RELATIONSHIP BETWEEN GASTROCNEMIUS FLEXIBILITY AND LOWER EXTREMITY INJURY IN DIVISION I CROSS COUNTRY ATHLETES

By

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CHAPTER I

INTRODUCTION

There is much speculation in the exercise science world as to the effectiveness of flexibility exercises. For years, people have viewed flexibility as essential to the prevention of injury in athletics. Flexibility has been thought to be achieved through stretching exercises. Therefore, most medical personal recommend stretching as a daily routine for their athletes (Arnheim & Prentice, 2006). In most cases, these stretching exercises are performed as a team with the supervision and instruction of the medical personnel, the coach, or both. However, stretching can be a time consuming endeavor, and if performed incorrectly, may even cause injury by stretching the tissue beyond its limits. In addition, there is the possibility that excessive stretching could decrease the stability of the joint which would also increase the possibility of injury (Arnheim & Prentice, 2006). Due to these concerns, it is necessary to determine if increased flexibility really does decrease injury rates.

The first question to consider is whether or not stretching exercises do increase flexibility. The literature appears to show that stretching does, in fact, increase flexibility both short-term from a single stretching session and after an extended period of routine stretching. Assuming this is the case, the next question is whether or not increased flexibility decreases the occurrence of injury. A few studies (Witvrouw, Lysens, Bellemans, Cambier, & Vanderstraeten, 2000; Krivickas & Feinburg, 1996; Hughes, 1985; Messner & Pittala, 1988; Warren, 1983; Mechelen, Hlobil, Kemper, Voorn, & Jongh, 1993; Ekstrand & Gillquist, 1982; Montgomery, Nelson, Norton, and Deuster, 1989; Pope, Herbert, Kirwan, and Graham, 2000; Bennett et. al, 2001; Jacobs and Berson, 1986) have considered this question; however, the subjects, joints measured, and methods of measuring flexibility vary widely and make comparison difficult. In addition, it does not appear that gastrocnemius flexibility has ever been studied in a population of elite long distance running athletes. The present study intends to study this population while measuring gastrocnemius flexibility in the most functional method possible.

Statement of the Problem

The problem in this study was to determine if a relationship existed between gastrocnemius flexibility and lower extremity injury in Division I collegiate men and women long distance runners. Research has shown that stretching does increase flexibility (Toft, Espersen, Kalund, Sinkjaer, Hornemann, 1989; Lucas & Koslow, 1984; Kibler & Chandler, 2003; Grady & Saxena, 1991; Kubo, Kankhisa, & Fukunaga, 2002; Worrell, McCullough, and Pfeiffer, 1994); however, there is conflicting evidence in the literature as to whether or not stretching, and the increased flexibility resulting from the stretching, decreases injury. In addition, as far as the literature review revealed, no study has used elite distance runners as subjects while tracking injuries sustained during a competitive season.

Purpose of the Study

Most collegiate long distance runners suffer from numerous lower extremity injuries in their careers such as tibial stress fractures or ankle sprains (Krivickas & Feinberg, 1996). Much speculation exists concerning the role of muscle tightness in injury incidences (Witvrouw, Lysens, Bellemans, Cambier, & Vanderstraeten, 2000; Krivickas & Feinburg, 1996; Hughes, 1985; Messner & Pittala, 1988; Warren, 1983, Mechelen, Hlobil, Kemper, Voorn, & Jongh, 1993; Ekstrand & Gillquist, 1982; Montgomery, Nelson, Norton, and Deuster, 1989; Pope, Herbert, Kirwan, and Graham, 2000; Bennett et. al, 2001; Jacobs and Berson, 1986). Thus, many athletes spend a good bit of time each day doing stretching exercises in an effort to ward off injury. By determining if a relationship exists between gastrocnemius tightness and lower extremity injury, one may be a step closer to determining if flexibility exercises may prevent injury in long distance runners.

Definitions

1. Dorsiflexion - the ability to bend the ankle so that the toes are close to the shin.
2. Elite athlete – an athlete who competes in their sport on a regular basis with enough skill that the athlete either is currently being compensated for their competition (i.e. scholarship) or is likely to in the near future (i.e. professional sponsorship).
3. Flexibility – the ability to move a joint or a series of joints through the full range of motion for that joint (Arnheim & Prentice, 2000).
4. Illiotibial band friction syndrome - a common lower extremity injury causing pain in the knee and hip.
5. Increased flexibility – an athlete has increased his or her flexibility from the previous measurement.
6. Injury – any pain or uncomfortable feeling, whether acute or chronic, which limits the ability of the athlete to compete at their normal level. An injury will cause a

runner to not finish a workout or to be forced to cross train rather than run for at least part of a practice.

7. Long distance athlete – an athlete who intends to compete in races of distances of longer than 800 meters.
8. Lower extremity – any body part inferior to and including the lower back.
9. Passive tension - the ability for the ankle to be stretched without the person moving it themselves with their leg muscles.
10. Stretching session – a time allotted to performing flexibility exercises on various areas of the body with the intention of gaining flexibility in those areas. Typically this would be daily for about 30 minutes.

