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Effects of Utilizing a Myofascial Foam Roll on Hamstring Flexibility

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The Effects of Utilizing a Myofascial Foam Roll on Hamstring Flexibility

(TITLE)

BY

Elizabeth Sherer

THESIS

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ABSTRACT

The purpose of this study was to identify if using a foam roller on the hamstring muscles would have positive effects and in turn increase hamstring flexibility. Hamstring injuries are prevalent in sports today. Lack of flexibility is seen as a possible cause for these injuries, so this study focused on a potential way of increasing hamstring flexibility. Self-induced myofascial release, using a foam roller, was the type of intervention used to try to have an effect on hamstring muscle flexibility. The use of a foam roller is becoming a popular tool utilized in many settings but there has been little research done on the benefits of this tool.

Eighteen college students from a weight training class participated in this four week study. Eight participants were in the control group, while ten participants used the foam roller two times per week for the four weeks study. Participants used the foam roller for three to five minutes each time they rolled out.

The sit-and-reach method was used before and after the four week study to determine hamstring flexibility. Each participant completed three trials for the sit-and-reach test and the average score was calculated from their trials. Paired t test analysis was used to determine the relationship between the control group and the myofacial foam rolling group in relation to hamstring flexibility. A p value of .05 was used to analyze the data.

The results of this study showed statistically significant increases in hamstring flexibility in the foam roller group ($t = -3.912$, $p = .004$) compared to the control group ($t = 0.000$, $p = 1.000$). After the four weeks that the study was conducted, the control groups mean stayed the same and the foam rolling groups mean increased compared to the initial measurements.

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CHAPTER I

INTRODUCTION

Hamstring injuries are one of the most prevalent injuries in sports today. There is an increasing trend in the incidence of hamstring injuries over the past several competitive seasons (Opar, 2012). Some of the investigators' possible speculations as to why this number is increasing includes: sports are being played by more people, the intensity and competitiveness of sports is growing and there is not as much time spent warming up as there should be before participating in sports. However, there has been no research found that explains why hamstring injuries are one of the most common injury in sports or why the number of injuries is increasing. Hamstring injuries predominantly occur in sports that rely on rapid, active knee extension and hip flexion such as sprinting, track and field, soccer, football, rugby, and Australian football (Croisier, 2004 & Opar, 2012). There is no definite known cause for hamstring injuries but some possibilities include: inadequate flexibility, muscle weakness, muscular strength imbalance, unsatisfactory warm-up, prior injury, fatigue, ethnicity, age, and poor running mechanics (Croisier, 2004; Fousekis, Tsepis, Poulmedis, Athanasopoulos, & Vagenas, 2011; Opar, 2012; & Watsford, 2012).

There is a lot of confusion among researchers as to why hamstring injuries occur. There are speculations as to why they occur, but there has not been any scientific data to prove that there is a specific reason or reasons for these injuries. Due to the prevalence of hamstring injuries, there is research being done on this topic but so far it is mostly speculation and trying to understand and to determine all the possible causes. Some possible questions about hamstring injuries are if the injuries result from accumulated microscopic muscle damage or as a result of a single event that exceeds the mechanical limits of the muscle; or if both contribute to the injury (Opar, 2004). There is also some debate as to whether asymmetries of the lower limb neuromuscular patterns would have an effect, such as one leg having tighter muscles than the opposite leg (Fousekis, 2011). These are questions in which there is research being conducted but no research to date was found that had any specific answers to these questions.

With any injury, there are both intrinsic and extrinsic factors that could be at fault. Extrinsic refers to the environment, whereas intrinsic deals with aspects within the athlete's body (Fousekis, 2011). Orchard (2001) suggests that intrinsic factors are more predictive of muscle strain than extrinsic factors. The physical contact between opponent players constitutes the main extrinsic factors (Fousekis, 2011), which will not examined in this study. Intrinsic etiologies includes asymmetries in muscle strength, flexibility, and proprioception, as well as joint instability, anatomical and anthropometric asymmetries, age, and previous injury (Croisier, 2004; & Fousekis, 2011). Previous findings regarding asymmetries in muscle flexibility and previous injuries are more definite in terms of their connections to the occurrence of muscle strains in the lower limbs (Fousekis, 2011).

There are many intrinsic possibilities as to why hamstring injuries occur as described above, such as muscular weakness, strength imbalances, and fatigue, but hamstring tightness is thought to be a significant predictor for hamstring injuries (Croiser, 2004; Hartig & Henderson, 1999; Huang, 2010; & Orchard, 2001). Not all researchers agree that hamstring tightness is a predictor due to the lack of clarity in definitions of flexibility and different ways of measuring flexibility (Gleim, 1997 & McHugh, 1999). There is little evidence supporting the belief that increased hamstring flexibility decreases the likelihood of injuries occurring (Fousekis, 2011). Following a hamstring injury, there is usually reduced range of motion at the knee and hip joints (Heiderscheit, 2010). Flexibility exercises targeting hamstring muscles are usually incorporated into the rehabilitation programs. There are numerous thoughts about how to decrease hamstring tightness which include static stretching, dynamic stretching, different massage techniques, and myofascial release techniques (Curran, 2008, Hartig, 1999, & Huang, 2010). With these different stretches and techniques, there have been varied reviews on which techniques are more beneficial than others (Croisier, 2004, Hartig, 1999, & Opar, 2004). It is not clear at this time that there is an exercise or rehabilitation tool that is superior for decreasing the occurrence of hamstring injuries.

Of all musculoskeletal injuries, hamstring injuries have the highest recurrence rate (Croisier, 2004). Limited research exists that explains why these injuries reoccur more often than others. Some of the investigators' theories that have been put forth to address this issue include: the athlete is not taking enough time to rehabilitate their injury properly, the initial reason for the injury is not being looked at or determined, and proper rehabilitation techniques are not being utilized to treat the hamstring injury. In regards to rehabilitation, the investigation of hamstring injuries usually has not been focused on where the site or location of where the injury occurred. The location of the hamstring injury can play a role in deciding the proper protocol to use during the rehabilitation process (Heiderscheit, 2010). Currently, there has not been any rehabilitation protocol for hamstring injuries that has been determined to result in the best outcome (Goldman & Jones, 2011). Reasons for these high rates of recurrent hamstring strains is not fully understood, but some other possible reasons may be the result of scar tissue formation, other structural changes, or that full function has not been restored (Engebretsen, 2010; & Heiderscheit, Sherry, Silder, Chumanov, & Thelen, 2010). The re-injury to the hamstring is usually more severe than the first time, and the time away from sport is generally twice as long (de Visser, 2012). In a study by Engebretsen (2010), the risk seems to increase gradually with the number of previous injuries and decrease with time since the previous injury. Another factor that could possibly increase the chances for hamstring injuries would include previous injury to the anterior cruciate ligament (ACL). Koulouris, Connel, Brukner, & Schneider-Kolsky (2007) reported that athletes with previous ipsilateral ACL reconstruction had an increased risk of hamstring re-injury compared to athletes with no previous ACL reconstruction. Previously injured players have more than twice the risk of sustaining a new hamstring injury (Engebretsen, 2010). With the recurrence rate of hamstring injuries so high, it is important for research to be done to determine the cause and to plan programs or protocols to decrease the number of occurrences. There are mixed reviews as to why hamstring injuries reoccur so frequently compared to other injuries. These reoccurrences cause chronic problems in terms of symptoms such as spasms, tightness, and tenderness, reduced performance, and time loss from the sport (Engebretsen, 2010).

Interventions that have been applied to reduce the incidence of hamstring injuries have focused primarily on increasing eccentric strength, correcting strength imbalances and improving flexibility (Opar, 2012). This study focused only on improving flexibility. One way many people try to increase flexibility is by stretching. Flexibility is considered to be one of the most important parameters of muscle function that facilitates the neuromusculoskeletal system's responsibility for complicated movements (Lardner, 2001). There have been mixed reviews about which type of stretching is more beneficial for flexibility, static, dynamic, ballistic, or proprioceptive neuromuscular facilitation (PNF) stretching (Spernoga, 2001). There has been a significant amount of research with contradicting results on the topic of stretching as to which type is most beneficial. Static stretching has been used for many years prior to activity but with new research there have been negative results on this type of stretching. Some research shows that static stretching prior to activity has a negative effect on performance and that players should only use dynamic stretching prior to or before activity to increase muscle temperature (Marek, Cramer, Fincher, Massey, Dangelmaier, Purkayastha, et al., 2005). Stretching has been the most common method prescribed to increase flexibility. However, in recent year's myofacial release techniques have been more commonly used to help treat soft tissue restrictions and increase flexibility (MacDonald, 2012).

This study focused on self-induced myofacial release and its relation to the effect on a person's hamstring flexibility. Self myofascial release, sometimes referred to as self massage, is a form of soft tissue therapy. It is a convenient and relatively inexpensive technique for people to use because there is no assistance needed by another person and can be done in any location. Snideman (2011) pointed out that self myofascial release is a good way for the athlete to monitor their body and determine if any specific muscle group requires extra attention. If a specific muscle group is more tender or sore than another, more time should be spent focusing on decreasing adhesions that have formed. Self myofascial release should not always be a comfortable feeling but it should not cause the athlete excruciating pain (Nelson, 2012). There are different tools that can be used for self myofascial release such as a foam roller, "The Stick", massage balls, and even sports equipment like a tennis ball or golf ball (Snideman, 2011). The self myofacial release technique for this study was performed using a foam roller.

The foam roller has been available for a number of years but has only recently grown in popularity. The foam roller is a multipurpose tool that can be used to improve core stability, balance, proprioception, soft-tissue mobility, and body awareness (Fiscella, 2004). This tool is ideal for many individuals because it can be used by all ages and body types. Foam rollers are a new trend in certain fields of rehabilitation and in the community but there is not much research to support the product as being beneficial other than from word of mouth. The products popularity grew relatively quickly which has limited the amount of scientific research done on this product. There are many different types of foam rollers that vary in size, density, and firmness. The foam roller can be used for many parts of the body including quadriceps, gluteal muscles, the iliotibial band, calves, the back and many more. Boyle (2006) found using the foam roller on the lower extremities usually works better than the upper extremities. There is not as much dense tissue in the upper body and most athletes are not as prone to upper body strains as lower. For this study, the hamstrings were the only focus while using the foam roller.

