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The Effect of an Elastic Eccentric Extensor Mechanism on Hamstring Function

Anna Elizabeth Sutton
whz4soccer@aol.com

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**THE EFFECT OF AN ELASTIC ECCENTRIC EXTENSOR MECHANISM ON
HAMSTRING FUNCTION**

**A Thesis Submitted to
the Graduate College of
Marshall University**

**In partial fulfillment of
the requirements for the degree of
Master of Science
in Exercise Science**

**by
Anna Elizabeth Sutton**

**Approved by
Dr. Matthew Comeau, Committee Chairperson
Dr. Gary McIlvain
Dr. Tim Tolbert**

Marshall University

December 2012

Dedication

I would like to dedicate this thesis to the most wonderful parents, Pete and Teresa Sutton.

Acknowledgments

I would like to thank several people for their help and participation, who made this thesis a possibility. To Dr. Comeau, I absolutely could not have done this without you. Your patience, your willingness to help, your knowledge and your hard work were more appreciated than you will ever know. To all of my participants, thank you for giving up your time and helping to make this thesis happen. I obviously could not have done this if it had not been for you all. Last, to my parents and family, thank you for enduring this long drawn out process with love, patience, and prayers. Thank you for your encouragement and for pushing me to finish this. I love you all very much.

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Abstract

Hamstring strains have a long recovery time, a high rate of recurrence, and are very common injuries in sports. Fatigue, improper warm-up, previous injury, strength imbalance, and poor flexibility have all been linked to hamstring injuries. Initial treatment of the hamstring typically consists of rest, ice, compression, elevation, and pain relief. However, no optimal treatment regimen has been developed based on carefully designed clinical trials. This study tested fourteen college-aged male and female subjects. Their gait was recorded using video tracking software with and without an elastic band (Theraband® Akron, Ohio) attached to the anterior surface of their waist and proximal tibia utilizing 1.5 inch white athletic tape (Johnson & Johnson© New Brunswick, New Jersey). With the results, a one-way, repeated measures ANOVA was conducted with the factor being the use of an elastic band and the dependent variable being angular velocity and its associated angle of flexion. The results for the repeated measures ANOVA indicated a significant time effect, Wilk's $\Lambda = 0.512$, $F(1,13) = 12.414$, $p = 0.004$. The results from our study show that angular velocity increased earlier in the range of motion than when the subject was not wearing the band. In order for the patient to control the leg, the hamstring muscle would have to assume more eccentric load. From this increased eccentric load, we can assume there would be an increase in eccentric strength and a decrease in injuries.

Chapter 1

Introduction

A hamstring strain, or a pulled hamstring as it is sometimes referred to, is a tear in one or more of the hamstring muscles. The semitendinosus, semimembranosus, and biceps femoris make up the hamstring muscle group. This group of muscles has many important functions. The hamstrings cross and act upon two different joints--the hip and the knee. The semitendinosus and semimembranosus extend the hip when the trunk is fixed; they also flex the knee and medially rotate the lower leg when the knee is bent. The long head of the biceps femoris extends the hip as walking occurs; both short and long heads flex the knee and laterally rotate the lower leg when the knee is bent. These functions cause the hamstring to play a crucial role in many daily activities, such as walking, running, jumping, and some movement control in the trunk. In reference to walking, the hamstring muscles are most important as an antagonist to the quadriceps in the deceleration of knee extension (Brughelli, 2011).

Hamstring strains are among the most common injuries in sports with a long recovery time and a high rate of recurrence (Best & Garrett, 1996; Heiderscheit, Sherry, Silder, Chumanov & Thelen, 2010)

Fatigue, improper warm-up, previous injury, strength imbalance, and poor flexibility have all been linked to hamstring injuries (Best & Garrett, 1996; Petersen & Holmich, 2005; Carlson, 2008; Heiderscheit et al. 2010). Initial treatment of the hamstring typically consists of rest, ice, compression, elevation, and pain relief. However, no optimal treatment regimen has been developed based on carefully designed clinical trials (Best & Garrett, 1996). There is likewise no consensus on optimal rehabilitation following initial treatment, but functional rehabilitation that includes stretching and strengthening has been emphasized (Best & Garrett, 1996). It was found that eccentric strength exercises were more effective than concentric exercise

and can assist standard stretching in re-establishing muscle length after injury (Arnason, Gudmundsson, Dahl & Johannsson, 1996).

