



SCHOOL of  
GRADUATE STUDIES  
EAST TENNESSEE STATE UNIVERSITY

East Tennessee State University  
Digital Commons @ East  
Tennessee State University

Electronic Theses and Dissertations

Student Works

12-2003

# The Effects of Neoprene Sleeve Application on Knee Joint Proprioception in Adolescent Female Athletes.

George Ballou Barrett  
*East Tennessee State University*

Follow this and additional works at: <https://dc.etsu.edu/etd>

 Part of the [Kinesiology Commons](#)

## Recommended Citation

Barrett, George Ballou, "The Effects of Neoprene Sleeve Application on Knee Joint Proprioception in Adolescent Female Athletes." (2003). *Electronic Theses and Dissertations*. Paper 839. <https://dc.etsu.edu/etd/839>

This Thesis - Open Access is brought to you for free and open access by the Student Works at Digital Commons @ East Tennessee State University. It has been accepted for inclusion in Electronic Theses and Dissertations by an authorized administrator of Digital Commons @ East Tennessee State University. For more information, please contact [digilib@etsu.edu](mailto:digilib@etsu.edu).

The Effects of Neoprene Sleeve Application on  
Knee Joint Proprioception in Adolescent Female Athletes

---

A thesis  
presented to  
the faculty of the Department of Physical Education, Exercise and Sport Sciences  
East Tennessee State University

In Partial Fulfillment of the Requirements for the Degree  
Master of Arts in Sports Sciences

---

by  
George Ballou Barrett  
December 2003

---

Diego deHoyos Ph D., Chair  
Tom Coates D. A., Committee Member  
Diana Mozen Ph D., Committee Member

Keywords: Proprioception, Knee, Female, Athlete

## ABSTRACT

### The Effects of Neoprene Sleeve Application on Knee Joint Proprioception in Adolescent Female Athletes

By

George Ballou Barrett

Fifteen female subjects ages 13-16 were recruited to determine if differences exist in knee joint proprioception, with and without application of a neoprene knee sleeve (NKS), when performing reproduction of target angle test (RTA), movement sensation test (MS) using a Biodex testing machine, and single leg standing test. Ten subjects had not worn a NKS and five subjects had worn a NKS.

After completing all IRB approved documentation subjects underwent a test trial of each of the three testing methods. Subjects were randomly assigned a number that determined if the subject began the test trial with or without a NKS. Three starting angles were identified for the MS and the RTA tests; error was used to determine accuracy in both tests. The single leg stand tests consisted of the test subject closing her eyes and standing for as long as possible, no longer than five minutes, on her dominant leg.

## DEDICATION

I would like to dedicate this thesis to my parents for always knowing the right things to do and say when I lost focus. I would like to dedicate this thesis to my grandparents for their encouragement and endless knowledge that they so willingly have shared with me.

## ACKNOWLEDGEMENTS

I would like to acknowledge the members of my thesis committee. First, I would like to thank my chairperson, Dr. Diego de Hoyos, for his guidance, patience, and unselfish devotion throughout my thesis experience. For their support and editorial contributions, I would like to thank Dr. Tom Coates and Dr. Diana Mozen. I would also like to thank my subjects for their dedication throughout this study. I would like to thank Bob Algee who assisted me during the data collection period. Finally, I would like to thank Mary Catherine Deaton for all that she does to help keep me on track throughout all my struggles at ETSU.

## CONTENTS

	Page
ABSTRACT .....	2
DEDICATION .....	3
ACKNOWLEDGEMENTS .....	4
Chapter	
1. INTRODUCTION .....	7
Statement of the Problem.....	9
Hypotheses.....	10
Assumptions.....	10
Limitation.....	10
Delimitations.....	11
Definition of Terms.....	11
2. REVIEW OF RELATED LITERATURE .....	13
The Female Student-Athlete .....	13
The Injured Knee and the Female Student-Athlete .....	14
Neoprene Knee Sleeve Use.....	15
The Role of Proprioception in Motor Control.....	17
Mechanisms and Characteristics of Proprioception.....	17
Methods Used to Assess Proprioception.....	20
Reproduction of Target Angles.....	21
Detection of Passive Motion.....	22

Balance Tests.....	22
Summary.....	23
3. RESEARCH METHODOLOGY .....	24
Design .....	25
Instrumentation.....	26
Research Protocol.....	26
4. RESULTS.....	28
Subjects.....	28
Balance Tests .....	29
Reproduction of Target Angles With and Without Neoprene Knee Sleeves.....	29
Results of Movement Sensation Test.....	30
Summary.....	31
5. SUMMARY AND RECOMENDATIONS .....	33
Balance Tests .....	34
Reproduction of Target Angles.....	35
Movement Sensation.....	36
Conclusions.....	39
Recommendations for Future Research.....	40
REFERENCES.....	41
APPENDICES.....	46
Appendix A: Institutional Review Board (IRB) .....	46
Appendix B: Informed Consent .....	53
Appendix C: Knee Health Questionnaire .....	58
Appendix D: Data Collection Sheet.....	60
VITA .....	61

## CHAPTER 1

### INTRODUCTION

The purpose of the present study is to compare the effect of neoprene knee sleeve application on active repositioning tests, on movement sensation tests, and on balance tests of healthy knees in female student-athletes. Changes in proprioception have been attributed to many factors including: gender, injury, and age. Participation by females in recreational and competitive sports has increased tremendously during recent years. Because female athletes are competing at a higher level and more regularly, they are also developing common musculoskeletal disorders that commonly need medical attention. A British sports injury clinic study found patella femoral syndrome accounting for 5% of all injuries seen and 25% of knee injuries (Devereaux & Lauchman, 1983). The effect of knee injury has been found to have a negative effect on knee joint proprioception (Friden et al., 1997; Jerosch & Prymka, 1996). Age-related declines in proprioception have been shown to occur in proportion to increase in subjects' ages (Petrella, Lattanzio, & Nelson, 1997; Skinner, Barrack, & Cook, 1984).

Knee joint proprioception has recently received much attention in relation to both the ability to consciously determine the position of a joint in space at a particular time. The common belief is that proprioceptive signals encode joint angles (Beers, Sittig, & Van der Gon, 1998). Three main components provide the basis of proprioception: static awareness of joint position, kinesthetic awareness of joint position, and closed loop efferent neural pathways (Lattanzio & Petrella, 1998). Static awareness of joint position focuses on specific tension felt by the related sensory organs. Kinesthetic awareness of joint position deals with the detection of movement and acceleration of the related joint and limbs (Beers et al., 1998). Closed loop efferent neural pathways allow for reflex response and the regulation of muscle stiffness (Friden et al., 1997).



Knee joint proprioception has been shown to be a indicator in injury rate of female athletes (Powell & Barber-Foss, 2000).

Many methods to assess knee joint proprioception have been described in recent research. The methods can be divided into four different categories: position sense, motion detection, balance maintenance, and neurological activation. Position sense refers to the individual's ability to sense motion at its initiation. Balance maintenance is specific to the lower body and is concerned with activation of the lower body to maintain a single double leg position. Neurological activation is used to measure the amount of activation that occurs at a specific location in relation to some joint movement or maintenance of position.

Neoprene knee sleeves (NKS) have been used for years to aid in both knee function and following knee injury. There are many reasons that have been suggested for the use of NKS these include: preservation of temperature at the joint, increased compressive pressure on the joint, and belief by most individuals that neoprene knee sleeves improve their ability to accomplish tasks. Sex-related injury patterns have been studied by Powell & Barber-Foss (2000) conclusions were made indicating females to have an increase in injury rate. Research has shown that NKS improve knee joint proprioception. Birmingham et al. (1998) compared the effect of NKS application on knee joint position sense in males and females. Eighteen males and females were tested to find differences in open and closed kinetic chain testing. The improvement in position sense was significantly less during the supine closed kinetic chain test ( $0.3^{\circ} \pm 1.4^{\circ}$ ) than during the sitting open kinetic chain test ( $1.2^{\circ} \pm 1.1^{\circ}$ ). Test subjects were asked, if they felt that NKS improved their performance. Seventy-two percent of the subjects reported that the NKS improved their overall performance. During the supine closed kinetic chain test only 15% of the subject's weight was used as resistance. The amount of resistance

used could be a weakness since that a force equal to the individual's body weight could be used. Test scores were evaluated separately for males and females, but no conclusions were made due to gender differences. McNair, Stanley, and Strauss (1996) found an 11% improvement in knee tracking with application of a NKS. Twenty individuals were tested, 10 men and women, to determine the interaction between application of NKS and testing scores. The testing procedure included the movement of one knee through a predetermined range of motion while the other knee tracks the motion. Pincevero, Bachmeier, and Coelho (2001) studied passive motion sensations felt at the knee. Twenty female and male subjects were tested using the same protocol. Knee angle was the primary measure to determine subject's ability to sense motion. More testing with the application of NKS is needed to identify and quantify improvements in proprioception due to this treatment.

In recent years the knowledge associated with assessment of proprioception and methods to improve it have made much progress. As reliable testing protocols are established, more accurate clinical tests of proprioception will be used to evaluate functional status of knee injuries. More research must be done to evaluate the interrelationship between proprioception and the use of NKS.

#### Statement of the Problem

The purpose of this study was to determine the impact of a NKS on knee joint proprioception in high school female athletes by measuring knee joint proprioception with and without a NKS. The principle outcome measures will be position sense, balance, motion detection, and neurological activation. Secondary outcome measures will test the impact of body weight, training status, and leg length.

### Hypotheses

Based on this study design and previous research available regarding knee joint proprioception, it was hypothesized that:

HA1: there was a significant difference between test trials with application of a NKS with respect to knee joint position sense.

HA2: there was a significant difference between test trials with the application of a NKS with respect to motion detection.