Significance of the Study

This study is useful for both members of the distance running community and those involved in preventing injuries in these athletes. If a relationship had been found between injury rates and flexibility, there would have been several implications. First of all, it would have implicated that it is important for long distance runners to maintain their flexibility in order to prevent injury. Also, pre-participation exams could check for gastrocnemius flexibility to identify athletes who would be more inclined to sustain lower extremity injuries. These athletes could then receive instruction and treatment to prevent these injuries. This study could possibly be useful for other athletes, but assumptions would need to be made with caution because of the different population studied.

Assumptions

The following assumptions were made:

1. The athletes reported their lower extremity injuries as defined in this study to the researcher.
2. The athletes' reported injuries were valid and not psychological in nature.
3. The goniometric measures were valid.
4. No other factors contributed to the injuries recorded. If lower extremity injuries occurred that were obviously not related to flexibility (i.e. laceration) they were not recorded in the study.
5. During the gastrocnemius flexibility data collection, athletes stopped stretching when they first feel a gentle stretch in their calf as they were instructed by the data collector.
6. The athletes continued their normal flexibility exercises throughout the study.

Limitations to the Study

The research may have been limited by the following:

1. The results of the study may not be generalizable to other populations.
2. It is impossible to control for other injury factors such as running surface, weakness, and overtraining.

Delimitations

This study had the following delimitations:

1. The subjects were Division I athletes on the Oklahoma State University Cross Country Teams.

2. The subjects competed (or intended to compete, if injured) in distances longer than 800 meters.
3. Recorded injuries included all of those reported to the researcher by the athletes in the low back, hip, thigh, knee, shin, calf, foot, and toe regions regardless of practice time lost because of the injury. Injuries that were not obviously related to flexibility (i.e. laceration) were not recorded in the study.

Hypothesis

The following null hypothesis was examined:

Ho = There would be no difference between the gastrocnemius flexibility of injured and un-injured athletes.

CHAPTER II

REVIEW OF THE LITERATURE

Over the years, flexibility exercises have been considered an essential part of the daily routine of athletes. These athletes and the people who work closely with them believe that stretching increases flexibility and increased flexibility decreases injury (Arnhiem & Prentice, 2006). Much research has already been done on the subject. This research has focused on determining if stretching increases flexibility, examining the relationship between gastrocnemius stretching and flexibility, determining the best method for measuring gastrocnemius flexibility, examining the relationship between gastrocnemius flexibility and running, and determining the relationship between stretching and injury reduction.

Stretching Increasing Flexibility

Many studies have been conducted to determine whether flexibility exercises actually increase muscle flexibility (Toft, Espersen, Kalund, Sinkjaer, Hornemann, 1989; Lucas & Koslow, 1984; Kibler & Chandler, 2003; Grady & Saxena, 1991; Kubo, Kankhisa, & Fukunaga, 2002; Worrell, McCullough, and Pfeiffer, 1994). Some have investigated the different types of stretching, tried to determine how much stretching is necessary for flexibility gains, or attempted to identify populations most likely to benefit from stretching. Almost all of the studies did show increases in flexibility after being on a stretching program (Toft, Espersen, Kalund, Sinkjaer, Hornemann, 1989; Lucas & Koslow, 1984; Kibler & Chandler, 2003; Grady & Saxena, 1991; Kubo, Kankhisa, & Fukunaga, 2002; Worrell, McCullough, and Pfeiffer, 1994).

Several studies have looked at the effects of different types of stretching. In one study, researchers found that stretching decreased muscle tension both after a single session of flexibility exercises, and after three weeks of twice-daily contract-relax stretching (Toft, Espersen, Kalund, Sinkjaer, Hornemann, 1989). In another study, Lucas and Koslow found that while all of the subjects increased their flexibility, no significant difference could be noted in hamstring-gastrocnemius flexibility after seven weeks of flexibility exercises using different stretching techniques (1984).

Many have focused on trying to determine the length of calendar time required to increase flexibility. Kibler and Chandler found that most increases in the range of motion of an individual on a flexibility program occur in less than one year (2003). Lucas and Koslow found significant increases in hamstring-gastrocnemius flexibility after subjects had only been on a program for seven weeks (1984). Kibler and Chandler showed that simply stretching twice a week, over an extended period of time, produced significant increases in flexibility (2003).

One study looked at whether or not flexibility training is effective for anyone, or just for those individuals who are inflexible to begin with. They found that stretching increases flexibility in subjects regardless of their pre-stretching muscle tightness (Toft, Espersen, Kalund, Sinkjaer, Hornemann, 1989). There appears to be plenty of evidence to show that stretching does significantly increase flexibility, even in those who are already flexible.

Gastrocnemius Stretching and Flexibility

In particular, runners are interested in gastrocnemius flexibility. The ability to pull the foot so that the toes are as close as possible to the shin is essential to performance. This can only be achieved if the gastrocnemius muscle is flexible. Ten degrees of flexibility is required to even walk properly (Worrell, McCullough, & Pfeiffer, 1994). Normal running requires 15 degrees of gastrocnemius flexibility (Krivickas & Feinburg, 1996). Injuries are likely to occur if an individual is unable to run properly. The lack of flexibility will force the individual into using other mechanisms such as overpronation which has been known to cause such conditions as Achilles tendonitis, tibial stress syndrome and medial knee pain (Arnheim & Prentice, 2006).