Although there is little documented research on the benefits of self myofascial release specifically, there is a lot of anecdotal evidence that proves massage to be beneficial. Self myofascial release has also been termed self massage. Massage can benefit athletes' biomechanical, physiological, neurological, and psychological systems (Snideman, 2011). Exerting mechanical pressure is theorized to decrease adhesions between tissue layers, improve muscle compliance, decrease muscle stiffness, and increase joint range of motion. Scar tissue is stiffer than the contractile tissue that it replaces, which may alter the mechanical environment and stiffness of the muscle fibers (Heiderscheit, 2010). Applying prolonged or amplified tension to a muscle belly with the foam roller will cause the muscle to relax (Fiscella, 2004). Snideman (2011) explains that massage seems to help athletes reduce ischemia by increasing skin blood circulation, blood flow to the muscles, parasympathetic activity, and the release of relaxation hormones and endorphins. The possible neurological effects deals with reflex stimulation with the goal to decrease neuromuscular excitability of the muscle and minimize trigger point activity and pain, muscle spasms, and excessive tension. Athletes who practice self myofascial release may experience an increased sensation of relaxation in the muscles and decreased anxiety (Snideman, 2011).

Statement of Purpose

The purpose of this study was to identify if using a foam roller to perform self-induced myofascial release (SMR) on the hamstring muscles would have positive effects and in turn increase hamstring flexibility. The effects were determined by measuring hamstring flexibility before and after four weeks of SMR. The sit-and-reach test was used to assess hamstring flexibility.

Research Question

1.) Will using the foam roller two times per week for the duration of three to five minutes for four weeks have an effect on hamstring flexibility?

Hypothesis

1.) It is hypothesized that the use of a foam roller on the hamstring muscles two times per week for four weeks will significantly increase hamstring flexibility.

Significance of This Study

There has been limited research on the benefits of self-myofacial release even though many practitioners use this technique for different musculotendinous treatments and rehabilitation (Curran, 2008, Healery, 2011, & MacDonald, 2012). Curran et al. (2008), examined the different effects of pressure when using two different types of foam rollers. One of the foam rollers was a smooth foam roller and the other was a more firm foam roller that was not smooth. The results of this study showed that the more firm foam roller that was not smooth exerted more pressure on the body than the smooth foam roller. The smooth foam roller deformed with the weight of the body. The conclusion that came from this study was that with the deeper penetration, the adhesions could be broken up better which could in turn possibly increase hamstring flexibility (Curran et al., 2008). Foam rollers have been shown to be an effective mechanism for relieving tightness or restriction in the fibrous bands of connective tissue or fascia that encase muscle throughout the body (Fiscella, 2004). In a study done by MacDonald (2012), self myofascial release was examined as part of a warm up to determine if it enhanced muscular performance. The results of this study showed that an acute bout of foam rolling greatly improved knee joint range of motion with no detrimental effects on neuromuscular force production. There have been other studies that have shown that massage has been beneficial for hamstring flexibility but self myofascial release has not been compared to those types of massage (MacDonald, 2012).

Many settings, including rehabilitation settings, use the foam roller as a tool for many different reasons. Some of those reasons include improve muscle compliance, decrease in delayed onset of muscle soreness, decrease adhesions in the tissue, increase joint range of motion, improve core stability, balance, and decrease muscle pains (Fiscella, 2004 & Snideman, 2011). Another one of those reasons being the thought that by using this tool, flexibility may be increased. The outcome of this study may shine light on this topic and possibly lead to more research ideas to see the benefits of using this tool. The foam roller is a popular tool in the rehabilitation world today and this study can be used to expand the knowledge of individuals who utilize this tool.

Limitations of This Study

1.) The study was performed for only four weeks.

2.) Participants used the foam roller only two times per week.

3.) This study had a small sample size.

4.) The participants in this study were not all at the same fitness levels and had different routines.

Delimitations of This Study

1.) The participants were all from a weight lifting class.

2.) The sit-and-reach method was used to record hamstring flexibility.

3.) There could have been possible examiner measuring errors with the sit-and-reach test during initial or final readings.

Basic Assumptions

1.) It was assumed that the participants were demonstrating the proper technique when foam rolling.

2.) It was assumed that the change in hamstring flexibility, if any was recorded, was due only to the treatment.

3.) The sit-and-reach test was assumed to be accurate for assessing hamstring flexibility based on a preponderance of prior research.

4.) The participants were relied upon to try their best on the sit-and-reach each time.

5.) Participants were relied upon to foam roll for 3-5 minutes each session.

Definitions of Terms

The following terms have been defined for the purposes of this study as follows:

1.) **Ipsilateral** means the same side of the body (http://medical-dictionary.thefreedictionary.com/ipsilateral).

2.) **Static stretching** involves stretching a body part to the furthest point possible without pain and holding the stretch for a certain amount of time (http://suite101.com/article/stretching-techniques-a126336).

3.) **Dynamic stretching** involved motion that is used to induce a stretch but in a controlled and fluid motion (http://suite101.com/article/stretching-techniques-a126336).

4.) **Ballistic stretching**, also known as bobbing or bouncing, are used to elongate muscles and push body parts past the limits of their current range of motion (http://suite101.com/article/stretching-techniques-a126336).

5.) **Proprioceptive neuromuscular facilitation (PNF)** stretching involved both passive and isometric muscle contractions and is done using a partner (http://suite101.com/article/stretching-techniques-a126336).

6.) **Myofacial release therapy** is a manual therapy technique, done by another person, used to help reduce restrictive barriers or fibrous adhesions seen between layers of fascial tissue (MacDonald, 2012).

7.) **Self-induced myofacial release technique** is where the individual uses their own body mass on a foam roller to exert pressure on the soft-tissue and there is no use of a therapist (MacDonald, 2012).

CHAPTER II

REVIEW OF LITERATURE

The review of literature emphasized the following aspects related to the present study: (a) hamstring anatomy and biomechanics, (b) hamstring injuries, (c) healing process, (d) reoccurrence of hamstring injuries, (e) stiffness, and (f) techniques to treat myofascial restrictions. There have been studies done to try to determine the best method to prevent, as well as treat, hamstring injuries but there are still gaps in the research. In this section, some of the research that has been done on this topic will be mentioned and talked about.

Hamstring Anatomy and Biomechanics

The hamstring muscle group is made up of three muscles, semitendinosus, semimembranosus, and biceps femoris, which has a long head and a short head. The semimembranosus muscle and the semitendinosus muscle are on the medial side of the posterior thigh, whereas the biceps femoris is on the lateral side of the posterior thigh. There are slight differences in what these muscles can do with rotational movements but they ultimately act as a unit to help flex the knee and extend the hip (Starkey & Ryan, 2002). The hamstrings are a biarticular muscle group, which means that it crosses the hip joint and the knee joint. The fact that the hamstring muscles cross two joints has been thought to make it more susceptible to injury (Blankenbaker & Tuite, 2010).

Gokaraju, Garikipati, and Ashwood (2008) showed that hamstring muscles are active during the entire gait cycle with higher peaks in activation during the terminal swing and early stance phases. The gait cycle is typically split into four phases which include the stance phase, early swing phase, middle swing phase, and the late swing phase (Higashihara, Ono, Kubota, Okuwaki, & Fukubayashi, 2010). The stance phase is from foot strike to toe off. Early swing phase is from toe off to maximum knee flexion. Middle swing phase is from maximum knee flexion to maximal hip flexion. Finally, the late swing phase is from maximum hip flexion to the next foot strike.

The hamstrings contribute most of the terminal swing hip extension and knee flexion torques (Schache, Kim, Morgan, & Pandy, 2010). The greatest force occurs when the hip is flexed and knee flexion reaches 90° (Gokaraju et al., 2008). The hamstring muscles are placed under extremely high loads in a lengthened position during the late swing phase. In contrast, the hamstring muscles generate most of the knee flexion and hip extension forces during the early stance phase (Higashihara et al., 2010) There is debate as to whether injury is more likely to occur during the stance or the swing phase of a running gait cycle (Chumanov, Heiderscheit, & Thelen, 2011; & Orchard, 2002).

During the terminal swing phase, the hamstrings are required to contract forcefully while lengthening to decelerate the extending knee and flexing the hip. The hamstring muscle must change from functioning eccentrically, to decelerate knee extension, to concentrically, becoming an active extensor of the hip joint (Petersen & Holmich, 2005). This change may make the hamstring muscle more susceptible to injury. It is in the terminal swing that the hamstring muscles reach their maximal length and load, especially the long head of the biceps femoris, which undergoes the greatest stretch and is put under the most strain (Opar et al., 2012; & Thelen, Chumanov, Best, Swanson, & Heiderscheit, 2005). The long head of the biceps femoris is the most often injured hamstring muscle; it lengthens throughout the latter half of the swing phase of sprinting with peak stretching occurring before foot contact (Thelen et al., 2005). There is not much definite research as to which head of the biceps femoris is injured more frequently (Woodley & Mercer, 2004). The terminal swing phase is considered the most hazardous due to the hamstring muscle-tendon units being at its longest stretch and when they are most heavily activated (Opar et al., 2012). In a study done by Yu et al. (2008), the activation of the hamstring muscles during the late swing phase was about two to three times greater than during the late stance phase and early swing phase of running.

A sprinting simulation done by Chumanov et al. (2011), demonstrated that biceps femoris loading increases with speed during the swing phase but not in the stance phase; also that the peak stretch and negative work demands occur only during the swing phase. In a simulation done by Thelen et al. (2005), the biceps femoris tendon begins to recoil before foot contact with the ground. These results show that tendon stretch during the late swing is substantial and acts to reduce the stretch that the muscle has to sustain and the amount of negative muscle work that must be done. The peak muscle stretch will decrease as tendon compliance is increased.

