascia following SMR are brought about by changing the thixotropic property of the fascia. This occurs when the friction between the targeted soft tissue and SMR device generates heat, which changes the fascia to a more fluid like state (Hansen et al. 2015). As a result, tissue becomes less resistant when a stretch is applied, allowing for greater range of motion (ROM) in joints (Mohr, Long & Goad, 2014).

One of the most popular SMR devices is the foam roller. A foam roller is a foam cylinder that varies in density, shape, and surface texture. These architectural differences may influence how the myofascial tissues are being massaged during treatment. For instance, a high-density foam roller may provide a more effective massage to the tissue than a less dense roller (Curran, Fiore & Crisco, 2008). Individuals use their own body mass directly on the foam roller to exert pressure on the soft tissue.

Foam rollers are most often used during warmup or recovery following exercise. A number of studies have investigated the acute benefits of foam rolling (FR) and the results are inconclusive. Studies by Hsuan, Nai-Jen, Wen-Lan, Lan-Yuen, and I-Hua (2017) and MacDonald et al. (2013) found that FR improved hamstring flexibility/knee ROM, but had no significant impact on muscular force. Conversely, a study by Couture, Karlik, Glass and Hatzel (2015) did not see significant changes in knee ROM, but a study by Halperin, Aboodarda, Button, Andersen and Behm (2014) did find increases in maximal force production. Peacock, Krein, Silver, Sanders, and Von Carlowitz (2014) had subjects foam roll the entire body, which led to improvements in power, agility, strength, and speed. Lastly, Škarabot, Beardsley, and Štirn (2015) found that both static stretching and FR increased passive ankle ROM.

Several studies have also studied the effectiveness of FR training on performance. Miller and Rockey (2006) studied the effect of thrice weekly FR sessions on hamstring flexibility over an 8-week time period. They found that FR did not increase hamstring flexibility. Although there were gains in ROM in the treatment group, they were not significant when compared to the control group. Scherer (2013) also examined the use of a foam roller on hamstring flexibility in a group of university students over the course of 4 weeks. They found no significant differences in hamstring flexibility compared to the control group. However, every individual in the FR group had positive changes. A 4-week study by Junker and Stöggl (2015) found increases in hamstring flexibility following both FR and contract-relax PNF stretching. Mohr et al. (2014) compared the effects of FR to static stretching on passive hip-flexion ROM over the course of 2 weeks. They had a FR group, a static stretching group, and a FR plus static stretching group. They found an increase in hip-flexion ROM in all three treatment groups, with the greatest gains observed in the combination group. Lastly, Bushell, Dawson and Webster

(2015) investigated the related benefits of FR on hip extension angle during a functional lunge following each of three sessions of FR. There were no significant increases in hip extension angle between the control group and FR group acutely or across time for all lunges.

Because the long-term benefits of FR are inconclusive, the purpose of this research study was to examine the effects of a 6-week FR program on ankle and knee ROM, low back and hamstring flexibility, agility, and vertical jump height.

METHODS

Subjects

Thirty-four volunteers (13 male, 21 female) were recruited from the University of Wisconsin- La Crosse campus to participate in this study. Due to the physical demands of the testing and training procedures, participants were required to be at least recreationally active (i.e., exercise at least 3 times per week for at least 30 minutes) and have no prior lower-leg injuries. Potential subjects completed the Physical Activity Readiness Questionnaire (PAR-Q) and a health history questionnaire to screen for cardiovascular and orthopedic contraindications to exercise. Those eligible then provided written informed consent before undergoing any testing or training procedures. Subjects were placed into FR (n=20) or control (n=14) groups based upon their availability to attend supervised training sessions. The protocol was approved by the University of Wisconsin La Crosse Institutional Review Board for the Protection of Human Subjects.

Procedures

All subjects attended an initial orientation session where the purpose and procedures of the study were explained to them. At this session subjects then had a chance to practice all of the tests administered as part of the study. Subjects underwent a series of tests at the beginning and end of the study period. Height was measured using a wall-mounted stadiometer. Weight was assessed using a Rice Lake 150-10-7 Floor Level Digital Scale (The Rice Lake Weighing Systems, Rice Lake, WI). Subjects then completed a 5-minute warm-up on a Schwinn Airdyne (Nautilus Inc, Vancouver, WA) stationary cycle at a self-selected speed. Following the warm-up, subjects were immediately assessed for ankle and knee ROM, low back and hamstring flexibility, vertical jump height, and agility. All the tests were administered in the order listed.

Ankle dorsiflexion and knee flexion, on the right leg, were measured using a Medigauge 900105 Dual-scale Electronic Digital Goniometer (Taylor Toolworks LLC, Columbia, MO). To measure ankle dorsiflexion, subjects sat on a table in an upright sitting position with their legs straight. Only their ankles were off the edge of the table. Instructions were given to dorsiflex their ankle as far back as possible. A measurement was taken when they could not go any further. The test was performed three times and the two closest measurements were averaged and used for data analysis. To measure knee flexion, subjects laid in a prone position with their knees at the edge of the table. The subjects were instructed to flex their knee as far back as possible. A measurement was taken when they could not go any further. The test was performed three times and the closest two measurements were averaged for data analysis.

Flexibility of the lower back and hamstrings were measured using a sit-and-reach test. Subjects removed their shoes and sat with their hips against a wall, with their legs extended straight out in front of them, with their feet flat against the sit-and-reach box (Novel Products Inc, Addison, IL). The subjects slowly reached forward as far as possible with their hands stacked on top of each other. Instructions were given to not lead with one hand or use jerky movements in an attempt to reach further. The investigator placed her hands on the subject’s knees to ensure the legs did not bend or leave the ground during the reach. The test was performed three times and the average of the two closest measurements was used in the data analysis.

