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The Effects of Different Warm-Up Modalities on Gluteus Medius Activation

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THE EFFECTS OF DIFFERENT WARM-UP MODALITITES ON GLUTEUS MEDIUS ACTIVATION

BY

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ABSTRACT

PURPOSE: Muscle imbalance assessment and treatment practices are becoming more commonplace in the field of strength and conditioning. For instance, exercises such as monster walks are being prescribed as a warm-up exercise with the specific aim of activating and/or strengthening the gluteus medius (GM) muscle. There is evidence to suggest that an individual with either a weak GM or one that is delayed in its onset has an increased risk of injury. However, this relationship has not been established in a resistance trained athletic population. Further, there is no evidence that commonly used glute activation (GA) exercises will acutely increase recruitment capabilities of the GM. Therefore, the primary purpose of this research is to examine the effects of different warm-up modalities on GA. METHODS: Nine men (age: 20.7 ±2.1 yrs; body mass: 86.0±12.97 kg; height: 177.5±13.1cm; body fat percent: 12.66 ± 4.0) and thirteen women (age: 20.2 ±1.4 yrs; body mass: 73.73±12 15.6 kg; height: 165.1±12.8cm; body fat percent: 22 ± 4.2) volunteered to participate in this randomized, cross-over study. Each participant was tested for GA using EMG while performing manual field tests (Cook Hip Lift and a Side-lying Abduction Test) prior to and after performing one of two warm-up exercise conditions; a standard dynamic warm-up (DW) or common GA exercises. Statistical significance was set at $p \leq 0.05$ RESULTS: There were no significant differences in EMG activity between the GA exercise and the DW condition as measured by area under the curve of the integrated EMG signal. There were also no main effects of the pre and post conditions. CONCLUSION: The findings suggest that a non-injured, athletic population is able to activate the GM without any additional stimulation. The resistance training experience of the participants varied greatly but all had at least 6 months prior training experience. Future studies should examine if there is a relationship between resistance training and GA, however it is possible that resistance trained athletes can adequately strengthen the GM through the course of normal training and subsequently would have no problems recruiting the GM. PRACTICALAPPLICATIONS**:** Strength & conditioning professionals have limited time with athletes. When coaching a resistance trained athletic population, the results of this study suggest strength & conditioning professionals should reallocate time spent on GA assessment to protocols that will enhance performance.

ACKNOWLEDGEMENTS

I would like to acknowledge and express sincere gratitude to all of those who have supported me throughout my graduate career at the University of Rhode Island. First and foremost, I would like to thank my graduate advisor, Dr. Disa L. Hatfield, for your continuous support and guidance throughout my graduate career at the University of Rhode Island. I am extremely grateful at all of the opportunities you have provided me with as a graduate student. They are very much appreciated. Thank you to my committee members, Dr. Deborah Riebe and Dr. James Agostinucci for all of your support and guidance throughout my graduate career. And thank you to my thesis defense chair, Dr. Peter Blanpied, for taking time out of your busy schedule to chair my thesis project.

Finally, I would like to thank my family for your love and support throughout my college career. You have provided me with the aspiration to try, the self-confidence to fail and the tools to succeed. I will be forever grateful.

Preface

This thesis is written to comply with the University of Rhode Island graduate school Manuscript Thesis Format. This thesis contains one manuscript: *The Effects Of Different Warm-Up Modalities On Glute Medius Activation.* This manuscript has been written in a form suitable for publication in *Journal of Strength & Conditioning Research*.

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INTRODUCTION

The field of Strength & Conditioning has grown exponentially in recent years. Founded in 1978, the National Strength Coaches Association (NSCA, 2012) has grown from 76 members in the United States to a current membership of over 30,000 in 52 countries (NSCA, 2012). A strength & conditioning professional's primary objective is to improve on-field performance of athletes (Oliver, G. D., Dwelly, P. M., et al., 2010).

Recent anecdotal evidence suggests strength coaches are performing muscle imbalance assessments and treatment practices to help achieve their primary goal. One area of focus of these practices is the gluteus medius. Exercises aiming to activate this muscle have become commonplace despite a lack of research in athletic populations.

Though research is limited, focused research on the gluteus medius is crucial to understanding movement. The lumbopelvic hip complex is made up of 29 pairs of muscles acting to stabilize the spine, pelvis and hips during movement. (Oliver et al., 2010). The gluteal muscles play an important role when it comes to athletic movement, acting as the primary hip abductor and providing frontal plane stabilization for the pelvis (Presswood, L., Cronin, J., et al., 2008). The primary role of the gluteus medius (GM) is to provide stability to the hip (Niemuth, P., 2007). Without adequate knowledge of the role the GM plays in athletic performance, athletes may be at higher risk of injury.

Disorder within the lumbopelvic hip complex have been associated with upper and lower extremity injuries (Oliver, et al., 2010). In particular, weakness has been associated with lower extremity injury and weaknesses in the hip abductors and external rotators have been identified as the best predictors of lower extremity injury (Niemuth, 2007). Activation disorders in the GM specifically has been linked to ACL tears, illiotibial band syndrome and patella-femoral syndrome and is also related to Trendelenburg gait. This reduction in gait efficiency causes a reduction in running speed (Presswood et al., 2008). There is evidence that activation of the GM is different in pathological and non-pathological populations (Tyler, T.F, Slattery, A. A., 2010). One study examined GM activation patterns in participants with chronic ankle sprains (Niemuth, 2007). The authors reported significantly slower EMG recruitment patterns of the GM in participants with hypermobile ankles. The same study also reported that the injured leg had significantly weaker hip abductors when compared to the non-injured leg but there was no difference in hip extensor strength (Niemuth, 2007). This clearly demonstrates that there is an association between activation and injury.

Because of the obvious importance of GA, most of the research has focused on injury prevention and pathological populations. (Luhban, A.J., Kernozek, T.W, et al., 2011). Side-lying hip abduction (SLHA) was used by Mascal and Powers in two case studies to manage patellofemoral pain and the results indicated the exercise was useful in abating pain in the participants (Mascal, C.L., Landel, R., Powers, C, 2003). Additionally the SLHA was used by Fredericson et al., to successfully rehabilitate recreation distance runners with Illiotibial Band Syndrome (Fredericson, M., Cookingham, C.L., Chaudhri, A.M., et al., 2000). Niemuth recommended the “monster walk” exercise to rehabilitate and strength the GM in injured atheltes. (Niemuth, 2007). Despite the prevalence of GA exercises in physical therapy settings and the growing presence in strength & conditioning facilities (Oliver, 2010) the literature is sparse when it comes to GA exercises and its effects on performance in a healthy athlete (Presswood et al., 2008).

Studies examining GA have been undertaken in non-resistance trained populations, however their application to a resistance trained, athletic population is questionable.

Recent research suggests that traditional static stretching prior to exercise does not provide the increased performance nor injury prevention that it was previously believed (Frantz, T.L. and M.D. Ruiz , 2011). A result of this has been an increased use of the dynamic warm-up (DW). The DW utilizes active motion and momentum rather than stretching at rest. The DW has emerged as the more modern way of preparing athletes for physical activity. This method utilizes active movement instead of static stretching at rest (Frantz, T.L. and M.D. Ruiz , 2011). While this method has been proven to better prepare athletes for physical activity it has not been studied as a valid form of muscle activation. However, many of the movements performed such as squatting, lunging and shuffling in DW mimic those that have been reported to activate muscles (Frantz and Ruiz, 2011; Luhban et al., 2011). Thus common DW protocol may provide enough of a stimulus to activate the GA without the need of performing additional, specific GA exercises.

Currently, laymen's literature prescribes the use of GA exercises for healthy, resistance-trained populations. The use of these exercises has been recommended as a warm-up as well as additional work after the warm-up (Martinez, 2012; Inspire Training Systems). These recommendations are all based on anecdotal evidence, have not been supported by the current research literature and were not published in refereed journals.