Two different studies reported on the effects of stretching on the gastrocnemius muscle. Both studies showed significant increases in flexibility after a stretching program despite several differences in the studies. Their subjects had different athletic backgrounds, stretched a different amount of time daily, and participated in the study for different amounts of time. However, both studies instructed their subjects to stretch every day (Grady & Saxena, 1991 and Kubo, Kankhisa, & Fukunaga, 2002). Toft, Esperson, Kalund, Sinkjaer, and Hornemann showed that stretching decreases passive tension, both immediately following stretching and over an extensive period of time (1989).

Kibler and Chandler aimed to increase flexibility in multiple joints of junior tennis players. While many joints showed significant increase, the gastrocnemius flexibility increased, but not significantly (2003). This may have been because, as opposed to the other studies, the athletes only stretched twice a week.

It has been proposed that foot position may affect gastrocnemius flexibility. In order to test that, Worrell, McCullough, and Pfeiffer looked to see if foot position during stretching affected the gain in flexibility. They determined that the amount of supination or pronation of the foot did not affect the flexibility gains from ten sessions of 20 second stretches (1994).

<u>Measuring Gastrocnemius Flexibility</u>

There are many different methods used to measure gastrocnemius flexibility. Most studies utilize goniometry to measure plantarflexibility, while a few used camera imaging. Arnheim and Prentice describe goniometry as the simplest and most widely used method for measuring joint range of motion (2006). In one of the goniometry studies, the numbers on the goniometer dial were covered in order to blind the researcher taking the measurements. A second researcher recorded the measurements (Worrell, McCullough, & Pfeiffer, 1994). In another study, the subjects stretched the muscles for 30 seconds before range of motion measurements were taken. In order to keep the knee straight or bent at a particular degree, subjects wore a knee brace, which kept their knee in the desired position (Wang, Whitney, Burdett, & Janosky, 1993). In an effort to mimic sport specificity, Witvrouw, Lysens, Bellemans, Cambier, & Vanderstraeten used goniometry in a weight bearing position (2000). Most of the other goniometry studies had the patient lying on a table in a non-weight bearing position. Norkin distinguishes between the purposes of measuring passive verses active range of motion. Active range of motion assesses the patient’s willingness to move, their coordination, their muscle strength, and the joint range of motion. On the other hand, passive range of motion assesses the integrity of articular surfaces as well as assessing the extensibility of the joint capsule, associated ligaments, and muscles (2003).

Gastrocnemius Flexibility and Running

Some investigators have examined gastrocnemius flexibility specifically in relation to running. According to Wang, Whitney, Burdett, and Janosky, runners have tighter hamstrings, gastrocnemius, and soleus muscles than non-runners despite the fact that most of the runners stretched daily while most of the non-runners did not. In addition, they discovered that there appears to be a positive correlation between the number of miles run each week and posterior muscle tightness; however no statistical analysis was performed. Finally, in the same study they found that the dominant leg exhibited tighter musculature than the non-dominant one in runners (1993). One may consider the theory that runners would benefit from gastrocnemius stretching because of their greater likelihood to have tight musculature in that region.

Stretching and Injury Reduction

While it is widely accepted that stretching increases flexibility, the ability of regular flexibility exercises to decrease injury is less understood. While some studies have shown increased flexibility to reduce the risk of injury (Witvrouw, Lysens, Bellemans, Cambier, & Vanderstraeten, 2000; Krivickas & Feinburg, 1996; Hughes, 1985; Messner & Pittala, 1988; Warren, 1983), others have actually correlated increased flexibility with increased injury rates (Mechelen, Hlobil, Kemper, Voorn, & Jongh, 1993; Ekstrand & Gillquist, 1982; Montgomery, Nelson, Norton, and Deuster, 1989; Pope, Herbert, Kirwan, and Graham, 2000; Bennett et. al, 2001; Jacobs and Berson, 1986).

Decreased flexibility in the gastrocnemius has been shown to be correlated highly with anterior knee pain in test subjects (Witvrouw, Lysens, Bellemans, Cambier, & Vanderstraeten, 2000). Krivickas and Feinburg found that in men illiopsoas and gastrocnemius tightness appeared to be the main indicators for injury. In their study, they recorded all of the lower extremity injuries sustained by athletes who had been previously screened and rated on whole body flexibility. They discovered that the more flexible a man was, the less likely he was to sustain an injury. However, women showed no correlation between flexibility and injury (1996). In a study using soldiers attending boot camp as subjects, Hughes found that recruits who had decreased dorsiflexion were almost five times more likely to develop a metatarsal stress fracture (1985). Messner and Pittala found decreased range of motion in runners who exhibited shin splints and in runners who exhibited illiotibial band friction syndrome (1988). Warren chose to study causes of plantar faciitis in runners. She discovered that those suffering from the ailment exhibited decreased dorsiflexion of the ankle. In addition, those who were diagnosed with and exhibited limited dorsiflexion recovered more slowly (1983).