Vertical jump was measured using a Just Jump Meter mat (Probotics Inc, Huntsville, AL). The mat was placed flat on a hard surface and was programmed on “1 jump mode.” Subjects were instructed to stand with both feet flat on the mat, shoulder width apart. Instructions were given to jump as high as possible and land with both feet on the mat. The subjects were encouraged to use countermovement of the arms during their jumps. The test was performed three times with a 30-second rest between each jump. The two closest measurements were averaged and used for data analysis.

Agility was measured using a T-test (American Council on Exercise, San Diego, CA), which includes forward, lateral, and backward movements (See Figure 1). Cones were set up at each point. Subjects were told to start behind the first cone. Subjects would sprint from cone A to cone B, side step from cone B to cone C, side step from cone C to cone D, side step from cone D to cone B, and backpedal from cone D to cone A all as fast as they could. The subjects were told to touch each cone and were advised to not cross their feet when sidestepping. Timing was done using an Accusplit 740mx Turbo

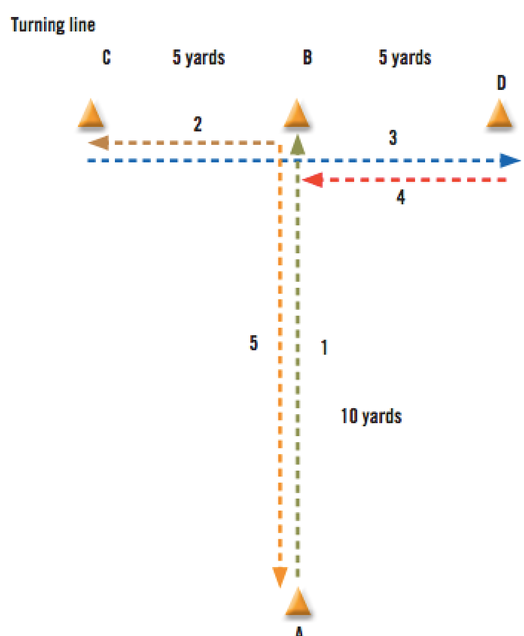

Figure 1. T-test procedure

stopwatch triggered by an IRD Wire (Brower Timing Systems, Draper, UT). The test was performed three times with a 2-minute rest period between trials. The average of the two closest times was used for data analysis.

Training

Subjects in the FR group participated in instructor-led FR sessions 3 days a week for 6 weeks. The foam roller used during this study was a 5.5”x13” GRID foam roller (TriggerPoint, Durham, NC). Subjects assigned to the FR group were given specific instructions on how to foam roll each body part, including demonstrations by the researchers to ensure correct technique. The subjects then foam rolled their lower back and bilaterally their buttocks, quadriceps, hamstrings, calves, and IT band. Each body part was foam rolled for 20 seconds. The entire sequence was repeated three times. Each session lasted approximately 15 minutes. Subjects in both groups were instructed not to change their dietary or exercise habits over the course of the 6-week period. After the 6-week training period, subjects were re-evaluated using identical pretesting procedures. Additionally, at the post testing, subjects in the FR group were asked to fill out a Perceived Performance Improvement Questionnaire that consisted of the six questions listed in Table 3.

STATISTICAL ANALYSIS

Independent t-tests were performed to identify any pre-testing differences between the experimental and control groups for each variable. A 2-way (pre-post x group) ANOVA with repeated measures was used to determine differences subsequent to the training period for each variable. When there was a significant F ratio, Tukey's post-hoc tests were used to make pairwise comparisons. Significance was set at an α level of 0.05 to achieve statistical significance. All analyses were conducted using the Statistical Package for the Social Sciences (SPSS, Version 25; SPSS Inc., Chicago, IL.)

RESULTS

All 34 subjects completed the testing and training protocol. Descriptive characteristics of the subjects, subdivided by group, are presented in Table 1. The FR and control groups were similar in age, height, and weight at the start of the study. All subjects in the FR group completed 18 foam rolling sessions during the 6-week training period. If a session was missed during the week, make-up sessions were held on the weekends.

Table 1. Descriptive characteristics of subjects in the foam rolling and control groups at the start of the study (N=34)

	Foam Rolling (n=20)	Control (n=14)
Age (yrs)	20.8±1.70	20.8±1.19
Height (in)	171.2±8.21	168.9±8.50
Weight (kg)	71.0±11.86	71.0±11.86

Values represent mean ± standard deviation.

There was no change in body weight over the course of the study for either group. Data for all of the criterion measures are presented in Table 2 and Figures 1-5, respectively. There were no significant pre-testing differences between the FR and control groups for any variable. There were no significant changes in knee ROM, vertical jump, or T-test time over the course of the study for either group. The FR group had a significant increase in sit-and-reach distance from pre to post testing which was significantly greater than the change in the control group. Both groups had significant improvements in ankle ROM over the course of the study.

Table 2. Changes before and after 6 weeks of foam rolling.

	Foam Rolling			Control		
	Pre	Post	Δ	Pre	Post	Δ
Sit & Reach (cm)	29.6±7.78	31.5±7.35*	+1.9#	35.1±9.10	33.4±9.65*	-1.6
Ankle ROM (degrees)	104.3±4.95	107.4±3.75*	+3.1	103.0±4.19	107.2±4.69*	+4.2
Knee ROM (degrees)	128.8±5.16	130.2±5.81	+1.4	127.6±5.51	128.3±5.39	+0.7
Vertical Jump (cm)	49.5±12.95	50.0±13.74	+0.2	50.8±10.62	49.0±9.42	-0.7
T-Test (sec)	11.7±1.36	11.5±1.38	-0.2	11.8±1.00	11.8±1.04	-0.0

Values represent mean ± standard deviation.
*Significantly different than pre (p<.05).
#Change significantly different than change for control group (p<.05).

