

FEAR OF REINJURY: A SURVEY OF NCAA  
ATHLETES POST ACL RECONSTRUCTION  
AND REHABILITATION

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Title

FEAR OF REINJURY: A SURVEY OF NCAA ATHLETES

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POST-ACL RECONSTRUCTION AND REHABILITATION

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By

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MASTER OF SCIENCE

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## ABSTRACT

Salvesen, Nicole Marie, M.S., Department of Health, Nutrition, and Exercise Sciences, College of Human Development and Education, North Dakota State University, May 2011. Fear of Reinjury: A Survey of NCAA Athletes Post-ACL Reconstruction and Rehabilitation. Major Professor: Dr. Jay Albrecht.

The purpose of this study was to determine if a fear of reinjury and degree of current knee pain, as measured by the Tampa Scale of Kinesiophobia (TSK) and Knee Injury and Osteoarthritis Outcome Score (KOOS) respectively, were associated with a collegiate athlete's decision to return to sport after suffering from an anterior cruciate ligament (ACL) injury, having reconstructive surgery, and performing rehabilitation. The secondary purpose of this study was to determine if the scores on the TSK varied among the athlete's pain at time of injury, age at time of injury, an athlete's return to a pre-injury level of activity, National Collegiate Athletic Association (NCAA) divisions, gender, graft type, mechanism of injury, and months since the time of injury. The tertiary purpose of this study was to determine if gender or the KOOS-Pain score affected an athlete's return to pre-injury level of activity. The results of this study may contribute to improvements in rehabilitation processes by orthopedic surgeons and sports medicine professionals in order to decrease the fear of reinjury in those athletes that are being treated for injuries to the ACL. Subjects for this study were selected from a group of 273 NCAA-sanctioned Division I, II, or III institutions. All subjects previously participated or were currently participating in NCAA sanctioned athletics during their college career and had suffered an ACL tear. Additionally, all of the subjects experienced ACL reconstruction surgery, rehabilitation for the ACL injury and repair surgery, and were cleared by a physician. Emails were sent to supervising athletic trainers of each randomly selected NCAA institution asking for their assistance through the distribution of an informational letter to

potential study participants. The informational letter provided student-athletes with a link allowing them to access the SurveyMonkey™ questionnaire, which utilized questions taken from the TSK and KOOS survey instruments, as well as a general questionnaire for collection of limited demographic data for each participant. A total of 14 males and 35 females (n = 49) participated in the study. The information collected in the current study revealed that the participants' fear of reinjury was only significantly related to an athlete's degree of current knee pain and overall quality of life after suffering from an ACL tear, reconstructive surgery, and rehabilitation. The results of the study indicated a statistical significance ( $p < 0.05$ ) between the participants' fear of reinjury and KOOS-Activities of Daily Living (ADLs) and KOOS-Sports and Recreation (Sports/Rec). Third, the results indicated a statistical significance between the fear of reinjury and the participants' age at the time of the injury to the ACL. The results of this study indicated that NCAA athletes, regardless of division, do, in fact, possess a high fear of reinjury. Although the factor regarding fear of reinjury was not found to be directly related to a return to pre-injury levels of activity in this study, improvements in rehabilitation processes and implementation of different psychological strategies by orthopedic surgeons and sports medicine professionals may help to decrease or eliminate the fear of reinjury in those athletes that are being treated for injuries to the ACL.

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## INTRODUCTION

Knee pain is one of the most common musculoskeletal complaints that physicians encounter annually as evidenced by a report of approximately 54% of athletes reporting some degree of knee pain to their physicians each year (Calmbach, 2003; Mody & Greene, 2001). Injuries to the anterior cruciate ligament (ACL) make up almost half of all ligamentous injuries that occur within the knee, many of which require surgery (Boden, Dean, Feagin, & Garrett, 2000; D'Amato & Bach, 2003). There are an estimated 50,000 to 75,000 ACL reconstructions performed annually in the United States, and the cost of one ACL reconstructive surgery and its corresponding rehabilitation process is estimated at \$17,000 (Frank & Jackson, 1997; Hewett et al., 2005; Hughes & Watkins, 2006; Johnson, Harner, & Maday, 1994). Based on previous studies examining not only the number of ACL tears that occur, but also the causes of ACL tears, it was found that female athletes are four to six times more likely to suffer an ACL tear than males participating in the same sport (Calmbach, 2003; Mody & Greene, 2001).