Kaminski et al (Kaminski, Wabbersen & Murphy, 1998) says the ability to withstand force and strain is a measure of the energy absorbed by the muscle before failure; therefore, increased eccentric strength can improve a muscle's ability to withstand force and strain without failing. Most muscle strain injuries occur during eccentric muscle actions; therefore, improving eccentric strength may help to diminish risk of injury. During leg movements such as walking and running, the hamstrings assist with hip extension and work to decelerate the extending knee prior to the foot striking the ground.

Carlson (2008) writes that, through biomechanical analysis of hamstring function using sprinters running on a treadmill, it has been shown that the maximal lengthening of the hamstring occurs at the end of the swing phase of gait, just prior to foot contact, when the hip is flexed and the knee flexion movement is reducing. Electromyographic analysis confirms that the maximal hamstring contraction also correlates to this portion of the running phase as the hamstrings apply a braking force to the quadriceps and hip flexors (Carlson, 2008). The period of maximal eccentric contraction in the running cycle, when the muscle is both lengthening and contracting at the same time, seems to carry a higher risk for muscle injury (Carlson, 2008). A low hamstring-to-quadriceps strength ratio will increase the extension moment through the knee, which could potentially stretch the eccentrically contracting hamstring beyond its elastic capabilities causing injuries (Carlson, 2008).

The hamstrings are made up of both fast and slow-twitch fibers. This means that the hamstring muscles can work in an explosive burst of power, but they are also able to contract for an extended time, such as in running (Hodgkinson, 2010). Eccentric exercises are used while

rehabilitating an injured hamstring, but they can also be used to prevent the injury from occurring in the first place. Kaminski (1998) states that hamstring injuries typically occur because of lack of adequate eccentric strength. It was also found that eccentric hamstring training significantly increases hamstring strength, which would prevent injury occurrence (Nunley, 2010). Specifically, the hamstrings eccentrically contract during the "catch" phase of walking and even more intensely during running (Nunley, 2010).

Heiderscheit et al (2010) stated that nearly one-third of hamstring injuries recur within the first year following a return to sport with subsequent injuries often being more severe than the original. More specifically, one-third of the hamstring injuries will recur with the greatest risk during the initial two weeks following return to sport. This high early reinjury rate is suggestive of an inadequate rehabilitation program, a premature return to sport, or a combination of both; therefore, further avenues need to be investigated to prevent this reinjury rate.

Purpose Statement

The purpose of the study was to determine the effect of an anteriorly placed elastic band, which accentuates the eccentric component of the hamstrings, on knee angular velocity.

Hypothesis

H₀: Placing an elastic band anteriorly on the thigh will not cause any change in knee angular velocity.

H₁: Placing an elastic band anteriorly on the thigh will cause a change in knee angular velocity.

Limitations

As there are differences in the physiology of males and females, gender is going to be a limitation. Also, any previous injury to the lower half of the body would affect the results.

Definition of terms

- *Elastic Band*--a latex band used for resistive exercises which provides both a concentric and eccentric force on the muscles. These bands help improve strength, range of motion, and cooperation of muscle groups (Thera-Band.com).
- *Eccentric*--Eccentric muscle strengthening describes an exercises performed by lengthening a muscle while it is loaded and contracting (Inverarity, 2009).
- *Concentric*--a type of muscle activation that increases tension on a muscle as it shortens (Quinn, 2009).
- *Kinematics*--“a branch of dynamics that deals with aspects of motion apart from considerations of mass and force” (Merriam-Webster, 2011).
- *Anteriorly*--“situated toward the front of the body” (Merriam-Webster, 2011).
- *Electromyography*--“an instrument that converts the electrical activity associated with functioning skeletal muscle into a visual record or into sound and has been used to diagnose neuromuscular disorders and in biofeedback training” (Merriam-Webster, 2011).