In a study done by Schache et al. (2010), the focus was on three different types of locomotion, walking, jogging, and sprinting. The peak hamstrings length was smallest when jogging and greatest for sprinting. As running speed increases, the hamstring muscles are stretched more rapidly (Higashihara et al., 2010). The peak hamstring load, including force, velocity, power and negative work, was smallest for walking and greatest for sprinting. This study found that prior to a muscle strain injury the injured hamstring displayed an increased peak length and force during terminal swing compared to the uninjured hamstrings. Finally for walking and jogging, the peak hamstring force was greatest during stance but for sprinting it was greatest during terminal swing (Schache et al., 2010). Hamstring injuries are more prevalent in sprinting exercises so the results of Schache's study is more in support that hamstring injuries occur during the terminal swing phase.

A thought for why injury would occur more during the stance phase is because it is a strong force in the opposite direction, usually the ground reaction force, which strains the hamstring muscle (Orchard, 2012). There is no conclusive evidence showing the time that the actual fibers tear in a hamstring strain. Based on studies done on the Achilles tendon and patellar tendon, it is considered that the stance phase is when the majority of the forces must be absorbed by tissues (Scott & Winter, 1990).

Hamstring muscles are subjected to high forces during both open and closed kinetic chain activities, which make them vulnerable to injury (Bennell, Wajswelner, Lew, Schall-Riaucour, Leslie, Plant, et al., 1998). The hamstring muscles may be susceptible to a late swing injury as a result of repetitive strides of high speed running (Heiderscheit et al., 2005 & Schache et al., 2009). Hamstrings are more likely to be injured during the stance phase when the limb is subjected to external loading via foot ground contact (Chumanov et al., 2011). There is still much research being done to determine why this is the case.

Understanding the structures and the biomechanics of the hamstring is important in trying to understand where the mechanism of injury occurs. There has been much research done on the topic of when the hamstring strain occurs in the gait cycle but more research is needed to clear up this controversy. Rehabilitation programs are often based on assumed injury mechanisms; having knowledge of the mechanism and time of injury can be crucial for possible treatment and rehabilitation protocols as well as new strategies to prevent hamstring injuries. This topic is very important in the research of hamstring injuries and will continue to be an issue until the research can give a more definite answer.

Hamstring Injuries

Hamstring injuries are characterized by an acute pain in the posterior thigh with disruption of the hamstring muscle group (Opar et al., 2012). Muscle injuries can be classified as direct or indirect injuries. Direct forms would include lacerations and contusions, whereas indirect would be strains (Petersen et al., 2005). Hamstring injuries are primarily strains but contusions can come with contact injuries. For the purpose of this study, only indirect forms will be looked at. Hamstring injuries are frustrating for medical staff, coaches, and players because the symptoms are persistent, healing time is a slow process, and the rate of reinjury is high (Petersen et al., 2005).

The severity of hamstring injuries can range from minor microscopic tearing, grade 1, to complete muscle tears, grade 3 (Prentice, 2009). A grade 1 injury is considered a strain which consists of microscopic tearing of a few muscle fibers with minor swelling and discomfort with no macroscopic muscle defect. Grade 2 injury is a partial tear, which represents an incomplete disruption of muscle fibers. Both grade 1 and 2 will result in some loss of function. A grade 3 injury is a complete tear with a complete rupture of the muscle with complete or nearly complete loss of muscle function (Blankenbaker et al., 2010; & Petersen et al., 2005). The severity of the injury will determine how long the athlete is out of play and the type of rehabilitation tools used to treat the injury. Clinical assessment is used to determine the grade and extent of the injury, only some cases use other means of examination such as imaging techniques. This method of assessment is the main way to diagnose hamstring injuries which may be an issue because it is not a very uniform way of diagnosing (Reurink, Goudswaard, Tol, Verhaar, Weir, and Moen, 2013). There are different classification systems used depending on the person assessing and the place in which the athlete is assessed, which makes comparing studies and results difficult. A uniform, reliable and validated classification system is needed to improve the comparability of outcomes and can be used by medical personnel who are diagnosing and treating athletes for management planning, prognostication, and rehabilitation decisions (Reurink et al., 2013).

A study by Croisier et al. (2002), stated that the average peak torque reduction of an injured hamstring muscles measured in the eccentric mode was doubled in comparison to the concentric values. This study did not state the severity of the injury but just that the hamstring muscle was injured. There was a difference in the hamstring to quadriceps ratio in their study that suggests there is insufficient eccentric braking capacity of the hamstring muscles compared with the concentric motor action of the quadriceps muscles (Croisier et al., 2002). This could be a potential reason as to why hamstring muscles are more commonly injured than quadriceps muscles.

Immobilization immediately after the injury is also a possibility but it brings some debate as well. A study done by Kilcoyne, Dickens, Keblish, Rue, & Chronister, (2011), suggested that immobilization following hamstring injury was beneficial in two possible ways. The first being that the pad and Ace wrap helps to limit the capillary bleeding. Also, the immobilizer prevents the slight knee flexion and toe walk caused by protective muscle spasms, sometimes seen in hamstring injuries. A brief period of immobilization may be beneficial, prolonged immobilization can be detrimental to the recovery period (Kilcoyne, 2011). There is no definite time that a person should be immobilized but the most common thought is no more than a week. There is not much research on the benefits and/or negatives of using immobilization following a hamstring injury. Some possible negatives might include decreased range of motion and increased adhesions or stiffness due to the inability to do the normal motion of walking.

A study done by Chumanov et al. (2007), found that there were potentially two inter-related risk factors that could contribute to hamstring injuries during high speed running. The first is that there is a large amount of negative work done over repeated strides and that may result in accumulated microdamage, which could predispose the muscle to injury. The second possibility is the fluctuations in neuromuscular control at high speed that could create stride-to-stride variability in hamstring stretch. With excessive stretch in any single stride, it could induce an acute onset of injury to the muscle. In layman's terms, the repeated strides may create an accumulation of small damages to the muscle and/or at high speeds of running the brain may not be as aware of its control of the muscles and some strides may stretch the muscle too far resulting in an injury.

Recent MRI (magnetic resonance imaging) studies demonstrate that over 90% of hamstring strain injuries occur at the muscle belly or the muscle-tendon junction (Askling, Tengvar, Saartok, & Thorstensson, 2007; & Koulouris et al., 2007). Hamstring muscle injuries that were detected by MRI were associated with a longer absence from competition than injuries that were not detected (Verrell, Slavotinek, Barnes, & Fon, 2003). The site of injury on the muscle may be different between late stance phase and late swing phase. Yu et al. (2008), showed that a strain injury might be more likely to occur at the hamstring muscle-tendon junction during the late stance phase than during the late swing phase. When trying to determine the specific site of injury there is little consistency with the terminology, making interpretation and comparison between different studies difficult (Woodley et al., 2004). Studies may state that the injury occurred in the muscle-tendon junction, however they did not specify as to if it was proximal or distal or give any indication as to a more specific location to use with future studies in the future. Many injuries are reported to occur near or at the muscle-tendon junction, but there were no patterns that emerged regarding where the injuries occurred within the complexes of each muscle (Woodley et al., 2004). On the other hand, injury may be more likely to occur at the muscle belly during the late swing phase than during the late stance phase.

As mentioned in the previous section, it is unknown in which phase injuries most likely occur. If the placement of the injury is determined by the phase in which the injury takes place, this may be a key aspect in the research that is missing. The biceps femoris is the most commonly injured hamstring muscle, usually occurring at the muscle-tendon junction and the adjacent muscle fibers (Opar et al., 2012). Based on the results of Yu et al. (2008), the most commonly injured hamstring muscle, biceps femoris, occurs during the swing phase compared to the stance phase.

Even though the biceps femoris muscle is the most commonly injured muscle of the posterior thigh, it is possible to injure more than just one muscle at a time (Woodley et al., 2004). Most commonly, if there are two muscles injured simultaneously it involves the long head of the biceps femoris and the semitendinosus muscles (De Smet and Best, 2000; Verrall et al., 2003). The possible reasons for encountering two muscle injuries simultaneously was not explained but it is possible for two muscles to be overstretched or forceful contractions (Woodley et al., 2004). If two muscles are injured simultaneously they are usually referred to as the primary and the secondary site of injury. The primary site would be the muscle that is injured the greatest and the secondary would be the one that has less damage. The use of the MRI would be the only way to determine which muscle was primary versus secondary site of injury. All of the participants in a study done by De Smet and Best (2000) sustained primary injuries of the biceps femoris and secondary injuries of the semitendinosus muscle. There has not been much research other than this study that was found to differentiate between primary and secondary injuries.

Knowing the different types of injuries and severities that can occur is important in understanding the rehabilitation aspects as well as possibly understanding the underlying problem. The different grades of injury will be beneficial in the rehabilitation aspect to estimate a timeline of return for the athlete after the injury has occurred. This can also be important in determining how much rehabilitation is needed to get the athlete back to 100% and back playing. The risk factors for hamstring injuries are just a couple of the possibilities but understanding the possible mechanism can help to decrease the number of injuries occurring. Understanding the part of the muscle that is injured is a possible key to understanding what caused the injury and what the mechanism of injury was. All of these components are beneficial to understand because they help identify what the possible underlying reasons for injury are and what possible preventative measures can be taken.

Healing Process

Although the initial treatment of rest, ice, compression, and elevation is accepted by medical staff for muscle strains, there is no definite agreement as to the best rehabilitation for hamstring injuries. The goal of rehabilitation is to restore the function of the injured body part to the best possible degree in the shortest amount of time (Petersen et al., 2005). Treatment is usually split up into different phases depending on when the injury occurred. The phases overlap in time depending on the severity of the injury. The three main phases for the healing process include the inflammatory response phase, fibroblastic-repair phase, and maturation-remodeling phase (Prentice, 2009).

The inflammatory response phase or acute phase begins as soon as the injury occurs and usually is considered to last up to anywhere from three to seven days. During this time of the rehabilitation is when rest, ice, compression, and elevation start. Cryotherapy, also known as cold therapy, should be used in this phase to try to limit the amount of inflammation. The main focus of this phase is to control hemorrhaging minimize and decrease inflammation and pain (Petersen et al., 2005).