The National Collegiate Athletic Association (NCAA) is concerned with the increasing number and types of sports injuries that athletes participating in sports suffer from, particularly ACL tears. The Injury Surveillance System (ISS) was created by the NCAA in order to provide current data on injury trends. Several studies have been performed following the creation of the ISS to determine the number of ACL injuries that occur in males and females, with a main focus being placed on the sports of basketball and soccer (Agel, Arendt, & Bershadsky, 2005; Arendt & Dick, 1995; Mihata, Buetler, & Boden, 2006). After reviewing published ISS data, there have been trends indicating that ACL tears occur more frequently to females in comparison to males participating in the

same sport, and also that females tend to suffer a greater number of non-contact ACL injuries. The data also indicate that the chance of suffering an ACL tear, regardless of sex, is more likely to occur in soccer than basketball (Agel et al., 2005; Arendt & Dick, 1995. Mihata et al., 2006).

The causes of ACL injuries have been studied frequently over the past 25 years . It has been found that there are a variety of factors which can be associated with ACL tears in males and females. Injuries to the ACL occur as a result of a contact or non-contact situation, and are linked to complications of different passive or dynamic stabilizers within the knee joint. Passive stabilizers (the bones, the joint capsule, menisci, and the knee ligaments), and the various dynamic stabilizers (muscles surrounding the knee) may predispose an athlete to an ACL injury. Other risk factors for an ACL injury include an increased Q angle of the knee, a decreased congruence between the femur and tibia, increased ligament laxity, an increased patellar tendon-tibia shaft angle (PTTSA), improper movement and muscle activity patterns, slowed reaction time, decreased muscle strength and stiffness, and muscular fatigue (Hughes & Watkins, 2006). The passive and dynamic risk factors are typically associated with an increased occurrence of non-contact ACL injuries, while contact ACL injuries occur resulting from a direct blow to the knee, causing increased anterior translation of the tibia on the femur, hyperextension of the knee, or external rotation paired with an extension movement (Starkey & Ryan, 2002).

Once an athlete suffers an ACL tear, recommendations are generally made for reconstructive surgery to repair the ACL and improve the overall stability of the knee joint which theoretically, will eventually allow the athlete to perform complex movements associated with athletics and their sport. Both the orthopedic surgeon and the patient must

agree upon a repairing medium, (the graft type) that is used to reconstruct the torn ACL. Graft choices available at the time of this paper include a patellar tendon graft, a hamstring graft, and a cadaver graft, each of which has its own positive and negative aspects (Kisner & Colby, 2007). However, it is the knowledge, expertise, comfort, and previous experience of the orthopedic surgeon that ultimately decides the type of graft that is right for the patient. It should be noted that aside from potential risk factors that may affect the healing of the new ACL, graft failures may still occur even if no complications or risk factors are present in the patient during or after the surgical procedure. Graft failure is more likely to occur in the early months of rehabilitation and can best be prevented through strict adherence to the rehabilitation protocol after surgery (Kisner & Colby, 2007).

The rehabilitation process after ACL reconstructive surgery typically lasts approximately six months, but can last as long as one year or more. The ultimate goal of ACL rehabilitation is to return the athlete to his or her pre-injury level of activity following reconstructive surgery (Kvist, 2004). Rehabilitation protocols can either be conservative or accelerated in nature, but certain factors which allow for a full return to sport, remain the same. Some of these factors include the following: adequate muscle strength and performance compared to the uninjured limb, minor pain or effusion, full range of motion (ROM), passed functional and static stability tests, associated injuries have been healed, and no limitations in psychological and social factors (Kvist, 2004). Aside from the actual protocol for ACL rehabilitation, strict adherence to the rehabilitation protocol on the part of the patient is key to any successful rehabilitation. Research has demonstrated that the use of three different psychological approaches can be applied to increase rehabilitation compliance. Sports medicine professionals can utilize the protection motivation theory, the

personal investment theory, and the cognitive appraisal models to increase rehabilitation adherence by their patients. These theories will also assist the sports medicine professionals in providing education, open lines of communication, social support, thought stoppage techniques, increased self-belief for the athlete, utilizing short- and long-term goals, and increasing the athlete's pain tolerance in order to increase adherence to rehabilitation protocols (Christakou & Lavallee, 2009).