HA3: there was a significant difference between test trials with the application of a NKS with respect to maintenance of balance.

### Assumptions

The following conditions were assumed to be factual in order to facilitate the research process.

1. Subjects will give a maximal effort during the balance tests.
2. Subjects will not make guesses as to movement detection.

### Limitation

The following is the primary limitation of this study:

The subjects were all volunteers from one local high school; therefore, selection bias could affect the outcomes of this study.

### Delimitation

The test group of fifteen volunteer subjects consisted of female high School athletes ranging from 13 to 16 years of age. Proprioception with and without application of a NKS will be measured by both the reproduction of target angles (RTA) and movement sensation (MS) tests. An isokenetic dynamometer will be used to identify a target joint angle for the RTA tests and initiate motion to detect for MS test. Balance will be measured by a timed single-leg stance test. The test protocols include reproduction of target angle (RTA) and movement sensation (MS) tests using an isokenetic dynamometer to identify a target joint angle for RTA test and to initiate motion to be detected for MS and balance testing which will involve a timed single-leg stance. The subjects will be asked to close their eyes before each of the test trials. Data analysis will be conducted using a repeated measures ANOVA.

### Definition of Terms

1. Balance – the ability of subjects to maintain knee joint position.
2. Isokenetic Dynamometer – machine used to test strength of limbs through controlled speeds and motions, also used to increase range of motion at the knee.
3. Joint mechanoreceptors – sensory organs of the peripheral nervous system that sense static and dynamic joint position.
4. Muscle mechanoreceptors – sensory organs of the peripheral nervous system that sense changes in length and tension in the muscle.
5. Motion detection – the ability of the test subject to sense initiation of movement of the joint or limb by some outside force.
6. Position sense – the ability of test subject to accurately detect and recreate joint position.
7. Proprioception – the test subject’s awareness of the joint or limb in space.

8. Skin mechanoreceptors – sensory organs of the peripheral nervous system that sense stretch of the skin and are located on the flexion and extension sides of the joint.

## CHAPTER 2

### REVIEW OF RELATED LITERATURE

The purpose of this study is to compare the effect of NKS application on active repositioning tests, on movement sensation tests, and on balance tests of healthy knees in female student-athletes. Knee joint function has been studied for many years, but little research has been completed focusing on female student-athletes. Five main topics were discussed in the following literature review: the female student-athlete, knee injury and the female student-athlete, neoprene knee sleeve use, the mechanisms and characteristics of proprioception, and the measurement of proprioception. The literature in this section will be used to establish the proposed study.

#### The Female Student-Athlete

Just a century ago properly educated individuals would have laughed at the idea of women competing at any level of athletic activity. Participation in such activities would have been viewed as undesirable and would have hurt their chances to lead normal lives. Much has changed since then. In the United States, the enactment and enforcement of the Title IX Educational Assistance Act of 1972 began an expansion of opportunities for women in sports. Title IX mandated that all institutions receiving federal funds provide equal opportunities for women for all sports programs. This precedence has trickled down to the high school level where female athletic programs continue to grow each year. Today's female high-school athletes can compete in athletics at all levels and are allowed to participate in any sports they choose regardless of tradition. In the 1994, NCAA participation study, the NCAA reported a nine percent increase in female participants in all NCAA athletic programs from 1989 to 1992.

## The Injured Knee and the Female Student-Athlete

One consequence of this increase in sport participation by females has been an increased rate of knee injury. Arendt and Dick (1995) compared the knee injury patterns among women and men in collegiate basketball and soccer. The female soccer athletes had a knee injury rate of 1.6 per 1000 athlete exposures compared to 1.3 for male soccer athletes per 1000 athlete exposures. The female basketball athletes had a knee injury rate of 1.0 per 1000 athlete exposures compared to 0.7 for male basketball athletes per 1000 athlete exposures. The primary mechanism of injury was non-contact for the female soccer athletes and showed an occurrence rate of 0.17 per 1000 athlete exposures compared to male soccer athletes at 0.05 per 1000 athlete exposures. The primary mechanism of injury was also non-contact for the female basketball athletes and showed an occurrence rate of 0.21 per 1000 athlete exposures compared to male basketball athletes at 0.04 per 1000 athlete exposures. Powell & Barber-Foss (2000) studied the incidence of injuries in comparable female and male high school sports. The comparable sports studied by Powell & Barber-Foss included: baseball, softball, male soccer, female soccer, male basketball, and female basketball. Overall knee injury comparisons showed that girls suffered 44% more knee injuries than did boys. In the past 10 years 1.4 million females have injured their anterior cruciate ligament (ACL); this was twice the amount injured just 10 years ago (Sullivan, 2001).

The key factors that contribute to the increased risk of knee injury in female athletes are baseline level of conditioning, lower extremity alignment, physiological laxity, pelvis width, tibial rotation, and foot alignment (Hutchinson & Ireland, 1995). Baseline level of conditioning will improve performance and reduce the instance of injury; however, for most female athletes, this baseline is significantly less than that of their male counterparts. Lower extremity alignment

contributes directly to the forces placed on the knee during movement. Physiological laxity is a reference to the basic flexibility and laxity differences between males and females. Increased hip width is associated with increased Q-angle, a measurement of the angle created by the line from the anterior-superior iliac spine and the patella and the line from the patella to the tibial tubercle, which can be linked to many patella disorders. Tibial rotation and foot alignment also influence stress placed at the knee. Understanding all these factors and providing strategies to decrease these factors, what can we as clinicians do to help further prevent problems? Knee bracing has received much attention as the solution to this problem, which can be used preventatively or following surgical procedures.

#### Neoprene Knee Sleeve Use

Neoprene knee sleeve (NKS) usage is a common treatment for a number of conditions associated with knee pain to female adolescents. Female student-athletes have been found to suffer from a number of knee overuse problems. Proprioception deficits have been linked to these problems and are being studied more intensively to help prevent problems.

For many years NKSs have been used following knee injury for reasons, such as, preservation of temperature at the joint, increased compressive pressure on the joint, and the belief by most individuals that NKS improved their ability to accomplish tasks. Many of the studies that have been completed have shown contrasting results.

In a study completed by Birmingham et al. (1998), a group of 18 male and 18 female test subjects completed two knee joint position sense tests that evaluated the effect of NKS application of open and closed kinetic chain tests. Each test required the subjects to move the knee to a starting position of 90° of flexion and then to five randomly assigned targets between 65° and 35° (Birmingham et al.). Subjects were blindfolded during the testing sessions to take



away visual stimuli, and 30 seconds were allowed between each effort. When the test subjects were asked to evaluate the effectiveness of the NKS on their performance; 72 % of the test subjects said that the NKS improved their performance, 14 % of the test subjects said that the NKS had no effect, and 14 % reported that it hindered their performance. The NKS effect observed during the supine closed kinetic chain test was  $0.3^{\circ} \pm 1.4^{\circ}$ . The NKS effect observed during the sitting open kinetic chain test was  $1.2^{\circ} \pm 1.1^{\circ}$ . These scores fell outside of the 95 % confidence interval, and therefore, were not significant.

In a contrasting study, McNair, Stanley, and Strauss (1996) studied the effects of knee bracing on proprioception during tracking tasks. The tracking tasks included passive motion of one knee with the KinCom and subjects were instructed to follow that movement with the opposite knee. An electrogoniometer was placed on the tracking limb and measured angles were compared to the KinCom angle display using a 100Hz-video acquisition system. The subjects completed two trials: one with and the other without application of the NKS. After the data were gathered and analyzed, an 11 % improvement in tracking was observed when subjects wore the neoprene knee sleeves.

The use of NKS has also been evaluated as a method to prevent anterior knee pain. BenGal et al. (1997) studied a group of 43 men and 17 women during an eight-week training period. BenGal et al. had 21 men and 6 women wear a NKS with a silicone patellar support during the eight-week training period. Data were collected during the first and eighth week of the study by investigators, who were blinded to the identity of the candidates.

The above studies show conflicting data about the effectiveness of NKS application. Neoprene knee sleeve usage is a common treatment for a number of conditions associated with knee pain common to female adolescents. Female student-athletes have been found to suffer

from a number of common knee overuse problems. Proprioception deficits have been linked to these problems and are being studied more intensively to help prevent problems. However as seen above the conclusions that have been made are inconsistent.

### The Role of Proprioception in Motor Control

Knee joint proprioception can be described as the sense of knee position in space, which is a small and very specific portion of motor control. The theory of motor control describes how our bodies sense and react to external stimuli. Motor control of a extremity is dependent upon visual, vestibular, and proprioceptive feedback and the reflexive and voluntary muscle responses (Johnston, Howard, Cawley & Losse, 1998). Adams (1971) suggested a closed loop theory of motor learning in which proprioceptive feedback provides the basis to trace movements and enables our bodies to compare movements to an internal standard to allow for coordinated movement. In the early 1900s, Sherrington (1906) defined proprioception as the knowledge of the positions and action of parts of the body from perceived sensations. Prevailing theories suggest that motor control is accomplished through properly monitored feedback received during the movement and the act of proper response to that feedback (Weiler and Awiszus, 2000).

### Mechanisms and Characteristics of Proprioception

The common belief is that proprioceptive signals encode joint angles (Beers et al., 1998). Three main components provide the basis of proprioception: static awareness of joint position, kinesthetic awareness of joint position, and closed loop efferent neural pathways (Lattanzio & Petrella, 1998). Visual, auditory and vestibular stimuli also play important roles in proprioception. Information obtained through these senses is vital to the initiation of protective muscular reflexes. These protective reflexes can help prevent an injury to an articular joint or

perhaps minimize the extent of injury. Sensation arises through activity in the sensory neurons located in the skin, muscles, and joint tissue (Grigg, 1994). Static awareness of joint position focuses on specific tension felt by the related sensory organs. Kinesthetic awareness of joint position deals with the detection of movement and acceleration of the related joint and limbs. Closed loop efferent neural pathways allow for reflex response and the regulation of muscle stiffness. Consequently, proprioception has recently become an important part of rehabilitation and training programs.