On the other hand, several studies show the opposite results. For example, a group of recreational runners were given education and instruction on stretching and warm-up exercises; however, there was no difference in the number of injuries suffered between them and the control group which did not receive the instruction and education (Mechelen, Hlobil, Kemper, Voorn, & Jongh, 1993). While the results could be due to the possibility that the athletes did not begin a stretching routine following the educational session, the results could also indicate that although stretching does increase muscle length, it does not in turn decrease injury rates. Another study that used recreational soccer players as subjects affirms this assumption. Ekstrand and Gillquist found no correlation between muscle tightness and past injuries in the soccer players (1982). Montgomery, Nelson, Norton, and Deuster also found no correlation between ankle dorsiflexion and tibial stress fractures in military trainees (1989). Pope, Herbert, Kirwan, and Graham found similar results in army recruits. Stretching did not significantly reduce lower extremity injuries after eleven weeks of intense physical training (2000). Bennett et. al. found no relationship between gastrocnemius flexibility and medial tibial stress syndrome in high school distance runners (2001). Finally, Jacobs and Berson actually found that participants in a 10 km race were more likely to be injured if they routinely stretched before exercise. They note that the literature is conflicting in the area of stretching and injury, but contend that those people who stretched before the race may have been stretching because of a previous injury which may have skewed their data (1986).

Summary

The literature does indicate that stretching exercises increase flexibility in most cases, even if the area being stretched is already flexible. Running requires some level of gastrocnemius flexibility, but there is conflicting evidence as to whether or not being more or less flexible affects injury rates in runners. Because of all of the different genders, ages, and activity levels of the subjects in each of these studies, it makes them difficult to compare. In addition, so many factors go into the development of an injury that it is difficult to isolate tight musculature as the main cause. One can only say that more research is needed on this subject. This study will try to shed more light on the subject by determining if there is a relationship between gastrocnemius tightness and lower extremity injury in elite distance running athletes.

CHAPTER III

METHODOLOGY

Subjects

The investigator recruited members of both the Men's and Women's Cross Country teams at Oklahoma State University, a Division I program. To qualify for the study, the subjects had to have been intending to compete in races of distances longer than 800 meters. Athletes participating in the study were between the ages of 18 and 22. A small number of athletes also competed in shorter distances, but the vast majority focused exclusively on the longer events. Of the athletes participating, one was from New Zealand, one was from Sweden, one was from Great Brittan, and 16 were from the United States of America.

Instrumentation

A standard goniometer with the numbers on the dial hidden by a piece of paper was used to measure the gastrocnemius flexibility. The dial was hidden from the first data collector and read and recorded by the second collector to maintain the blindness of the study. The fulcrum of the goniometer was placed on the lateral maleolus with the stationary arm in line with the greater trochanter of the femur and the movement arm in line with the head of the 5th metatarsal as described by Norkin (2003).

Lower-extremity injuries were recorded in a widely used computer based injury tracking system called Sports Injury Monitoring System (SIMS) distributed by Med Sports Systems. All injury reports were recorded on paper as a back-up method.

Research Design and Procedure

Preliminary Procedures

All Oklahoma State athletes receive a pre-participation examination in which past medical history is revealed. They are screened for any existing injuries that would limit participation before they are cleared to participate in intercollegiate athletics. The athletes signed a consent form before participation in the study which released these records to the researcher.

Members of both the Men's and Women's Cross Country teams received a consent form informing them of the purpose of the study and what their role would be should they choose to participate. If the pre-participation examination revealed a lower body injury, the athlete was not permitted to participate in the study.

Operational Procedures

Before their first competition, each athlete was measured for gastrocnemius flexibility. Gastrocnemius flexibility was tested functionally by having the athlete stand in a lunge position with the back leg held as straight as possible. The straight knee position ensured that the gastrocnemius muscle was isolated. While keeping the heel in contact with the ground, the athlete bent the opposite knee until a gentle stretch was first felt. The measurements were taken by the researcher. The researcher was blind to the numbers on the dial which were covered. A second researcher, an athletic training student or another athletic training Graduate Assistant, recorded the numbers from the goniometer. The second tester was blind to the subject because of a screen between the subject and the second tester. Athletes were randomly assigned a number by pulling their names out of a hat. Their number was used in place of their name in all records in order to maintain confidentiality. Each athlete was measured three times on each ankle and the average was recorded. There was no stretching before the measurements were taken, however a warm-up in which the athlete jogged 800 meters on the OSU track was performed in order to warm the muscles the way they would be during a typical cross country practice or competition. The measurements were taken again at the end of the study to determine if flexibility had changed during the course of the study. This was done because a stretching routine was not prescribed by the researcher. Each athlete stretches differently according to their own backgrounds. Many would not be willing to give up the routine they have been using successfully for years.

When one of the participating athletes maintained a lower body injury during the course of the Cross Country or Indoor Track season of 2005-2006, the initial evaluation of the injury, the maintenance records, and the time loss statistics were carefully recorded by using a computer based injury tracking system. Only lower-extremity injuries were recorded for the purpose of this study. This included low back, hip, thigh, knee, calf, shin, ankle, foot, and toe injuries.

Statistical Analysis

A t-test was performed to determine if the average flexibility of the injured athletes was different than the average flexibility of the non-injured athletes. The hypothesis was tested at the .05 level of significance.

CHAPTER IV

RESULTS

This investigation tested the hypothesis that athletes who are more flexible are less likely to sustain injuries. The research had an alpha level set at .05 and the null hypothesis stated that there would be no difference between the gastrocnemius flexibility of injured and un-injured athletes. As a result of the nature of most overuse injuries, the injury was often reported by the athlete rather than being observed by the researcher. Thus, the reporting of the injury to the researcher was rather subjective.