Sports medicine professionals and orthopedic surgeons alike must continue their attempts to understand, and learn more about, the psychology of sports injuries in order to better serve their athletes. By doing so, sports medicine professionals will also be able to provide additional recommendations and referrals to sports psychologists who have a greater knowledge of psychology, and may be able to impact the athlete in a positive manner. Studies are limited examining psychological issues that restrict an athlete from returning to full activity after undergoing ACL reconstructive surgery.

Chmielewski et al. (2008) and Kvist, Sporrstedt, Ek, and Good (2005) examined the fear of reinjury during and after the completion of the rehabilitation protocols. Chmielewski et al. (2008) focused on the fear of movement/reinjury levels at different times throughout the rehabilitation process. They found that the fear of movement/reinjury was decreased as the time after surgery increased, was inversely related to the subjects' functional levels, and contributed to functional levels the most when the subjects were most likely to begin a return to sports. Kvist et al. (2005) focused on whether or not the fear of reinjury was a significant factor for returning to a previous level of activity in patients who had undergone an ACL reconstruction and rehabilitation. They found that 24% of patients did not return to their pre-injury level of activity as a result of a fear of reinjury and that the

rate of returning to a pre-injury level of activity was lower in contact sports than non-contact sports. They also found that patients who did not return to their pre-injury level of activity expressed a greater fear of reinjury as indicated by the Tampa Scale of Kinesiophobia (TSK) and a decreased knee-related quality of life score as indicated by the Knee Injury and Osteoarthritis Outcome Score (KOOS) (Kvist et al., 2005).

In order to provide the best environment for an athlete to return to play, sports medicine professionals must place a great amount of focus on a strict adherence to the rehabilitation protocol by their patients. It is also important for the sports medicine professional to consider the psychology of rehabilitation adherence, as well as the psychology of the actual injury as a part of the rehabilitation process. Lastly, the fear of reinjury may be a determining factor in whether or not an athlete returns to his or her pre-injury level of activity. By understanding that a fear of reinjury may be a limiting factor for an athlete, addressing this issue as a part of the rehabilitation process may increase the success of the surgical procedure, rehabilitation process, and ultimately the success that an athlete has in his or her respective sport should they choose to return.

### **Statement of Purpose**

The purpose of this study was to determine if a fear of reinjury and degree of current knee pain, as measured by the TSK and KOOS respectively, were associated with a collegiate athlete's decision to return to sport after suffering from an ACL injury, having reconstructive surgery, and performing rehabilitation. The secondary purpose of this study was to determine if the scores on the TSK varied among the athlete's pain at time of injury, age at time of injury, an athlete's return to a pre-injury level of activity, NCAA divisions, gender, graft type, mechanism of injury, and months since the time of the injury. The

tertiary purpose of this study was to determine if gender or the KOOS-Pain score affected an athlete's return to pre-injury level of activity.

### **Research Questions**

1. Did the fear of reinjury and degree of current knee pain relate to an athlete's decision to return to sport after suffering from an ACL reconstructive surgery and rehabilitation?
2. Was there a relationship between the TSK and KOOS scores?
3. Was there a relationship between the TSK scores and the athlete's level of pain at the time of injury?
4. Was there a relationship between the TSK scores and the athlete's age at the time of injury?
5. Was there a difference between TSK scores among athletes from NCAA Division I, II, and III schools?
6. Was there a gender difference with regard to TSK scores?
7. Did TSK scores differ between graft choice (patellar tendon, hamstring, or cadaver)?
8. Did TSK scores differ between with respect to the mechanism of injury (contact or non-contact)?
9. Did TSK scores differ considering the time lapse since the occurrence of an ACL injury?
10. Was there a relationship between gender and an athlete's return to a pre-injury level of activity?

11. Was there a relationship between the KOOS-Pain score and an athlete's return to a pre-injury level of activity?

### **Significance of Study**

The significance of the study was to compare the fear of reinjury and degree of current knee pain with an athlete's decision to return to sports after suffering from an ACL injury, reconstructive surgery, and complete rehabilitation. The results of this study may contribute to improvements in rehabilitation processes by orthopedic surgeons and sports medicine professionals in order to decrease the fear of reinjury in those athletes that are being treated for injuries to the ACL.