Therefore, the purpose of this study was to examine the affects of different warm-up modalities on acute GA. The researchers hypothesized that there would be no difference between warm-up modalities and acute GA as measured by EMG values during two separate tests

METHODS

Experimental Approach to the Problem

This was a randomized, crossover design that consisted of each participant completing 3 testing sessions. Participants completed a single informational visit consisting of the signing of an informed consent (Appendix I) and health history questionnaire (Appendix II) as well as anthropometric measures. Afterwards, every participant received each intervention in a randomized order. Two intervention testing sessions consisted of the participant completing a DW or a GA exercise protocol l. During each trial every participant was tested for GA using EMG while performing manual field tests. One week later the participant received the other condition.

Participants

Twenty-two (female =13 age: 20.2 ±1.4 yrs; body mass: 73.73±12 15.6 kg; height: 165.1±12.8cm; body fat percent: 22 ± 4.2, male=9 age: 20.7 ±2.1 yrs; body mass: 86.0±12.97 kg; height: 177.5±13.1cm; body fat percent: 12.66 ± 4.0) URI athletes between the ages of 18 and 25 were recruited for the study (which was approved by the University of Rhode Island's Institutional Review Board) and signed an Informed Consent. Inclusion criteria were that the participant had to be a current athlete at URI and uninjured.

Procedures

Anthropometric Measures

Anthropometric measures were taken. Weight was measured with a digital scale (Life Measurements Incorporated, Concord, CA). Height was measured using a wall-mounted stadiometer at the first intervention. Body composition was assessed using air displacement plethysmography (Life Measurements Incorporated, Concord, CA).

Field Tests

Two field tests were used to assess each participant's GA. The first GA test used was the Cook Hip Lift (Boyle, M., 2004). To perform the test the participants lay supine with their feet flat on the ground. One knee was pulled to the chest and held there. A tennis ball was placed between the knee and the abdomen; a cue used to ensure the hip stays flexed. From this position the participant pushed through the foot on the floor and extended the hip while keeping the opposite knee as close to the chest a possible. A 4-point grading sheet was used based on techniques commonly used in the field (B. Hartmen, personal communication, 24 September 2013)(Appendix III). The test was graded as Pass/Fail with a failing grade being received if two or more of the grading criteria were not met.

The second GA test used in this study was the side lying hip abduction test (SLHA). Participants' lay on their side. The top leg remained straight while the bottom leg was bent. They then abducted the top leg through a full range of motion, brought it back to the start position, then abducted the leg again against manual resistance from an investigator. Investigators applying the resistance were given the same instructions and were familiarized with this field test. This test was chosen over other tests because it is a common field test in the strength and conditioning field (Presswood et al., 2008). The participants were then scored based on established criteria set forth (Appendix IV). The SLHA was originally devised for patients with neurological disorders but it is the most commonly used test for non-pathological populations (Presswood et al., 2008).

EMG Measures

The GM was recorded during the field tests using a Biometrics data acquisition system and analysis EMG system (Biometrics Ltd. Newport, UK). The skin over the GM muscles was shaved and cleaned in preparation for electrode placement. One bipolar 9mm silver/silver-chloride EMG surface electrodes was midway between the iliac crest and the greater trochanter on the skin overlying the GM (Earl, 2004; O'Dwyer, C., Sainsbury, D., et al., 2011). A rectangular metal plate (3-5 cm) was used as the ground electrode and was placed on the upper thigh of the opposite leg. The electrodes were secured to the skin with tape. The myoelectric signal was amplified 1000x with a band pass filter of 100-1000Hz. Signals were digitized at 1000Hz using a Biometrics data acquisition system and analysis EMG system.

For analysis, the EMG signal was full wave rectified and integrated using the "work done" function with the Biometrics Analysis software. Area under the curve was then identified. For the CHL values, analysis began at the start of EMG activity and ended after eight seconds. For the SHLA values, analysis began at the start of EMG activity and ended after two seconds. All values are expressed by microvolts per second (mv-s).

GA Intervention

In the GA intervention participants performed one exercise called the “monster walk” exercise. During the “monster walk” participants stood in a half squat position and then stepped laterally. During each step the lead leg abducted landed just outside the shoulders, then the back leg adducted and returned the body to the starting position. A resistance band was placed just below the knee. A medium resistance “mini band” was used for all participants (Perform Better Ltd., Cranston, RI). Ten steps were performed to the participants’ right and then 10 more steps were performed to the participants’ left for each set. Three sets were performed with a thirty-second rest interval.

DW Intervention

The DW intervention was the standard DW used by URI Strength and Conditioning staff. Synthesized from commonly used techniques, (Boyle, M., 2004, Frantz and Ruiz, 2011) the DW used was one set forth by the URI strength & conditioning staff. Appendix V lists the exact order of the routine and describes the movements. All movements were performed one way for 47 feet (half the length of a basketball court). It is, however, important to note that the exact specifics of the routine are not are seen as the primary method of activation, rather the routine as a sum of all its parts. Any arrangement of dynamic exercises would produce comparable results (Frantz and Ruiz , 2011).

Controls for Internal Validity

Participants were asked to wear the same footwear for both trials. In addition, they were asked to refrain from caffeine for 24 hours prior to the trials to control for any possible ergogenic effects. The researchers also asked them to maintain their normal diet throughout their time in the study. Testing was scheduled for the same time of day for all trials to minimize any differences in eating and sleeping patterns.

Statistical Analysis

All data was tested for normalcy with Levene's Test For Equality Of Variances. A repeated measures ANOVA (Time x Intervention) was performed to analyze the data, with time being pre- and post-testing measures and trial being the DW and GA interventions. Significance for all analysis was set a $p \leq 0.05$.

RESULTS

There were no significant effects of time or intervention in the area under the EMG curve during the Cook Hip Lift or the SLHA. Figure one illustrates CHL area under the EMG curve values for male and female participants before and after the DW intervention. Figure two shows CHL area under the EMG curve values for male and female participants before and after the GA intervention. Figure three shows pre and post area under the EMG curve values for the SHLA in both male and female participants for the DW intervention. Figure four illustrates pre and post area under the EMG curve values in both male and female participants during the SLHA for the GA intervention.

DISCUSSION

The major finding of this study was that neither a DW nor GA exercise had a significant effect on acute activation of the GM. The current investigation indicates a DW is sufficient to activate the GM without additional GA exercises.

Similar to the current study, Soderberg and Dostal investigated GM activation in a healthy population. Supporting the findings of the current study, these studies suggest that healthy, adult populations are able to effectively activate the GM. However, no athletes were used in those studies. Fredercison et al., examined between limb differences of GM strength in distance runners with illiotbial band syndrome. Twenty-four (female=14, male=10) collegiate and club long-distance runners performed the side-lying abduction test on both the injured and non-injured legs. The results revealed that the injured leg created significantly less force than the non-injured leg (Fredericson, 2000). The results indicate that injury to the GM is a major cause of decreased activation in the injured leg only. Along with illiotibial band syndrome, GM dysfunction can also include patellofemoral pain and Trendelenbrug Gait, in which the GM is weak and cannot support the hip during single-leg stances (Presswood et al., 2008). Consequently, the pelvis tilts downwards towards the leg that is in motion (Presswood et al., 2008). However, the results of the Fredericson et al. (2000) study suggest that GA is decreased only when injury or dysfunction is present, therefore a healthy athletic population would not require additional specific GA exercises.

There is research to support the use of the DW as a GA modality in a non-injured population. Luhban et al. examined activation of the GM during commonly used therapeutic exercises. Eighteen healthy females between the ages of 18 and 26 performed double-leg squat, single-leg squat, and front step-up unloaded as well as double-leg squat, single-leg squat, and front step-up with a resistance band around the knees. The investigators report GM activation when performing unloaded double and single legged squats as well as single leg step-ups, which are common exercises performed in a strength and conditioning facility (Luhban et al., 2011). However, the study was descriptive in nature. The study merely outlined the amount of GM activation pre and post exercise; it did not compare these modes to any other form to GA exercises. Nonetheless, the exercises utilized by this study are similar to those used in a DW.

In a similar report, Soderberg and Dostal performed a randomized, crossover study in order to examine the onset and activation of the GM during functional activities. Ten healthy, adult participants were asked to perform shoe tying on a knee, crawling, running, stair climbing and walking. Electromyography measures were lowest for shoe tying while on one knee but there was no statistical difference in EMG activity for running, stair climbing and walking. (Soderberg and Dostal,1976). This suggests that a typical DW, complete with single-leg exercises, provides enough stimuli to activate the GM.