The second phase is the fibroblastic repair phase and this is when the scar tissue begins to form and the repair of the injured tissue follows. This phase can range from within the first few days following injury and can last as long as four to six weeks (Prentice, 2009). In this phase it is important to continue muscle action and motion to prevent atrophy and continue to promote the healing process (Petersen, 2005). It is also important in this phase to not let adhesions to limit the athlete with range of motion, so flexibility should be monitored and progressive work to increase strength should be done (Petersen et al., 2009). Medical practitioners who work with hamstring muscle injuries face an ongoing dilemma of requiring some new collagen formation for the muscle-tendon unit to carry load and generate torque about a joint, while at the same time seeking minimal scar formation in order to minimize stiffness (Orchard & Best, 2002). Once full range of motion has been achieved, exercises that work concentric contractions can be incorporated.

The final phase, the maturation-remodeling phase is a long-term process in which the alignment and strength of the tissue should be addressed; this phase may require several years to be complete (Prentice, 2009). Depending on the severity of the injury, this phase could start as soon as up to a few weeks after the injury occurred. With more serious of injuries, this phase will start later than with simple grade 1 injuries. During this final stage athletes may be ready to return to play but that does not mean that their body has fully healed from the injury and may take months to years to be fully healed. If a complete rupture of the hamstring muscle is present then surgery is a realistic consideration but surgery is not usually needed unless the muscle has avulsed (Petersen, 2005). If surgery is needed, the rehabilitation process will be a lot slower than with just a muscle strain and the healing process will be longer.

Return to play for hamstring injuries is accomplished by increasing hamstring strength and flexibility to the normal values of that athlete. Pain free activities are progressed from jogging at low intensity to running and then finally sprinting (Petersen et al., 2005). All of these progressions should be done with the athlete feeling no pain because that will be a good indicator for when the athlete is ready to return to play. It is agreed that for rehabilitation it is important to restore strength, endurance, and flexibility prior to return to competition in the best hopes to try to decrease the chances of reinjury (Hoskins & Pollard, 2005).

Hamstring injuries do not tend to be a quick rehabilitation injury and they take longer time to recover than some other injuries. Every hamstring injury with every athlete will be different. The severity of injury and the athlete's body will determine the time it takes to heal, so every rehab will vary to some degree. It is important that when the athlete is ready to participate in their sport again that they continue their rehabilitation protocol to try to decrease the chances of reinjury and continue to strengthen their hamstring muscles. If the athlete tries to return to sport too quickly and before their body is ready, it may result in a recurrent or more severe injury.

Reoccurrence of Hamstring Injuries

Hamstring muscle strain injuries can be frustrating because of the persistence of symptoms, the unknown possible cause, slow healing, and high re-injury rates (Yu et al., 2008). When the hamstring is re-injured, the second time is usually more severe than the first and the time away from sport is generally twice as long (de Visser, Reijman, Heijboer, & Bos, 2012). Hamstring injuries have the highest reoccurrence rate of all injuries (Croisier, 2004). Scar tissue is thought to not be as functional as the original tissue; therefore the risk for reinjury is increased (Taylor, Dalton, Seaber, & Garrett, 1993). Early loading will help to minimize secondary atrophy, but can itself increase the risk of reinjury while the scar tissue is still weak (Orchard & Best, 2002). While a good amount of muscle strains reoccur during the first week after return, for the hamstring muscles there is a significantly increased risk of recurrence for many weeks after return to play (Orchard & Best, 2002).

A study by Orchard (2001), confirmed that a recent history of a strain of one muscle group confers an increased risk of injury to surrounding muscle groups. So when an athlete returns to play from a hamstring strain, they are not only more likely to reinjure the hamstring muscle, but are also more likely to strain a quadriceps muscle (Orchard, 2001). During the rehabilitation process following the hamstring injury, the mechanical chain needs to be looked at and the areas surrounding the injury need to be strengthened as well.

Research has tried to determine possible ways to help prevent the reoccurrence of hamstring injuries. A study done by Upton, Noakes, & Juritz (1996), concluded that wearing thermal pants might have a role in preventing recurrent hamstring injuries. The data suggested that the group who wore thermal pants all the time had a longer injury-free period. There may be other risk facts that are more important but their study showed that wearing thermal pants can reduce the risk of hamstring injuries during rugby (Upton et al., 1996). This is the only research found on this topic but due to its positive results, future studies might look into its potential.

Looking at the reoccurrence rate of hamstring injuries is an important aspect due to how high this rate is. When people understand the likelihood of hamstring injuries occurring more often after an injury, then maybe people will incorporate more of a continuous rehabilitation program following hamstring injuries. There has not been any research found on the effectiveness of decreasing the amount of hamstring injuries following a continued rehabilitation program. The rehabilitation protocol used may seem to be successful when the athlete can return to play sooner but it is important to remember that the re-injury rate is high and that will be the test of the rehabilitation (Reurink, 2013). This could be a possible study for the future to see if there is an effect on the reoccurrence rate of hamstring injuries if rehabilitation would continue for a longer period of time following an injury. Other possible studies could look at different rehabilitation protocols and determine if one protocol decreases the likelihood of hamstring injuries reoccurring following the return to sport.

Stiffness

Musculotendinous stiffness is defined as the amount of tension residing in the muscle-tendon unit (Watsford et al., 2010). Musculotendinous stiffness has been identified as a potential intrinsic risk factor for soft tissue injuries, such as hamstring injuries. This stiffness has been thought to lead to a greater susceptibility to recurrence of hamstring strain injuries. Muscle "tightness" or flexibility is focused on joint range of motion, whereas stiffness is concerned with the mechanical properties of the muscle.

Musculotendinous stiffness may be reduced through the performance of flexibility training. With this being said, it could enable the modification of musculotendinous stiffness, which may decrease soft tissue damage and injury (Watsford et al., 2010). Muscle shortness and muscle contractures restrict the normal muscle action and therefore are considered as limiting factors for range of motion (Athanasios, 2005). In a study done by Watsford et al. (2010), it appeared that players who recorded relatively high bilateral hamstring and leg stiffness values may have a higher risk for sustaining soft tissue hamstring injury during the season. Worrell et al. (1994) concluded that increasing hamstring muscle flexibility was an effective method for increasing muscle performance. In this study, it demonstrated that chronic flexibility training can reduce musculotendinous stiffness. Common thought is that gains in flexibility are due to the mechanical changes in the muscle (Weppler, 2010). These mechanical changes include viscoelastic deformation, plastic deformation, increased sarcomere length, and neuromuscular relaxation.

In the next section possible ways to decrease this musculotendinous stiffness is discussed. There has not been any definite research saying that musculotendinous stiffness is the primary cause for hamstring injuries. To be able to decrease this stiffness would mean potentially decreasing the number of hamstring injuries. Decreased flexibility and increased stiffness have been seen as a possible cause for injuries but is not seen as the only potential cause. There may be more than just one cause to hamstring injuries but this study is just focusing on this one aspect. The methods in the next section have been thought to be beneficial, but there is still continued research on how beneficial they are.

Techniques to Treat Myofascial Restrictions

Soft-tissue injuries represent a significant percentage of athletic injuries and can occur from chronic and/or acute mechanisms, such as injury, disease, inactivity, or inflammation (MacDonald et al., 2012). Soft-tissue injures are common in sports today so it is difficult to say that there are single possible reasons for injuries to occur. These injuries stimulate the development of inelastic, fibrous adhesions between the layers of the myofascial system that prevent normal muscle mechanics and decrease soft-tissue extensibility; this can also be known as fascial restrictions (MacDonald et al., 2012). These adhesions can alter surrounding joint mechanics, resulting in pain and further pathology. Repeated stress placed on soft-tissue due to overuse or inactivity may cause abnormal cross-links and scar tissue to form in the fascia. These abnormal cross-links and scar tissue may inhibit biomechanics and reduce joint range of motion (MacDonald et al., 2012). The treatment and rehabilitation programs for these injuries should address this myofascial component to facilitate complete recovery and function (Curran et al., 2008).

Self-massage work has become an integral part of the athlete performance process, including recovery and injury prevention. When performed properly, it has many benefits for athletes, including maintenance of soft tissue and orthopedic health, as well as assistance in the process of optimizing mobility and posture for improved sports performance. Therapeutic massage is one modality that can be used to release trigger points that may accumulate (Richter, 2012). There is a place for self-massage in every athlete's regimen according to Snideman (2011).

In a study done by Huang (2010), there was a significant increase in hip flexion range of motion, also classified as hamstring flexibility, with only 10 seconds and 30 seconds of musculotendinous massage. This indicates that a brief duration massage at the musculotendinous junction can provide an increase in hamstrings flexibility that is comparable to other common methods of stretch with a shorter time commitment. Short-duration massage at the musculotendinous junction can provide range of motion improvements similar to other stretching techniques. Some say that massage may increase range of motion by reducing the muscle's ability to detect pain and therefore allow a greater range of motion before discomfort (Weeraponh, Hume, & Kolt, 2005).

Soft-tissue injuries can be treated in many ways with some debate, but massage therapy continues to be one of the most common therapeutic modalities to treat them. Myofascial release therapy was developed to help reduce restrictive barriers or fibrous adhesions seen between the layers of fascial tissue (MacDonald et al., 2012). Myofascial release is a manual technique that works both with the muscles and the fascia of the body (Sefton, 2004). Fascia is multidirectional and ubiquitous, it wraps around and through all of the muscles of the body. Movement, body heat, stretching, and massage soften fascia, making it more pliable and adaptable (Sefton, 2004). Self-myofascial release (SMR) techniques have become a common technique to treat myofascial restrictions and to restore soft-tissue extensibility. Applying prolonged or amplified tension to a muscle belly with the foam roller will cause the muscle to relax (Fiscella, 2004). Acute spasms or chronic tightness respond well to pressure with motion (Sefton, 2004). As people roll their myofascia across the foam roller, tension is placed across the muscle that the Golgi Tendon Organ responds to and sends a proceeding relaxation signals to the brain

(Richter, 2012). When the fascia begins to relax and then releases, the tissues are then moved into a position of stretch. Patient relaxation during myofascial release is crucial for achieving the greatest fascial and soft-tissue deformation (Swann, 2002). If an athlete or patient is tense during myofascial release, the outcomes will not be as positive.

Self-myofascial release is starting to become a popular new technique, by physicians and athletic trainers, in place of using the traditional methods of treating soft-tissue injuries. With self-myofascial release, the patient uses their own body weight on the myofascial roller to exert pressure on the opposing soft tissue. Using the foam roller increases blood flow to targeted muscle groups and alleviate muscle tightness which can hinder proper body mechanics (Georgilopoulos, 2012).