Proprioception occurs because of specialized nerve endings that provide information about the stimulus being applied. Locomotion and other whole body movements cannot occur if normal proprioception is not intact (Bevan et al., 1993). Grigg (1994) divided the specialized nerve endings into four main groups: skin mechanoreceptors, muscle mechanoreceptors, joint mechanoreceptors, and mechanoreceptors in other related tissue.

Skin mechanoreceptors are important because they sense stretch of the skin. Joint rotation causes stretching of the skin and related tendons and ligaments on one side of the joint and relaxation of the opposing structures. Slow-adapting type-2 cutaneous neurons sense lateral stretching of the skin which might help signal joint position. Fast-adapting type 1 cutaneous neurons can also be linked to proprioception through their sense of vibrations occurring in the skin. These type 1 cutaneous neurons have also been shown to sense unnatural sensations.

Muscle mechanoreceptors are important specifically because they sense stretch and tension in the muscle-tendon unit. Capaday (1998) demonstrated that vibration of muscle tendons caused illusions of movement. He demonstrated that these illusions of movement caused participants to undershoot normal target movements when a vibration stimulus was applied to the involved muscles.

The muscle spindle is sensitive to changes in muscle length. Muscle spindles, fusiform in shape, are contained in a connective tissue sheath and consist of 2 to 12 unique muscle fibers. The sum of all of the components that form the muscle spindles are called intrafusal muscle fibers, and these fibers run parallel to the regular contractile muscle fibers. Group I afferents (fast conducting neurons) are connected to the primary sensory endings of the muscle spindles. These fast conducting neural pathways allow the muscle spindles to react to the rate of stretch (lengthening) in the muscle. A second muscle mechanoreceptor is the golgi tendon organ which is sensitive to stretch in the tendon. The golgi tendon organs are activated as a result of either an active force being placed on them by any attached muscle fiber or by a passive force. The golgi tendon organs can respond to forces of less than 0.2 newtons.

Joint mechanoreceptors include bare nerve endings, ruffini endings, pacinian corpuscles, and golgi tendon organs. These receptors are found in the joint capsule, ligaments, tendons, and articular surfaces. Bare nerve endings are responsible for sensations of pain. Since they are non-myelinated they are slow conducting, and they have a high threshold for excitation. Bare nerve endings are most commonly found in the articular surfaces, ligaments, and capsules of joints.

Ruffini endings are located within the outer joint capsules. In the knee, they are found in clusters of three to six in the collateral and cruciate ligaments, the joint capsule, and the menisci of the knee (Lattanzio & Petrella, 1998). Each cluster formation is innervated by a singular myelinated (fast transmitting) axon. Type I ruffini endings are low-threshold mechanoreceptors and are responsible for sensations of joint angle, velocity, and pressure. These ruffini endings are most commonly found on the flexion side of joints; therefore, they are generally considered to be responsible for detection of the end range of motion into extension (Grigg, 1994).

Pacinian corpuscles are conical in shape, elongated, and enclosed in a multilaminated connective tissue capsule (Lattanzio and Petrella, 1998). They can be found in ligaments, tendons, and joint capsules. Pacinian corpuscles can also be found in the menisci of the human knee. Pacinian corpuscles are responsible for sensing acceleration and termination of movement.

The golgi tendon organs of the joint are structurally identical to muscle-golgi tendon organs. They are high-threshold, slow adapting mechanoreceptors. Joint-golgi tendon organs are only activated at extreme angles of joint displacement. They can be found in ligaments and in the menisci of the knee (Lattanzio & Petrella, 1988). All joint mechanoreceptors are vital for normal joint proprioception.

#### Methods Used to Assess Proprioception

Testing proprioception plays an important role in the clinical setting because it gives an objective tool to measure the successfulness of the rehabilitation process as a measure of gain in motor control and muscle function. Clinicians have devised many different methods to assess proprioception. The methods most commonly used in scientific studies and clinical protocols include detection of passive motion, balance, and reproduction of target movements. Most of the methods used test both legs to compare bilateral ability. Isokenetic dynamometers are used to measure power outputs, and can also be used to produce and measure passive and active ranges of motion. Measurements of position sense can be used to demonstrate the amount of error that occurs when attempting to complete a positioning task.

#### Reproduction of Target Angles

Proprioceptive feedback is one of the main reasons that humans can maintain a bipedal stance. Proprioceptive feedback is essential for normal locomotion and movement of all limbs.

Understanding this, we can measure proprioception by testing the subjects' ability to reproduce a previously identified motion or target position.

The studies that have contributed research about this concept, rely on the subjects' abilities to concentrate and learn the target motions (Birmingham et al., 1998; Friden et al., 1997; Stillman, McMeeken, and Macdonell, 1998). Testing commonly consists of a learning period in which the subjects undergo a training program, designed to thoroughly teach the testing protocol. In some studies the angles that the subjects will be required to reproduce are identified (Al-Othman, Moussa, and Eraky, 1998; Stillman et al., 1998). For example, Al-Othman et al. used a simple test to measure active reproduction of target angles in the clinic. Each subject was asked to raise his or her foot off the floor where a measurement grid was laid to approximately 90° of knee flexion and 90° of hip flexion and then to replace their foot in its original starting position. Testing for target positions is measured by error, and, in this test, testing can be measured by the error in the return position of the foot on the grid. Brockett, Warren, Gregory, Morgan, and Proske (1997) studied position sense by positioning the uninvolved joint at 30°, 60°, and 90° of flexion. The subjects were then instructed to recreate the target angles with the opposite joints. Birmingham et al. (1998) used an isokenetic dynamometer to identify target positions and to measure the subjects' abilities to reproduce these positions.

#### Detection of Passive Motion

Although assisted passive movements are not a common occurrence in everyday life, they can be used to measure proprioception in the scientific setting. Studies are usually concerned with the perception of movement and the direction of movement. Most studies use a mechanical switch or verbal cue by the test subject to identify the initiation of passive motion by the observer. The detection of movement can be felt before the direction of movement can be

discerned, and some researchers propose, that without the identification of both sensations, the test cannot be accurate (Refshauge, Chan, Taylor, and McCloskey, 1995). Detection of the specific speed of the motion is also a method commonly used to measure proprioception (Refshauge et al.; Weiler & Awiszus, 2000). Passive motion detection can be used to establish differences due to injury or due to imbalance in subject's ability to detect abnormal stimulus (Friden et al., 1997).

### Balance Tests

One type of test used to measure proprioception in female athletes is a balance test. Balance testing is more commonly used in the clinical setting to establish gains in the proprioceptive capacity of injured limbs and to help evaluate injured athletes' readiness to return to activity for injured patients (Zatterstrom, Friden, Lindstrand, and Moritz 1994). Studies concerned with balance testing are primarily focused on the test subjects' abilities to maintain a certain position or to maintain balance during a testing protocol. Neoprene knee sleeve application is a treatment that is commonly administered when testing proprioception.

Dynamic balance is specifically concerned with the maintenance of balance and muscular control while the center of gravity is constantly being changed (Johnston et al., 1998; Kinzey and Armstrong 1998). Preservation of a stable bipedal stance depends on the interaction amongst the specialized nerve cells. Studies use bipedal and unipedal standing positions in a variety of testing protocols.

### Summary

Knee joint proprioception has been shown to play a vital role in proper ambulation and general movement. This review of literature provides an overall summary of proprioception. The research also establishes current techniques used to measure knee joint proprioception. The

findings and designs of previous studies can be used effectively to create new studies and add to the present body of knowledge. Although studies have shown that more research needs to be completed to further the understanding of knee joint proprioception.

NKS were found to increase proprioception in some studies but had no effect in others. In studies that showed no effects of application of NKS, subjects reported to have felt that the knee sleeves aided in their tasks. In addition, age was not used as an independent variable in any of the tests reviewed in the literature. The research revealed that testing procedures have been established for measuring proprioception. Studies found that the occurrence of injury hindered knee joint proprioception.

Obviously there is a lack of literature showing the effects of NKS usage on knee joint proprioception in female athletes and its correlation to age. By studying NKS application, a more complete understanding of knee joint proprioception can be accomplished. Effectiveness of NKS and techniques to better measure knee joint proprioception should be identified through a combination of testing methods. The relationships among age, NKS use, and proprioception can be defined and used to understand improving of knee joint proprioception better.



## CHAPTER 3

### RESEARCH METHODOLOGY

The use of NKS has been a mainstay for treatment of many common knee problems. Clinicians have struggled for many years to find an effective and efficient protocol for measuring knee joint proprioception enabling them to evaluate the functional level of an individual. The desired functional level for each individual differs as to each individual desires to do after the rehabilitative process is complete. If the pre-injury functional level is not determined before an injury is sustained, measurements of functional level are made on the non-injured or uninvolved limb (McCarthy, Buxton, Hiller, Doyle, and Yamada, 1994). Functional levels vary greatly between athletic and non-athletic populations; therefore, testing protocols and procedures have been not been clearly defined because of age related differences in the population being tested. Some of the testing methods include single-leg hops, single-leg vertical jumps, horizontal (side to side) jumps, isokinetic strength, position sense, and many other tests coupled with many variations of these methods (Al-Othman et al., 1998; Kinzey and Armstrong, 1998) . Understanding proprioception and being able to accurately measure it will enable clinicians to help return patients to regular functional levels.