In addition to the type of movement, load intensity may be a factor in EMG GM activity. Complementing the study done by Soderberg and Dostal, Earl examined the activity of the GM during single-leg stances when a load is applied. Twenty healthy, adults participated in the study. Each participant was attached to a cable column and asked to hold a single-leg stance for five seconds. Two trials were performed two minutes apart with loads of 2.26 kg and 4.53 kg respectively. The greatest EMG activity of the GM was observed at the 4.53 kg load (Earl, 2005), indicating greater GA with heavier loads. In the current study, a wide range of athletes participated. The athletes were involved in a variety of sports including power and endurance sports and it can be hypothesized that they had vastly differing strength capabilities. Only one standard resistance band was used for the GA intervention and it may be the resistance band provided a greater relative level resistance for some of the weaker athletes and less for the stronger athletes, leading to differences in recruitment of the GM. Thus, this may explain the high standard deviation during the GA intervention.

The participants had all been resistance training for at least 6 months and many had been resistance training for several years. Exercises typically included in the strength training programs including squats, dead lifts and variations of the power clean. All of these exercises activate the GM. The hypothesis is that because the participants in the current study were very-well resistance trained athletes, their GM was strong and properly functioning. Current research literature supports this hypothesis. Deschenes and Kraemer (2002) indicated that neural adaptations continue after the commonly cited initial four to eight weeks of resistance training and that after 12 months these neural adaptations may be play a significant role in further strength gains. Neural adaptations include increased muscle recruitments, increased firing rate of muscles and a decrease in inhibitory mechanisms. This may be the reason why the participants in the current study all had recorded EMG GM activity.

The laymen's literature suggests that activating the GM is an important part of an exercise program. Martinez (2012) suggested performing the "monster walk" 15 to 20 minutes prior to performing squats. Additionally, Reinold (2009) recommended including the SLHA as a component of the warm-up. This strategy is seen in other training programs, a sample exercise program from Neal Pire at Inspire Training Systems suggested using the SLHA in a warm-up prior to a workout (Inspire Training Systems). The findings of the current study suggest that athletic populations do not require specific GA exercises for successful GM activation. Thus, the use GA exercises are of a questionable nature, especially in strength & conditioning settings. The laymen's literature, however, recommends the use of GA for in broad populations: healthy athletes, elite athletes, and young athletes.

To further the influence of GA exercises in strength & conditioning settings, Brett Contreras (2010) performed a pseudo-scientific study where EMG was used on the GM in an effort to discover the three "best" exercises to target the muscle. Contreras then performed 25 different exercises. This study was not published in a peer-reviewed, scientific journal but rather on his blog. His "findings" are contrary to the previous controlled study done by Earl. Contreras suggested that the light loads were best at activating the GM. However, Contreras provided no detailed methodology. No subject numbers, inclusion and exclusion criteria randomization, exercise order or statistical measures were specified. Correspondingly, nothing was controlled for in the study. Contreras did not control for injury status, prior exercise experiences and diurnal variations as the current investigation did. Because there is a lack of methodology, there is no way of knowing if Contreras performed all the exercises on the same day. If so, certainly fatigue would the internal validity of the study (Contreras, 2010). The work done by Contreras further exemplifies the growing need for well planned, controlled studies like current investigation. To date, the laymen's literature is dominated by anecdotal evidence such as this.

Using the area under the rectified EMG curve is standard practice for quantifying raw EMG data (AD Instruments, 2012). Brindle et al., (2003) used area under the curve to examine changes in EMG activity during stair ascent and descent. Sixteen participants (female =12, men = 4) were analyzed for GM activity during stair ascent and descent. Patients had reported anterior knee pain during the previous two months. Then a control group (n=12, female = 7, men = 5) performed the same task. Participants in the control group had no prior history of knee pain. The results indicated that participants with knee pain showed delayed onset of the GM as well as shorter durations of activity while ascending stairs when compared to participants with no knee pain. While descending stair participants had shorter durations of EMG activity than those who had no knee pain (Brindle, 2003). This study demonstrates that measuring the area under the curve is an effective way of analyzing EMG data.

The current study had several strengths. Participants performed both visits within one week of each other. Also, both testing visits were done at the same time on the same day in random order, which ensured that the participants were in similar states during the visit. In this way participants acted as their own controls. Additionally, all the participants were athletes who had performed the movements before at the same facility with the same coaching staff. Participants had also been resistance training at URI for at least than six months. In addition, electrodes were placed by only investigator and once the electrodes were placed they remained intact during the entire trial. Electrodes were not continuously placed, removed and replaced. This decreases the amount of potential error and ensures that the same muscle was being tested throughout the entire trial. Also, during pilot testing intra-rater reliability (coefficient of variance) was less than 3%.

However, the study is not without its limitations. Prior to the current study, the strength & conditioning coaches did not have a systematic way of performing the side-lying abduction test. This may have lead to a variable amount of pressure applied to each participant's leg during the test, resulting in inconsistent GM activation. However, the SLHA test is a common field test that is performed in strength and conditioning settings (Presswood, et al., 2008). Despite the limitations of the SLHA test, it was chosen for high external validity. Also, the same resistance band was for each participant. While this may have aided in inflating the high standard deviation due to differences in strength, it is possible that it would have been even higher had some athletes used a band that offered more resistance.

This is the first study to examine the acute effects of both a DW and GA exercises on GA. The results indicate that strength & conditioning coaches would be better suited performing only the DW instead of allotting time to GA exercises. A standard DW offers well-researched benefits such as increased blood flow to warm the muscles as well as physiological preparation for a work out (Frantz and Ruiz, 2011). Future studies should examine the potential chronic effects of GA exercises in resistance trained, athletic populations.

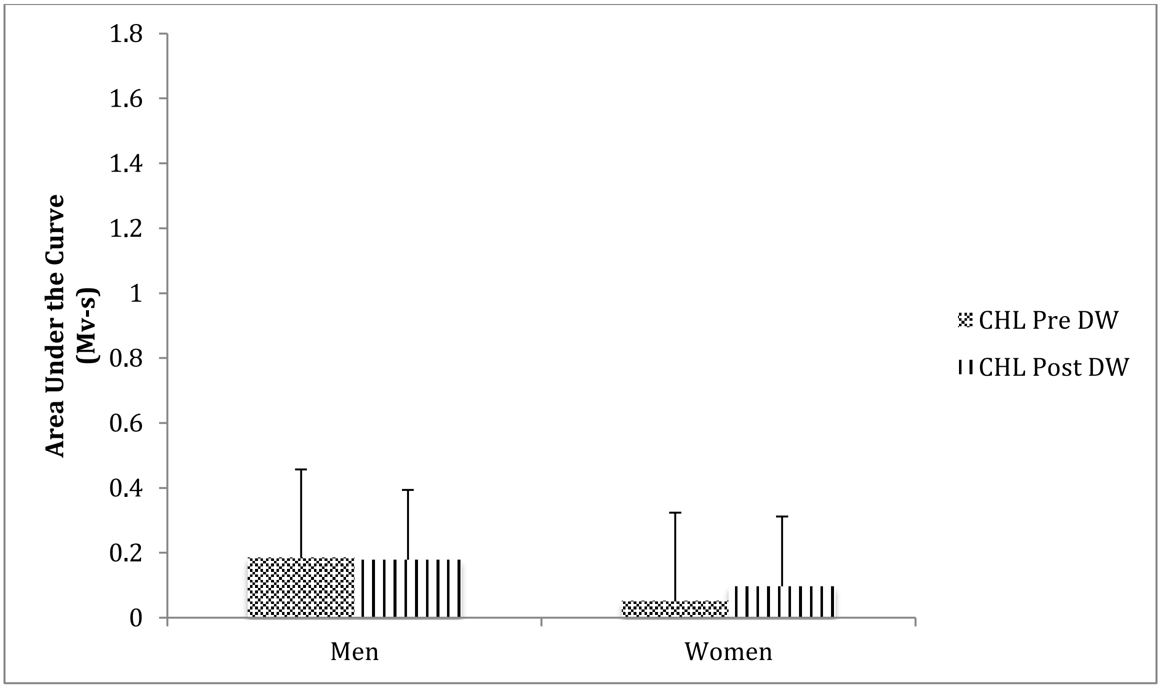
Strength & conditioning professionals have limited time with athletes. When coaching a resistance trained athletic population, the results of this study suggest strength & conditioning professionals should reallocate time spent on GA assessment and treatment to protocols that will enhance performance.