The foam roller is an ideal tool for SMR because it can be used by all ages and body types (Fiscella, 2004). The myofascial roller can be used on many different parts of the body if the patient varies up the position they are isolating (Curran et al., 2008). The SMR technique places direct pressure and a sweeping motion with rolling on the soft-tissue, stretching the tissue and generating friction between the soft-tissue and the foam roller. This friction causes the fascia to become warm, promoting the fascia to take on a more fluid-like form, breaking up the fibrous adhesions between the layers of fascia and then ultimately restores soft-tissue extensibility (Sefton, 2004). The possibility of releasing the muscle tissue that is preventing people from moving properly, they will be able to place themselves in positions needed for success (Richter, 2012).

In a study done by Sharp (2012), the benefits of using a hands on approach of myofascial release called the Emmet technique was compared to the use of self-myofascial release using the foam roller. The results of Sharp's study suggested that using the Emmet technique, the hands on approach, was more beneficial to increasing range of motion compared to using the foam roller. Both groups showed improvement where the control group decreased, however, the hands on approach showed much more improvement than the self-myofascial release technique. Vertical jump was also looked at with this study and there was no significant change between the foam rolling group and Emmet groups, however foam rolling showed an improvement against the control group. Sharp's study focused on the iliotibial band (IT band) compared to this study that focused on effects to the hamstring muscle group.

Foam rollers originated as part of the Feldenkrais Methods, a mind-body modality that combines theory from motor development, biomechanics, psychology, and martial arts (Feldenkrais, 1972). With the Feldenkrais Method, the student is encouraged to experiment and ideally become more aware of their movement and not need much assistance from the teacher (Jain, 2004). The Feldenkrais method uses foam rollers to restore alignment, instill body awareness, improve posture and flexibility, challenge neuromuscular control and alleviate muscular tension and pain. (Fiscella, 2004). The Feldenkrais method is a type treatment that is not seen to be a quick fix to problems, it is a gradual treatment that people can become more aware of their own body and potentially lead to benefits with physical problems that they might have (Jain, 2004).

A study by Mohr concluded that using the foam roller for 3 two minute repetitions increased hip flexion range of motion. This study focused on static stretching and the use of a foam roller. There were four groups, just a stretching group, just a foam rolling group, a combination of the use of a foam roller with a static stretching protocol, and a control group for the duration of 2 weeks. The combination group had the greatest increase in hamstring flexibility but all of the groups saw increases except the control group. Mohr's study used a passive straight leg raise test in their study compared to the sit-and-reach method used in the current study.

A study done by Miller and Rockey (2006), looked at the use of a foam roller three days a week for eight weeks on individuals who were considered to have tight hamstrings prior to the study beginning. The results for their study did not reveal a significant difference in the interaction between the foam rolling group and the control group. Both of the groups in their study did have an increase in the range of motion but when compared with each other there were no significant differences between the foam rolling group and the control group. Miller and Rockey's study used an active knee extension procedure compared to the sit-and-reach technique used in this study.

Foam rollers can also be referred to as ergogenic aids because they are substances or devices that are designed to improve human performance in sport and other activities (Williams, 1998). Foam rolling can be implemented into numerous rehabilitation settings to promote soft-tissue extensibility, help increase range of motion, and promote optimal skeletal muscle function (Curran et al., 2008). It is also believed that foam rolling can correct muscular imbalances, alleviates muscles soreness, relieves joint stress, and improve neuromuscular efficiency (Curran et al., 2008; & Swann & Graner, 2002). Foam rolling prior to a workout can help decrease muscle density and promote a better warm up. Foam rolling after a workout may help muscles recover from strenuous exercise (Boyle, 2006). After using the foam roller, it should return to its full shape. If it does not, it is too soft to be effective (Livestrong.com). If a person is new to using a foam roller it may be ideal for them to start off with a softer foam roller due to the pain they may experience the first couple times of use. As the individual's body becomes more flexible and the adhesions begin to be worked out, the person can increase to a more dense foam roller. The harder material of myofascial roller that is used, the more soft-tissue pressure and the better isolated contact area on the soft-tissue compared to a myofascial foam roller of softer material (Curran et al., 2008).

Effective soft tissue release must stay under the body's protective guarding threshold. This means that if the participant is wincing and holding their breath during their self-myofascial release, they are not accomplishing very much. Self-myofascial release may be uncomfortable, but it should never painful. Pressure to both muscle and fascial tissue excites sensory receptors which are known to cause a relaxation (Nelson, 2012). There is a point, however, where too much pressure that is applied too quickly will cause a guarding, self protecting response. If the participant's nervous system senses a threat, their body will not be very receptive to any type of release. The sensory system plays a large role in the success of self-myofascial release, so it is important for the participant to work with their tissue, superficial to deep. (Nelson, 2012). Fascia surrounds muscles, bones, organs and joints with no interruption. The functional significance of this must be studied further, but it seems that mechanical tensions do extend through fascial connections. (Nelson, 2012).

Stretching may be beneficial to improve the length of the muscle, but SMR and massage work to adjust the tone of the muscle. SMR offers the benefits of stretching and the breakdown of soft-tissue adhesions and scar tissue (Robertson, 2008). Some possible reasons to use SMR techniques could include to improve mobility and range of motion, reduce scar tissue and adhesions, decrease tone of overactive muscles, improve quality of movement, and decrease the amount of money spent because the participant can foam roll by themselves instead of having to have someone do a massage on them (Robertson, 2008).

Possible other self-myofascial equipment that could be used for release techniques could include a medicine ball, tennis ball, or The Stick®. The medicine ball may be more versatile than a foam roller because it can hit more of a focal spot as well as work in more of a three-dimensional way. A tennis ball would be convenient for muscle or fascia groups of a smaller surface area. The Stick® has more of a narrow diameter that can help you reach some tendons (Robertson, 2008).

Out of the possible self-myofascial equipment, The Stick® is probably the most used especially in the running setting, such as track. It is designed to assist people in the deep manipulation of soft tissues, particularly muscles (Mikesky, Bahamonde, Stanton, Alvey, & Fitton, 2002). A negative about the stick could be that it sometimes, depending on the muscle being rolled, requires someone to use the tool on the participant but it might get deeper than the foam roller. A study done by Mikesky et al. (2002), concluded that there were no statistically significant changes with hamstring flexibility or vertical jump following an acute pretreatment with The Stick® but the speed in the 20-yard dash did have positive changes. The thought to why the first performance measures did not increase was that those motions were only one dimensional whereas running is more of a complex movement.

Myofascial techniques have become popular recently with a lot of research still in the process to determine how beneficial they may be. There is a lot of anecdotal evidence that states that myofacial release using the foam roller is beneficial but there have not been a lot of scientific studies to test this. Myofascial release has been around for many years but new tools such as the foam roller has not been out or popular very long. With the growing popularity of the foam roller, there is bound to be more scientific research being done to determine the benefits of using this tool.

CHAPTER III

METHODOLOGY

This study examined the relationship between the use of a foam roller and the effects on hamstring flexibility in a group of University students enrolled in a Weight Training class. The purpose of this chapter is to describe the: (a) participants and setting, (b) instrument, (c) procedures, (d) data collections, and (e) data analysis.

Participants

All of the students in the Weight Training class were invited to participate in this study. Twenty healthy students (age 21.3 ± 3.2 years) volunteered for this study. All of the participants in this study had to fill out a health history questionnaire prior to beginning the class. The information was examined prior to this study to ensure all of the participants were healthy enough to participate in weight training activities. To be included in the data analysis, participants that were in the foam rolling group were required to use the foam roller two times per week for the four week study. Participants were selected because they were in the weight training class as one of their activity classes so they were active at least two times per week. Convenience sampling was used with this study which means that the subjects were selected because of their convenient accessibility and proximity to the researcher. Individuals were excluded from the study if they were injured and not participating in class at the time of the study. If participants became injured during the time of the study, they were dropped from the study. All participants signed a consent form before they were allowed to participate in this study. Any participant was allowed to terminate their participation in the study during any point if they so wished without penalty or consequence to their evaluation in the Weight Training class. Participants did not receive compensation for participating in this study and it did not affect their weight training grade in any way. Permission to conduct this study was granted by the Eastern Illinois University Institutional Review Board.

Setting

Data collection was completed in the Eastern Illinois University Weight Training classroom in the Lantz building. The participants were tested using the sit-and-reach method during their weight training class in the Weight Training room in the Lantz building. The sit-and-reach method was used prior to beginning the study and again when it was concluded. Participants in the foam rolling group completed the task of foam rolling during their class period on Tuesdays and Thursdays. The weight training class met at the same time every Tuesday and Thursday so the results of the sit-and-reach measurements did not have to take different times of day into consideration. The investigator was in the Weight Training classroom every day that the study was being conducted was available to answer any questions that participants might have had as well as to make sure the participants were using the proper technique when using the foam rollers on their hamstring muscles. The data were collected indoors during February for the span of four weeks so there were no environmental limitations.

Instrumentation

The Figure Finder Flex-Tester (Novel Products, Inc., Rockton, Illinois) was utilized in this study to collect the sit-and-reach measurements of the students to assess hamstring flexibility. Hamstring flexibility was measured prior to the study starting and after four weeks when the intervention was completed.

Figure Finder Flex-Tester Box

The sit-and-reach box was obtained from the Kinesiology department at Eastern Illinois University. The box was used to record the hamstring flexibility of the participants in the Weight Training class. This type of box was chosen because the participant pushes the sliding marker to the distance they can reach. The sliding marker is beneficial for this study to help avoid errors in reading the distance reached. The Figure Finder Flex-Tester comes with scales printed in inches and centimeters, as well as a built in foot plate to prevent slipping.

Myofascial Foam Roller

Myofascial foam rollers were obtained from the Eastern Illinois University Athletic Training facility. The foam rollers were composed of a uniform polystyrene foam cylinder with a 36 centimeter length and a 6 centimeter width. This type of foam roller is a common type of foam roller used in Athletic Training facilities and other locations such as gyms and other rehabilitation settings. The foam rollers were already in the weight training classroom so that all participants in the foam rolling group could choose when to use the foam rollers during their class period and would not have to leave to use them.