### **Definition of Terms**

Anterior – referring to the front or the location close to the front of any organ (Anderson, Jefferson, & Novak, 2000).

Articulation – a junction or connection between two different bones (Anderson et al., 2000).

Concave – a rounded, semi-depressed surface that is similar to the hollowed out inner surface of a sphere (Anderson et al., 2000).

Condyle – a rounded projection located on a bone, typically near an articulating surface (Anderson et al., 2000).

Congruence – a state of agreement between two surfaces; the ability of one surface to fit into another (Oxford University Press, Inc., 1998).

Convex – a rounded, semi-elevated surface that is similar to the exterior surface of a sphere (Anderson et al., 2000).

Distal – referring to the part of the organ that is located farthest from the point of reference (Anderson et al., 2000).

Effusion – the escape of fluid into a tissue or joint capsule: swelling (Anderson et al., 2000).

Electromyography (EMG) – a diagnostic test to determine the electrical activity that occurs within skeletal muscles at rest, during voluntary contraction, and during electrical stimulation (Anderson et al., 2000).

Inferior – referring to the lower surface of an organ or other structure (Anderson et al., 2000).

Intercondylar – the area of space located between two condyles (Anderson et al., 2000).

Isokinetic – a type of exercise that varies the resistance placed on a muscle to allow the muscle to shorten and lengthen at the same speed throughout the desired ROM (Anderson et al., 2000).

Isotonic – a type of exercise which maintains a constant amount of tension on a muscle as it shortens and lengthens throughout the desired ROM (Anderson et al., 2000).

Kinematic – refers to mechanics of joints that deal with the possible motions of the body (Anderson et al., 2000).

Kinetic – refers to any motion of the body (Anderson et al., 2000).

Lateral – refers to the part of the organ that is located furthest from the midline of the body or other structure (Anderson et al., 2000).

Laxity – a loose feeling in a normal or abnormal motion of a joint (Anderson et al., 2000).

Medial – refers to the part of the organ that is located closest to the midline of the body or other structure (Anderson et al., 2000).

Musculoskeletal – refers to the skeletal system and muscular system as one system that works together (Anderson et al., 2000).

Non-contractile – the inability of a structure to shorten when stimulated by a nerve (Anderson et al., 2000).

Pathogen – refers to any microorganism that is capable of producing a disease within the body (Anderson et al., 2000).

Posterior – refers to the back or a location close to the back of any organ (Anderson et al., 2000).

Prophylactic – an intervention, typically through prescribed medications, to prevent the formation diseases within the body (Anderson et al., 2000).

Proprioception – the unconscious perception of the body's movements in space which are detected by nerves within the body (Anderson et al., 2000).

Proximal – referring to the part of the organ that is located nearest to the point of reference (Anderson et al., 2000).

Revascularization – the restoration of blood supply to a part of the body after it has been injured or surgically repaired (Anderson et al., 2000).

Superior – refers to the upper surface of an organ or other structure (Anderson et al. 2000).

Tensile – the capability of a muscle, ligament, or tendon to be stretched (Oxford University Press, Inc., 1998).

Translation – a motion in the body in which one point of the body moves parallel to another point (Oxford University Press, Inc., 1998).

Tuberosity – a protrusion of bone and is typically a location for muscle attachment (Anderson et al., 2000).

Valgus – a force placed on a joint which causes that joint to be angled toward the midline of the body, stressing the medial aspect of the joint (Anderson et al., 2000).

Varus – a force placed on a joint which causes that joint to be angled away from the midline of the body, stressing the lateral aspect of the joint (Anderson et al., 2000).

## REVIEW OF LITERATURE

The purpose of this study was to determine if a fear of reinjury and degree of current knee pain, as measured by the Tampa Scale of Kinesiophobia (TSK) and Knee Injury and Osteoarthritis Outcome Score (KOOS) respectively, were associated with a collegiate athlete's decision to return to sport after suffering from an anterior cruciate ligament (ACL) injury, having reconstructive surgery, and performing rehabilitation. The secondary purpose of this study was to determine if the scores on the TSK varied among the athlete's pain at time of injury, age at time of injury, an athlete's return to a pre-injury level of activity, National Collegiate Athletic Association (NCAA) divisions, gender, graft type, mechanism of injury, and months since the time of the injury. The tertiary purpose of this study was to determine if gender or the KOOS-Pain score affected an athlete's return to pre-injury level of activity. The current study sought to provide more information as to whether or not the fear of re-injury is a limiting factor in a full return to sport in NCAA Divisions I, II, and III.