TABLES AND FIGURES

Table 1. Participants Descriptive Data

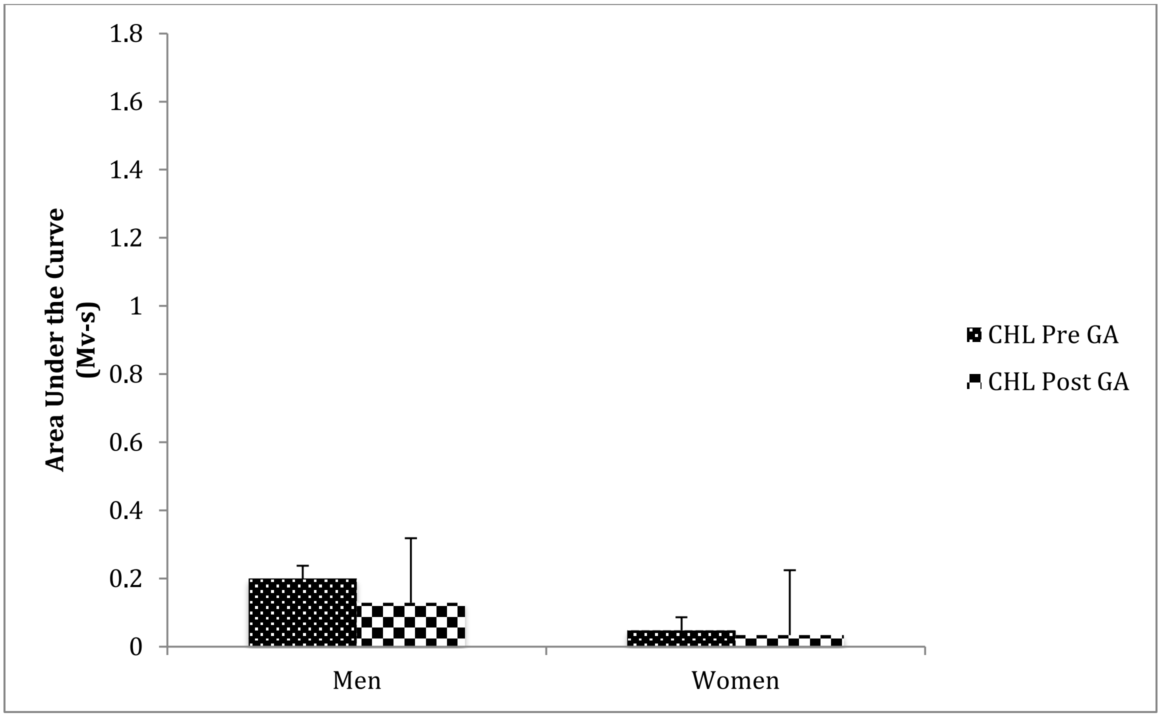
	Men	Women
N	9	13
Age (years)	20.7 ± 2.1	20.2 ± 1.4
Body Mass (kg)	86.0 ± 12.97	73.73 ± 15.6
Height (cm)	177.5 ± 13.1	165.1 ± 12.8
Body Fat (%)	12.66 ± 4.0	22 ± 4.2

Figure 1. Cook Hip Lift Pre and Post Area Under The EMG Curve Values For Male and Female Participants For Dynamic Warm-up Intervention



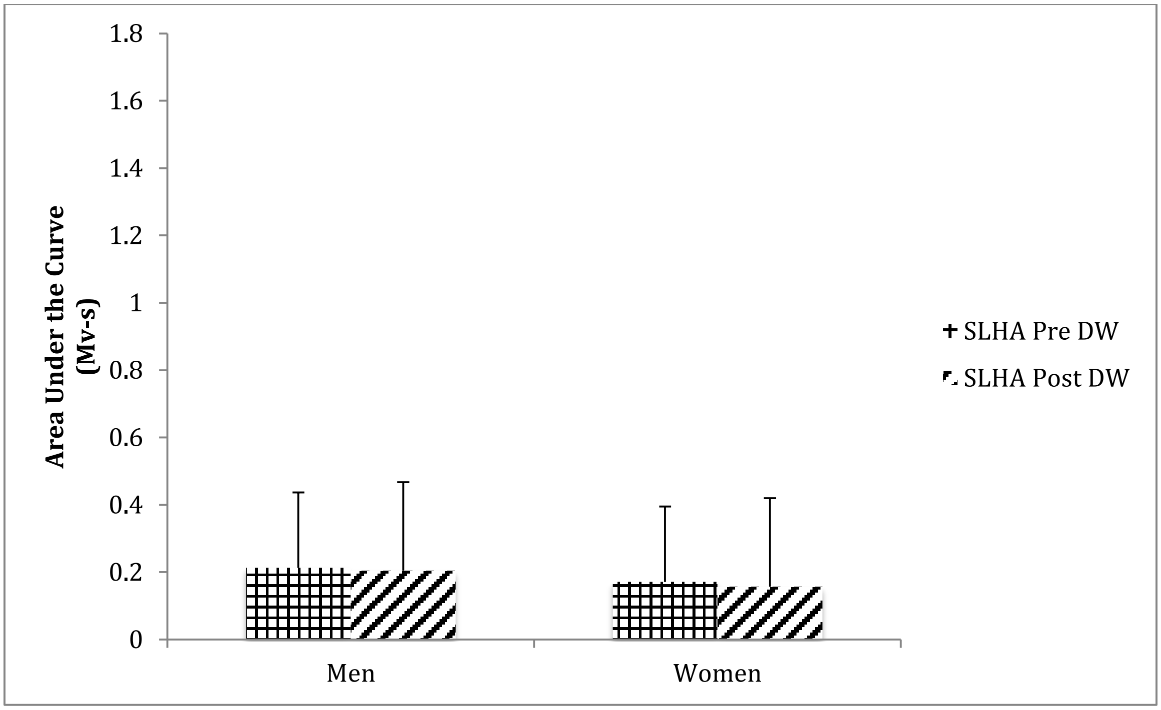
CHL = Cook Hip Lift
DW = Dynamic Warm-up

Figure 2. Cook Hip Lift Pre and Post Area Under The EMG Curve Values For Male and Female Participants For Glute Activation Intervention



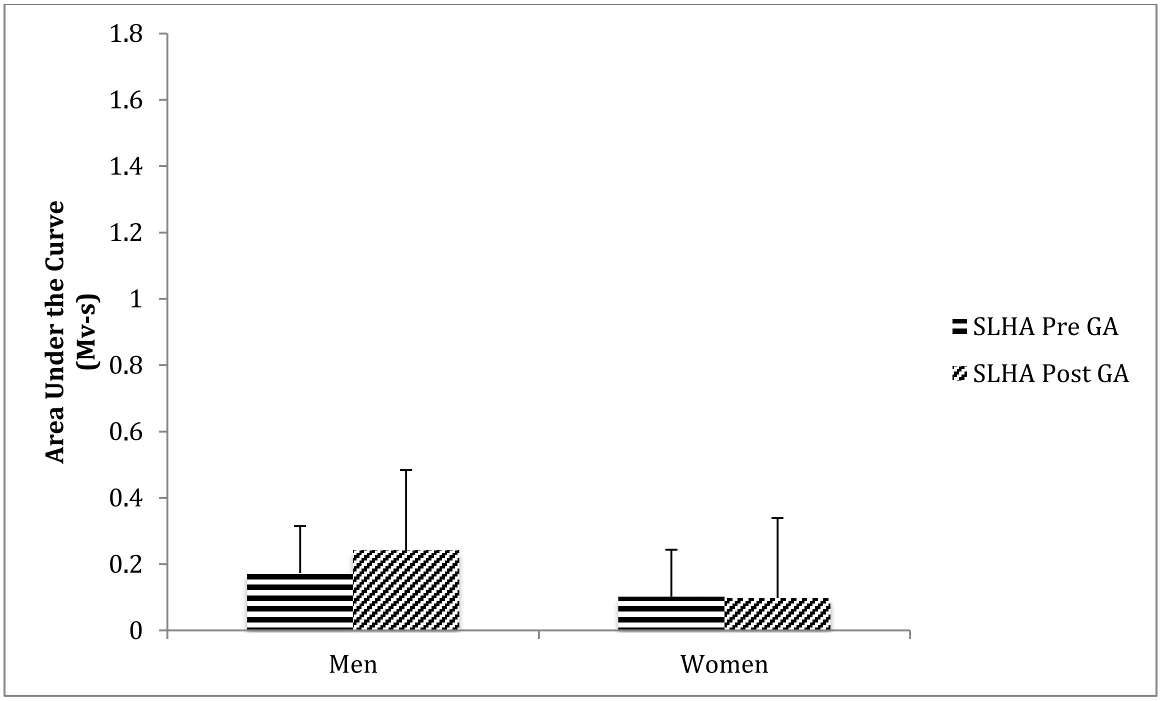
CHL = Cook Hip Lift
GA = Glute Activation