General Subject Characteristics

The subjects in this study were men and women Division I Cross Country and Indoor Track Athletes at a single school. The athletes ranged in age from 18 to 22. Of the 19 subjects, 8 were women and 11 were men. One was from New Zealand, one was from Sweden, one was from Great Brittan, and the rest were American. They were all cleared to participate in the 2005-2006 school year after being examined by the team physician. They all anticipated participation in events longer than 800 meters.

Summary of Results

The average measurement of dorsiflexion at the beginning of the study was 17.081 degrees [SD = 4.193]. The average at the second measure was 15.738 degrees [SD = 4.242]. Seventy-nine percent of the athletes had decreased dorsiflexion from the first measurement to the second measurement. Fifty-eight percent of the athletes had sustained an injury as defined in this study. Of the injured athletes, the average dorsiflexion at the beginning of the study was 18.85 degrees [SD = 3.113]. At the second measurement the dorsiflexion was 16.72 degrees [SD = 4.25]. Using a t-test (t=0.123), no difference was found between the flexibility of injured athletes and the flexibility of un-injured athletes. The null hypothesis was not rejected.

<u>Explanation of Results</u>

The data show no difference between the flexibility of injured and un-injured athletes. Other items of interest were the higher percentage of females with injuries and the fact that the flexibility of the athletes decreased during the study (Table I).

TABLE I

GASTROCNEMIUS MEASUREMENTS OF BOTH ANKLES IN RELATION TO GENDER AND INJURY OCCURRENCE

	1st Measurement		2nd Measurement		
Gender	Left	Right	Left	Right	Injury
female	15	14	13	9	no
	11	15	14	13	
	10	11	14	13	
male	22	22	20	26	no
	24	13	19	24	
	23	25	16	23	
male	11	15	16	16	yes
	13	17	15	15	
	15	14	15	15	
male	12	16	20	22	no
	14	19	14	20	
	12	20	16	20	
female	16	18	15	15	yes
	13	13	15	15	
	14	14	12	15	
female	16	21	16	18	yes
	16	22	15	18	
	17	21	16	18	
female	18	20	14	14	yes
	19	16	12	14	
	18	19	14	15	
male	16	21	16	17	yes
	17	20	17	19	
	23	20	16	16	
female	16	20	14	15	no
	24	19	15	15	
	12	19	10	8	
male	7	7	11	14	no
	8	12	12	15	
	10	11	10	16	
male	17	18	16	20	no
	17	21	16	19	
	21	19	18	19	
male	21	19	12	14	no
	18	19	9	14	
	25	18	10	9	
female	28	14	6	16	yes
	26	15	11	12	

	13	15	11	11	
male	16	21	22	22	yes
	17	22	22	23	
	19	20	23	21	
male	14	11	10	12	no
	13	13	12	10	
	13	15	13	13	
male	23	20	19	19	yes
	19	20	19	19	
	20	20	19	19	
male	13	14	18	18	yes
	24	18	15	18	
	21	29	15	15	
female	22	29	14	10	no
	24	29	6	9	
	25	30	7	13	
female	26	23	25	24	yes
	27	23	27	24	
	29	25	29	26	

CHAPTER V

DISCUSSION

The results of this study showed that the injured athletes were more flexible than the non-injured athletes both at the first and second measurements. However, these results were not significant using a 0.05 significance level. Further studies will have to be done before it can be theorized that increased flexibility causes injury. Other studies have come to this conclusion (Mechelen, Hlobil, Kemper, Voorn, & Jongh, 1993; Ekstrand & Gillquist, 1982; Montgomery, Nelson, Norton, and Deuster, 1989; Pope, Herbert, Kirwan, and Graham, 2000; Bennett et. al, 2001; Jacobs and Berson, 1986). An explanation could be that tighter muscles support the joints more, thus reducing injuries. Also, of interest is the number of females who sustained injuries compared to the number of males. Seventy-five percent of the females in the study suffered time-loss injures, while only 45% of the males did. It is often noted in studies that males are less likely to report injuries and illnesses and take medications prescribed by doctors. Another interesting result of the study was the finding that most of the athletes displayed a decrease in flexibility during the course of the study. While no data was collected with regard to the amount or type of flexibility training done by the athletes, several of them reported stretching regularly. Their decrease in flexibility may come from the nature of running. Athletes often report feeling that their muscles are tighter after a run. This could be from a number of factors including muscle hypertrophy, increased blood flow to the area, or the repetitive motion in a limited range of motion. This decrease in flexibility could be a protective mechanism, based on the findings of this study.

Significance of Findings

According to the findings noted in this project, it may be unwise to counsel elite long distance runners to stretch their gastrocnemius to reduce injury. In addition, each injury should be evaluated carefully to determine if flexibility exercises are indicated for rehabilitation. Because flexibility increases following a stretching session regardless of the tightness or looseness of the joint prior to stretching (Toft, Espersen, Kalund, Sinkjaer, Hornemann, 1989), it may not be wise to prescribe flexibility exercises to every injured athlete. Increased flexibility may actually increase the possibility that the athlete could sustain another injury in the future. On the other hand, it is good to keep in mind that many factors, such as bone density, diet, weather, biomechanics, or running surface, can lead to injury in long distance athletes. Flexibility alone may not be the culprit in a time-loss injury.