The purpose of the present study is to compare the effect of NKS application on active repositioning tests, on movement sensation tests, and on balance tests of healthy knees in female student-athletes. Female subjects who were active have been found to have an increased rate of knee injury. As discussed previously, proprioception of the knee is accomplished by interactions between peripheral afferent neural stimuli and the brain. The interactions between the two allow us to understand spatial and temporal information about our bodies as we move

through space. Proprioceptive signals encode joint angles (Beers et al., 1998); therefore, proprioceptive information is received from joints, limbs, and their surrounding tissue and gives our body information including angular position, initiation of movement, cessation of movement, and their position in relationship to the rest of the body. The information that is received by the brain is used to carry out a wide variety of tasks ranging from simple tasks such as standing to more difficult tasks such as kicking a ball or running. Deficits in proprioception have been associated with an increase in both the frequency of injuries and also re-injury of the knee (Lephart, Pincivero, Giraldo, and Fu, 1997). The topics discussed within this chapter are (a) subjects, (b) design, (c) instrumentation, and (d) research protocol.

### Subjects

Study subjects were adolescent female high school athletes between the ages of 13 and 16 years old. Subjects were selected using a convenience sample due to the control that is established using pre- and post-tests. Subjects were randomly assigned to a testing protocol as a control for any norms that may be seen due to test sequence. Each subject completed the IRB approved informed consent form before participating in the study. A copy of this form is supplied in appendix A.

### Design

An experimental design with an individual control for each test was used. Each subject was randomly assigned to a specific testing sequence. The research was conducted primarily to determine differences in proprioception due to application of a neoprene knee sleeve. The independent variables were testing sequence and application of NKS. The dependent variables were scores on movement sensation, reproduction of target angle, and balance tests.

### Instrumentation

Data was collected using a Biodex isokenetic dynamometer to measure angular displacement and target angle error.

### Research Protocol

The knee-testing portion of the study was completed using movement sensation (MS), reproduction of target angle (RTA), and balance (BT) tests. Testing for MS and RTA was completed using an isokenetic dynamometer. Testing for BT was completed using a stopwatch and video analysis to determine time in single leg stance. The dominant legs were selected after rolling a ball toward the individual and having her kick the ball to establish dominance. The testing protocol was used on the dominant leg. All tests were completed with the subject's eyes closed. All tests were completed with and without application of NKS.

During the RTA and MS tests, subjects were seated with their backs against a rigid back rest oriented approximately 85° above the horizontal, and hips in approximately 90° of flexion. Here pelvis was secured to the test table and the backrest using a seatbelt. The lower legs were secured to the lever arm with a resistance pad. During the BT, subjects were asked to maintain a single-leg stance for as long as possible, but no longer than five minutes. The test subject's knees were evaluated with and without the NKS.

During the RTA tests, three target angles were passively identified. These angles were 15°, 30°, and 90° away from the starting position of 90° of flexion into flexion. Test subjects were asked to close their eyes during each test trial. Subjects were asked to reposition their knee to the target angle after the target angle was identified and the knees returned to the starting position. Two test trials were accomplished at each of the three positions for each test. Absolute error was the test measure.

During the MS test, subjects were asked to report movement sensation from each of the target angles. These angles were 15°, 30°, and 90° away from the starting position of 90° of flexion. Movements occurred at an angular displacement of 5°s per second. Two test trials were accomplished at each of the three positions for each test. Absolute error was the test measure.

During BT, subjects were asked to maintain a single leg standing position for as long as possible. Subjects began the test in a bipedal stance and were told to lift their non-dominant leg when they were ready. The tester started a stopwatch when the test subjects' feet left the floor. The stopwatch was stopped when the test subjects' foot contacted the floor. Two test trials were accomplished with and without the neoprene knee sleeve. A rest period of 15 to 30 seconds was allowed between test trials. Each test trial lasted no longer than five minutes.

The three test types were conducted to show differences where they exist. Test subjects were not pushed to perform outside of their capacities. The raters were completely unbiased and refrained from influencing the test.

## CHAPTER 4

### RESULTS

Current research suggests that use of a NKS will improve knee-joint proprioception. The majority of current literature focuses on the effects of knee-joint proprioception in response to NKS application in adult males. The purpose of this study was to determine the effects of NKS application on knee-joint proprioception in female high school athletes. Specifically, this study measured the effect that NKS had on balancing ability, accuracy of knee-joint repositioning, and on knee joint sensitivity to movement.

#### Subjects

Fifteen female high school athletes volunteered for this study. All tests were conducted in a repeated measures design on the dominant leg of each subject. All subjects completed each test two times, once while wearing a NKS and once without wearing a NKS. Anthropometric characteristics of the study population are listed in Table 1. The values in all tables include mean values for the entire subject population. One standard deviation (SD) for the means is also listed.

Table 1

Anthropometric Characteristics of Subjects

Variable	Mean	SD
Age (yr)	15.33	0.72
Height (cm)	165.27	6.40
Weight (kg)	64.61	15.82
Body Fat %	23.87	6.15
Interscholastic Sports Played (yr)	1.93	0.88
Training Frequency (days/week)	4.27	1.33

Balance Tests

The single leg stance test (SLS) was used to assess balance. The mean SLS duration in seconds and one SD did not indicate that there was a significant difference when a NKS was used. SLS with the NKS yielded a mean value of 43.73 seconds and a SD of 19.47. SLS without the NKS yielded a mean value of 45.02 and a SD of 21.68. Results indicate that there were no significant treatment differences in SLS time.

Reproduction of Target Angles With and Without Neoprene Knee Sleeves

The mean repositioning errors (degrees) and standard deviations measured during the reproduction of target angle (RTA) tests with and without NKS are presented in Table 2. Results indicate that repositioning accuracy was significantly greater at a knee joint angle of 60° when

wearing the NKS compared to when one was not worn. There was also a significant learning effect ( $p= 0.05$ ) between the first repositioning trial at the 75° knee-joint test position. The second of the two repeated measures attempts was 38% more accurate than the first trial.

Table 2

RTA tests absolute error measurements with and without NKS

Repositioning error (degrees)	Knee joint angle (degrees)		
	75°	60°	45°
Without NKS	Mean 4.27	3.67	3.00
	SD 5.23	2.87	2.04
With NKS	Mean 4.80*	1.87†	2.33
	SD 3.43	1.81	2.19

\* $p= 0.01$ , accuracy within NKS trial significantly lower at 75° vs both 60° and 45°

† $p= 0.05$ , significantly greater accuracy with NKS

#### Results of Movement Sensation Test

During the Movement Sensation (MS) test, subjects were asked to report movement sensation, beginning at each of the three test angles (75°, 60°, and 45° of knee flexion). Table 3 presents the means and standard deviations for MS both with and without NKS. Compared to the trial without NKS, movement sensation was significantly ( $p = 0.01$ ) more accurate during the NKS treatment at the 75° knee-joint test position. During the NKS treatment, MS accuracy also

significantly ( $p= 0.03$ ) improved between the first trial at 75° of knee flexion compared to 60° of knee flexion.

Table 3

MS tests absolute error measurements with and without NKS

MS		Knee joint angle (degrees)		
		75°	60°	45°
Without NKS	Mean	0.87	0.67	0.60
	SD	1.06	0.89	0.63
With NKS	Mean	1.53*	1.20	0.53 <sup>†</sup>
	SD	1.64	1.78	1.06

\* $p= 0.03$ , error with NKS significantly greater at 75° Vs 60°

<sup>†</sup> $p= 0.01$ , significantly greater accuracy with NKS Vs without NKS

### Summary

In summary, NKS application significantly improved proprioception of knee-joint movement at 60° and 45° knee-joint test angles during the RTA and the MS tests. Additionally, repositioning accuracy significantly improved during the NKS treatment between the initial test angle of 75° and subsequent test angles of 60° and 45°. During the MS test, movement sensation also significantly improved during the NKS treatment between the initial test angle of 75° and subsequent test angle of 60°. A significant learning effect occurred between the first and second RTA testing trials in this repeated measures study. However, the NKS or no NKS testing



order was randomized; thus, this learning effect had no impact on the main outcomes of this study.

## CHAPTER 5

### SUMMARY AND RECOMENDATIONS

The purpose of this study was to compare the effects of NKS application on female high school athletes. This study included an initial anthropometric assessment of the female student-athletes, a familiarization period, two SLS test trials, two RTA test trials, and two MS test trials. Three angles, 75°, 60°, and 45°, of knee flexion were used for the RTA and the MS tests. The sequence of testing, NKS or no NKS treatment first, was randomly decided. Finally, repeated measures ANOVA tests were conducted to identify significant differences between both treatments and test angles (75°, 60°, and 45°) for the RTA and MS tests. Previously, female student-athletes had not been the focus of studies of NKS application and the effect it had on knee-joint proprioception. Today's female high school athletes can compete in athletics at all levels and are allowed to participate in any sport they choose regardless of tradition. This study increased the understanding of the effects of NKS application on knee-joint proprioception in female high school athletes.

This study indicated that knee-joint repositioning accuracy was significantly ( $p= 0.05$ ) greater at a knee joint angle of 60° when wearing the NKS as compared to when one was not worn. Movement sensation was also significantly ( $p= 0.01$ ) increased at a joint angle of 45° when a NKS was worn. Learning effects for the first versus second trials in this repeated measures study design also occurred during the 75° trial of the RTA test. Although the NKS may have provided increased knee proprioceptive information, its contribution may have been minor compared with the somatosensory information already available from the sensory

receptors in the muscles, skin, and joints. Regardless of the underlying mechanisms, any improvement in proprioception can be viewed as a positive effect.

### Balance Tests

The SLS test was used to determine balance in this study. Application of a NKS did not affect balancing ability in the female high school athletes; thus, it appears that either knee-joint proprioception was not altered during this test and that changes in knee-joint proprioception did not have an impact on balance.