Figure 3. Side-lying Hip Abduction Pre and Post Area Under The EMG Curve Values For Male and Female Participants For Dynamic Warm-up Intervention



SLHA = Side-lying Hip Abduction
DW = Dynamic Warm-up

Figure 4. Side-lying Hip Abduction Pre and Post Area Under The EMG Curve Values For Male and Female Participants For Glute Activation Intervention



SLHA = Side-lying Abduction
GA = Glute Activtion

List of Appendices

Appendix I

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CONSENT FORM FOR RESEARCH

You hereby volunteer and give consent to participate in the research study comparing the difference of glute activation exercises and a dynamic warm-up on muscle activation.

I, ____

Residing at ____ (zip) ____________

(telephone) ______________________ (date of birth) ____________ (age) ____________

have been asked to take part in a research project described below. The researcher will explain the project to you in detail. You should feel free to ask questions at any time. If you have more questions later, Disa Hatfield, Ph.D., or Rick Nadell, the individuals responsible for this study, will discuss them with you. You must be at least 18 years old to be part of this research project.

DESCRIPTION OF THE PROJECT

You have been asked to take part in a study that will examine the differences between a dynamic warm-up and lightweight resistance exercises on muscle activation.

WHAT WILL BE DONE

If you decide to take part in this study here is what will happen:

You will visit the Human Performance Laboratory or Strength & Conditioning Facility in Tootell on three occasions. The first visit will be for preliminary testing and will last approximately 30 minutes. During this session you will complete a medical history questionnaire and we will measure your percentage of body fat, height and weight. Your body fat will be tested using a device called the BodPod.

You will then be asked to take part in the first of two exercise trials, with the second taking place one week after the first. The first trial will consist of the participants performing a dynamic warm-up: simple movements such as lunging, squatting and light moving stretches. You will be asked to perform these movements for a stretch of 10 yards. After completing the dynamic warm-up, you will then be asked to complete 2 tests (side lying hip abduction and the Cook hip lift). For the second trial, then you be asked to perform one light glute exercise for 3 sets of 10 repetitions.

The preliminary visit will involve the following:

1. BODY COMPOSITION MEASUREMENTS: The following physical characteristics
   will be recorded: age, height, and body weight. Your percentage of body fat will

be

   determined by something called air displacement plesmography. For this measurement, you will be asked to sit inside the BodPod machine and comfortably rest for 2-5 minutes while your body fat percentage is estimated. Your body fat is estimated in this fashion by calculating the amount of air you displace inside the known area of the BodPod.

2. QUESTIONNAIRES: We will ask you to complete a medical health history questionnaire and a nutrition/activity profile to ensure that you don't have any known medical conditions that would prohibit you from taking part in this study.

The exercise trials will involve the following:

1. DYNAMIC WARM-UP: We will ask you to perform a similar dynamic warm-up you do before your strength & conditioning work out. Under the instruction of a Certified Strength & Conditioning Specialist you will perform 8 movements (7 different ones, one will be performed twice). These movements are as follows: High knee walk, walking heel up, straight leg walk, forward lunge, backward lunge, carioca (twice) and drop step squat.

2. GLUTE ACTIVATION EXERCISES: You will be asked to perform an exercise called "Monster Walks". It will target the outside of your hip (gluteus medius). An elastic band will be placed around your legs, just at the bottom of your kneecap. You will then be asked to side step to one side 10 times and then perform 10 more steps to the other direction. This will make up one set, you will be asked to perform 3 sets.

3. GLUTE ACTIVATION TESTING: To measure the amount of activation in your muscles we will use an EMG. Two stickers will be placed on the outside of your hip, just below the hip bone.

   To assess the differences between the dynamic warm-up and the glute activation exercises you will be asked to perform two simple tests. The first will be the side lying abduction test. You will be asked to lay on your side. The Strength & Conditioning professional will put their hand on your hip and knee and you will be asked to try and raise your leg against their resistance. You will then be asked to flip sides and test the next leg.

   The second test you will be asked to perform is the Cook hip lift. You will be asked to lie on your back and hug one knee to your chest. Then you will be asked to push through the heal of the other leg and push your hips upward.

You may not consume any nicotine, alcohol or drugs 48 hours prior to each exercise trial session. This includes over-the-counter anti-inflammatory (such as ibuprofen), herbal remedies, supplements, topical analgesics (such as Icy Hot), or prescription drugs that may affect the results of the study (such as narcotic-containing drugs.). We will ask you to repeat the tests at the time each week. Also, we will ask you to eat a similar meal before each practice trial.

RISKS OR DISCOMFORTS

There are no known risks for the following procedures: height, weight, and use of the BodPod.

The exercise trials may make you feel tired. The exercises in this study are considered light but they may lead to some slight soreness. This soreness may last for a day. Every effort will be made to minimize risks and the risk of injury by medical history screening and monitoring procedures that are designed to anticipate and exclude the rare individual for whom exercise might be harmful.

It is possible that the exercise may result in muscle/tendon/ligament injury, or muscle soreness. All these risk are no greater than those that may occur during the normal course of training. The Investigator does not have a plan to cover the cost of any injuries in the course of participation. Subjects will be given first aid and evaluated by the University of Rhode Island Health Services and referred to your personal doctor, if needed. If you have any difficulty the exercise will be terminated for that day.

BENEFITS OF THE STUDY

You will receive information on how well you activate your gluteus medius muscles. You will receive a report of your personal measurements, including body fat percent.

CONFIDENTIALITY

Any information obtained from you during the study will remain confidential and you will not be identified by name in any publication or reports that result from this study unless you give written consent to such publication. All records will be coded and stored by subject identification codes. Records of codes will be locked and stored in a file cabinet in Dr. Disa Hatfield's office in 210 Flagg Road at the University of Rhode Island. The researchers will be the only people to have access to these records. Records will be kept for 3 years and then destroyed.

DECISION TO QUIT AT ANY TIME

The decision whether or not to take part in this study is entirely up to you. You do not have to participate in this study. If you decide to take part in this study, you may quit at any time. Whatever you decide will be accepted and there is no way you will be penalized. Your decision to participate and/or terminate your participation will not affect your grades in any classes. If you wish to quit, simply inform Rick Nadell at (508)-245-3623 or Disa Hatfield at (401)-874-5183 of your decision. Rick Nadell may terminate your participation in this study at any time if you show obvious signs of non-compliance with the study protocols (ie not participating in the exercises.)

RIGHTS AND COMPLAINTS

If you are not satisfied with the way this study is performed, you may discuss your complaints with Rick Nadell (508)-245-3623 or Disa Hatfield (401)-874-5183, anonymously if you choose. In addition, you may contact the office of the Vice-President for Graduate Studies, Research and Outreach, 70 Lower College Road, Suite 2, University of Rhode Island, Kingston, RI, telephone: (401) 874-4328.