Null Hypothesis

There was no difference between the flexibility of injured and un-injured athletes.

1. Results of the study showed that the flexibility of injured and un-injured elite long distance runners is not different at the 0.05 level of significance.
2. Therefore, the null hypothesis was not rejected.

Concluding Remarks

It is necessary to note that each injury may have been caused by something other than the flexibility of the gastrocnemius. As noted before, running surface, the athlete's stride efficiency, dietary factors, and other influences may be involved in the injuries. In addition, the small numbers of subjects in the study limit the applicability of this study to the larger population. For example, because of the characteristics of the athletes in this study, the results may not apply to high school athletes or recreational runners. It would be very interesting to see if significance could be found with a larger sample size. Further research would be justified.

Recommendations

1. Conduct more research with larger sample sizes.
2. Conduct more research on different populations such as high school athletes or recreational runners.
3. Monitor the flexibility exercises that the athletes are doing during the course of the study.
4. Collect more injury data to see how long the injury lasted and what types of injuries occurred.
5. Take more frequent measurements of gastrocnemius flexibility to determine when in the season the flexibility is lost.

BIBLIOGRAPHY

Arnheim, D. D., & Prentice, W.E. (2006). Principles of Athletic Training (12th ed.). McGraw-Hill, Boston.

Bennett, J. E., Reinking, M. F., Pluemer, B., Pentel, A., Seaton, M., & Killian, C. (2001). Factors contributing to the development of medial tibial stress syndrom in high school runners. Journal of Orthopaedic and Sports Physical Therapy, 31, 9, 504-510.

Ekstrand, J. & Gillquist, J. (1982). The frequency of muscle tightness and injuries in soccer players. The American Journal of Sports Medicine, 10, 2, 75-78.

Grady, J. F., & Saxena, A. (1991). Effects of stretching the gastrocnemius muscle. The Journal of Foot Surgery, 30, 5, 465-469.

Hughes, L. Y. (1985). Biomechanical analysis of the foot and ankle for predisposition to developing stress fractures. The Journal of Orthopaedic and Sports Physical Therapy, 7, 3, 96-101.

Jacobs, S. J. & Berson, B. L. (1986). Injuries to runners: A study of entrants to a 10,000 meter race. The American Journal of Sports Medicine, 14, 2, 151-155.

Kibler, W. B., & Chandler, T. J. (2003). Range of motion in junior tennis players participating in an injury risk modification program. Journal of Science and Medicine in Sport, 6, 1, 51-62.

Krivickas, L. S., & Feinberg, J. H. (1996). Lower extremity injuries in college athletes: relation between ligamentous laxity and lower extremity muscle tightness. Arch Phys Med Rehabil, 77, 1139-1143.

Kubo, K., Kanehisa, H., & Fukunaga, T. (2002). Effect of stretching training on the viscoelastic properties of human tendon structures in vivo. Journal of Applied Physiology, 92, 595-601.

Lucas, R. C., & Koslow, R. (1984). Comparative study of static, dynamic, and proprioceptive neuromuscular facilitation stretching techniques on flexibility. Perceptual and Motor Skills, 58, 615-618.

Messier, S. P., & Pittala, K. A. (1988). Etiologic factors associated with selected running injuries. Medicine and Science in Sports and Exercise, 20, 5, 501-505.

Montgomery, L. C., Nelson, F. R. T., Norton, J. P., & Deuster, P. A. (1989). Orthpedic history and examination in the etiology of overuse injuries. Medicine and Science in Sports and Exercise, 21, 3, 237-243.

Norkin, C. C. & White, D. J. (2003). Measurement of joint motion: A guide to goniometry. F. A. Davis, .

Pope, R. P., Herbert, R. D., Kirwan, J. D., & Graham, B. J. (2000). A randomized trial of preexercise stretching for prevention of lower-limb injury. Medicine and Science in Sports and Exercise, 32, 2, 271-277.

Toft, E., Espersen, G. T., Kalund, S., Sinkjaer, T., & Hornemann, B. (1989). Passive tension of the ankle before and after stretching. The American Journal of Sports Medicine, 17, 4, 489-494.

Wang, S. S., Whitney, S. L., Burdett, R. G., & Janosky, J. E. (1993). Lower extremity muscular flexibility in long distance runners. JOSPT, 17, 2, 102-107.

Warren, B. (1984). Anatomical factors associated with predicting plantar faciitis in long-distance runners. Medicine and Science in Sports and Exercise, 16, 1, 60-63.

Witvrouw, E., Lysens, R., Bellemans, J., Cambier, D., & Vanderstraeten, G. (2000). Intrinsic risk factors for the development of anterior knee pain in an athletic population. The American Journal of Sports Medicine, 28, 4, 480-489.

Worrell, T. W., McCullough, M., & Pfeiffer, A. (1994). Effects of foot position on gastrocnmeius/soleus stretching in subjects with normal flexibility. JOSPT, 19,6, 352-356.

van Mechelen, W., Hlobil, H., Kemper, H. C. G., Voorn, W. J., & de Jongh, H. R. (1993). Prevention of running injuries by warm-up, cool-down, and stretching exercises. The American Journal of Sports Medicine, 21, 5, 711-719.