Anterior cruciate ligament injuries are very common injuries in sport that can occur at the knee joint and have the potential to be very debilitating. Injuries to the ACL may hinder an athlete's return to sport if not surgically repaired and the rehabilitation protocol prescribed by the orthopedic surgeon and/or sports medicine professionals is not followed. A successful surgical procedure and rehabilitation protocol is often identified by an athlete's ability to return to his or her previous level of activity or sport. There are many issues that can arise both during and after an ACL reconstruction that may make it difficult for the athlete to return to full activity, one of which is the fear of reinjury. This review of literature addresses the problem by examining the prevalence of ACL injuries, the anatomy

of the knee joint, causes of ACL injuries, surgical considerations for ACL reconstruction, and rehabilitation following an ACL reconstruction. The review of literature also examines the psychology of rehabilitation adherence and the psychology of sports injuries, previous studies that examine the fear of reinjury after ACL reconstructive surgery, and a brief overview of two surveys used in this current study, the TSK and the KOOS.

### **Prevalence of Anterior Cruciate Ligament Injuries**

Knee pain is one of the most common musculoskeletal complaints that physicians encounter each year, with as many as 54% of athletes reporting some degree of knee pain (Calmbach, 2003; Mody & Greene, 2001). In that regard, the majority of athletic injuries are comprised of traumatic knee injuries (Senter & Hame, 2006) with almost half of all ligamentous injuries in the knee isolated to the ACL (Boden, Dean, Feagin, & Garrett, 2000; D'Amato & Bach, 2003).

Each year there are an estimated 80,000 to 100,000 ACL injuries that occur in the United States (Griffin et al., 2000; Wojtys, 1994), with approximately 70% occurring during athletic activities (Boden et al., 2000; D'Amato & Bach, 2003; Miller III, 2003). Nearly 80% of ACL tears tend to be non-contact in nature, and occur as a result of a high-risk task, such as cutting, jumping, landing, or stopping (Herman et al., 2008). Furthermore, female athletes are four to six times more likely to suffer an ACL injury when compared to male athletes that are participating in the same sport. Males and females combined suffer approximately 38,000 ACL injuries in the United States annually (Hewett et al., 2005; Hughes & Watkins, 2006).

There are an estimated 50,000 to 75,000 ACL reconstructions performed each year to prevent overall knee instability and increase the chances that the patient will return to his

or her pre-injury level of activity (Frank & Jackson, 1997; Johnson et al., 1994). The typical cost of an ACL reconstructive surgery and full rehabilitation process is estimated at \$17,000 per case (Hewett, Lindenfeld, Riccobene, & Noyes, 1999). At the national level, approximately \$646 million is spent each year on the surgical procedure and total rehabilitation for female athletes alone (Hewett et al., 2005).

The NCAA, the governing body of collegiate athletics, is concerned with the increasing number and types of sports injuries that its participants experience, particularly injuries to the ACL. In 1982, the NCAA created the Injury Surveillance System (ISS) in order to provide current data on injury trends. Medical staff from the participating institutions report the number of injuries and exposures to participation on a weekly basis and record and enter inventory items into the system such as, when an injury occurred, the mechanism of injury, the equipment worn, the position played, the event that the injury occurred in (game or practice), and the amount of time was passed during the event before the injury occurred (Agel et al., 2005; Arendt & Dick, 1995; Mihata et al., 2006). Arendt and Dick (1995) performed a study using ISS to assess ACL injuries that occurred in male and female soccer and basketball players in the NCAA over a five-year period. They reported that female NCAA athletes had a significantly higher rate of ACL injury than male athletes in both basketball and soccer.