It is not the policy of the University of Rhode Island to compensate subjects in the event that a research procedure results in physical or psychological injury. The University of Rhode Island will, however, make its best effort to refer you to appropriate services, upon request, if injury does occur. You may discuss this question with Rick Nadell or Disa Hatfield. However, if you experience any problems related to this study you should contact your personal physician.

I, the undersigned, have received, in my opinion, an adequate explanation of the nature, duration and purpose of this research investigation, the means by which the study will be conducted, and any possible inconvenience, discomforts, risks or adverse effects on my health which could result from my participation.

I have read the Consent Form. My questions have been answered. My signature on this form means that I understand the information and I agree to participate in this study.

______________________________	______________________________
Signature of Participant	Signature of Researcher
______________________________	______________________________
Printed Name	Printed Name
______________________________	______________________________
Date	Date

Appendix II

HUMAN PERFORMANCE LABORATORY MEDICAL HISTORY QUESTIONNAIRE

Study Name Street
City Email
Sex
Subject # Age
DOB
Stat e Zip
Phone

PLEASE ANSWER ALL OF THE FOLLOWING QUESTIONS AND PROVIDE DETAILS FOR ALL "YES" ANSWERS IN THE SPACES AT THE BOTTOM OF THE FORM.

YN
YN

1 Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
2 Has your doctor ever denied or restricted your participation in sports or exercise for any reason? 3 Do you ever feel discomfort, pressure, or pain in your chest when you do physical activity? 4 In the past month, have you had chest pain when you were not doing physical activity? 5 Do you lose your balance because of dizziness or do you ever lose consciousness?
6 Does your heart race or skip beats during exercise? 7 Has a doctor ever ordered a test for you heart? (i.e. EKG, echocardiogram)
8 Has anyone in your family died for no apparent reason or died from heart problems or sudden death before the age of 50?
9 Have you ever had to spend the night in a hospital?
10 Have you ever had surgery?
11 Please check the box next to any of the following illnesses with which you have ever been diagnosed or for which you have been treated.
High blood pressure Asthma Bladder Problems Coronary artery disease Metabolic Syndrome
Elevated cholesterol Epilepsy (seizures) Anemia Lung problems
Diabetes Kidney problems Heart problems Chronic headaches
12 Have you ever gotten sick because of exercising in the heat? (i.e. cramps, heat exhaustion, heat stroke) 13 Have you had any other significant illnesses not listed above? 14 Do you currently have any illness? 15 Do you know of any other reason why you should not do physical activity?
16 Please list all medications you are currently taking. Make sure to include over-the-counter medications, birth control pills, and medications to treat diabetes or high cholesterol.
Drugs/Supplements/Vitamins Dose Frequency (i.e. daily, 2x/day, etc.)

DETAILS:17 Please list all allergies you have. Substance
Reaction
YN 18
Have you smoked? Cigarettes
Cigars Pipes
If yes, #/day
Age Started
If you've quit, what age?
19 Do you have a family history of any of the following problems? If yes, note who in the space provided.
High blood pressure High cholesterol Diabetes
Heart disease Kidney disease Thyroid disease
20 Please check the box next to any of the following body parts you have injured in the past and provide details.
YN
Head
Neck Upper back Lower back Chest
Hip Thigh
Knee Ankle Foot
Calf/shin Shoulder Upper arm Elbow Hand/fingers
How long ago did you start?
21 Have you ever had a stress fracture? 22 Have you ever had a disc injury in your back? 23 Has a doctor ever restricted your exercise because of an injury? 24 Do you currently have any injuries that are bothering you?
25 Do you consider your occupation as? Sedentary (no exercise)
Inactive-occasional light activity (walking)
Active-regular light activity and/or occasional vigorous activity (heavy lifting, running, etc.)
Heavy Work-regular vigorous activity
26 List your regular physical activities Activity How often do you do it? How long do you do it?

ADDITIONAL DETAILS

Appendix III

COOK HIP LIFT GRADING RUBRIC

Pass/Fail

________ Down leg – Neutral hip

extension

________ Contact with the ball at all

times

________ Hamstrings cramp

________ Position is held for 15

seconds

Description of hip abduction test	
Supine hip abduction (Grade 0,1)	Supine with legs extended. Muscle contraction can be palpated and the hip abducted through partial range of motion. Palpation of greater trochanter helps ensure true abduction at the hip joint is taking place without movement of the pelvis
Supine hip abduction (Grade 2)	Supine with legs extended. Anterior superior iliac spine and greater trochanter are palpated to ensure true hip joint abduction is occurring. Leg is abducted at hip join through full range of motion
Side lying hip abduction (Grade 3)	Side lying hip abduction (bottom leg bent). Leg extended at the kneed joint, slightly extended at the hip joint. Participant can abduct leg at the hip joint through full range of motion without backward movement of the pelvis, flexion or internal rotation of the hip (Figure 1)
Side lying hip abduction (Grade 4,5)	Same as above except with resistance from tester applied to the lateral aspect of the knee

3 out of 4 need to receive a Pass for the participant to pass the test.

Appendix IV

HIP ABDUCTION GRADING RUBRIC

Description of hip abduction test	
Supine hip abduction (Grade 0,1)	Supine with legs extended. Muscle contraction can be palpated and the hip abducted through partial range of motion. Palpation of greater trochanter helps ensure true abduction at the hip joint is taking place without movement of the pelvis
Supine hip abduction (Grade 2)	Supine with legs extended. Anterior superior iliac spine and greater trochanter are palpated to ensure true hip joint abduction is occurring. Leg is abducted at hip join through full range of motion
Side lying hip abduction (Grade 3)	Side lying hip abduction (bottom leg bent). Leg extended at the kneed joint, slightly extended at the hip joint. Participant can abduct leg at the hip joint through full range of motion without backward movement of the pelvis, flexion or internal rotation of the hip
Side lying hip abduction (Grade 4,5)	Same as above except with resistance from tester applied to the lateral aspect of the knee

APPENDIX V

DYNAMIC WARM-UP

1. Knee Pull
2. Quad Pull
3. Figure Four
4. Chicken Walk
5. Lunges
6. Alternating Squat
7. Shuffle (down & back)
8. Carioca (down & back)
9. High Knee Run
10. Butt Kick

Appendix VI

REVIEW OF THE LITERATURE

Gluteus Medius Function & Performance. The lumbopelvic hip complex there are 29 pairs of muscles that work to stabilize the spine, pelvis and hips while performing movements (Oliver et al., 2010). One of these muscles is the gluteus medius (GM) (Oliver et al., 2010). The GM is a primary hip abductor. Also, the GM performs lateral rotation (Presswood et al., 2008).

Additionally, the GM provides stability in the front plane during walking and running (Presswood et al., 2008). The GM provides stability of the hip just before and after foot contact with the ground during the late swing phase and early and middle stance phases of running the (Niemuth, 2007). Thusly, the GM's role is to prevent the contralateral hip from tilting during movement (Presswood et al., 2008).

Because of its important bioanatomical and biomechanical role, the GM also plays a role in athletic performance. As running speed increases the GM's role expands. The GM is also important during low speeds such as walking and jogging acting primarily a stabilizer. As running speeds approach and surpass 7m/s the GM increases its force production. The GM adds the hip's already increasing force production to allow for greater stride frequency and therefore greater running speeds (Dorn, et al., 2012). Hence, weakness in the GM may lead to decreased running speeds and consequently reduced athletic performance.

Laymen's literature suggests that athletic populations are capable of compensating for weakness in the GM. The theory is that athlete's are so used to compensating for injury that they can compensate for muscles weakness as well. Former

Boston Red Sox Head Athletic Trainer Mike Reinold suggests that elite level athletes can compensate for weakness in the GM without apparent signs of Trendelenburg Gait. Instead, the hip remains neutral but the lower extremity will adduct and internally rotate (Reinold, 2012). If athletes are, in fact, able to compensate for weakness in the GM without signs of Trendelenburg Gait then testing the GM is of vital importance to detect any dysfunction and prevent injury

Testing the Gluteus Medius. Testing muscles is considered fundamental for program planning and evaluation; the scores are used to assess the effectiveness of the program (Freese et al., 1987). There are two ways to evaluate the GM: through EMG testing or through manual testing. EMG has been proven to be the most reliable while manual testing has been proven to be the least reliable (Bolga et al., 2007; Freese et al., 1987).