Procedures

Prior to the beginning of the study, participant's hamstring flexibility was measured using the sit-and-reach method. The sit-and-reach method was used for this study because it is highly related to hamstring flexibility (Baltaci, Un, Tunay, Besler, & Gerceker, 2003). The participants were instructed to not have a warm up period before being tested. Participants were instructed to remove their shoes and to place the soles of their feet flat against the footplate. Hands and fingers were placed on top of each other with their palms face down on the Flex-Tester box. The hands were overlapped and the participants were instructed to keep their fingers at the same level to decrease error. The participant was then instructed to bend forward as far as possible and to push the sliding marker as they bent forward. The participant's knees were extended and they were instructed to not bend them when they were reaching forward. The examiner was checking to make sure there was no bend in the participant's knee during the measurements as well as to make sure that the fingers remained directly over one another. As the participant was bending forward they were pushing the sliding marker as far as they could reach.

The sliding marker was placed at zero centimeters to start and then pushed forward as far as the participant could reach. The researcher recorded the length at which the marked ended and that ended the first trial. The marker then was reset to the zero centimeters mark and the second trail was ready to begin. The participants completed three trials in total. The examiner then averaged their three scores together. The average scores were used to compare the pre-test measurement and the post-test measurement following the four week intervention.

The participants were divided into two different groups, a control group or a foam rolling group that was to use the foam roller two times per week. The participants were randomly assigned into each group and then were told which group they were in after they completed the initial sit-and-reach test. The participants were randomly selected into which group they were in by drawing their names from a hat. This method was used to try to eliminate any bias as to which group an individual was selected into. The participants that were assigned to the control group had their hamstring flexibility measured at the beginning of the study and then at the end of the study. Throughout the rest of the study they were instructed to continue with their normal activities. Participants in the foam rolling group were asked to use the foam roller two times per week for the four week duration that the study was being conducted. The foam rolling group was instructed on how to use the myofacial foam roller by the researcher prior to the study beginning. Participants were instructed to use the foam roller on their hamstring muscles for a total of 3 to 5 minutes.

To use the foam roller, the participants were instructed to sit on the ground and to place the foam roller perpendicular to their thigh under the belly of the muscles. Their arms should be extended behind them for support and for them to shift their weight so the posterior surface of the thigh moves forward and backward over the surface of the foam roller. They should use their arms to propel them back and forth so they roll over their entire hamstring muscle.

The participant's legs were kept straight with their ankle plantar flexed. The foam roller starts just under the gluteus muscles and should be rolled down the posterior leg to just above the knee. This movement should not be rushed but should instead be in a fluid motion over the hamstring muscle group at a comfortable pace. A key to ensuring a quality response from self-myofascial release is to perform the technique slowly with steady, constant movements. If participants go through the motions too quickly they will not reach their desired results (Snideman, 2011).

The participants were instructed to start with both legs on the foam roller and roll up and down their hamstrings for 30 seconds and then to take a 30 second break. Once their 30 second break was up, the participants were supposed to foam roll out just their right leg. When foam rolling only the right leg, the left leg was crossed over the right leg so that it was not resting on the floor. In order to increase the pressure on the soft tissue, all the participant has to do is apply more of their body weight to the roller (Cressey & Robertson, 2004). By crossing one leg and foot over the other, more load can be applied to target the hamstring muscle. After foam rolling the right leg out for 30 seconds they took another 30 second break. This same process was then done on the left leg following their break. Once the participant finished foam rolling their left leg and had rested they were done for the day.

Participants were also instructed to search for tender areas or trigger points while they were using the foam roller and to roll these areas out to decrease density and over-activity of the muscle. The researcher instructed the participants to use the foam roller for at least 3 minutes but the participants were allowed up to 5 minutes if they found those tender spots that needed extra time spent working them out. With a little direction on where to look, most participants easily find the tender spots on their own. Some people may need some instruction on the positioning of the roller, such as parallel, perpendicular, or 45 degrees, depending on the muscle (Boyle, 2006). The investigator was present during every day of the testing to be of assistance to any of the participants that were in the study.

The foam rolling group was asked to complete this sequence two times per week for the four weeks of the study. If a participant missed a class period during the time of the study, they were asked to foam roll their hamstrings outside of class. This was done to maintain consistency in the number of times that each participant used the foam roller. All participants were encouraged to continue living their daily lives as normal as before the test had begun.

At the end of the four week period of the study, the participant's hamstring flexibility was measured again using the sit-and-reach test. The same protocol and Test-Flex box was used for both measurements. The participants completed three trials, like they had during the pre-test, and the same researcher recorded the measurements to decrease the chances of error occurring. The mean of the three trials was recorded as the sit-and-reach distance. Following the post-test measurements, the pre-test and post-test mean measurements were compared to determine if there were any changes.

Data Collection

Data were collected during the pre-participation trials and after the study was finished. The researcher manually recorded the sit-and-reach measurement of each participant for the three trials. The researcher wrote down the distance that the participant pushed the sliding marker on the Flex-Tester box for each trial. Each participant completed three reaches in which they pushed the marker as far as they could on the box. The mean of the three trials was then calculated using a calculator and recorded; this was done for both the pre-participation measurements and after the testing period was finished. All of the data were recorded and stored in an Excel file that only the researcher and the faculty sponsor had access to. The data that were recorded in the Excel file were then imported into SPSS to be analyzed.

Data Analysis

Paired t test analysis was used to determine whether there was a difference in mean sit-and-reach distance between two groups. Ninety five percent confidence intervals were computed for all correlation coefficients. Statistical Package for Social Sciences (SPSS) was used for the statistical analysis. A alpha level of $p \leq .05$ was used to determine statistical significance in this study.

CHAPTER IV

RESULTS

The purpose of this study was to identify if using a foam roller to perform self-induced myofascial release (SMR) on the hamstring muscles would have positive effects and in turn increase hamstring flexibility. The effects were determined by measuring hamstring flexibility before and after four weeks of SMR.

Following the four weeks of the study paired t-tests were used to compare the mean hamstring flexibility scores between the control group and the myofascial foam roller group. The foam rolling group had 10 participants who started and completed the study. The control group had 10 participants who started the study but only 8 of the participants finished the study. The 2 participants who did not complete the entire study dropped out of the weight training class for reasons independent of their participation. For the final numbers analyzed for this four week study, there were 10 participants in the foam rolling group and there were 8 participants in the control group. Figures 1 and 2 describe the changes observed before and after the study.

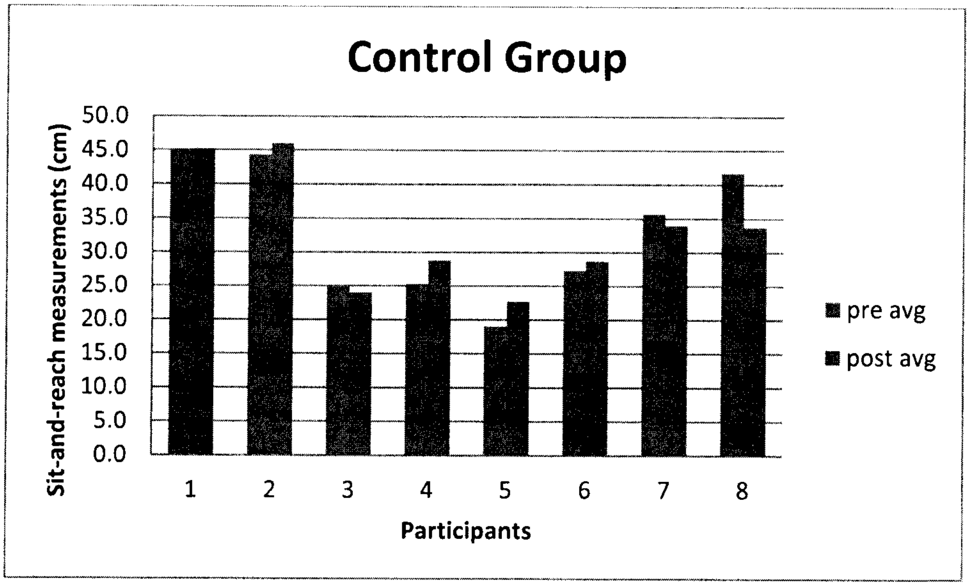

Figure 1: Pre-test and post-test results of the distance reached by participants in the control group.

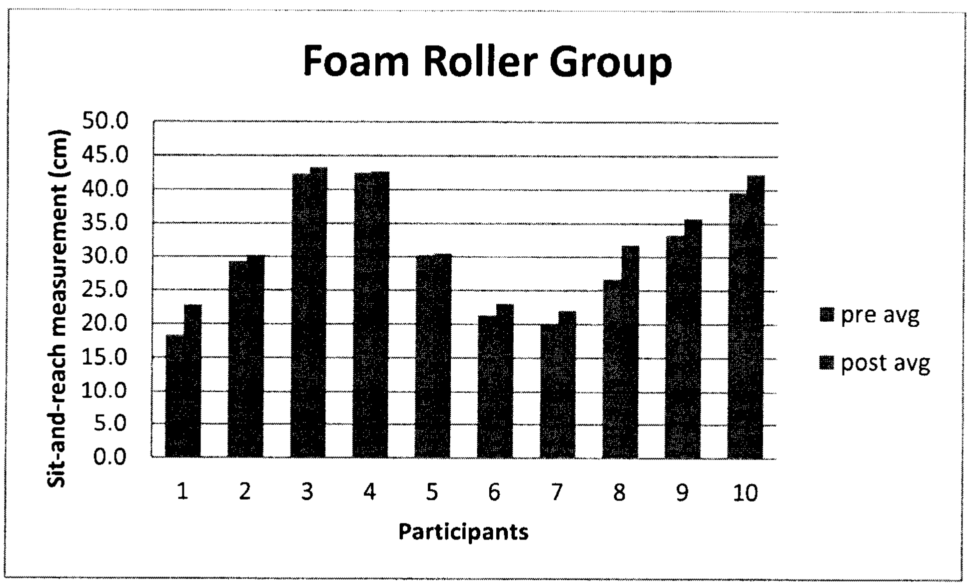

Figure 2: Pre-test and post-test results of the distance reached by participants in the foam roller group.