Agel et al. (2005) sought to determine if the trends found by Arendt and Dick (1995) continued by reviewing the NCAA ISS for men's and women's basketball and soccer from 1989 through 2002, a total of 13 academic years. The authors found that over the 13-year period, there were a total of 1268 ACL injuries reported through ISS, with 682 ACL injuries occurring in basketball (514 female, 168 male) and 386 ACL injuries

occurring in soccer (394 females, 192 males). No significant differences were seen between male and female basketball athletes when contact versus non-contact ACL injuries were compared. However, there was a significant difference in injury rates for male and female athletes, regardless of sport, when contact versus non-contact ACL injuries were compared, demonstrating that a majority of non-contact ACL injuries occurred in females (Agel et al., 2005). When comparing the total number of ACL injuries between males and females, the injury rates for female athletes were significantly higher, regardless of the sport. Also, male and female soccer players sustained ACL tears at a significantly higher rate than male and female basketball players. Overall, the findings of Agel et al. (2005) showed similar trends to the findings of Arendt and Dick (1995), and demonstrated that there were differences in injury rates of the ACL between males and females, with females experiencing the higher injury rate.

A study performed by Mihata et al. (2006) reflected a similar purpose to the studies performed by Arendt and Dick (1995) and Agel et al. (2005). An additional focus of the Mihata et al. (2006) study was on identifying trends of ACL injuries in both men's and women's lacrosse. Again, the authors of the study used ISS data from 1989 to 2004 (15-year period) to examine sex and game-specific ACL injury rates (Mihata et al., 2006). The authors found that over the 15-year period, there were 212 ACL injuries that occurred in men's soccer, 457 ACL injuries that occurred in women's soccer, 175 ACL injuries that occurred in men's basketball, 551 ACL injuries that occurred in women's basketball, 169 ACL injuries that occurred in men's lacrosse, and 146 ACL injuries that occurred in women's lacrosse (Mihata et al., 2006). After statistical analysis, Mihata et al. (2006) found no significant differences between the ACL injury rates (given per 1000 athlete

exposures) of males and females in the sport of lacrosse during the 15-year review period. However, for the sports of basketball and soccer, significant differences were again seen between injury rates of males and females, and were similar to the results of Arendt and Dick (1995) and Agel et al. (2005) (Mihata et al., 2006).

### **Knee Anatomy**

The knee joint is a complex hinge joint that allows for athletic motions to occur, including walking, running, cutting, and jumping, and relies on many different stabilizing features for it to function properly. In order to understand injuries that occur to the ACL, it is important to understand the anatomy of the knee. The knee joint consists of two different articulations, the tibiofemoral joint (an articulation between proximal tibia and distal femur) and the patellofemoral joint (an articulation between the patella and the anterior distal femur) (Hughes & Watkins, 2006; Starkey & Ryan, 2002). The articulating surface of the proximal tibia contains two, shallow condyles, which correspond to the two convex condyles of the distal femur. The two condyles of the femur are separated by the intercondylar notch. The articulation between the proximal tibia and the distal femur is made stronger with the help of the medial and lateral menisci, which serve a variety of purposes. The menisci

deepen the articulation [between the distal femur and proximal tibial plateau] and fill the gaps that normally occur during the knee's articulation, increasing load transmission over a greater percentage of the joint surfaces, improve lubrication for the articulating surfaces, provide shock absorption, and increase the stability of the joint. (Starkey & Ryan, 2002, p. 190)

Aside from the menisci, four ligaments (two collateral ligaments located outside the joint capsule and two cruciate ligaments located inside the joint capsule) aid in the stabilization of the knee. The medial collateral ligament (MCL) is the primary stabilizing ligament in the knee and protects the knee against valgus forces, while also acting as a secondary restraint against external rotation of the tibia and anterior translation of the tibia on the femur (Starkey & Ryan, 2002). The lateral collateral ligament (LCL) is the primary restraint against varus forces placed on the knee between full extension and 30 degrees of flexion, with a secondary purpose of restraining excessive internal and external rotation of the tibia on the femur (Starkey & Ryan, 2002).

The two cruciate ligaments function to ensure normal movement of the tibial plateau on the articular surface of the distal femur and vice versa. These ligaments are located in the intercondylar notch of the distal femur and cross each other inside the joint capsule. The posterior cruciate ligament (PCL) attaches to the anterior inferior medial plateau of the distal femur and the posterior aspect of the tibial plateau, while the ACL attaches to the posterior inferior lateral plateau of the distal femur and the anterior aspect of the tibial plateau (Hughes & Watkins, 2006; Starkey & Ryan, 2002). The PCL is considered the primary stabilizer of the knee and offers a majority of protection against posterior forces that are placed on the knee joint (Starkey & Ryan, 2002), while the ACL acts as a static stabilizer against anterior translation and internal and external rotation of the tibia on the femur, as well as hyperextension of the tibiofemoral joint (Starkey & Ryan, 2002).