Chapter 2

Review of the Related Literature

Hamstring strains are among the most common injuries to occur in sports (Best & Garrett, 1996; Heiderscheit et al. 2010). They are very frustrating for the athlete, the physician, and the athletic trainer as they have a long recovery time and a high rate of recurrence (Best & Garrett, 1996; Carlson, 2008; Heiderscheit et al. 2010). Best and Garrett (1996) state that, during walking and running, the hamstring muscles function primarily to decelerate the extending knee prior to foot strike and to assist with hip extension after foot strike. In the first half of the swing phase of the running/walking cycle, the hip rapidly flexes. Knee flexion is passive during this period and results from the rapid forward acceleration of the thigh during hip flexion. Midway through the swing phase, however, while hip flexion continues, the knee begins to rapidly extend. Finally, during the latter part of this swing phase, the hamstring muscles decelerate the forward swing of the tibia, therefore opposing the activity of the quadriceps muscles (Best & Garrett, 1996) Efforts have been made to correlate EMG data and time of maximum muscle activity with time of injury during this gait cycle. Best and Garrett (1996) state that initial treatment is typically the use of rest, ice, compression, elevation, and pain relief. Compression of the affected area with an elastic wrap may help to reduce any swelling, and, as far as pain relief, NSAID's can be used for seven to ten days (Best & Garrett, 1996). However, no optimal treatment regimen has been developed. Likewise, there is currently no consensus on optimal rehabilitation following this initial treatment; however, functional rehabilitation that includes stretching and strengthening has been emphasized (Best & Garrett, 1996).

Petersen and Holmich (2005) state that there is a lack of clinical research on the effectiveness of rehabilitation programs for hamstring strains. The most common modifiable

factors of hamstring injury are imbalance of muscular strength with a low hamstring to quadriceps ratio, muscle fatigue, hamstring tightness, insufficient warm up, and previous injury (Petersen & Holmich, 2005). The studies they used in their article suggested that hamstring strains occur during the later part of the swing phase when the hamstrings are working to decelerate knee extension; that is, the muscle develops tension while lengthening (Arnason, Gudmundsson et al. 1996; Woods, Hawkins, Maltby, Hulse, Thomas & Hodson, 2004). This deceleration means that the hamstrings must change from functioning eccentrically, to slow down knee extension in the late swing, to concentrically, becoming an active extensor of the hip joint. It has been suggested that it is during this rapid change from eccentric to concentric function that the muscle is the most vulnerable to injury (Petersen & Holmich, 2005).

Heiderscheit et al (2010) stated that nearly one-third of hamstring injuries recur within the first year following a return to sport with subsequent injuries often being more severe than the original. More specifically, one-third of the hamstring injuries will recur with the greatest risk during the initial two weeks following return to sport. This high early reinjury rate is suggestive of an inadequate rehabilitation program, a premature return to sport, or a combination of both. They also said that there is mounting evidence that the risk of reinjury can be minimized by utilizing rehabilitation strategies that incorporate neuromuscular control exercises and eccentric strength training. During its recovery from being injured, the hamstrings must be properly rehabilitated to safely handle high eccentric loading upon returning to running. (Heiderscheit et al. 2010) discussed hamstring rehabilitation with a focus on muscle remodeling and stated eccentric strength training has been advocated in the rehabilitation of hamstring injuries. It has been suggested that the high injury recurrence may be attributed to a shorter optimum musculotendon length for active tension in the previously injured muscle. Such a shift

in the force-length relationship could be a training effect, i.e., repeated performance of strengthening with concentric exercises during rehabilitation. In healthy control subjects, the performance of controlled eccentric strength training exercises has been shown to facilitate a shift in peak force development to longer musculotendon lengths (Heiderscheit et al, 2010). Therefore, eccentric strength training following a hamstring injury may effectively restore optimum musculotendon length for active tension to normal, thereby reducing the risk of reinjury (Heiderscheit et al, 2010). Given the high incidence of hamstring strain injuries that occurs across a variety of sports and activities and the substantial tendency for injuries to recur, the greatest impact may be achieved by developing improved techniques for preventing initial injury. Based on identified risk factors for injury, prevention strategies have been suggested that target specific risk factors, such as deficits in hamstring flexibility and strength. Heiderscheit, et al. (2010) writes about how the incorporation of eccentric hamstring exercises as part of routine training has been found to substantially reduce the incidence of hamstring strain. A recent prospective investigation determined through isokinetic testing that a strength imbalance between the eccentric hamstrings and concentric quadriceps ratio resulted in a 4-fold increase in risk of hamstring injury compared to a normal strength profile (Heiderscheit et al, 2010). The authors suggested that an insufficient eccentric capacity of the hamstring muscles to offset the concentric action of the quadriceps during terminal swing resulted in the increased injury risk. The addition of eccentric hamstring strength exercises as part of preseason and in-season training for elite soccer players reduced the incidence of hamstring strain injuries. Although the reduced injuries might simply be attributed to the increase in peak hamstring eccentric strength, it has also been suggested that the injury risk-reduction benefit from eccentric training may be due, in

part, to the resultant shift in peak force development to longer muscle lengths (Heiderscheit et al, 2010).