The hypothesis stated above for the balance test was that there would be a significant difference between test trials with the application of a neoprene knee sleeve with respect to maintenance of balance. Due to the findings, we must reject this hypothesis. These results suggest that there was no positive or negative result derived from the use of a NKS in movements that require a tremendous amount of static balance.

Kaminski and Perrin (1996) studied balance during a single-leg and double-leg stance with male subjects,  $21.7 \pm 5.5$  years of age. Testing was completed with eyes open, and scoring was not based on timed performance but on sway index. The sway index is a numerical value in centimeters of the standard deviation of the time and distance the subject spends away from his center of balance. Our findings were similar compared to the finding of Kaminski and Perrin that SLS trials showed no difference when NKSs were applied to the knee.

Aniss et al. (1990) studied anterior and posterior sway during stable double-leg test trials with subjects between the ages of 29 and 43 years. The test measured activation of anterior and posterior muscle activation. Aniss et al. reported small changes in sway during their tests. Similar to these findings, our test showed no significant change in ability to maintain single-leg stance during test trials with and without a NKS.

### Reproduction of Target Angles

RTA tests were also completed with and without a NKS. Repositioning accuracy at 60° of knee flexion was significantly ( $p = 0.05$ ) improved when a NKS was worn compared to when one was not worn. Additionally, during the NKS trial, repositioning to the 60° and 45° test angles was significantly ( $p = 0.05$ , 38%) more accurate compared to the 75° test angle.

Our hypothesis for the RTA test stated that there would be a significant difference between test trials due to application of a NKS with respect to knee joint position sense. The results of this study supports the hypothesis as stated, prior to this study. These results suggest that there was a positive benefit derived from the use of a NKS in RTA movements specifically during the 60° test trial.

Birmingham et al. (2000) also presented similar findings in respect to accuracy error measures with 39 female and 20 male subjects  $22.43 \pm 1.81$  years of age. Birmingham et al. measured RTA with or without a NKS and axially loaded (a force equal to 15% of subjects body weight was applied through tibia) or non-loaded. Similar to our study, in Birmingham et al.'s study the subjects' legs were moved from a starting position of 90° to a target angle, and then the subjects were asked to reposition their legs to the target angle. However, Birmingham et al. used five randomly assigned target angles instead of three-fixed target angles. They reported only one significant ( $p < 0.01$ ) difference, that was measured during the non-axially loaded test without the NKS. This measured difference was that the non-axially loaded test without the NKS produced significantly ( $p < 0.01$ ) greater directional error scores than did the test trials performed without the NKS.

Skinner et al. (1982) studied age-related decline in proprioception. The study group range was from 20-82 years of age. Repositioning tests were completed randomly at angles from 5°- 25° of extension. Ten tests were accomplished; five in each leg, accuracy was recorded in degrees to which the movements were reproduced. As in the present study, testing was completed in an upright seated position with the subjects' knees at a starting position of 90° of flexion. Skinner et al. found joint position sense deteriorated with age. Due to our test groups age, we can conclude that measurements of proprioception are at an optimal level.

Kaminski and Perrin (1996) studied 36 healthy male subjects age  $21.7 \pm 5.5$ . Test subjects were placed in a supine position with their knees at a beginning angle of 90° of flexion. Repositioning error was measured at 15°, 25°, 35°, and 75° degrees away from the starting position. Kaminski and Perrin reported that active repositioning test trials yielded higher error scores than did passive repositioning trials. Our findings were similar because NKS application did not negatively or positively effect knee joint proprioception in RTA at all test angles. However, in our study NKS did enhance subjects' ability to reproduce ability during the 60° test. Once again our isolated positive effect helps us understand that NKS application can be helpful to knee joint proprioception.

### Movement Sensation

The MS tests were done to assess movement sensation sensitivity of the knee joint of the dominant leg. At 45° of knee flexion, movement sensation was a significantly ( $p= 0.01$ ) improved by 11% when a NKS was worn compared to when one was not worn. During the NKS treatment, MS accuracy also significantly ( $p= 0.03$ ) improved from the first trial at 75° of knee flexion compared to the second trial at 60° of knee flexion.

Our hypothesis for the MS test was that there would be a significant difference between test trials with the application of a neoprene knee sleeve with respect to motion detection. Based on the results of this study, the research hypothesis cannot be rejected for the MS test. Our findings indicate that there was an increase in test subjects' abilities to perform this test at the 45° test angle with a NKS. In fact, the subjects were 11% more accurate with the NKS.

These results were similar to findings by Pincivero et al. (2001) who studied movement sensation of college- aged ( $24.2 \pm 2.7$  yr) males ( $n = 20$ ) and females ( $n = 20$ ). Pincivero et al. reported movement sensation was perceived more readily toward the last 30 to 40 degrees of extension. Similarly, the present study reported significant findings at 45° of extension. They used test angles of 15°, 30°, and 60° of flexion. Pincivero et al. measured movement sensation during a prone position with a Biodex System II Dynamometer. Pincivero et al. measured an increase in movement perception that could be linked to enhancement of somatosensory sensations due to NKS application.

Refshauge et al. (1995) reported differences in movement sensation at the hip, knee, ankle, and toe joints caused by variance in angular velocity. Subjects were asked to tell when they felt motion; and, once they could determine the direction, it was also reported. During Refshauge et al.'s study, test subjects were placed on their sides at 25° of flexion to measure knee movement sensation. Four test trials were accomplished using four angular velocities of 0.1, 0.5, 5, and 12.5 degrees per second. Conversely, the present study only used an angular displacement velocity of 5 degree per second. Perhaps more test trials could be completed with a greater variance in angular displacement to evaluate further difference in our study. Refshauge et al. found that of the four joints, both the hip and knee had the lowest degree of movement

sensation. The findings of this study suggest that movement sensation of the knee at 5 degrees per second had a mean error of 0.5° degrees. During the present study means were all greater than 0.5°. The differences between our study and theirs could be a result of difference in the testing apparatus and procedures.

MacDonald, Hedden, Pacin, and Sutherland (1996) studied the perception of passive motion at the knee. Subjects that were tested consisted of four groups of males and females: those with anterior cruciate ligament (ACL) deficiency ages 15-41, those with ACL reconstructed by hamstring graft ages 18-32, those with ACL reconstructed by bone patellar tendon-bone graft ages 21-39, and healthy control groups ages 23-39. Testing was completed in the 30° to 40° range of flexion on both left and right knees. Angular displacement during testing was 0.5 degrees per second in this study. There were differences seen with the controls having a 2% difference between their left and right knees. The anterior cruciate ligament deficient group had 25% difference in movement sensation between their healthy and uninjured knees. The data presented for the control group are similar to the data we collected with mean error being  $\geq 1^\circ$  compared to our mean error also being  $\geq 1^\circ$ . These findings show a consistency between our tests due to the similarity of mean error and testing procedures.

Friden et al. (1997) studied movement sensation during test trials between 20° and 40° of knee flexion. Test subjects consisted of 11 male and 5 female, ages 15- 36 years. Subjects were placed on their sides in the apparatus designed by the researchers. Test trials were performed on normal healthy knees and knees that had knee ligament injury. Differences were found between the two groups more toward the end range of motion showing the injured group to be less

accurate than the healthy group. These tests further mirror the differences we saw during our MS test trials.

### Conclusions

A variety of external knee supports, such as braces, sleeves, and elastic bandages, are commonly used in many sport and clinical settings with the assumption that these supports promote proprioception, improve performance, and increase safety during activity. In this study, NKS application presented no detrimental effects to knee-joint proprioception. At some angles, NKS application even appears to have had positive effects on knee-joint proprioception. NKS application caused a decrease in error for the RTA test during the 60° test trial, and NKS application caused an increase in sensitivity of movement sensation during the 45° test trial. The results of the study suggest that NKS application is sometimes beneficial and never detrimental to knee-joint proprioception. The 75° to 45° knee-joint angle testing sequence for all tests may have had an impact on improving accuracy based on the learning effects measured in the RTA and MS tests. Specifically, with NKS application, subjects' scores began to improve in subsequent trials during both RTA and MS testing. SLS trials, however, did not seem to be affected by NKS application in any of the test trials.

The findings of this study demonstrate that NKS application can cause improvements in female high school athletes' knee-joint proprioception. However, these differences were seen at isolated test angles. Learning effects were also isolated to the NKS application trials. In the present study, learning effects due to repeated testing did not impact the validity of our between treatment comparison. The NKS or no-NKS testing order was randomized; thus, both groups had similar opportunities to experience a learning effect.



It should be noted that NKS application was never found to have a detrimental effect on knee-joint proprioception in female high school athletes. Further research is needed to fully understand if NKS affects performance in female high school athletes. We can conclude that using a NKS would not hinder female high school athletes and that NKS application may even be beneficial.

#### Recommendations for Future Research

The findings of this study aid in the understanding of how knee-joint proprioception is affected by NKS application in adolescent female athletes. The question that must now be asked is: How can this information be applied to this population? Further research is needed to identify if the application of a NKS actually helps increase an individual's performance. Also, since NKS application is commonly used following an injury, would the NKS be a beneficial way to reduce or prevent knee injuries? Finally, differences in proprioception with and without a NKS were measured in the adolescent athletes in the present study. It is unknown whether NKS application would also occur for females at different ages or fitness levels.