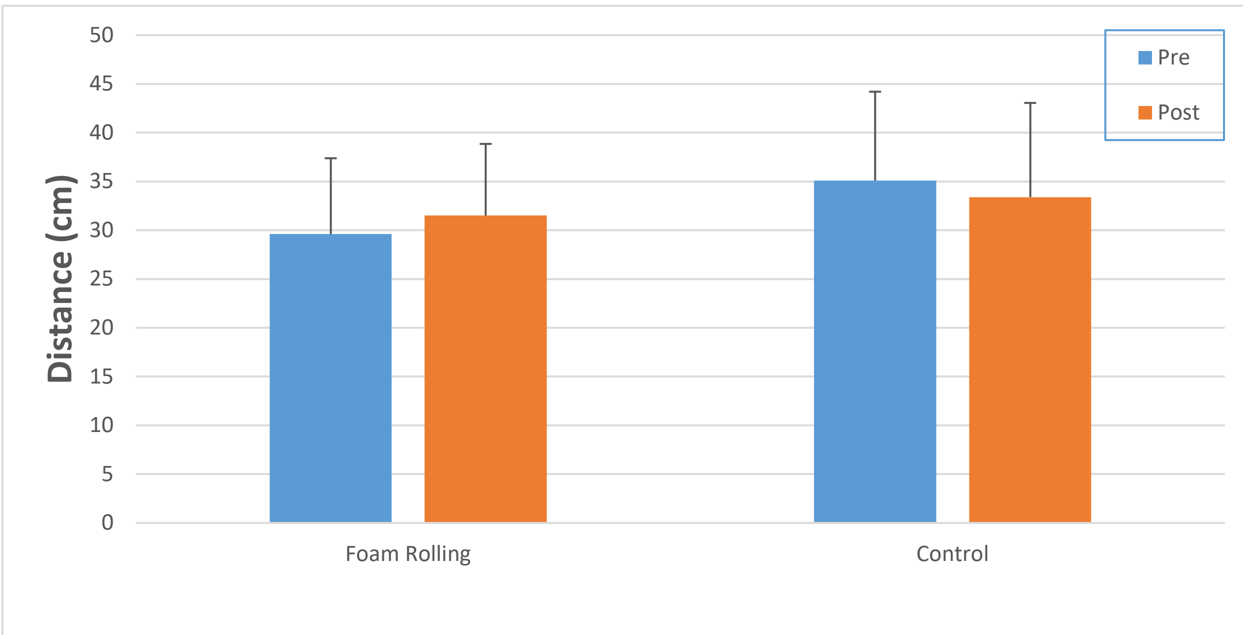

Figure 1. Change in hamstring flexibility from pre to post testing.

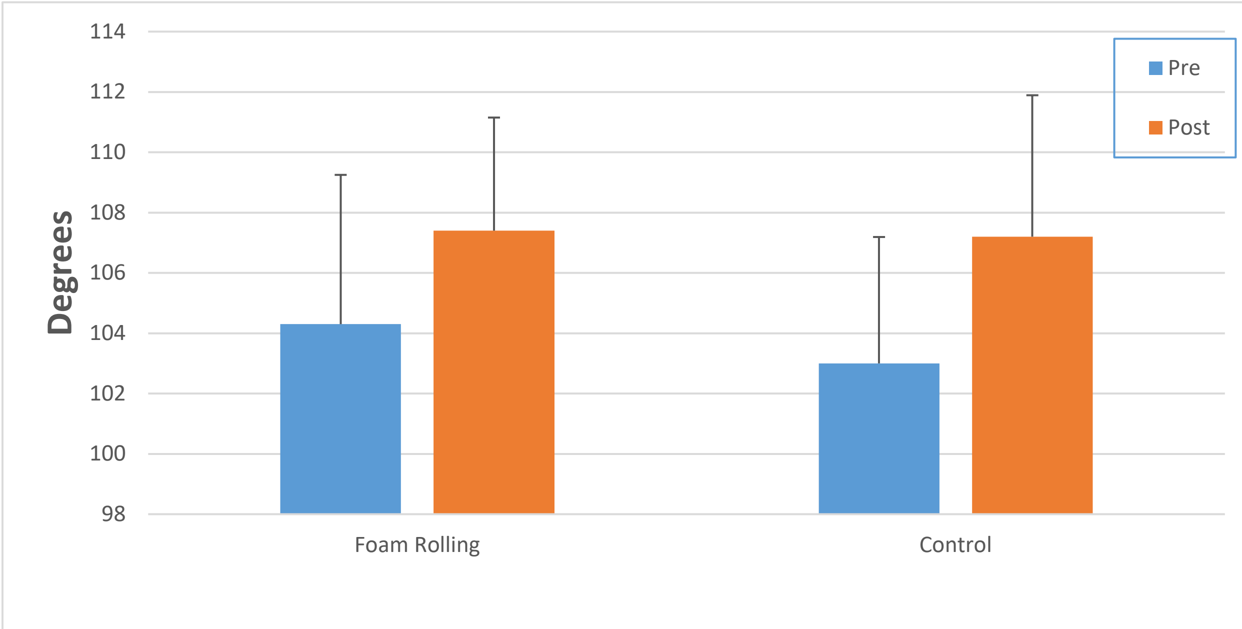

Figure 2. Change in ankle range of motion from pre to post testing.