Kaminski, et al. (1998) compared concentric versus eccentric hamstring strength training and their clinical implications. They stated that eccentric muscle actions are often the last line of defense against muscle injury and ligament disruption. Also, those eccentric muscle actions are capable of producing higher forces at approximately twenty percent less oxygen consumption, carbon dioxide production, and energy expenditure than equal bouts of concentric work.

Kaminski et al, (1998) performed a study on twenty-seven male students. The volunteers had to meet the requirements of having had no previous injuries to the hamstrings, knee, or hip joints, no history of performance-enhancing drug use, no weight training of the lower extremity during the past six months, and no previous illness or condition limiting participation. Subjects were then randomly assigned to one of three treatment groups: a control group, eccentric training group, and concentric training group. Each of these groups consisted of nine subjects. Data was collected from a 1RM using a Cybex isotonic prone hamstring curl apparatus equipped with the Negator eccentric-loading counterbalance weight system. The subjects were seated in the dynamometer chair with their body securely fastened to the seat and the thigh held firmly by the thigh stabilizer. The volunteers then performed three submaximal and three maximal warm-up repetitions before testing. A one minute rest was provided then the subjects performed three maximal concentric and three eccentric repetitions. Following the pretesting sessions, the subjects began a six week hamstring strength training program. They exercised twice a week for a total of twelve training sessions. The control group refrained from lower extremity strength training during the study. Participants in the training group initiated each workout session with a three minute stationary bike warm-up followed by the aforementioned lower extremity flexibility

program. Each group started with one set of eight repetitions using 50% of their predetermined 1RM value. Both the concentric and the eccentric loads were equal at this point in time. After the warm up, the subjects in the concentric training group performed two sets of eight repetitions using a weight equal to 80% of their 1RM value. The subjects in the eccentric group also performed two workout sets of eight repetitions; however, the concentric load was placed at 40% of the 1RM value and the eccentric load was placed at 100% of the 1RM value for both sets. Training sessions were separated by a two day rest period and, if the participant was able to complete both training sets of eight repetitions without failure, his or her 1RM value was increased by 5.44 kg. The next hamstring strengthening exercise would begin using this new 1RM value. The concentric group maintained a workout load of 80% of their adjusted 1RM value at all times, whereas the eccentric group maintained a concentric:eccentric ratio of 40%:100% of the adjusted 1RM. Subjects in each of the three groups returned at the end of the six week training period and underwent post testing with the same procedures as pretesting. Results for this study showed that 1RM value ratios improved 28.8% in the eccentric training group and only 19.0% in the concentric training group after six weeks of hamstring strength training. The results from this study support the idea that isotonic eccentric overload training may increase concentric strength to a greater degree than concentric training would. (Kaminski et al, 1998) suggest that, because most muscle strain injuries occur during eccentric muscle actions, improving eccentric strength would therefore help to diminish risk of injury.

In a study examining elbow flexors, Komi and Buskirk (1972) showed significant concentric strength gains for both isotonic concentric and eccentric training groups but found that the eccentric group increased strength to a greater degree than the concentric group. Ellenbecker et al, (1988) compared isokinetic eccentric and concentric training of shoulder

internal and external rotators and concluded that eccentric isokinetic training actually produced the greatest increases in concentric strength.

Askling et al, (2003) wanted to evaluate whether a preseason strength training program for the hamstring muscle group, emphasizing eccentric overload, could affect the occurrence and severity of hamstring injuries during the competition season in elite male soccer players. Thirty players were randomly divided into two groups: a training group and a control group. The only difference between the groups was that the training group received additional specific hamstring training during a ten week preseason period. Also, all hamstring injuries were registered during the total observational period of ten months. The training group performed a total of sixteen sessions of specific hamstring strength training every fifth day for the first four weeks and every fourth day during the last six weeks. The specific hamstring training consisted of both concentric and eccentric actions and was performed on an ergometer. This study resulted in a significant increase in both concentric and eccentric strength in the training group compared with the control group. The most important result of the study was that the number of hamstring injuries decreased significantly in the training group. There were thirteen (N=30) reported hamstring injuries in the two groups during the ten month study period; ten (of thirteen) occurred in the control group and only three (of thirteen) occurred in the training group. In addition, there were significant increases in strength and speed in the training group. These results indicate that addition of specific preseason strength training for the hamstrings, including eccentric overloading, would be beneficial for elite soccer players both from an injury prevention and from performance enhancement point of view.