## REFERENCES

- Adams, J., A. (1971). A closed-loop theory of motor learning. *Journal of Motor Behavior*, 3, 111-119.
- Al-Othman, A., Moussa, M., & Zakaria, M. (1998). A simple outpatient test for proprioception in the anterior cruciate ligament-deficient knee. *Orthopedics*, 21,677-679.
- Aniss, A., Diener, H., Hore, J., Gandevia, S., & Burke, D. (1990). Behavior of human muscle receptors when reliant on proprioceptive feedback during standing. *Journal of Neurophysiology*, 64, 661-670.
- Arendt, E., & Dick, R. (1995). Knee injury patterns among men and women in collegiate basketball and soccer. NCAA data and review literature. *American Journal of Sports Medicine*, 23, 694-671.
- BenGal, S., Lowe, J., Mann, G., Finsterbush, A., & Matan, Y., (1997). The role of the knee brace in the prevention of anterior knee pain syndrome. *American Journal of Sports Medicine*, 25, 118-122.
- Beers, R., Sittig, A., & Denier, J. (1998). The precision of proprioceptive position sense. *Experimental Brain Research*, 122, 367-377.
- Bevan, L., Cordo, P., Carlton, L., & Carlton, M. (1994). Proprioceptive coordination of movement sequences: discrimination of joint angle versus angular distance. *Journal of Neurophysiology*, 71, 1862-1872.
- Beers, R., Sittig, A., & Denier, J. (1998). The precision of proprioceptive position sense. *Experimental Brain Research*, 122, 367-377.
- Birmingham, T., Cramer, J., Inglis, T., Mooney, C., Murray, L., Fowler, P., & Kirkley, S. (1998). Effect of a neoprene sleeve on knee joint position sense during sitting open kinetic

- chain and supine closed kinetic chain test. *American Journal of Sports Medicine*, 26, 562-566.
- Birmingham, T., Inglis, T., Kramer, J., & Vandervoort, A. (2000). Effect of a neoprene sleeve on knee joint kinesthesia: influence of different testing procedures. *Medicine & Science in Sports & Exercise*, 304-308.
- Brockett, C., Warren, N., Gregory, J., Morgan, D., & Proske, U. (1997). A comparison of the effects of concentric versus eccentric exercise on force and position sense at the human elbow joint. *Brain Research*, 771, 251-258.
- Capaday, C., & Cooke, J. (1981). The effects of muscle vibration on attainment of intended final position during voluntary human arm movements. *Experimental Brain Research*, 42, 228-230.
- Devereaux, M., & Lauchman, S., (1983). Athletes attending a sports injury clinic--a review. *British Journal of Sports Medicine*, 17, 137-142.
- Friden, T., Roberts, D., Zatterstrom, R., Lindstrand, A., & Moritz, U. (1997). Proprioception after an acute knee ligament injury: a longitudinal study on 16 consecutive patients. Journal of Orthopaedic Research, 15, 637-644.
- Grigg, P. (1994). Peripheral neural mechanisms in proprioception. *Journal of Sport Rehabilitation*, 3, 2-17.
- Hutchinson, M., & Ireland, M. (1995). Knee injuries in female athletes. *Sports Medicine*, 19, 288-302.
- Jerosch, J., & Prymka, M. (1996). Knee joint proprioception in normal volunteers and patients with anterior cruciate ligament tears, special account of the effect of a knee bandage. *Archives of orthopaedic and trauma surgery*, 115, 162-166.

- Johnston, R., Howard, M., Cawley, P., & Losse, G. (1998). Effect of lower extremity muscular fatigue on motor control performance. *Medicine & Science in Sports & Exercise*, 1703-1707.
- Kaminski, T., & Perrin, D. (1996). Effects of prophylactic knee bracing on balance and joint position sense. *Journal of Athletic Training*, 31, 131-136.
- Kinzey, S., & Armstrong C. (1998). The reliability of the star-excursion test in assessing dynamic balance. *Journal of Orthopedic and Sports Physical Therapy*, 27, 356-360.
- Lattanzio, P., & Petrella, R. (1998). Knee proprioception: a review of mechanisms, measurements, and implications of muscular fatigue. *Orthopedics*, 21, 463-471.
- Lephart, S., Pincivero, D., Giraldo, J., & Fu, F. (1997). The role of proprioception in the management and rehabilitation of athletic injuries. *The American Journal of Sports Medicine*, 25, 130-137.
- MacDonald, P., Hedden, D., Pacin, O., & Sutherland, K. (1996). Proprioception in anterior cruciate ligament-deficient and reconstructed knees. *The American Journal of Sports Medicine*, 24, 774-778.
- McCarthy, M., Buxton, B., Douglas, W., Hiller, B., Doyle, J., & Yamada, D. (1994). Current protocols and procedures for anterior cruciate ligament reconstruction and rehabilitation. *Journal of Sport Rehabilitation*, 3, 204-217.
- McNair, P., Stanley, S., & Strauss, G. (1996). Knee bracing: Effects on proprioception. *Archives of Physical Medicine and Rehabilitation*, 77, 287-289.
- National Collegiate Association Participation Study: 1989-90 to 1992-93. Overland Park, KS, National Collegiate Athletic Association, 1994

- Petrella, R., Lattanzio, P., & Nelson, M. (1997). Effects of age and activity on knee joint proprioception. *American Journal of Physical Medicine & Rehabilitation*, 9, 235-241.
- Pincevero, D., Bachmeier, B., & Coelho, A. (2001). The effects of joint angle and reliability on knee proprioception. *Medicine & Science in Sports & Exercise*, 1708-1711.
- Powell, J., & Barber-Foss, K. (2000). Sex-related injury patterns among high school sports. *The American Journal of Sports Medicine*, 28, 385-403.
- Refshauge, M., Chan, R., Taylor, J., & McCloskey, D. (1995). Detection of movements imposed on human hip, knee, ankle, and toe joints. *Journal of Physiology*, 488, 231-241.
- Sherrington, C., S. (1906). On the proprioceptive system, especially in its reflex aspects. *Brain*, 29, 467-482.
- Skinner, H., Barrack, R., & Cook, S. (1984). Age-related decline in proprioception. *Clinical Orthopaedics and Related Research*, 184, 208-211.
- Stillman, B., McMeeken, J., & Macdonell, R. (1998). Aftereffects of resisted muscle contractions on the accuracy of joint position sense in elite male athletes. *Archives of Physical Medicine and Rehabilitation*, 79, 1250-1254.
- Sullivan, D. (2001) One mended knee: in the past decade 1.4 million female athletes suffered ACL injuries—twice as many as in the previous 10 years. Are you not if you can help it. *Sports Illustrated for Women*, 3,62+
- Weiler, H., & Awiszus, F. (2000). Nonspecific velocity and amplitude hunting reveals different specific detection performance of flexion and extension movements in the human knee joint. *Experimental Brain Research*, 131, 375-380.

Weiler, H., & Awiszus, F. (2000). Differences between motion-direction perception and unspecific motion perception in the human knee joint. *Experimental Brain Research*, 132, 523-530.

Weiler, H., & Awiszus, F. (2001). Characterisation of human knee-joint proprioception by means of a signal-detection theory. *Experimental Brain Research*, 138, 110-117.

Zatterstorm, R., Friden, T., Lindstrand, A., & Moritz, U. (1994). The effect of physiotherapy on standing balance in chronic anterior cruciate ligament insufficiency. *The American Orthopaedic Society for Sports Medicine*, 22, 531-536.

## APPENDICES

### APPENDIX A:

#### INSITUTIONAL REVIEW BOARD

##### Narrative Description Guidelines

**1. Thesis Title**

The effects of neoprene sleeve application on knee joint proprioception in adolescent females.

**2. Place to be Conducted**

Testing will be carried out in the Physical therapy office at Appalachian Orthopedics, Professional Park Building 3, Johnson City.

**3. Objectives**

The primary objective of this project is to examine methodological issues regarding quantification of the effects of neoprene knee sleeve. Specific objectives include 1) measure the effects of neoprene knee sleeve (NKS) application on knee joint proprioception in adolescent females. Specifically the primary objective is to measure the effect of neoprene knee sleeve application on balance, reproduction of target angles, and movement sensation.

**4-5. Summary and Subject Recruitment**

Many people, especially adolescent females experience knee pain that is caused by a number of mechanisms. These mechanisms include acute onset injury, chronic onset injury, and genealogical factors. Many of these knee problems are treated with anti-inflammatory medications, strengthening through rehabilitation, and neoprene sleeve application. The worst cases require surgery to restore the knee to normal working order.

Many doctors feel that the application of a neoprene sleeve will speed patients to recovery. Neoprene sleeves provide increased compression at the joint, which helps decrease swelling of the knee joint. Neoprene sleeves are also used to maintain temperature at the knee joint. The purpose of the present study is to test the effects of neoprene sleeve application on knee joint proprioception and function in female adolescent athletes.

**Subjects.** Fifteen subjects for this study will be recruited from Washington county Tennessee. Recruited by word of mouth.

**Inclusion Criteria.**

**Subjects must meet the following Criteria to be included in the study:**

- **Female gender**

- Age 13-16 years
- Member of school athletic team or plan to be in the upcoming year

**Exclusion Criteria.**

**Subjects will be excluded from participation in this research study for the following criterion:**

- Knee surgery

**General Design.** Test sessions will last approximately 90 minutes. All tests will be conducted with and without the neoprene knee sleeve treatment conditions and each of the tests will be conducted in duplicate. The three tests are balance testing (BT), reproduction of target angle testing (RTA), and movement sensation testing (MS). The testing session will be randomized for each subject.

**6-7. Research Data and Role of Human Subjects.**

The types of data collected from the test subjects will include knee health history, athletic participation and knee joint proprioception measurements.

**Testing.** During each testing session the dominant leg will be determined by rolling a soccer ball toward the subject and having them kick the ball. All tests will be completed with and without application of neoprene sleeve. The neoprene knee sleeves will be purchased from the Medco Corporation Tonawanda, New York. The test will occur in the following order.

**Test 1. The maintenance of balance test.**

For this test we will ask the subject to stand on one leg and we will use a high-speed video camera to measure how many seconds they can remain standing on one leg before they put their other leg down. We will videotape only their knees and feet during this test.