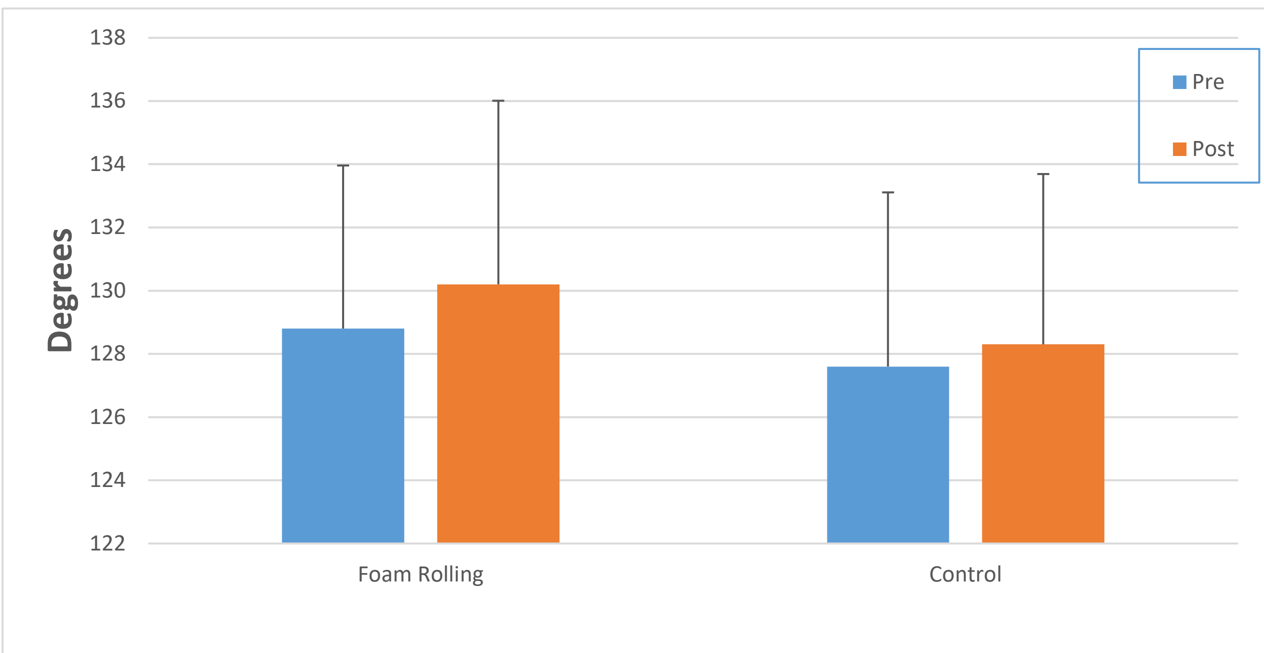

Figure 3. Change in knee range of motion from pre to post testing

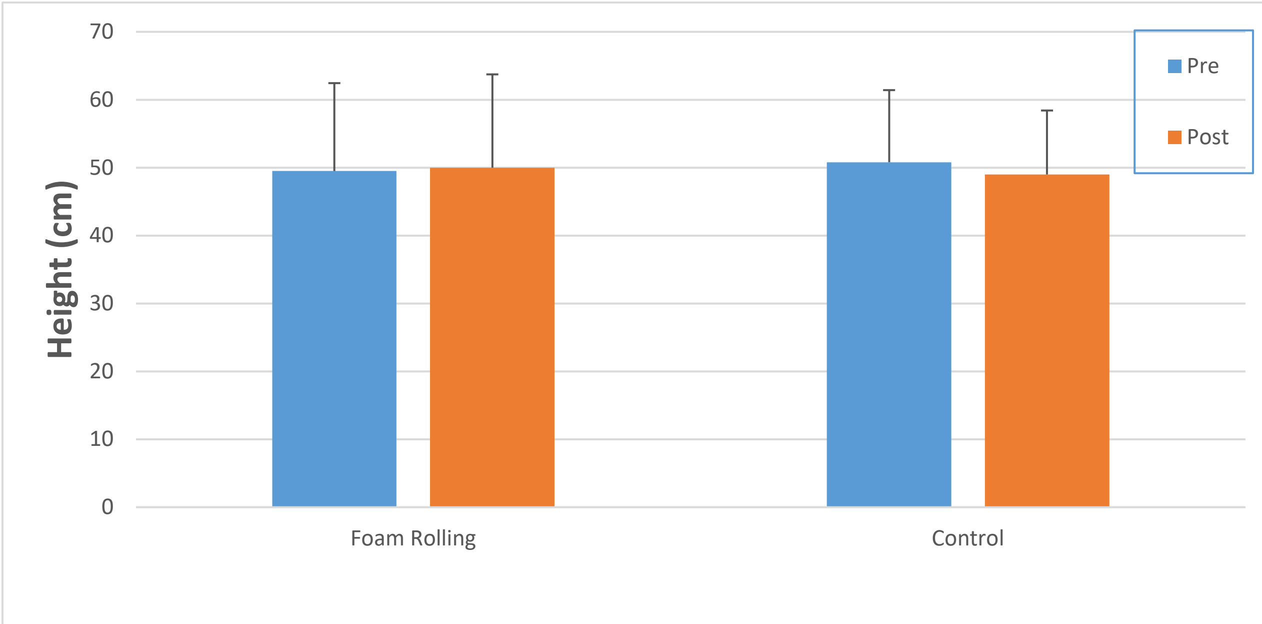

Figure 4. Change in vertical jump height from pre to post testing

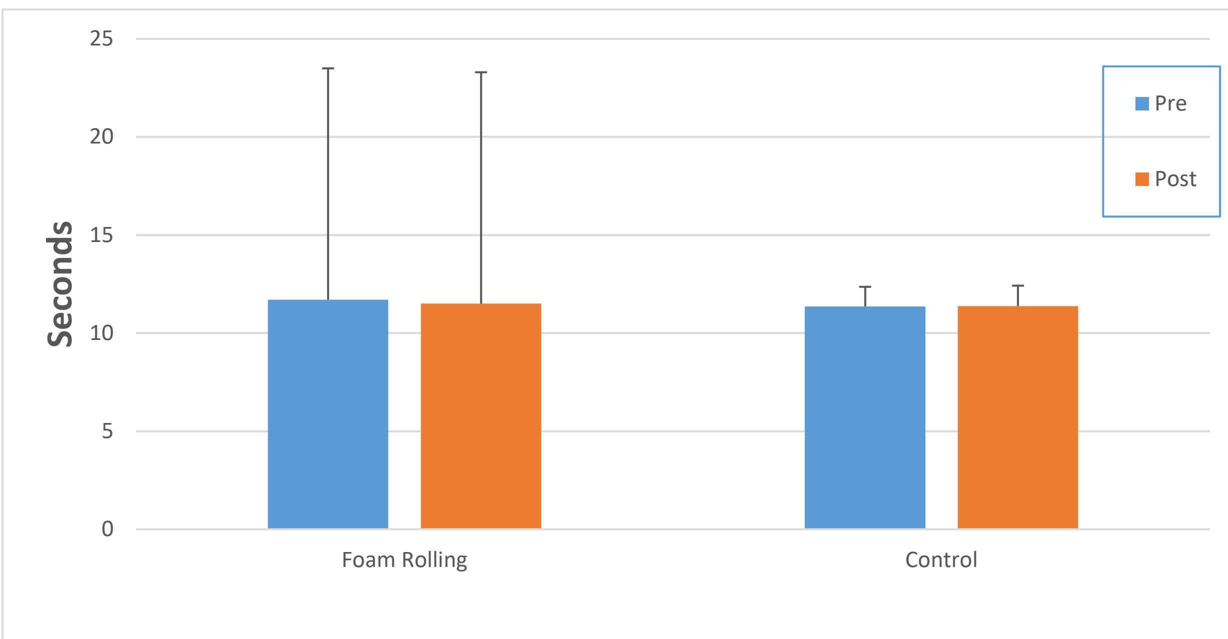

Figure 5. Change in speed during T-Test from pre to post testing.

Answers to the Perceived Performance Improvement Questionnaire are presented in Table 3. It was found that the FR group felt more flexible and felt like they could jump higher at the conclusion of the study.

Table 3. Questionnaire answered by foam rolling group asking if they felt improvement in all performance areas after 6 weeks of foam rolling (N=20)

	Yes	No
I feel more flexible	17	3
I feel more agile	9	11
I feel like I have more range of motion in my ankle	9	11
I feel like I have more range of motion in my knee	10	10
I feel stronger	10	10
I feel like I can jump higher	15	5

DISCUSSION

The purpose of this study was to determine the training effect of FR on ankle and knee ROM, hamstring and lower back flexibility, agility, and vertical jump height. We found no significant changes in knee ROM, vertical jump height, or T-test time over the course of the study. We did find a significant improvement in hamstring and lower back flexibility as measured by the sit-and-reach test. The results for ankle ROM were inconclusive, since both the FR and control groups had significant increases over the course of the study.

Several studies have examined the effectiveness of FR training on performance. Collectively, the results are inconclusive. Our results are in agreement with two other studies that found significant improvements in lower back and hamstring flexibility after completing a FR training program. Junker and Stöggl (2015) found increases in hamstring flexibility after performing 30-40 seconds of FR or 3 sets of contract-relax PNF stretching over the course of 4-weeks. Mohr et al. (2014) also found increases in passive hip-flexion ROM after 2 weeks of FR, static stretching, or after doing a combination of the two, with greater gains observed in the combination group.

In contrast to the findings of the present study, a number of studies did not find significant improvements in hamstring flexibility after completing a FR training program. Bushell et al. (2015) measured hip extension angle via functional lunge after three weeks of FR and found no significant improvements acutely or across time.

Similarly, it was also found hamstring flexibility did not increase after 4 (Scherer, 2013) or 8 (Miller & Rockey, 2006) weeks of FR when compared to the control groups. Both groups had subjects FR for 30-60 seconds at a time.