Wright et al, (1999) state that the hamstring muscle group, except for the short head of the biceps femoris, consists of two joint muscles crossing the knee and hip joints. As a result, the

hamstrings may be at a greater risk of injury because of increased stresses made possible by the interactions of the two joints (Garrett, Califf & Bassett, 1984). Hamstring injuries are common when the stresses in these muscles are high, such as in athletic events requiring high speed, acceleration, or strength (Garrett et al, 1984). Therefore, a lack of strength or a strength imbalance between the hamstring and quadriceps groups has been shown to be a predictor of hamstring injury (Garrett et al, 1984). Wright et al, (1999) stated that, to develop strength in the hamstrings, resistance must be applied against movements that incorporate the use of the hamstrings. They assume that, the greater the activity of the hamstrings during an exercise, the greater the increase in strength will be.

In conclusion, all of these studies lead to the fact that an anteriorly placed elastic counterforce will influence knee kinematics and hamstring function. As Heiderscheit et al. (2010) state, the high early reinjury rate of the hamstring is suggestive of an inadequate rehabilitation program, a premature return to sport, or a combination of both; therefore, a new hamstring strength training technique needs to be developed. Kaminski et al. (1998) state that hamstring injuries typically occur because of lack of adequate eccentric strength. If this new technique includes eccentric training in the full range of motion of the hamstrings, there should be a decrease in hamstring injuries.

Chapter 3

Methods

Fourteen college age subjects (N=14) reported to the Visualization Laboratory on the Marshall University campus. Upon arrival, each subject completed a health history questionnaire. If there was a past history of lower extremity injury, then the subject was excluded from participating. After inclusion was determined, each subject read and signed an informed consent. The project had received IRB approval from Marshall University. To begin, the subject stood in the Organic Motion staging area to begin the calibration procedures. After the calibration procedure was completed to orient the tracking software to the subject, the subject was asked to walk at a normal pace back and forth within the stage for approximately 60 seconds. Once gait had been normalized, the video tracking system was activated and the subject's gait pattern was recorded. Upon completion of the recording, the subject exited the stage and an elastic band (Theraband® Akron, Ohio) was attached and secured to the anterior surface of their waist and proximal tibia utilizing 1.5 inch white athletic tape (Johnson & Johnson© New Brunswick, New Jersey). After the elastic band was positioned, the subject was then allowed to walk around the room to normalize gait and become accustomed to the TheraBand®. Once gait was normalized, the subject reentered the Biostage and walked back and forth for approximately 60 seconds. After the subject was comfortable walking with the band, the video tracking software once again recorded the subject's gait pattern. After the subject's gait was recorded, the subject exited the stage, the elastic band was removed and the subjects were free to go.

The video recordings were analyzed focusing on angular velocity (m/s) and the amount of knee flexion and extension (degrees) that occurred at the knee during the gait cycle. A within

subjects' repeated measures analysis of variance (ANOVA) was utilized to determine significant differences ($p < 0.05$) in angular velocity (m/s) between the gait cycles.

Chapter 4

Results

A one way repeated measures ANOVA was conducted with the factor being the use of an elastic band and the dependant variable being angular velocity and its associated angle of flexion. The means and standard deviations for angular velocity and the associated angle of flexion are presented in Table 1. The results for the repeated measures ANOVA indicated a significant time effect, Wilk's $\Lambda = 0.512$, $F(1,13) = 12.414$, $p = 0.004$. Figure 1 displays the means and standard deviations for the knee flexion angle under each treatment condition (band and no band) where maximum angular velocity occurred.

Figure 1: Knee flexion angle where maximum angular velocity occurred (Mean + SD)