**Test 2. The reproduction of target angle test.**

During the RTA and MS tests, subjects will be seated with their backs against a rigid back rest oriented approximately 85° above the horizontal, and hips in approximately 90° of flexion. Their pelvis will be secured to the test table and the backrest using a seatbelt. The lower leg will be secured to the lever arm with a resistance pad. Three target angles will be passively identified during the RTA and the MS tests. These angles will be 15°, 30°, and 90° away from the starting position of 90° of flexion.

For this test the subject will be asked to sit in a machine that will measure leg movement. We will ask the subject to move one leg to one exact place and then we will use the machine to measure how close they were able to get to that place. We will ask the subject to close their eyes for about 5 seconds when moving their leg during this test. Each test



will be performed three times while they are wearing a neoprene knee sleeve and three times without wearing a neoprene knee sleeve.

The exact name of the machine that will be used to measure your leg movements is called a Biodex isokenetic testing machine by the Biodex Corporation Shirley, New York.

### **Test 3. Movement sensation test.**

For this test we will ask the subject to sit in the same machine as in the reproduction of target angle test. We will move their leg to one of three starting positions. The subject will be asked to put ear protectors on and close their eyes. We will then use the machine to move your leg. When the subject feels any motion they will use a button to stop the machine. The subject will only have to keep their eyes closed and the ear protectors on for a short period of time during each test trial.

### **8. Specific Risks to Subjects**

The balance test may cause slight soreness that should not persist any longer than five minutes. There are no known risks related to the Reproduction of target angle test or the Movement sensation test.

### **9. Benefits to Subjects**

The present study will provide data to better understand movement of the knee joint with and without a neoprene knee sleeve in female high school athletes. You will be given a summary of your test results after all of the data is collected. However you will not be paid or otherwise compensated for participating in this study.

### **10. Inducements**

No payment will be given to subjects but subjects will be given access to further testing to learn more about their ability.

### **11. Subject Confidentiality**

Each subject's right to privacy will be maintained. The medical information will be available for inspection by the ETSU/IRB. All information about the patients will be

treated confidentially and will not be released, except as noted above, unless required by law.

## **12. Informed Consent**

The informed consent is attached. All subjects and subjects parents will have the informed consent explained to them and all their questions will be answered. The subject's parents will be required to sign the consent in order to participate in the study.

## **13. Adverse Reaction Reporting**

All adverse reactions will be reported verbally to the IRB chairman within 24 hours, and in writing to the IRB Board within 10 days of occurrence.

## **14. Pertinent Literature**

Adams, J., A. (1971). A closed-loop theory of motor learning. Journal of Motor Behavior, 3, 111-119.

Al-Othman, A., Moussa, M., & Zakaria, M. (1998). A simple outpatient test for proprioception in the anterior cruciate ligament-deficient knee. Orthopedics, 21(6), 677-679.

Aniss, A., Diener, H., Hore, J., Gandevia, S., & Burke, D. (1990). Behavior of human muscle receptors when reliant on proprioceptive feedback during standing. Journal of Neurophysiology, 64(2), 661-670.

Barrack, R., Lund, P., & Skinner, H. (1994). Knee joint proprioception revisited. Journal of Sports Rehabilitation, 3, 18-42.

Beers, R., Sittig, A., & Denier, J. (1998). The precision of proprioceptive position sense. Experimental Brain Research, 122, 367-377.

Bevan, L., Cordo, P., Carlton, L., & Carlton, M. (1994). Proprioceptive coordination of movement sequences: discrimination of joint angle versus angular distance. Journal of Neurophysiology, 71(5), 1862-1872.

Birmingham, T., Cramer, J., Inglis, T., Mooney, C., Murray, L., Fowler, P., & Kirkley, S. (1998). Effect of a neoprene sleeve on knee joint position sense during sitting open kinetic chain and supine closed kinetic chain test. American Journal of Sports Medicine, 26(4), 562-566.

- Brockett, C., Warren, N., Gregory, J., Morgan, D., & Proske, U. (1997). A comparison of the effects of concentric versus eccentric exercise on force and position sense at the human elbow joint. Brain Research, 771, 251-258.
- Ciccotti, M., Kerlan, R., Perry, J., & Pink, M. (1994). An electromyographic analysis of the knee during functional activities. American Journal of Sports Medicine, 22(5), 645-650.
- Devereaux, M., & Lauchman, S. (1983). Athletes attending a sports injury clinic--a review. British Journal of Sports Medicine, 17(4), 137-42.
- Grigg, P. (1994). Peripheral neural mechanisms in proprioception. Journal of Sport Rehabilitation, 3(3), 2-17.
- Heuett, T., Stroupe, A., Nance, T., & Noyes, F. (1996). Plyometric training in female athletes: decreased impact forces and increased hamstring torque. American Journal of Sports Medicine, 24(6), 765-773.
- Horak, F., & Diener, H. (1994). Cerebellar control of postural scaling and central set in stance. Journal of Neurophysiology, 72(2), 479-493.
- Irrgang, J., Whitney, S., & Cox, E. (1998). Balance and proprioceptive training for rehabilitation of the lower extremity. Journal of Sport Rehabilitation, 3, 68-83.
- Johnston, R., Howard, M., Cawley, P., & Losse, G. (1998). Effect of lower extremity muscular fatigue on motor control performance. Medicine & Science in Sports & Exercise, 1703- 1707.
- Kinzey, S., & Armstrong C. (1998). The reliability of the star-excursion test in assessing dynamic balance. Journal of Orthopedic and Sports Physical Therapy, 27(5), 356-360.
- Lattanzio, P., & Petrella, R. (1998). Knee proprioception: a review of mechanisms, measurements, and implications of muscular fatigue. Orthopedics, 21(4), 463-471.
- Lephart, S., Pincivero, D., Giraldo, J., & Fu, F. (1997). The role of proprioception in the management and rehabilitation of athletic injuries. The American Journal of Sports Medicine, 25(1), 130-137.
- Lephart, S., Kocher, M., Fu, F., Borsa, P., & Harner, C. (1992). Proprioception following anterior cruciate ligament reconstruction. Journal of Sports Rehabilitation, 1, 188-196.
- MacDonald, P., Hedden, D., Pacin, O., & Sutherland, K. (1996). Proprioception in anterior cruciate ligament-deficient and reconstructed knees. The American Journal of Sports Medicine, 24(6), 774-778.

- Mazevet, D., & Pierrot-Deseilligny, E. (1994). Pattern of descending excitation of presumed propriospinal neurons at the onset of voluntary movement in humans. Acta Physiology Scandinavia, 150, 27-38.
- McCarthy, M., Buxton, B., Douglas, W., Hiller, B., Doyle, J., & Yamada, D. (1994). Current protocols and procedures for anterior cruciate ligament reconstruction and rehabilitation. Journal of Sport Rehabilitation, 3, 204-217.
- McDougall, J., Bray, R., & Sharkey, K. (1997). Morphological and immunohistochemical examination of nerves in normal and injured collateral ligaments of rat, rabbit, and human knee joints. The Anatomical Record, 248, 29-39.
- McNair, P., Stanley, S., & Strauss, G. (1996). Knee bracing: effects on proprioception. Archives of Physical Medicine and Rehabilitation, 77(3), 287-289.
- Muller, W. (1996). Form and function of the knee its relation to high performance and to sports. The American Journal of Sports Medicine, 24(6), S104-S106.
- Nelson, K. (1990). The use of knee braces during rehabilitation. Clinics in Sports Medicine, 9(4), 799-811.
- Petschnig, R., Baron, R., & Albrecht, M. (1998). The relationship between isokinetic quadriceps strength test and hop tests for distance and one-legged vertical jump test following anterior cruciate ligament reconstruction. Journal of Orthopedic and Sports Physical Therapy, 28(1), 23-32.
- Raunest, J., Sager, M., & Burgener, E. (1996). Proprioceptive mechanisms in the cruciate ligaments: an electromyographic study on reflex activity in the thigh muscle. The Journal of Trauma: Injury, Infection, and Critical Care, 41(3), 488-493.
- Refshauge, M., Chan, R., Taylor, J., & McCloskey, D. (1995). Detection of movements imposed on human hip, knee, ankle, and toe joints. Journal of Physiology, 488, 231-241.
- Sherrington, C., S. (1906). On the proprioceptive system, especially in its reflex aspects. Brain, 29, 467-482.
- Skinner, H. (1993). Pathokinesiology and total joint arthroplasty. Clinical Orthopaedics and Related Research, 288, 78-86.
- Stillman, B., McMeeken, J., & Macdonell, R. (1998). Aftereffects of resisted muscle contractions on the accuracy of joint position sense in elite male athletes. Archives of Physical Medicine and Rehabilitation, 79, 1250-1254.

Taylor, R., Marshall, P., Dunlap, R., Gable, C., & Sizer, P. (1998) Knee position error detection in closed and open kinetic chain tasks during concurrent cognitive distraction. Journal of Orthopedic and Sports Physical Therapy, 28(2), 81-87.

Valeriani, M., Restuccia, D., Lazzaro, V., Franceshi, F., Fabbriani, C., & Tonali P. (1996) Central nervous system modifications in patients with lesion of the anterior cruciate ligament of the knee. Brain, 119, 1751-1762.

Wise, A., Gregory, J., & Proske, U. (1996). The effects of muscle conditioning on movement detection thresholds at the human forearm. Brain Research, 735, 125-130.

Zatterstorm, R., Friden, T., Lindstrand, A., & Moritz, U. (1994). The effect of physiotherapy on standing balance in chronic anterior cruciate ligament insufficiency. The American Orthopaedic Society for Sports Medicine, 22(4), 531-536.

### **13. Location of Records**

All data and samples will be coded numerically by subject. The master sheet for these codes and questionnaires obtained from subjects will be retained by the principal investigator in a separate file housed in the office of Diego DeHoyos, Ph. D., that is located in the Mini Dome. No names, initials, or other identifying characteristics will be reported in the thesis. Data will be kept at least 10 years.