One of the biggest problems when trying to compare the results of different studies is the tremendous variation in study design. For example, Junker and Stöggl (2015) incorporated a 5-10 minute general jogging warm-up prior to testing. Bushell et al. (2015) gave their subjects instruction on the FR protocols, but subjects were not allowed to practice. Miller and Rockey (2006) measured hamstring flexibility by active knee extension, performed lying supine on a table; whereas Mohr et al. (2014) used a passive technique where investigators used external force to aid in full ROM. Similar to the present study, Scherer (2013) used sit-and-reach to assess hamstring flexibility, while Junke and Stöggl (2015) used a stand-and-reach test, which is the same action as the sit-and-reach but done in from a standing position.

One of the most common methods used to improve flexibility and joint ROM is static stretching (Kalichman & David 2017). Static stretching for 15-60 seconds has been shown to increase flexibility and ROM in a number of studies (Hsuan et al. 2017). However, recent studies found that static stretching during warm-up decreases force production and muscular force (Peacock et al. 2014). It is felt that the decreased neuromuscular performance after static stretching may be attributed to stretching-induced sarcomere damage. Although FR may not have made a significant change to muscular power in the present study, positively speaking, it did not decrease performance as seen from static stretching. FR is thought to enhance soft-tissue pliability, which allows increased joint ROM without causing any damage to the cross bridges and sarcomeres of the muscle (MacDonald et al. 2013). Damaging the sarcomere results in a reduction in force production. Recent research demonstrating the effects of static stretching on muscle-tendon unit stiffness has shown that decreased stiffness after static stretching was not because of changes in fascicle length, but rather a combination of muscle stiffness and changes to the surrounding connective tissue (Langevin, 2006).

There were several limitations involving the methodology of this study which could have impacted results. This study was only conducted on college-aged individuals, so the possible effects of using the foam roller on different age groups was not able to be determined. It is possible that using older or less athletic subjects may have resulted in greater benefits. Participants were encouraged not to change their dietary or exercise regimens while being a part of this study. However, this was not monitored. The participants in the FR group were instructed how to utilize the foam roller properly for this study, as described in the methods section, but pressure was not measured. They were instructed to foam roll each body part for only 20 seconds at a time three times through, for a total of 60 seconds spent on each muscle group per day. Other studies incorporated longer FR times.

Ankle and knee ROM were measured actively meaning the participants flexed their ankle or knee as far as possible. There was no way to tell if they were using their full ROM or not. Several other studies actually applied external force to force subjects into a greater ROM. We did not use external force to reach full ROM at the joint. This could have an effect on the measurements taken.