Using the area under the rectified EMG curve is standard practice for quantifying raw EMG data (Ad Instruments, 20). Branch et al., (1989) used the area under the curve to determine whether or not knee braces altered the muscle firing amplitude and/or duration in the participant's hamstring and quadriceps during cutting activities. Ten participants (female = 4, male = 6) performed fifteen trials. Five trials were performed without a knee brace, five trials with a strap dominant brace and five trials with a shell dominant brace. The area under the curve was used to examine the EMG activity of the posterior and anterior leg during the trial.(Branch and Uhl. 1989).

Specific to the GM, Brindle et al., (2003) used area under the curve to examine changes in EMG activity during stair ascent and descent. Sixteen participants (female =12, men = 4) were analyzed for GM activity during stair ascent and descent. Patients had reported anterior knee pain during the previous two months. Then a control group (n=12, female = 7, men = 5) performed the same task. Participants in the control group had no prior history of knee pain. The results indicated that participants with knee pain showed delayed onset of the GM as well as shorter durations of activity while ascending stairs when compared to participants with no knee pain. While descending stair participants had shorter durations of EMG activity than those who had no knee pain (Brindle, 2003). This study demonstrates that measuring the area under the curve is an effective way of analyzing EMG data.

Bolga and Uhl examined the reliability on EMG normalization measure on the GM during three open chain and three closed chain exercises. The study population consisted of 13 participants (7 men, 6 women; age = 24 ± 7 years; height = 1.6 ± 0.2m; weight = 765.2 ± 137.3 N). Participants had no current lower extremity injury and had not had a significant injury in the past year (Bolga and Uhl ,2007).

After the participants were prepped for the EMG they performed 6 exercises: standing hip abduction, standing hip abduction with flexed hip, single leg stance with contralateral load, side-lying hip abduction, single leg stance with contralateral load and flexed hip, and pelvic drops. Each exercise was performed 15 times to a metronome set at 60 beats per minute to ensure similar rates between participants. For the 3 open chain exercises a cuff weight equal to 3% of the participant's body weight was attached to the right ankle. The weight was placed on the left ankle for the 3 closed chain exercises (except for the pelvic drop). (Bolga and Uhl, 2007).

The authors of the study reported two measures of reliability. For maximum voluntary isometric contractions the study demonstrated high reliability and was recommended for continued use in healthy populations. Dynamic measures of the EMG revealed low reliability for peak dynamic methods but acceptable measures of for mean dynamic methods were considered acceptable (Bolga and Uhl,2007). These findings suggest that maximum EMG recordings during movement may be skewed while mean values are more reliable. The research professional should proceed with caution of maximum values appear drastically different than the mean.

While the findings of Bolga and Uhl's study found the EMG to be a reliable measure when testing the GM, a study by Freese et al., found manual testing of the GM to be less reliable. The study consisted of 110 particpants (50 female, 60 males; age = 41 ± 17 years) who were referred to physical therapy at the St. Louis University Hospital for a variety of musculoskeletal and neurological disorders including low back pain, gunshot wound, cervical pain, chondromalacia, rheumatoid arthritis and connective tissue disease. Testing was performed by 11 staff physical therapists at the St. Louis University Hospital. All of the examiners were graduates of an accredited university program with the average number of years of experience being 2.3 (± 1.2 years) (Freese et al., 1987).

Testing was performed during the participants' daily treatment session. The GM was tested bilaterally. Each therapist tested each participant. Scores were given on a scale of 0-5 with zero being unable to perform the movement at all and 5 being the best possible score. The numbers were also given correlating qualitative measures (Freese et al., 1987).

The finding of the study indicated that manual testing of the GM provided poor reliability. Scores of the same grade or within one grade were reported 88-92% of the time. Because scoring is largely subjective and the relatively large functional difference between each interval of one grade several therapists being within one grade is of questionable value. This level of accuracy may not be adequate to make decisions moving forward (Freese et al., 1987).

Gluteus Medius Pathology. Weakness in the GM is related to pathological conditions in lower extremities (Thorborg et al., 2012). A number of studies have investigated and identified an association between hip weakness and general lower body injuries, with GM weakness being the best indicator of injury (Niemuth, 2007).

In a two-year study, Leetun et al., investigated the role of hip stability in lower body injuries among 139 male and female athletes. The population consisted of 79 females (mean age = 19.1 ± 1.37 yr, mean weight = 65.1 ± 10.0 kg) and 60 males (mean age = 19.0 ± 0.90 yr, mean weight = 78.8 ± 13.3 kg). Participants were pre-tested within 2 weeks of the commencement of each athlete's organized practice (Leetun et al., 2006).

Pre-testing consisted of 5 tests in a randomized order. Participants performed an isometric hip abduction test in the side lying position on a treatment table; isometric external hip rotation was tested with participants seated in a chair with hips and knees flexed at 90°; the muscle capacity of the posterior core was tested with a Biering-Sorensen test; the lateral core muscle capacity was tested by having participants perform a side bridge test; and the anterior core was tested with the use of the straight leg lowering test. Because the investigators questioned the sensitivity of the straight leg lowering test the participants in the second year of the study performed a flexor endurance test instead. The head athletic trainer for each team or individual participating in the study recorded the incidence of all back and lower extremity injuries during the course of 1 season. (Leetun et al., 2006).

Of the 139 participants 41 (24.5%) sustained an injury to the back or lower body. Some participants were injured multiple times, a total of 48 injuries occurred during the study. Of these injuries 27% occurred during a competitive event and 17% of the injuries were a result of physical contact to a participant. Those who experienced injuries generally had lower core stability scores during pretesting; strength scores for hip abduction and hip external rotation were statistically significant. (Leetun et al., 2006).

Leetun et al., concluded that hip weaknesses were strong predictors of lower extremity injuries in an athletic population (Leetun, 2006). However, the study fails to provide an intervention. While it is important to note that there is a correlation between weak hip muscles and lower extremity injuries the study does not and cannot say whether there is a causal effect.

In another study, Nadler et al., examined hip muscle asymmetries. The study consisted of 210 NCAA Division I athletes, 140 males and 70 females. A dynamometer was used to test the hip extensor and abductor strength unilaterally. Pretesting occurred as the participants began their pre-participation physicals for their respective sports. Participants then reported lower extremity injuries over the following year (Nadler et al., 2000).Of the 210 participants in the study, 74 (35.2%) experienced an injury to the lower extremity. On a percentage basis females (27/70, 38.57%) were more likely to become injured than males (47/140, 33.6%). While there was no significant correlation between muscle weakness and injury in males, there was statistical significance among female participants (Nadler et al., 2000).

Nadler et al., concluded that asymmetries in the hip extensors and abductors man help explain the difference in injury rates between sexes. Similar to the study done by

Leetun et al., the Nadler study shows a correlation between hip muscle weaknesses and lower extremity injuries in females. Also, like the Leetun study, the Nadler does not provide an intervention. While the asymmetries in the hip musculature may be correlated to lower body injuries it is hard to say whether or not they are the cause.

Glute Medius Rehabilitation and Strengthening. In light of these studies, the need to recognize and address weakness in the GM after an injury, as well as before, is evident (Earl, 2005). Exercises aiming to strengthening the hip abductors are frequently incorporated into rehabilitation programs for people with hip, knee and ankle injuries. These exercises are also suggested as a means of preventing acute knee and ankle injuries (Thorborg et al., 2012).

Several different exercises and variations of these exercises aimed at strengthening the GM exists. It is beyond the scope of this manuscript to list in detail the exercises used to strengthen the GM. This review of the literature will focus on the side-lying leg lift/adduction and the "monster walk" exercises; as these are the most common exercises used for GA in athletic populations (anecdotal).

Fredericson et al., examined hip abductor weakness in distance runners with iliotibal band syndrome. The study consisted of 54 participants, 30 (14 female, 16 male) served as the control group while 24 (10 female, 14 female) served as the treatment group. The control group population was Stanford University cross-country runners while the treatment group consisted of collegiate and club long-distance runners (Fredericson et al., 2000).