APPENDIX A

AGREEMENT TO PARTICIPATE

IN RESEARCH FOR THE ATHLETE

RELATIONSHIP BETWEEN GASTROCNEMIUS FLEXIBILITY AND LOWER EXTREMITY INJURY IN DIVISION I CROSS COUNTRY ATHLETES
Agreement to participate in Research

Authorization
I, (participant) _________________________, hereby authorize or direct Kathleen Kolb, or associates or assistants of her choosing, to perform the following procedure. The data collected during this study will be used by the above listed to fulfill the requirements necessary for the completion of a master's program of study in Health and Human Performance Program at Oklahoma State University in Stillwater, Oklahoma.

Description of research and associated risks/benefits

1. This study involves researching the correlation between gastrocnemius flexibility and lower extremity injuries in NCAA Division I distance runners. It is being conducted through Oklahoma State University by Kathleen Kolb, who is a graduate student in the Health and Human Performance Department at OSU.
2. The purpose of this study is to determine if a relationship exists between gastrocnemius tightness and lower extremity injury in elite distance runners. The duration of the subject's participation will be the amount of time that they are involved in the Cross Country and Indoor Track season of 2005-2006. The season will last from the beginning of September 2005 to the middle of March 2006.
3. The athlete will be measured before the first competition of the 2005 Cross Country season for gastrocnemius flexibility. This is a non-invasive procedure stretching the calf by assuming a lunge position until a stretch is felt. The angle of the ankle will be measured using a goniometer. The procedure will be repeated three times on both legs. An 800 meter jog will be performed immediately prior to measurement as a warm-up. This will be done only once before the season and again one more time before the completion of the study. The procedure can be expected to take approximately 30 minutes each time.
4. Lower-extremity injuries sustained during the 2005-2006 Cross Country and Indoor Track seasons that result in ending practice early or the necessity to cross-train rather than run for any practice will be recorded as it is on a regular basis. The type of injury, date of injury, location of injury, and amount of participation missed due to the injury will be made known to the researcher.
5. There are no risks involved in the research, only the inconvenience of time spent to measure flexibility.
6. Each athlete will be randomly assigned a number. That is how they will be tracked and information kept confidential. Access to the information will be restricted to the researcher and the research committee chair. This information will be kept in a locked file cabinet in which only the primary researcher has the key.

7. All identifying material not normally collected by the Athletic Trainer during the season will be stored separately from data and destroyed by the researcher following the satisfactory completion of the master's degree. Only the primary researcher and the committee chair will have access to this data.
8. The researcher will be made aware by the Athletic Training Department if a pre-existing injury is identified during the pre-participation examination which would prevent an athlete from being able to participate.

Please feel free to contact the researcher with any questions or concerns at any time during the research process:

Kathleen Kolb
1124 S. Walnut St. Stillwater, OK 74074
Oklahoma State University
(405) 744-6652

Questions, concerns, or complaints about the research or subject's rights should be directed to Dr. Sue Jacobs, IRB Chair, Oklahoma State University, 415 Whitehurst Hall, Stillwater, OK 74078, (405) 744-1676.

Voluntary Participation

I understand that participation is voluntary and that I will not be penalized if I choose not to participate. I also understand I am free to withdraw my consent and end my participation in this project at any time during the data collection without penalty after I notify the project director Kathleen Kolb at (405) 744-6652.

Consent Documentation for Written Informed Consent

I have read and fully understand the consent form. I sign it freely and voluntarily. A copy has been given to me.

Date ____________ Time ____________ am/pm

Participant Name (print) ___________________ (signed) ________________________

I certify that I have explained all elements of this form to the subject or his representative before requesting the subject or his representative to sign it.

(signed) ____

Kathleen Kolb
Project director

Please return this completed form to Kathleen Kolb. A copy will be given to you for your records.

APPENDIX B

AGREEMENT TO PARTICIPATE

IN RESEARCH FOR THE COACH

RELATIONSHIP BETWEEN GASTROCNEMIUS FLEXIBILITY AND LOWER-EXTREMITY INJURY IN DIVISION I CROSS COUNTRY ATHLETES

Kathleen Kolb
Informed Consent for Research
Oklahoma State University
August 2005

Informed consent of Oklahoma State University distance coach:

Date ________________

I, ____________________________, the distance coach at Oklahoma State University give my consent to allow my distance athletes to participate in the research being conducted by Kathleen Kolb as part of her requirements for completion of her master's degree. I understand that my athletes will be measured for gastrocnemius flexibility before the first competition. I also understand that lower extremity injuries will be tracked as they are usually done during the 2005-2006 Cross Country and Indoor Track seasons. I further understand that all information not typically collected will be kept confidential by assigning each athlete a number between 1-200 and that all such data will be destroyed at the end of the study.

(coach) X _____________________________________

Please return the signed form to Kathleen Kolb.

APPENDIX C

DATA COLLECITON SCRIPT

Data Collection Script

Before touching the subject, the first data collector will say the following:

"In order to mimic real life, we would like you to jog an 800 on the track at the speed you would normally do for an easy warm-up before competition or a workout. When you are finished, return immediately so that we can continue the measurements."