## Causes of Anterior Cruciate Ligament Injuries

Injuries to the ACL are either contact or non-contact in nature and occur as a result of risk factors associated with passive or dynamic stabilizers of the tibiofemoral joint. Passive stabilizers are made up of non-contractile structures such as the tibia and femur, the joint capsule, the lateral and medial menisci, and the four ligaments (MCL, LCL, ACL, and PCL), whereas dynamic stabilizers consist of the muscles that cross the tibiofemoral joint, including the quadriceps and hamstrings (Hughes & Watkins, 2006). Passive stability risk factors may be associated with the Q angle of the knee, congruence between the femur and tibia, and ligament laxity (Hughes & Watkins, 2006). Dynamic stability risk factors may stem from the patellar tendon-tibia shaft angle (PTTSA), the movement pattern of the body, muscle activity patterns, reaction time, muscle strength and stiffness, and muscular fatigue (Hughes & Watkins, 2006).

As previously mentioned, there are passive stabilizers that may place an athlete at an increased risk for an ACL injury. The geometry of the articular surfaces between the femur and tibia may affect both the Q angle and the congruence of the articular surfaces between the femur and the tibia. The Q angle is defined as the angle formed by the line connecting the anterior superior iliac spine (ASIS) to the middle of the patella and the line connecting the tibial tuberosity to the middle of the patella (Hungerford & Barry, 1979). Furthermore, the Q angle is typically greater in females than in males (Herrington & Nester, 2004; Horton & Hall, 1989). Herrington and Nester (2004) measured the Q angles of 51 males and 58 females that were physically active and had no previous history of any lower extremity injuries (Herrington & Nester, 2004). The results demonstrated that the average Q angle was significantly greater in females (13.9 degrees) than in males (11.5

degrees) (Herrington & Nester, 2004). A larger Q angle causes an increased knee valgus angle to occur, and a previous study has shown that an increased valgus angle has been directly associated to an increased risk for an ACL injury (Olsen, Mykelbust, Engebretsen, & Bahr, 2004).

The second geometrical factor that may place an athlete at an increased risk for ACL injury is the congruence between the distal femur and proximal tibial plateau. As previously mentioned, the distal femur has two convex condyles which correspond to two slightly concave surfaces on the tibial plateau. These articulating surfaces are not very congruent, but with the help of the menisci, the congruence becomes quite high in a healthy knee (Hughes & Watkins, 2006). However, if the menisci are damaged in any way, there may be a decreased congruence between the articulating surfaces and a decrease in passive stability of the tibiofemoral joint as a result (Hughes & Watkins, 2006). The congruence between the two surfaces is also affected by the intercondylar notch width (the wider the notch, the less congruence there is between surfaces). It should also be noted that the narrower the width of the intercondylar notch, the smaller the space that is available for the ACL and the PCL. Females tend to have a narrower intercondylar notch width, and studies have shown that there is a greater incidence of ACL injuries in subjects who have a narrower intercondylar notch width (Ireland, Balantyne, Little, & McClay, 2001; Uhorchak et al., 2003). Uhorchak et al. (2003) performed a longitudinal study over a four year period which measured the intercondylar notch width of army cadets (711 males, 113 females) using x-rays. During the four years of the study, a total of 24 non-contact ACL injuries occurred (16 males, 8 females). The study results indicated that the width of the intercondylar notch was significantly narrower in females (15.6mm) than in males

(17.7mm) and that the intercondylar notch width was significantly narrower in the non-contact ACL injured subjects than in those who were not injured (Uhorchak et al., 2003).