CONCLUSION

In conclusion, the current study did find a significant improvement in lower back and hamstring flexibility after 6 weeks of FR. We also found that FR did not negatively affect athletic performance, as measured by agility or vertical jump height. Subjects felt more flexible and felt like they could jump higher at the end of the study. These findings may explain some of the allure of FR. As FR becomes increasingly popular in the fitness industry, additional studies are needed to determine further benefits of FR.

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APPENDIX A

INFORMED CONSENT

INFORMED CONSENT

Acute and Chronic Benefits of Foam Rolling

I, ________________________________, volunteer to participate in a research study being conducted at the University of Wisconsin-La Crosse.

Purpose and Procedures

- The purpose of this research is to compare the potential benefits of foam rolling on flexibility, agility, mobility, and lower-extremity power after a 6-week training program.
- I realize that I may be randomly assigned to either a foam rolling or control group. The foam rolling group will be required to complete three workouts per week for 6 weeks. Each workout will last approximately 30 minutes. Workouts will be held in Mitchell Hall on the UWL campus. If I am assigned to the control group I will be required to maintain my current exercise habits during the 6-week training period.
- My participation in this study will involve the completion of a series of tests before and after the training program. These tests will include:
    - A sit-and-reach test to assess my hamstring flexibility.
    - A mobility test to assess the range or motion in my ankles and thighs.
    - A shuttle run to assess my agility.
    - A vertical jump test to assess my lower body power.
- Total time commitment for this study will be approximately 15 hours, including all of the testing and training sessions.
- Research assistants will be conducting the research under the direction of Dr. John Porcari, a Professor in the Department of Exercise and Sport Science.

Potential Risks

- I may experience muscle fatigue and muscle soreness as a result of completing the exercise tests and workouts used in the current study. However, the risk of serious life-threatening complications (e.g., heart attack, stroke, death) is extremely low (<1/10,000 tests) in apparently healthy adults, but are always possible with any type of exercise.
- All testing and training sessions will be stopped immediately if there are any complications.
- Individuals trained in CPR and Advanced Cardiac Life Support (ACLS) will be available during all supervised training sessions and an Automatic External Defibrillator (AED) is available in both the testing and training facilities. Additionally, the instructors who will be conducting the training sessions have experience in leading exercise using foam rollers.

Benefits

- As a participant in this study, I will learn by base level of flexibility, mobility, power, and agility.
- As a result of the training sessions I will be participating in, it is reasonable to expect an improvement in at least some of the above measurements.
- I will also receive a foam roller at the conclusion of the study, regardless of my group assignment.

Rights and Confidentiality

- My participation in this study is entirely voluntary.
- I may choose to discontinue my involvement in the study at any time, for any reason, without penalty.
- The results of this study have the potential of being published or presented at scientific meetings, but my personal information will be kept confidential and only group data will be presented.

Participant: ____
Date:___________________

Investigator: ____
Date:___________________

APPENDIX B

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The purpose of this document is to review the literature regarding research relevant to the effects of a 6-week foam rolling (FR) program on performance; emphasizing the following areas related to the present study: (a) history of massage therapy, (b) importance of stretching (c) myofascial release and connective tissue, (d) static stretching, and (e) FR. There are gaps in current research regarding the chronic effects of FR due to a lack of studies.

History of Massage Therapy

The history of massage therapy dates back thousands of years to ancient cultures that believed in its medical benefits. The first written records on massage therapy are found in China and Egypt. The first Chinese text called "The Yellow Emperor's Classic Book of Internal Medicine" was published to English in 1949 and has become a leading source in massage therapy training and teaching (All Allied Health Schools, n.d.). As an occupation, massage therapy dates back to the Colonial times (1700's), where antecedents of today's massage therapists were called *rubbers. Rubbers* received their name because they used manual rubbing and friction when treating orthopedic problems. *Rubbers* typically were women hired by surgeons to assist with the rehabilitation process. The women generally had little education; although they possessed a unique skill for hands-on therapy (Benjamin, 2015). From the early 20th century through today, in the United States, newly improved massage techniques were discovered. The new hands-on techniques were used predominantly on World War I soldiers who suffered from neurological injury or shell shock. Later in the 20th century, increasing interest in massage therapy lead to regulation of the practice in many states. As a result of regulation and acceptance, massage therapy has earned a legitimate place in the world of alternative medicine. Today's therapists continue to be motivated through a common goal, made centuries ago: to help others heal their physical and emotional well-being and experience a higher quality of life (Natural healers, n.d.). For some time, massage has not only been used to improve quality of life, but also to enhance muscle relaxation, reduce muscle tension and soreness, and to improve athletic performance.

The Importance of Stretching and Massage

There are many reported benefits of stretching, and massage. Those benefits are thought to help athletes by enhancing performance and reducing risk of injury. Massaging and stretching causes a decrease in motor unit activation, all while increasing flexibility and decreasing muscular pain (Jacobson & Behara, 2017). Massage therapy is an umbrella term for hundreds of assisted and self-myofascial release techniques. Massage produces mechanical pressure directly to the muscle tissue. The pressure is expected to increase muscle amenability, which would then result in an increased joint range of motion (ROM) (Weerapong, Hume, & Kolt, 2005).

In order to maintain mobility and full ROM in joints, being flexible is necessary. Areas in the lower extremities that are critical for mobility include the quadriceps, hamstrings, hip flexors, and calf muscles. Being more agile and acquiring better balance are also important factors in protecting independence. Remaining independent and avoiding incidents such as falls is specifically prevalent as one ages. Dr. David Nolan, a physical therapist at Harvard-affiliated Massachusetts General Hospital, explains how stretching has a cumulative effect. The cumulative effect of stretching explains how perfect flexibility does not happen in one day, it is something that needs to be worked on over time and requires some commitment. Stretching is something that should be done on a regular basis. It is important to aim for a flexibility program that prescribes daily stretches at least 3-4 days/week. When muscles are not stretched regularly, they are tight and remain in a shortened state. When a muscle is too tight and is unable to fully extend, it will be weak when it is required to stretch for a given activity or movement. By avoiding weakness and limited ROM, a condition called myofascial pain syndrome can be avoided (Weerapong et al., 2005). Myofascial pain syndrome is a common chronic condition characterized by myofascial trigger points and fascial restrictions (Kalichman & David, 2017). Myofascial pain syndrome is considered to be one of the most frequent causes of muscular pain (Aguilera et al. 2009, Borg-Stein & Simons, 2002). The prevalence of myofascial pain syndrome varies from 21% of patients in an orthopedic clinic, to 30% of general medical clinic patients, to as high as 85% to 93% of patients in specialty pain management centers (Borg-Stein & Simons, 2009).