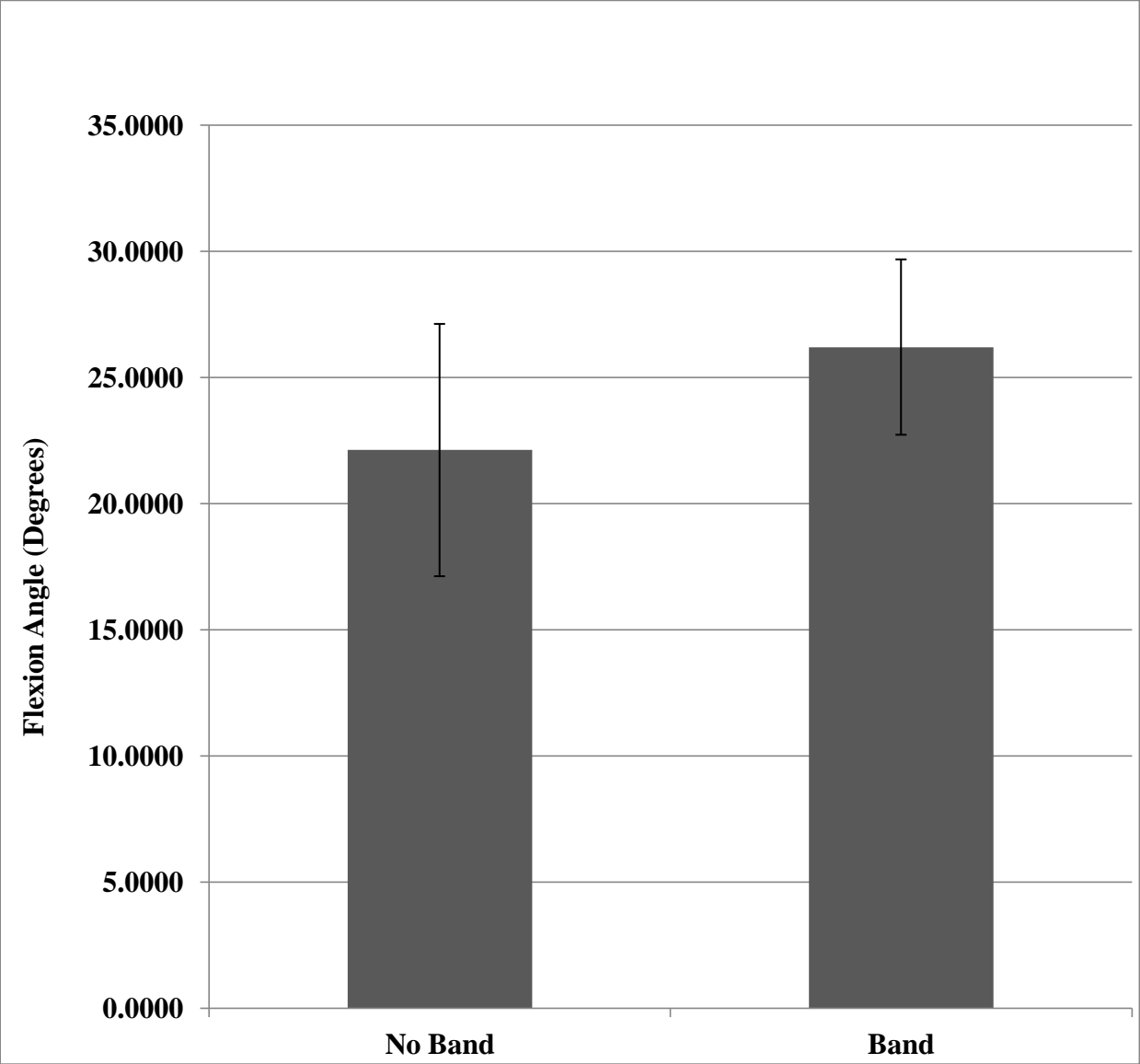


Table 1: Mean and Standard Deviation

	Angular Velocity No Band (m/s)	Flexion at Max. Velocity No Band (degrees)	Angular Velocity With Band (m/s)	Flexion at Max. Velocity With Band (degrees)
Mean	0.0896	22.1226	0.0922	26.2042
SD	0.0224	4.9996	0.0297	3.4753

Chapter 5

Discussion

Hamstring strains are among the most common injuries to occur in sports (Best & Garrett, 1996; Heiderscheit et al, 2010). One-third of the hamstring injuries will recur with the greatest risk during the initial two weeks following return to sport. This high early reinjury rate is suggestive of an inadequate rehabilitation program, a premature return to sport, or a combination of both (Heiderscheit et al, 2010). Heiderscheit et al (2010) stated that there is mounting evidence that the risk of reinjury can be minimized by utilizing rehabilitation strategies that incorporate neuromuscular control exercises and eccentric strength training. Functional rehabilitation that includes stretching and strengthening has been emphasized; however, there is currently no consensus on optimal rehabilitation following this initial treatment (Best & Garrett, 1996).

Given the high incidence of hamstring strain injuries that occur and the tendency for these injuries to recur, the greatest impact may be achieved by developing improved techniques for preventing initial injury. Based on identified risk factors for injury, prevention strategies have been suggested that target specific risk factors such as deficits in hamstring flexibility and strength. Heiderscheit et al. (2010) discuss how the incorporation of eccentric hamstring exercises as part of routine training has been found to substantially reduce the incidence of hamstring strain.