Baseline hip abductor strength was measured in both the treatment and control groups. The slide-lying hip abduction test was performed and was measured with a hand-held dynamometer placed on the lateral malleolus. Five trials were executed on each leg. Because a hand-held dynamometer was used, scores were normalized for body weight & height using the following equation:

$$\% (BW \times h) = Torque (N \times m) \times 100/BW(N) \times h(m)$$

BW was the participants body weight in Newtons and h was height measured in meters (Fredericson et al., 2000).

These baseline measures demonstrated a statistically significant difference in hip abductor strength between the treatment and control groups. Abductor strength in the injured limb of female participants produced 7.82 (± 1.93) %BWh of torque compared to 9.82 (± 2.98) in the non-injured limb and 10.19 (± 1.10) in the control groups (Fredericson et al., 2000).

The same trend was found in male participants during pretesting. Male participants were able to generate 6.86 (± 1.19) %BWh of torque in injured limbs compared to 8.62 (± 1.16) in noninjured legs and 9.73 (± 1.30) in the control group (Fredericson et al., 2000)

After pretesting was completed participants in the treatment group underwent a 6-week rehabilitation program. The program consisted of anti-inflammatory drugs, local application of ultrasound with corticosteroid gel, stretches and a muscle strengthening programming aimed at strengthening the GM (Fredericson et al., 2000).

The strengthening program revolved around side-lying abduction and pelvic drop exercises. Each exercise was initially performed for 1 set of 15 repetitions, progressing to 3 sets of 30 repetitions. Participants were instructed to increase the workload by 5 repetitions daily provided there existed no post-workout soreness the following day (Fredericson et al., 2000).

At the end of the 6 weeks of rehabilitation participants were post-tested. Female participants in the treatment group produced average of 10.55 %BWh of torque in the hip abductors, a 34.9% increase. Male participants in the treatment group produced 10.38 %BWh of torque in the hip abductors, a 51.4% improvement. Twenty-two of the 24 particpants were pain free and a follow-up done by 6 later found no recurrences (Fredericson et al., 2000).

This study is demonstrates that the GM can be strengthened the study but does have limitations. The overall program aimed was at rehabilitating the participants and allowing them to return to running. Because strengthening the GM wasn't the sole focus of the study other rehab modalities were included. This makes it impossible to say if the results, especially the disappearance of pain, were solely the result of the GM exercises.

In a similar investigation, Mascal et al. examined an exercise program that strengthened the hip, pelvis and trunk musculature in two case studies of participants with patellofemoral pain. Bother participants in the study were females. Participant A was a 20 year old while participant B was 37 years of age (Mascal et al., 2003).

Both participants were tested for baseline measurements. A self-administered questionnaire was used to assess a person's functional status as well as patellofemoral pain when performing functional tasks. The maximum score on this questionnaire is 100. Participant A scored a 76; participant B scored a 70. A 10-cm visual analogue scale was used to assess the most aggravating movements. A score of 0 indicated no pain while a score of 10 indicated the most pain ever experienced. Participant A scored a 5/10 for walking after 2 hours and a 4/10 when climbing 2 flights of stairs. Conversely, participant B scored a 7/10 when descending a single step, a 10/10 when descending an entire flight of stairs and an 8/10 when walking 2 miles (Mascal et al., 2003).

Quantitative measures of hip abductor strength were also used. The GM was tested using a side-lying abduction test. A hand dynamometer was used to measure the force produced in Newtons. Three trials were performed and then averaged. Participant A produced 53.4 N of force while participant B produced 44.5 N. In the authors' opinion, both participants exhibited significant weakness in the GM (Mascal et al., 2003).

The intervention was carried out over the next 3 months. Both participants were scheduled for either 1 or 2 physical therapy appointments per week. The hip musculature was progressively strengthened. Progression was allowed when a participants could perform 2 sets of 15 repetitions with form described in the study. During weeks 0-6 both participants focused on non-weight-bearing exercises. The next progression was during weeks 6-10, both participants advanced to weight-bearing exercises. Finally, during weeks 10-14 both participants proceeded to functional movement training (Mascal et al., 2003).

Following week 14, both participants were re-evaluated. Scores on the self-administered functional status questionnaire improved. Participant A increased her score from a 76 to and 85 while participants B improved from a 70 to an 84. Participant A reported no pain and patient reported a significant reduction in pain. Participant B reported the ability to ascend and descend stairs with no pain and only scored a 2/10 when standing for a considerable amount of time (Mascal et al., 2003).

The objective measurements improved to corroborate the improved subjective scores. Participant A increased GM strength by 50%, improved from 53.4 N to 80.1 N. An even more dramatic increased was observed in participant B. GM strength was increased from 44.5 N to 84.6 N, a 90% increase (Mascal et al., 2003).

While the case study presented by Mascal (2003) is significant it also has some limitations. The study is significant because it appears to demonstrate a relationship between improved GM strength and relief of patellofemoral pain. However, because the study lacks a control group and is only powered by 2 participants the results may not be conclusive. Also, the GM was not the only muscle strengthened in the treatment, the gluteus maximus as well as the abdominals were also strengthened. This makes it impossible to say if the improvements seen in the GM were directly responsible for alleviating of patellofemoral pain.

In a review article on iliotibial band syndrome, Fredericson et al., recommended the side-lying leg lift exercise for strengthening the GM. This recommendation was made for a population of people with iliotibial band syndrome. These injured athletes, according to Fredericson et al. should start with one set of 20 repetitions and progress to three sets of 20 repetitions daily (Fredericson, et al., 2000). These recommendations reflect a general theme for this exercise in injured populations.

Heller suggests a similar prescription for strengthening the GM. The author suggests using the side-lying hip abduction. Unlike Fredericson et al. however, Heller suggests one set of between 3 and 20 repetitions. Additionally, it is suggested that the exercise be performed unloaded. Heller does suggest, though, that the exercises be performed once or twice times per day (Heller, 2003).

Strengthening the GM does not have to be done from a side-lying position, however. A more functional exercise has been prescribed for both injured and healthy populations. Niemuth suggested the "monster walks" exercise as a way of strengthening the GM in rehabilitation programs (Niemuth, 2007). The author also recommended the exercise as a prevention strategy (Niemuth, 2007). Because of the multidirectional nature of sports, Page & Ellenbecker recommended "monster walks" to strengthen the GM. Specifically the authors recommended the exercise for athletes participating in football, tennis and soccer (Page and Ellenbecker, 2004), but do not make any suggestions for sets or repetitions.

Current laymen's literature suggests that the "monster walk" and the side-lying leg lift/adduction exercises are becoming increasingly popular as a means of activating the GM in athletes. In fact, Eric Martinez suggests that GM activation is still growing in popularity and will become much more frequently used. Martinez suggests performing the "monster walk" 15 to 20 minutes prior to performing squats (Martinez, 2012).

The side-lying leg lift/adduction is also, in laymen's literature, reported to activate the GM in athletic populations. Reinold recommended using the side-lying leg lift/adduction exercise during an active warm-up (Reinold, 2009). In a sample exercise program from Neal Pire at Inspire Training Systems suggested using the side-lying leg lift/adduction as to active the GM prior to a workout (Inspire Training Systems).

Addition To The Literature. It is clear there that the majority of the literature focuses on injury occurrence and rehabilitation. The studies that focus on strengthening the GM, do so in injured populations rather than non-injured and/or athletic populations. To date there is paucity in the literature examining the role of GM strengthening in athletic populations, injury prevention, pain and sports performance (Presswood et al., 2008).

Strength and conditioning coaches are using GM activation exercises without any scientific evidence for their population. In injured populations, GM exercises have been shown to alleviate pain and injury in pathological populations. Studies have also seemingly found a correlation between GM strength and injury occurrence. Strength and conditioning professionals, however, have extrapolated these findings to athletic populations. Strength and conditioning professionals are now performing GM activation exercises as a way of increasing performance as well as preventing injury.

This study aims to examine the effects of an acute GM activation exercise compared to a dynamic warm-up. If there is any activation of the GM then further research needs to be done examining the role of the GM in sports performance. If no additional activation occurs then strength and conditioning professionals will now be able to better allocate their already limited time with athletes.

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