Weerapong et al. (2005) also reported that massage provided positive effects on anxiety and depression. Lastly, sport massage may be beneficial when aiming to avoid and prevent injuries. However, stretching muscles before they are warmed up could cause more harm than good. It is important to increase blood flow and get the body moving before the muscles are expected to exert themselves. Dr. Nolan states that “all it takes to warm up the muscles before stretching is 5-10 minutes of light activity.”

Myofascial Release and Connective Tissue

Massage therapy is not the only form of myofascial release. Myofascial release is a muscle manipulation technique either administered by a therapist or self-administered (Hansen et al., 2015). Myofascial release is a soft tissue technique that induces a stretch deep into constricted fascia (Barnes, 1997). Fascia is tough connective tissue that spreads throughout the body from head to toe, separating all tissues and organs in the body (Langevin, 2006). Fascia surrounds every muscle, bone, nerve, blood vessel and organ all the way down to the cellular level; integrating the whole body. Tightening of the fascial system is a protective mechanism in response to trauma or a specific stimulus (Barnes, 1997). A recognizable characteristic of connective tissue is its plasticity and adaptability when regularly put under strain (Scheip & Müller, 2013). When fascia loses its malleability due to trauma, it becomes restricted and is a source of tension affecting the rest of the body. During myofascial release, a sustained pressure is applied to the tight, restricted fascia. After 90-120 seconds of this release method, the tissue will adapt and return back to its previous pliability (Barnes, 1997). Fascia is well supplied with sensory nerve endings. The restoration of length and health to the myofascial tissue will reduce pressure on these structures, decreasing pain (Barnes, 1997). While connective tissue is very plastic in response to varying levels of mechanical stress, these changes take place over the course of days to weeks after a change in posture or activity (Langevin, 2006). Fascia changes slowly and the results are longer lasting (Scheip & Müller, 2013). Myofascial release stimulates fascia as well as the muscle surrounding the fascia that is being targeted; proposing that when stimulated properly, fascia can actually aid in forced muscular contraction (Hansen et al., 2015).

Static Stretching

One form of self-myofascial release is static stretching. Static stretching is a form of stretching where the individual holds a position, stretching targeted muscle groups to the point of slight discomfort for a set period of time (Hansen et al., 2015). The goal of stretching is to increase ROM and decrease resistance to stretch, allowing for free, fluid movements and enhanced performance. Static stretching for 15-60 seconds has been shown to increase flexibility and ROM in a number of studies (Hsuan, Nai-Jen, Wen-Lan, Lan-Yuen, & I-Hua, 2017). Shrier (2004) found that even though the immediate effects of stretching decreases visco-elasticity and increases stretch tolerance, the effect of stretching over 3 to 4 weeks seems to only affect stretch tolerance, with no change in visco-elasticity. The process by which regular long-term stretching improves performance is likely to be related to stretch-induced hypertrophy. When a muscle is stretched for 24 hours a day, some hypertrophy appears even though the muscle has not been contracting (Shrier, 2004). Recent strength and conditioning research has demonstrated that static stretching during warm-up decreases force production and muscular force (Peacock, Krein, Silver, Sanders, & Von Carlowitz, 2014).

Foam Rolling

Another form of self-myofascial release is FR. Instead of a therapist providing manual therapy to soft tissue, individuals use their own body mass directly on firm, foam cylinders to exert pressure on the soft tissue. The technique of FR involves small undulations back and forth over dense foam rollers. The movement typically starts at the proximal end of the muscle working down to the distal end and vice versa. The small undulations put a direct, sweeping pressure on the soft tissue. Therapy treatments on fascia claim to alter either the density, tonus, viscosity, or arrangement of individual fibers through manual pressure (Scheip & Müller, 2013). It is hypothesized that the changes to fascia following self-myofascial release are brought about by changing the thixotropic property of the fascia. This occurs when the friction between the targeted soft tissue and self-myofascial release device generates heat, which changes the fascia to a more fluid like state (Hansen et al. 2015). FR is thought to break up fibrous adhesions between the layers of fascia, restoring soft-tissue extensibility (MacDonald et al., 2013). As a result, tissue becomes less resistant when a stretch is applied, allowing for greater ROM in joints (Mohr, Long & Goad, 2014).

FR was first used by practitioners of Feldenkrais method in the 1980's. Feldenkrais practitioners utilized foam rollers as body supports and to do standing balance work with their clients (Heffernan, 2016). Foam rolling aims to improve mobility and ROM, reduce scar tissue and adhesions, improve quality of movement, and replace hands-on sessions or deep tissue massage (Kalichman & David, 2017). Foam rollers are best used in treating large muscle groups. Each muscle group has a designated position and protocol with different starting and end points (Weerapong et al., 2005). By varying body positions, patients can use foam rollers to isolate specific areas of the body. Some research that focuses on myofascial release through massage suggests that it may act as a mood enhancer and counteracts fatigue, thus acting as an ergogenic aid (Healey, Hatfield, Blanpied, Dorfman & Riebe, 2014). Researchers have also found that self-myofascial release reduces arterial stiffness, increases arterial tissue perfusion, and improves vascular endothelial function which are related to tissue relaxation (Cheatham & Stull, 2018). Changes in tissue perfusion after foam rolling could be explained by the release of vasoactive substances, such as nitric oxide. Vasoactive substances are produced by vascular endothelial cells, which play an important role in the regulation of vascular constriction and dilation (Hotfiel et al., 2017). It is generally accepted that mechanical stress applied to endothelial cells leads to the release of nitric oxide. Okamoto, Masuhara, and Ikuta (2014) observed a statistically significant increase in plasma nitric oxide concentration after self-myofascial release and concluded that FR reduced arterial stiffness and improved vascular endothelial function.