Kaminski et al. (1998) performed a study comparing concentric versus eccentric hamstring strength training in twenty-seven healthy male subjects. Their results suggest that, as most muscle strain injuries occur during eccentric muscle actions, improving eccentric strength would therefore help to diminish risk of injury.

Askling et al, (2003) wanted to evaluate whether a preseason strength training program for the hamstring muscle group, emphasizing eccentric overload, could affect the occurrence and severity of hamstring injuries during the competition season in elite male soccer players. This study resulted in a significant increase in both concentric and eccentric strength in the training group compared with the control group. The most important result of the study was that the number of hamstring injuries decreased significantly in the training group. There were thirteen (N=30) reported hamstring injuries in the two groups during the ten month study period; ten (of thirteen) occurred in the control group and only three (of thirteen) occurred in the training group. In addition, there were significant increases in strength and speed in the training group. These results indicate that addition of specific preseason strength training for the hamstrings, including eccentric overloading, would be beneficial for elite soccer players, both from injury prevention and from performance enhancement point of view.

The results from our study show that angular velocity increased earlier in the range of motion than when the subject was not wearing the band. In order for the patient to control the leg, the hamstring muscle would have to assume more eccentric load. From this increased eccentric load, we can assume there would be an increase in eccentric strength and a decrease in injuries. The maximum angular velocity with the band as opposed to no band occurred earlier. This effect on angular velocity would cause the hamstring to have to start firing earlier in the swing phase of walking. The band also put more stress on the hamstring. The combination of the increased eccentric load and the maximum angular velocity occurring earlier during the increased eccentric phase would result in an increase in hamstring strength. When using this band, caution should be taken so as to not add too much stress. Band thickness and tension should be increased gradually as the patient's hamstring strength increases.

These results should be taken into consideration and further research should be done on how this band can be incorporated to improve hamstring strength for rehabilitation purposes or injury prevention. Other factors such as EMG data should also be considered.

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Appendix A

IRB



w w w . m a r s h a l l . e d u

Office of Research Integrity

Institutional Review Board

401 11th St., Suite 1300

Huntington, WV 25701

FWA 00002704

IRB1 #00002205

IRB2 #00003206

March 18, 2011

Matthew Comeau

RE: IRBNet ID# 209404-1

At: Marshall University Institutional Review Board #1 (Medical)

Dear Dr. Comeau:

Protocol Title: [209404-1] The effects of an anterior elastic counterforce on knee kinematics and hamstring function

Expiration Date: March 18, 2012

Site Location: MU


Type of Change: New Project APPROVED

Review Type: Expedited Review

In accordance with 45CFR46.110(a)(4)(6), the above study and informed consent were granted Expedited approval today by the Marshall University Institutional Review Board #1 (Medical) Chair for the period of 12 months. The approval will expire March 18, 2012. A continuing review request for this study must be submitted no later than 30 days prior to the expiration date.

If you have any questions, please contact the Marshall University Institutional Review Board #1 (Medical) Coordinator Trula Stanley at (304) 696-7320 or stanley@marshall.edu. Please include your study title and reference number in all correspondence with this office.

Appendix B
Informed Consent

	Marshall University IRB	
	Approved on:	3-18-11
	Expires on:	3-18-12
	Study number:	209404

Informed Consent to Participate in a Research Study

The Effects of an Anterior Elastic Counterforce on Knee Kinetics in Healthy College Aged Subjects

Matthew J Comeau, PhD, ATC, CSCS, Principal Investigator

Introduction

You are invited to be in a research study. Research studies are designed to gain scientific knowledge that may help other people in the future. You may or may not receive any benefit from being part of the study. There may also be risks associated with being part of research studies. If there are any risks involved in this study then they will be described in this consent. Your participation is voluntary. Please take your time to make your decision, and ask your research doctor or research staff to explain any words or information that you do not understand.

Why Is This Study Being Done?

The purpose of this study is to determine the effect an anterior force applied to the knee through the use of an elastic band has on the kinetic properties of the knee

How Many People Will Take Part In The Study?

About 30 people will take part in this study. A total of 40 subjects are the most that would be able to enter the study.

What Is Involved In This Research Study?

Before you begin the study, the following would occur

- Report to the Viz lab in the Engineering building
- Read consent form and sign if willing to participate
- Height, weight, and the length of your leg from your hip to your ankle will be measured with a tape measure.