## APPENDIX B:

### INFORMED CONSENT

East Tennessee State University  
Informed Consent to Participate in Research

Page 1 of 4

#### Principal Investigators

Diego De Hoyos, Ph.D., Assistant Professor, Department of Physical Education, Exercise and Sports Science  
George Ballou Barrett, Graduate Student, Department of Physical Education, Exercise and Sports Science

#### Title of Project

The effects of neoprene sleeve application on knee joint proprioception in adolescent females.

This informed consent will explain about being a research subject in an experiment. It is important that you read this material carefully and then decide if you wish to participate as a volunteer. During this informed consent process I will explain everything to you and your parents or guardians and answer any questions you or they may have. There may be some terms in this document that are unfamiliar to you. Please identify these unfamiliar terms and I will fully explain them to you. I will be happy to answer any questions you may have about this research study.

#### Purpose of the Research

Many companies make sleeves which can be slipped over joints such as your elbow or knee. These sleeves are made of soft material called neoprene. The companies who make the neoprene sleeves say that there are many reasons why it is good to use these sleeves. Many people use these neoprene sleeves to feel better or to prevent injury while playing sports.

This study will help us learn whether neoprene knee sleeves improve either your balance or your ability to feel movement in your knee. Only female adolescent athletes will be asked to volunteer for this study because scientists do not know very much about how young athletes feel when using neoprene knee sleeves.

#### Duration

As a participant in this study, you will be asked to participate in testing on one day. Your visit will include some tests to measure your knee movement and will last about 1 hours. You are free to withdraw from the study at any time.

## Exclusion Criteria

To participate in this study you must be a member of your schools athletics program or plan to join during the upcoming year. For this study, we can only accept volunteers who have never had knee Surgery or that have been treated for chronic knee pain.

## Procedures

General Design. You will be asked to complete one testing session, which will last about ninety minutes. Before testing begins you will complete a knee health and athletic background questionnaire. Then we will ask you to do each of the following three knee tests. These test will be conducted on a standard, diagnostic machine used daily in clinics.

### **Test 1. The maintenance of balance test.**

For this test we will ask you to stand on one leg and we will use a high-speed video camera to measure how many seconds that you can remain standing on one leg before you put your other leg down. We will videotape only your knees and feet during this test.

### **Test 2. The reproduction of target angle test.**

For this test we will ask you to sit in a machine that will measure your leg movement. We will ask you to move one of your legs to one exact place and then we will use the machine to measure how close you were able to get to that place. We will ask you to close your eyes for about 5 seconds when you move your leg during this test. Each test will be performed three times while you are wearing a neoprene knee sleeve and three times without wearing a neoprene knee sleeve.

The exact name of the machine that will be used to measure your leg movements is called a Biodex isokenetic testing machine.

### **Test 3. Movement sensation test.**

For this test we will ask you to sit in the same machine as in the reproduction of target angle test. We will move your leg to one of three starting positions. You will be asked to put ear protectors on and close your eyes. We will then use the machine to move your leg. When you feel any motion you will use a button to stop the machine. You will only have to keep your eyes closed and the ear protectors on for a short period of time during each test trial.

**Data Collection.** The type of data that will be collected from you will include completion of questionnaires on your knee health history and experience.

### **Possible Risk/ Discomforts**

During performance of testing some discomfort may occur due to the Balance test. Primarily, you may experience a slight burning sensation in you leg during the balance test if your leg muscles get tired during the balance test. This sensation usually goes away in about five minutes. There has not been any risk or discomforts reported during the Reproduction of target angle and Movement sensation testing and most volunteers reported that the knee sleeve provides a comfortable sensation for the knee. As with any new exercises or movements there may be some discomfort due to a change in your daily routine.

### **Possible Benefits**

The present study will provide data to better understand movement of the knee joint with and without a neoprene knee sleeve in female high school athletes. You will be given a summary of your test results after all of the data is collected. However you will not be paid or otherwise compensated for participating in this study.

### **Inducements**

No payment will be given to subjects but subjects will be given access to further testing to learn more about their ability.

### **Contact for Questions**

If you have any questions or research related problems at any time, you may call Diego DeHoyos, Ph.D. at 423/439-5796 or Ballou Barrett at 423/737-2907. You may call the chairman of the Institutional Review Board at 423/439-6134 for any questions you may have about your rights as a research subject.

### **Confidentiality**

Every attempt will be made to see that your results are kept confidential. A copy of the records from this study will be stored in the Department of Physical Education, Exercise and Sports Sciences in room E-116 for at least 10 years after the end of this research project. The results of this study may be published and/or presented at conferences without naming you as a subject. Although your rights and privacy will be maintained, the Secretary of the Department of Health and Human Services, the East Tennessee State University/V.A. Medical Center Institutional Review Board, the Food and Drug Administration, and the ETSU Department of Physical Education, Exercise and Sports

Sciences have access to the study records. Your records will be kept completely confidential according to current legal requirements. They will not be revealed unless required by law, or as noted above.



**Compensation for Medical Treatment**

East Tennessee State University will pay the cost of emergency first aid for any injury that may happen as a result of your being in this study. They will not pay for any other medical treatment. Claims against ETSU or any of its agents or employees may be submitted to the Tennessee Claims Commission. These claims will be settled to the extent allowable as provided under TCA Section 9-8-307. For more information about claims call the Chairman of the Institutional Review Board of ETSU at 423/439-6134.

**Voluntary Participation**

The nature demands, risk, and benefits of the project have been explained to me as well as are known and available. I understand what my participation involves. Furthermore, I understand that I may withdraw from the study at any time without penalty. I have read or have had read to me, and fully understand the consent form, I sign freely and voluntarily. A signed copy has been given to me.

Your study record will be maintained in strictest confidence according to current legal requirements and will not be revealed unless required by law or as noted above.

---

Signature of Parent or Guardian	Date
Signature of Investigator	Date
Signature of Witness	Date

**The effects of neoprene sleeve application on knee joint proprioception in adolescent females.**

**Principal Investigators: Diego DeHoyos, Ph. D., George Ballou Barrett**

I am a graduate student at East Tennessee State University and I am doing a thesis to complete my requirements to graduate. The thesis I am working on is about knee joint proprioception and the effect that a neoprene knee sleeves (braces) has on knee joint proprioception. Knee joint proprioception is your ability to sense the position of your knee in space. I am using female subjects like you to do my research because not many studies have focused on you age group or your abilities.

If you decide to participate in the study you will be asked to participate in testing on one day. Your visit will include some tests to measure your knee movement and will last about 1 hour. You are free to withdraw from the study at any time.

---

Signature of Volunteer

Date

APPENDIX: C

KNEE HEALTH QUESTIONNAIRE

Knee Health Questionnaire

Name: \_\_\_\_\_ SN: \_\_\_\_\_

Age: \_\_\_\_\_

Height: \_\_\_\_\_

Weight: \_\_\_\_\_

1. List any sports you have played within the past six months.

2. How many days do you exercise per week? (circle the appropriate number)

1 2 3 4 5 6 7

3. How often do you have knee pain? (circle all that apply)

Once a week    Twice a week    More than three times a week

Once a month    Never    Other: (please explain) \_\_\_\_\_

\_\_\_\_\_

4. Have you ever had a knee injury that required examination by a doctor? Yes/No if yes which knee? R/L

5. Have you ever had knee surgery? Yes/No If yes which knee? R/L

6. Have you ever worn a neoprene knee sleeve (knee brace)? Yes/No If yes which knee?R/L

APPENDIX D:

DATA COLLECTION SHEET

**For determining the effectiveness of neoprene sleeve application on knee joint proprioception.**

**Principal Investigators: Diego DeHoyos, Ph. D., George Ballou Barrett  
Data Sheet**

Name \_\_\_\_\_ Date \_\_\_\_\_

Domiant Leg \_\_\_\_\_

Seat Position (back) \_\_\_\_\_ Seat Position (leg) \_\_\_\_\_ Movement arm Position \_\_\_\_\_

Height \_\_\_\_\_ Weight \_\_\_\_\_ Bioelectrical fat test \_\_\_\_\_ % fat  
\_\_\_\_\_ FF M

**Balance Test:**

Timed one leg stand \_\_\_\_\_

**Repositioning Test:**

Test1 \_\_\_\_\_ Score \_\_\_\_\_ Test 1 \_\_\_\_\_ Score \_\_\_\_\_

Test 2 \_\_\_\_\_ Score \_\_\_\_\_ Test 2 \_\_\_\_\_ Score \_\_\_\_\_

Test 3 \_\_\_\_\_ Score \_\_\_\_\_ Test 3 \_\_\_\_\_ Score \_\_\_\_\_

**Movement Sensation Test:**

Test1 \_\_\_\_\_ Score \_\_\_\_\_ Test 1 \_\_\_\_\_ Score \_\_\_\_\_

Test 2 \_\_\_\_\_ Score \_\_\_\_\_ Test 2 \_\_\_\_\_ Score \_\_\_\_\_

Test 3 \_\_\_\_\_ Score \_\_\_\_\_ Test 3 \_\_\_\_\_ Score \_\_\_\_\_

## VITA

George Ballou Barrett

Personal Data:      Date of Birth: April 24, 1976  
                            Place of Birth: Dublin, Georgia  
                            Marital Status: Single

Education:            Georgia College and State University, Milledgeville, Georgia;  
                            Sports Medicine, B.S., 1998  
                            East Tennessee State University, Johnson City, Tennessee;  
                            Physical Education, M.A., 2003

Professional  
Experience:            Graduate Assistant, East Tennessee State University, Department of  
                            Athletic Training, 1998-1999  
                            Head Athletic Trainer, David Crockett High School, 1999-Present