After the athlete returns from the jog, the first data collector will say:

"Now we want you do a calf stretch in the lunge position. The calf you are stretching will be behind you. Please keep the heel of this leg on the floor and hold the leg as straight as possible. Then bend your other knee just until you first feel a stretch in the first leg. Hold this position until I have measured the angle and tell you that you can relax."

This procedure will be repeated three times on each leg.

APPENDIX D

TEAM MEETING SCRIPT

Team Meeting Script

At the team meeting before the first practice of the 2005 Cross Country season, the researcher will pass out consent forms to the athletes identified by the coach as eligible for participation. The following script will be used to explain the research to the athletes:

"Hello, I am Katie Kolb, a graduate student in the Health and Human Performance Department here at Oklahoma State University. I am doing a research project of interest to long distance runners and am asking for your help. I am seeking to determine if calf flexibility has any relationship to lower body injury in distance runners. In order to do this, I need long distance athletes who will be willing to take some time to allow us to measure calf flexibility twice between now and the end of the Indoor Track season. In addition, all of your lower body injuries will be recorded during both the Cross Country and Indoor Track seasons. The two times when you will be measured for calf flexibility can be expected to take about 30 minutes each. There will be no chance of injury during these sessions. In addition, there is no compensation for participation other assisting me, and there is no consequence for not participating. All of your flexibility scores and injury information will be kept confidential. In addition, by signing the consent form you are agreeing that I will be allowed to check with the physicians that you have passed your pre-participation exam and are able to compete. I will be here for a few minutes after the meeting to answer any questions and collect the consent forms of anyone who chooses to participate. Thank you for your time!"

APPENDIX E

IRB APPROVAL

Oklahoma State University Institutional Review Board

Date	Monday, August 08, 2005
IRB Application No	ED067
Proposal Title:	Correlation Between Gastrocnemius Flexibility and Lower-Extremity Injury in Division I Cross Country Athletes
Reviewed and Processed as	Expedited

Status Recommended by Reviewer(s): Approved Protocol Expires: 8/7/2006

Principal Investigator(s)

Kathleen L. Kolb	Tona Palmer
1124 S. Walnut St.	427 Willam
Stillwater, OK 74074	Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 415 Whitehurst (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Sue C. Jacobs

Sue C. Jacobs, Chair
Institutional Review Board

VITA

Kathleen Lynn Kolb

Candidate for the Degree of

Master of Science

Thesis: RELATIONSHIP BETWEEN GASTOCNEMIUS FLEXIBILITY AND LOWER-EXTREMITY INJURY IN DIVISION I CROSS COUNTRY ATHLETES

Major Field: Health and Human Performance, Applied Exercise Science

Biographical:

Education: Received a Bachelor of Arts in Athletic Training at Messiah College in May 2003. Completed the requirements for the Master of Science Degree in Health and Human Performance with an emphasis in applied exercise science from Oklahoma State University in July 2006.

Experience: Provided athletic training services including writing exercise programs for injured Division I athletes as Graduate Assistant Athletic Trainer for Oklahoma State University Men's and Women's Cross Country and Track and Field Teams, Fall 2004 – February 2006. Athletic Trainer for Oklahoma State Intramurals, Fall 2005. Provided athletic training services for several camps hosted by Oklahoma State University, Summer 2004 – present. Provided game coverage for Perkins-Tryon High School football team through HeathSouth, Fall 2003. Organized and provided athletic training services for numerous Messiah College hosted youth sports camps, Summer 2003. Messiah College Student Athletic Trainer, February 2001- May 2003.

Professional Memberships: National Athletic Trainers Association, Oklahoma Athletic Trainers Association

Certifications: NATA-BOC certified, Oklahoma State Licensed Athletic Trainer, ARC Emergency Response, CPR for the professional rescuer, AED Essentials, Lifeguard Training, and ARC Instructor

Name: Kathleen Lynn Kolb Date of Degree: July, 2006

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: RELATIONSHIP BETWEEN GASTOCNEMIUS FLEXIBILITY AND LOWER EXTREMITY INJURY IN DIVISION I CROSS COUNTRY ATHLETES

Pages in Study: 37 Candidate for the Degree of Master of Science

Major Field of Study: Health and Human Performance

Scope and Method of Study: The purpose of this study was to determine if a relationship exists between gastrocnemius flexibility and lower extremity injury in Division I collegiate men and women long distance runners. Participants in the study were 19 men and women Division I collegiate long distance runners. All participants passed a pre-participation physical and intended to compete in distances longer than 800 meters. Each participant had his or her gastrocnemius flexibility measured twice during the course of the study and injury rates were tracked. A t-test was used to test the null hypothesis.

Findings and Conclusions**:** The average measurement of dorsiflexion at the beginning of the study was 17.081 degrees [SD = 4.193]. The average at the second measure was 15.738 degrees [SD = 4.242]. Seventy-nine percent of the athletes had decreased dorsiflexion from the first measurement to the second measurement. Fifty-eight percent of the athletes had sustained an injury as defined in this study. Of the injured athletes, the average dorsiflexion at the beginning of the study was 18.85 degrees [SD = 3.113]. At the second measurement the dorsiflexion was 16.72 degrees [SD = 4.25]. Using a t-test (t=0.123), no difference was found between the flexibility of injured athletes and the flexibility of un-injured athletes. The null hypothesis was not rejected.

ADVISOR'S APPROVAL __________________Tona Palmer______________________