Self-myofascial release is an inexpensive and highly accessible tool for maintaining flexibility and treating myofascial pain. FR is easy to perform independently instead of relying on a therapist. FR is shown to improve both active and passive ROM, reducing soft tissue adhesions and aid in alleviating muscle soreness (Hsuan et al., 2017). Pain and fatigue are often associated with specific trigger point tissue damage. One of the more commonly researched therapeutic approaches to pain and recovery has been trigger point soft tissue massage therapies (Peacock et al., 2014). Unlike rehabilitation therapy, self-myofascial release is often used pre- or post-performance for warm-up and recovery. Curran, Fiore, and Crisco (2008) determined that a higher density foam roller significantly increased soft tissue pressure and isolated the soft tissue contact area, potentially increasing the effects FR has on improving soft tissue health.

There are two ways to look at performance effects of FR: acute and chronic. There is an abundance of research on the acute effects of FR on performance. However, the results are mixed. Halperin et al. (2014) found that an acute FR increased maximal force output. Some studies found that an acute bout of FR positively affected lower extremity flexibility and ROM as well as improving power, speed and agility (MacDonald et al., 2013, Peackock et al., 2014). Hsuan et al. (2017) found positive effects of FR on hamstring flexibility, but negative effects on muscle strength. Hansen et al. (2015) came to the conclusion that an acute bout of FR does not significantly impact anaerobic power output after 30, 60, or 90 seconds of FR.

If an acute bout of FR could lead to performance improvements such as increased flexibility, strength, power and agility, what effect would a long-term study have on these factors? This is where research lacks information and evidence. Five studies have looked at the chronic effects of FRon performance measures (Miller & Rockey, 2006, Sherer, 2013, Mohr, Long & Goad, 2014, Bushell, Dawson & Webster, 2015, and Junker & Stöggl, 2015).

Miller and Rockey (2006) studied the effect FR had on hamstring flexibility over an 8-week time period. The study used 23 healthy college students. They had a FR group and a control group. A Flexometer was used to measure active knee extension before and after the 8-week program. The FR group rolled three days a week for a duration of eight weeks. Three exercises were performed for 1 minute continuously. In between the 1 minute of foam rolling, subjects would take 1-minute rest periods. The group was instructed to continue with normal activity and to avoid additional stretching beyond their normal routine. At the end of the 8 weeks, both groups had significant increases in ROM in both legs. It was concluded that FR was an ineffective technique for increasing hamstring flexibility over an 8-week time period. Although there were gains in ROM in the treatment group, they were insignificant when analyzed with the control group.

Sherer (2013) examined the relationship between the use of a FR and hamstring flexibility in a group of University students. The study included 20 healthy students who had a background in weight training. They were split into two groups: a FR group and a control group. The FR group was required to use the foam rollers two times per week for 4 weeks. They would roll their hamstring muscles for 3-5 minutes; rolling for 30 seconds separated by 30 second rests. They rolled both legs at the same time first and then each leg individually. Results found no significant differences in hamstring flexibility for the control group. For the FR group, hamstring flexibility increased in each individual.

Mohr, Long and Goad (2014) studied the effect of FR and static stretching on passive hip-flexion ROM over the course of 2 weeks. The study included 40 subjects who were recreationally active as defined by engaging in physical activity 1 to 5 hours/week. Participants were randomly assigned to one of the four training groups: static stretching, FR, static stretching and FR, and control. Subjects reported to the laboratory on 6 days, separated by at least 48 hours. They were pre and post tested for passive hip flexion ROM of the dominant leg using a bubble inclinometer. Results found an increase in hip-flexion ROM across all treatment groups, with the greatest gains being in the FR and static stretching combination group. Clinically, their results can be used to support the use of a foam roller in combination with a 2-week static stretching protocol.

Bushell, Dawson and Webster (2015) investigated the relevance of FR on hip extension angle in a functional lunge. The purpose of their study was to determine whether FR the anterior portion of the thigh resulted in increases in hip extension in an active movement such as the lunge. They evaluated 31 physically active, college-age students who had not used a FR in the last 4 months. The subjects would position their dominant leg forward during their forward lunge. They had a FR group and a control group. Subjects performed two lunges during three different sessions 1 week a part. The foam FR would roll the quadriceps muscles for three, 1-minute bouts followed by 30-second rest periods. Lunges were done to track hip extension angle using the largest angle, indicating the deepest part of the lunge. This was done to test if FR produces immediate and lasting effects on hip extension angle. Their results showed no significant increases in hip extension angle between groups immediately or across time for all lunges performed. Only significant increases in hip extension angle occurred within session 2. Both pre and post-lunge mean hip extension angles in session 3 did not differ significantly from session 1 baseline lunge.

Junker and Stöggl (2015) studied the training effect of FR on hamstring flexibility compared with a contract-relax PNF method and a control group. The training period lasted for 4 weeks with 3 training sessions per week. The FR group was asked to perform 3 sets of FR for 30-40 seconds each set. They measured hamstring flexibility using a stand-and-reach test. They found that hamstring flexibility improved in both treatment groups and no changes were seen in the control group.

Despite the popularity of FR, the physiological effects are still being studied and no shared consensus has been made regarding the benefits on ROM, recovery, and performance. The direct benefits of FR remains inconclusive, however, there appears to be no negative effect on performance. Additional research on the potential benefits of FR and the ideal protocol need to be conducted.

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