During the study, you will:

- Walk back and forth in the Biostage for approximately 30 seconds
- Have an elastic band will be applied to the anterior side of your hip extending down the front of your leg to just under your knee. It will be secured with tape and underwrap.
- Walk back and forth in the Biostage for approximately 30 seconds
- Have tape removed and you will be free to go.

How Long Will You Be In The Study?

You will be in the study for about approximately 30 minutes to 1 hour.

You can decide to stop participating at any time. If you decide to stop participating in the study, we encourage you to talk to the investigators or study staff to discuss what follow up care and testing could be most helpful for you.

Subject's Initials _____

The study doctor may stop you from taking part in this study at any time if he/she believes it is in your best interest; if you do not follow the study rules; or if the study is stopped.

What Are The Risks Of The Study?

Being in this study involves some risk to you. You should discuss the risk of being in this study with the study staff.

You should talk to your study doctor about any side effects that you have while taking part in the study.

Risks and side effects related to the effects of the elastic band include: some body hair may be pulled when interacting with the theraband or tape. Other than that, there are no risks to you.

Are There Benefits To Taking Part In The Study?

If you agree to take part in this study, there may or may not be direct benefit to you. We hope the information learned from this study will benefit other people in the future. The benefits of participating in this study may be: to determine the effects of an elastic force on the overall function of the knee.

What About Confidentiality?

We will do our best to make sure that your personal information is kept confidential. However, we cannot guarantee absolute confidentiality. Federal law states that we must keep your study records private. Nevertheless, certain people other than your researchers may also need to see your study records. By law, anyone who looks at your records must keep them completely confidential.

Those who may need to see your records are:

- Certain university and government people who need to know more about the study. For example, individuals who provide oversight on this study may need to look at your records. These include the Marshall University Institutional Review Board (IRB) and the Office of Research Integrity (ORI). Other individuals who may look at your records include: *the federal Office of Human Research Protection*. This is done to make sure that we are doing the study in the right way. They also need to make sure that we are protecting your rights and your safety.

If we publish the information we learn from this study, you will not be identified by name or in any other way.

What Are The Costs Of Taking Part In This Study?

There are no costs to you for taking part in this study. All the study costs, including any study medications and procedures related directly to the study, will be paid for by the study. If you sustain an injury while participating in this study, you will be paid no compensation and you will be responsible for any medical costs relating to this injury. Also, costs for your regular medical care, which are not related to this study, will be your own responsibility.

Subject's Initials _____

Will You Be Paid For Participating?

You will receive no payment or other compensation for taking part in this study.

What Are Your Rights As A Research Study Participant?

Taking part in this study is voluntary. You may choose not to take part or you may leave the study at any time. Refusing to participate or leaving the study will not result in any penalty or loss of benefits to which you are entitled. If you decide to stop participating in the study we encourage you to talk to the investigators or study staff first to learn about any potential health or safety consequences.

Whom Do You Call If You Have Questions Or Problems?

For questions about the study or in the event of a research-related injury, contact the study investigator, Matthew Comeau, PhD at 696-2925 8:00 am – 5:00 pm. You should also call the investigator if you have a concern or complaint about the research.

For questions about your rights as a research participant, contact the Marshall University IRB#1 Chairman Dr. Henry Driscoll or ORI at (304) 696-7320. You may also call this number if:

- You have concerns or complaints about the research.
- The research staff cannot be reached.
- You want to talk to someone other than the research staff.

You will be given a signed and dated copy of this consent form.

SIGNATURES

You agree to take part in this study and confirm that you are 18 years of age or older. You have had a chance to ask questions about being in this study and have had those questions answered. By signing this consent form you are not giving up any legal rights to which you are entitled.

Subject Name (Printed)

Subject Signature

Date

Person Obtaining Consent

Date

Principal Investigator

Date

Witness (If not applicable, omit this line)

Date

Subject's Initials _____

Appendix C

Data

Angular Velocity No Band (m/s)	Flexion at Maximum Velocity No Band (degrees)	Angular Velocity With Band (m/s)	Flexion at Maximum Velocity With Band (degrees)
.11	24.90	.10	26.53
.10	27.31	.08	28.45
.08	27.49	.08	28.46
.11	21.84	.08	28.04
.07	20.47	.07	22.72
.11	20.08	.09	25.30
.07	20.03	.07	25.93
.07	22.66	.07	22.76
.07	21.70	.08	25.74
.07	10.47	.14	25.76
.10	27.64	.18	34.63
.09	27.95	.09	28.76
.14	15.08	.09	23.15
.07	22.09	.08	20.62