Each participant completed three trials of the sit-and-reach test and the mean of those three trials were then determined. The mean sit-and-reach pre-testing measurement for the control group was 32.89 ± 10.1 Standard Deviation (SD) centimeters and the post-testing measurement was 32.89 ± 8.8 SD centimeters. The pre-testing measurement for the foam roller group was 30.37 ± 9.0 SD centimeters and the post-testing measurement was 32.44 ± 8.4 SD centimeters. There was no significant change in sit-and-reach distance for the control group ($p=1.00$) while the observed change in response to 4 weeks of foam rolling was significantly greater after the intervention ($p= 0.004$). All of the data described above is also in Table 1 seen below.

Table 1: Paired t-test results for pre to post changes in sit-and-reach distance in the control and foam roller groups.

Paired t-test		
Control	Pre-mean	32.8875 cm
	Post-mean	32.8875 cm
	T score	0.000
	significance	1.000
Foam Roller	Pre-mean	30.3700 cm
	Post-mean	32.4400 cm
	T score	-3.912
	significance	0.004

The change of the mean length that the participants in the foam roller group could reach was a significant change. This was made clear when looking at the significance which was 0.004. With the significance being less than .05, this study is able to reject the null hypothesis. The hypothesis of this study stated that the use of a foam roller on the hamstring muscles two times per week for four weeks will increase hamstring flexibility.

The mean measurement for the first trials of the foam roller group was lower than for the control group. As mentioned previously, the pre-testing mean for the foam roller group was 30.37 centimeters and the control groups mean was 32.89 centimeters. The difference of these two groups was 2.52 centimeters. The mean measurement of the post-testing trials for the foam roller group was still lower than for the control group but there was less of a difference. The post-testing mean for the foam roller group was 32.44 centimeters and the control mean was 32.89 centimeters. The difference of the two groups after the study was .45 centimeters. There was a change of 2.07 centimeters difference from when the study started compared to when the study ended. For a visual example, the mean measurements for both groups can be found in Table 2 below.

Table 2: Pre-testing and post-testing mean measurements for the control and foam roller groups.

pre-mean foam	30.3700
pre-mean control	32.8875
post-mean foam	32.4400
post-mean control	32.8875

CHAPTER V

DISCUSSION

The objective of this study was to determine if using a foam roller on the hamstring muscle group would have positive effects and in turn increase hamstring flexibility. The hypothesis was that the use of a foam roller on the hamstring muscles every day for four weeks would increase hamstring flexibility.

Hamstring injuries are one of the most common injuries in sports and there is an increasing trend in their occurrences. The hamstring muscles actively work to flex the knee and extend the hip while also assisting with rotational movements and stabilization of the knee joint (Alter, 1996; & Gokaraju, Garikipati, & Ashwood, 2008). Hamstring muscle strains can be difficult to deal with because of the persistence of symptoms, the frequently unknown etiology of the injury, the slow healing process, and the high re-injury rate. Due to the high re-injury rate of the hamstring muscle, it would be beneficial to be able to decrease the likelihood of the initial injury taking place. There is no definite known cause of hamstring injuries but one possible cause is thought to be poor flexibility. This study did not focus on the likelihood of hamstring muscle injury occurring but solely on the aspect of hamstring flexibility and if it was affected after using SMR.

There are many interventions in which researchers and practicing medical professionals have tried to incorporate to reduce the incidence of soft-tissue injuries, such as hamstring injuries. Some of these interventions have focused on increasing eccentric strength, correcting strength imbalances, and improving flexibility. This study chose to focus only on the aspect of increasing flexibility. Muscles, joints, fascia, tendons, and ligaments all have an influence on flexibility. There are mixed reviews as to what the most beneficial way to increase flexibility may be but some of the most common techniques include static stretching, dynamic stretching, ballistic stretching, proprioceptive neuromuscular facilitation and myofascial release techniques.

Different types of myofascial release have become popular within recent years and are thought to be beneficial for decreasing soft tissue restrictions. It is suggested that myofascial release techniques reduce pain, increase tissue extensibility, and decrease muscle spasms as a result of breaking the pain-spasm cycle (Paolini, 2009). This is accomplished by releasing the muscle spasms and decreasing the adhesions, thus restoring normal homeostasis to the connective tissue (Paolini, 2009). Myofascial release is also used to help reduce resistive barriers or fibrous adhesions within the layer of the fascia. Applying tension and pressure with motion onto the fascia can help to alleviate adhesions and to alleviate acute spasms and chronic tightness (MacDonald, 2012). For this study, self-induced myofascial release was the type of intervention examined to determine the effect on hamstring muscle flexibility.

Self myofascial release, also known as self massage, is a form of soft tissue therapy that a person applies to themselves. This method is convenient for the individual receiving the treatment because they do not have to pay someone to help them and they can do self myofascial release techniques whenever is convenient for them. There are different tools that can be used for self myofascial release such as a foam roller, “The Stick”, massage balls, and even some sports equipment such as tennis balls or golf balls. This study focused only on using a foam roller as the tool to carry out self myofascial release.

The foam roller was chosen for this study due to the growing popularity of this tool in rehabilitation settings, as well as in gyms. This tool can be used for many different purposes such as core stability, balance, proprioception, and soft-tissue mobility. A decrease in soft-tissue mobility, or stiffness, has been identified as a potential intrinsic risk factor for soft tissue injuries, such as hamstring injuries (Watsford et al., 2010). Chronic flexibility training is thought to help reduce musculotendinous stiffness. This type of self myofascial release places direct pressure and a sweeping motion over the muscle with rolling on the soft-tissue, stretching the muscle, and generating friction between the layers of fascia. This friction is thought to be beneficial in breaking up the fibrous adhesions and restoring soft-tissue extensibility (MacDonald, 2012).

Another benefit of using the foam roller is that it can be maneuvered and used on many muscles in the body. Changing a persons’ positioning can help to exert the pressure of the foam roller on different body parts. The person uses their own body weight as the applied pressure and uses their own body to move them through the motion. There are different lengths of foam rollers which make them more travel friendly and easier to use on different parts of the body. The foam roller has been thought to correct muscular imbalances, alleviate muscle soreness, increase range of motion and flexibility, and to relieve joint stress (Curran et al., 2008; Fiscella, 2004; Snideman, 2011; & Swann & Graner, 2002).

When comparing the means for the two groups after the pre-trials, the control group had a greater mean than the foam rolling group. The starting mean for the control group was 2.5 centimeters greater than the foam rolling groups mean. After the four weeks that the study was conducted, the control groups mean did not change and the foam rolling group's mean increased significantly compared to the initial trials. As mentioned in the results section, the change was drastic enough to make the data statistically significant. These findings support the hypothesis that the use of a foam roller on the hamstring muscles two times per week for four weeks will increase hamstring flexibility demonstrating that the self myofascial release was effective for improving hamstring flexibility.

For this study, using a foam roller as the self-myofascial release tool showed to have a positive effect on hamstring flexibility. There has been speculation with little scientific proof that the foam roller can be beneficial, however, there are not many scientific studies to support this claim. This study did show some benefit for the subjects who used the foam roller every day for four weeks. The foam roller is said to increase flexibility due to the sweeping motion that occurs which decreases the amount of adhesions present beneath the skin. This study did not focus on the physiological changes associated with using the foam roller but instead just focused on if there was a change with hamstring flexibility. The investigator of this study speculates that the participants benefited from the foam roller because heat was produced when using the foam roller relaxed the muscles and the adhesions were then broken up from the sweeping motion which in turn increased the participants hamstring flexibility. However, there needs to be further research completed to analyze the physiological adaptations and to know if the adhesions being broken up were the cause of the hamstring increase.

The implications of the improvement seen on hamstring flexibility are still unknown. There is no scientific data saying that increasing hamstring flexibility will decrease the amount of hamstring injuries. There are many possible causes for the occurrence of hamstring injuries but research has not pointed out one main cause. This study needs to be conducted again with a longer duration to see if the improvements in hamstring flexibility would decrease the amount of hamstring injuries that would occur. A possible future study on a sports team would be ideal because the athletes could complete the study with foam rollers in the off season and during season the amount of hamstring injuries could be analyzed to see if there was a difference compared to previous season. It is unknown if the improvements seen in this study have a high enough magnitude to decrease the amount of hamstring injuries or possibly improve performance. Future studies would have to be conducted to analyze how much of an improvement is beneficial to have an effect on those aspects.

Reason for the Subjects and the Method

The subjects for this study were selected to get a variety of individuals involved. Many studies are done on the same type of person, (i.e. team or sport specific); this study used a random weight lifting class from Eastern Illinois University. The class used for this study had students who were just entering college as freshman up to students about ready to graduate as seniors. There were a variety of individuals with different areas of study and activity levels within this weight training class. Within the class there were some athletes who were familiar with working out and there were also individuals who lived more of a sedentary life and who had never been in an activity class before. The variety of individuals is beneficial to this study because the foam roller has been said to be useful and beneficial to all types of people. This study was completed at the same time for each of the testing days. The subjects had class from 11 am until 12 pm, so that helped to illuminate some chances of having varying results by using different times within the day. Subjects were randomly selected, based on drawing names from a hat, into either the foam roller group or the control group; this was chosen to try to get a better sense of the benefits of the roam roller on different types of individuals.

There are many different types of maneuvers and protocols that can be used to determine hamstring flexibility. This study used the sit-and-reach method for numerous reasons. The sit-and-reach method has been utilized by investigators and in studies for many years and it is seen as a reliable tool because there is not much room for error. This study was conducted by one investigator and there were 18 participants involved in this study. All of the testing was completed during the subject's weight training class at Eastern Illinois University. With the time allotted and the reliability of the sit-and-reach test it was the best choice for the technique used to measure hamstring flexibility because the sit-and-reach box is a portable tool that was convenient for this type of study.

Other possible techniques would include the active knee extension procedure or the straight leg raise test. These other two types of techniques leave room for investigator error and have more chances of varying results. Both of those procedures use a goniometer to get the measurements and the placement and likelihood of investigator error increases with that. Using the goniometer at two different times in a study may vary on placement that the investigator uses which could affect the results of the study. With using the sit-and-reach method, there is less of a chance that the investigator will make an error. The participant is instructed and observed throughout the study so that the body positioning is correct which eliminates possible error there. The subject pushes the sliding marker with both hands on the marker as far as they can reach without breaking the proper form. The investigator is only responsible for watching the participants form to make sure it is the correct way as discussed in the protocol and record the distance that the sliding marker moves. The sit-and-reach box is pre-marked with the measurements so it helps to decrease the chances of error. A possible negative of the sit-and-reach method is not taking into account the affect that calf and back flexibility. It is assumed that the sit-and-reach method solely looked at hamstring flexibility for this study but this type of maneuver could not take out the effects of those two other body parts. The same sit-and-reach box was used for the pre-test measurements and the post-test measurements for this study.

The results may have been different if the other two types of recording with the goniometer were used due to possible errors. The placement of the goniometer needs to be placed at the same locations both times and on the same spot for every individual. This would have been difficult for the investigator to do with 18 participants in the time allotted. If the other techniques were used hamstring flexibility would have been recorded with angles compared to the centimeters with the sit-and-reach box. The sit-and-reach method can be used in a repeated test by a different investigator and have close to the same measurements, but with a goniometer it would be difficult because investigators may line up the points differently. After reviewing all the possible ways to determine hamstring flexibility, the sit-and-reach technique was chosen to help produce the most accurate results.

Benefit for Athletic Training and Other Health Care Fields

Evidence-based practice is an approach to clinical practice that has been gaining importance in medical fields as of recent years. This type of practice has been around health care fields such as nursing for quite some time, but the field of athletic training has been trying to adopt these practices for the past couple of years. Evidence-based practice is making decisions about the clinical care of individual patients based on the current best available evidence in the professional literature (Prentice, 2009). Another important aspect of evidence-based practice is that it helps to keep treatments and rehabilitation, evaluation skills, and effectiveness of therapeutic modalities up to date. Without using the best available evidence, it is hard to give the best care possible to the individual being cared for (Hertel, 2005). Its basic thoughts are that practical decisions should be made based on research studies and that the research studies are considered evidence. Usually the types of studies that are considered to be evidence are those that are quantitative studies instead of theoretical studies and qualitative studies. This study is a quantitative study that showed to have statistically significant results in favor of the foam roller for hamstring flexibility. This study could be beneficial for other health care fields because it shows evidence, at least for this current study, that this type of self myofascial release did have a positive effect on the hamstring muscle group flexibility of the participants. There is no evidence as of yet that increased hamstring flexibility will decrease hamstring injuries but decreased flexibility is seen as a potential cause for injuries. There is not very much statistical data out today on the use of the foam roller instead it is more anecdotal evidence; which health care fields are trying to move away from.

There are many health care professionals and facilities that are starting to utilize the foam roller as a self myofascial release technique. However, there is very little data stating the true benefits of the roam roller. The popularity of the foam roller has grown so rapidly in the past years that there has not been time for the studies and research to be done on all the possible benefits. As of late, there is beginning to be more research on the topic of the foam roller but there are a lot of areas in which need to be looked and determined if it is beneficial. Individuals who utilize the foam roller have positive comments about the tool but that cannot be relied upon for long. The popularity of this tool has begun to open eyes of many health care practitioners but to be able to give reliable information to the individuals being helped, there needs to be more research done on the foam roller. This study looked only at the effect the foam roller had on the hamstring muscle group in regards to flexibility. The foam roller is a tool that can be used on many different body parts but there is no evidence out yet saying that it will be beneficial for other aspects of the body. With time there will be more research on the foam roller but for the time being, this study can hopefully be used as a stepping stone to show that using the foam roller has a positive effect on hamstring flexibility.

Limitations

This study had several limitations. Data in this study were obtained from a small sample size. The final number for this study was 8 participants in the control group and 10 participants in the foam rolling group. The data did prove to be statistically significant but the small sample could poorly represent the true population because this study was done on only one weight training class at Eastern Illinois University. Even with the small participant size, this study can be used to help create other studies that have more participants.

This study was only conducted on college age individuals, so the possible effects of using the foam roller on different age groups was not able to be determined. With more of a variety in participants of different age, the results may differ than with this study. However, with the positive results that this study did show, the foam roller can be seen as a beneficial tool for this age group in relation to hamstring flexibility.

Finally, the participants in the foam rolling group were relied upon to roll out their hamstrings two days per week for the duration of the study and the time that was set to utilize the foam roll. They were allowed to foam roll during any part of the class period and the investigator was present every day. The time in which the participants used the foam roller was not timed with a stop watch to make it exactly the same each time so the participants were relied upon to try to be consistent with how long they used the foam roller. The participants in the foam rolling group were instructed how to utilize the foam roller properly for this study, as described in the methods section, but they were also told to focus on any tender areas they might have. Some participants might have had more tender areas or trigger points than others and focused on those areas instead of completing the 30 seconds for each method of foam rolling. If participants did not follow the exact time line given or the correct procedure the results may not be the same for future studies. There were no previous studies that had mentioned the proper amount of time to utilize the foam roller, so for this study the time frame was from 3 to 5 minutes depending on how many trigger points participants had.

Conclusion

This study showed that subjects using the foam roller had a greater improvement in hamstring flexibility compared to those in the control group. It was concluded from the results of this study that in this sample of college age individuals enrolled in a weight training course, four weeks of self myofascial release therapy produced significant improvements in hamstring flexibility compared to a control.

Future Studies

To ensure that this study was reliable and would have the same results in future studies, a larger sample size should be used. This study only had 18 college age participants in total which does not depict the population as a whole. This study used a weight training class to allow for a variety of individuals, but a question that should be answered is would the results be the same if athletes of a sport were to be the only participants in the study. Another population that would be of interest to complete a study on would be the older population. Manufactures of the myofascial foam roller advertise that this tool will be beneficial for all individuals of any age and body build. It also could be interesting to complete a study that has both younger and older individuals partaking in a randomized study to determine if the results that this study had would truly represent the populations.

Another interesting aspect that could be looked at with foam rollers is the duration at which the results last. The current study showed statistically significant increase in hamstring flexibility but will those results last for very long if the individuals do not use the foam roller. Looking at their results after stopping the use of the foam roller could be interesting to see if they still have any of the increased flexibility that they had gained from the study; or how quickly did their flexibility return to what they were prior to the testing.

This study focused on hamstring flexibility due to the high incidence rates of hamstring injuries, but an area that needs to be looked at more carefully is if flexibility plays a role in risk of injury. There are mixed reviews as to if flexibility is a risk factor for injury. If this study was to be done over a longer time frame, the two groups could be compared and seen if the incidence of hamstring injuries decreased with the seen benefits. This would be a difficult task to do with the current participants in the study due to them not all participating in activities that put them at risk for hamstring injuries. If this study was conducted on a sports team that are seen to be at a high risk for hamstring injuries, it would be interesting to see if implementing the foam roller into weekly routines would decrease the likelihood of hamstring injuries.

Other future studies could vary the duration of the study as well as the amount of times per week the participants are foam rolling or the amount of time that they are actually using the foam roller. There has not been much reported on the best known duration for using the foam roller so determining that could be a big step for individuals who use the foam roller. The frequency of use of the foam roller is also a big question that many people have. How many times per week is most beneficial for using the foam roller and would using the foam roller before or after an activity be better or more beneficial. There are a lot of areas in which could be looked at with the foam roller because not much is known on the topic. Within a couple years, there will probably be more research out on this instrument due to the popularity that it has had. There are many different locations in which foam rollers are being utilized and the varying individuals who could benefit from using it.

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APPENDIX A

CONSENT FORM FOR PARTICIPANTS

Consent Form

Dear Student:

My name is Elizabeth Sherer and I am a graduate student from the Kinesiology and Sports Studies department at Eastern Illinois University. I am sending this letter to explain why I would like for you to participate in my study. This study is designed to assess whether using the foam roller will increase their hamstring flexibility.

With your permission, I will assign you to either be in the control group or in a foam rolling group. Your participation in this study is completely voluntary and will not affect your weight lifting class in any way. You may quit this study at any time by simply telling me that you no longer want to continue. There will be no consequences of any kind if you decide to withdrawal from this study. The study will be conducted for the duration of a month in the weight training room. All participants will complete the sit-and-reach test prior to testing and following the testing. Participants will be randomly assigned to which group they are partaking in. Participants in the foam rolling group will roll out their hamstrings for a total of three minutes two times per week. Participants in the control group will only take part in the measurements before and after the test. There are no known risks involved in this study and you will not receive any compensation for your participation. A possible benefit of participating in this study is that you may experience an increase in hamstring flexibility.

To protect your confidentiality, myself and my faculty sponsor, John Storsved, will be the only individuals who has access to the data. This data will not be shared with anyone, unless required by law. I will store the data in Excel on my computer and use a number in the place of your name. The results of this study will be maintained by me, Elizabeth Sherer, and my faculty sponsor, Dr. John Storsved. If you have any questions or if you would like to receive a final copy of this report please contact me at (515) 953-8032 or email me at edsherer@eiu.edu.

This letter will serve as a consent form for your participation and will be kept in the Athletic Training office at Eastern Illinois University. If you have any questions about this study, please call Dr. John Storsved, the faculty sponsor of this project at 217-581-2690.

If you have any questions or concerns about the treatment of human participants in this study, you may call or write:

Institutional Review Board
Eastern Illinois University
600 Lincoln Ave.
Charleston, IL 61920

Telephone: (217) 581-8576
E-mail: eiuirb@www.eiu.edu

You will be given the opportunity to discuss any questions about your rights as a research subject with a member of the IRB. The IRB is an independent committee composed of members of the University community, as well as lay members of the community not connected with EIU. The IRB has reviewed and approved this study.

Please return this form to your basketball coach by January 14th, 2013.

Sincerely yours,

Elizabeth Sherer

I, _______________________________________, hereby consent to the participation of the investigation herein described. I understand that I am free to withdraw my consent and discontinue my participation at any time.

____

Signature of Participant Date

I, the undersigned, have defined and fully explained the investigation to the above subject.

____

Signature of Investigator Date