The last factor that affects passive stability of the tibiofemoral joint is ligament laxity (Watkins, 1999). A study by Hutchinson and Ireland (1995) found that females demonstrated increased joint laxity when compared to males. This increased joint laxity is considered to be a contributing factor to the greater incidence of ACL injuries in females (Hutchinson & Ireland, 1995). Reasons for ligament laxity between individuals is still unknown, but it is thought to be due to differences in ligament length and the ligament's resistance to stretching (tensile stiffness) (Hughes & Watkins, 2006). The effect of hormones on the ligaments in the body, particularly that of the ACL, may be a reason for increased ligament laxity and is thought to be a reason for the increased incidence of ACL tears in females. Within the ACL, there is a presence of estrogen and progesterone receptors, and the fluctuation of these sex hormones in female athletes (due to the menstrual cycle) may affect the mechanical properties of the ligament (Liu, Al-Shaikh, Panossian, Finerman, & Lane, 1997; Slauterbeck, Clevenger, Lundberg, & Burchfield, 1999). Slauterbeck et al. (1999) studied the effect of estrogen on the tensile strength of the ACL in rabbits. It was found that estrogen significantly decreased the tensile strength of the ligament in rabbits, and researchers suggested that similar effects may be seen in humans (Slauterbeck et al., 1999). Further studies have been conducted that investigate the phase of the menstrual cycle and the occurrence of non-contact ACL injuries (Slauterbeck et al., 2002; Wojtys, Huston, Boynton, Spindler, & Lindenfeld, 2002). These studies are inconclusive as Wojtys et al. (2002) found that there was a higher incidence of ACL

injuries between days ten to 14, while Slauterbeck, et al. (2002) found that there was a higher incidence of ACL injuries between days one and two of the menstrual cycle.

Aside from the passive stability risk factors that may place an athlete at an increased risk for an ACL injury, there are also dynamic stability risk factors that have been shown to increase an athlete's risk for an ACL injury. Dynamic stability is necessary to provide overall joint stability during complex movements such as jumping, landing, side-stepping, and cutting maneuvers that are commonly used during athletic participation. Dynamic stability affects muscle function and can either assist or hinder kinetics and kinematics of athletic activities. The first dynamic stability factor is the patellar tendon-tibia shaft angle (PTTSA), which is comprised of the angle between the tibial shaft and the line of action of the patellar tendon (Hughes & Watkins, 2006). When the quadriceps contract and the knee is fully extended, there is an anterior shear force applied to the tibia, therefore placing increased strain on the ACL (Boden et al., 2000; Nunley, Wright, Renner, Yu, & Garrett, 2003). Nunley et al. (2003) compared the effect of different knee flexion angles on the PTTSA and found that the anterior shear force was greatest when the knee was near full extension (Nunley et al., 2003). Nunley et al. (2003) also found that the PTTSA was 3.6 degrees greater in females than in males when the knee was moved through a range of motion (ROM) from 0 degrees to 90 degrees. The findings of Nunley et al. (2003) are consistent with those found by Boden et al. (2000) who surmised that non-contact ACL injuries occur more frequently when the knee is close to full extension.

The movement patterns and muscle activity patterns of the body also greatly affect the strain placed on the ACL during activity. Three studies were performed with an aim of analyzing kinetic and kinematic movements of the body and determining differences

between males and females during different athletic tasks (Chappell, Yu, Kirkendall, & Garrett, 2002; Malinzak, Colby, Kirkendall, Yu, & Garrett, 2001; Salci, Kentel, Heycan, Akin, & Korkusuz, 2004). These studies found that females land with less knee flexion (Chappell et al., 2002; Malinzak et al., 2001; Salci et al., 2004), a greater knee valgus angle (Malinzak, et al., 2001), greater knee extension moments (Chappell et al., 2002), and produce an increased ground reaction force (Salci et al., 2004) when compared to males; all which place increased stress on the ACL. Normal muscle activity patterns should result in no shear forces being placed on the ACL. However, if the quadriceps exert more force than the hamstrings, anterior translation of tibia on the femur may occur, placing increased stress on the ACL. This imbalance in the body is often known as quadriceps dominance (Ford, Myer, & Hewett, 2003). Malinzak et al. (2001) performed a study that measured motion at the knee joint and electromyographic (EMG) activity of the hamstrings and quadriceps in 9 females and 11 males during running, cross-cutting, and side-cutting. The EMG data demonstrated increased quadriceps activation and decreased hamstrings activation in females when compared to males. Zeller, McCroy, Kibler, and Uhl (2003) also performed a study that measured EMG of the quadriceps and hamstrings in nine female and nine male athletes while performing a one-legged squat with the dominant leg. It was found that females produced greater total muscle activation of the lower extremity and significantly greater total and maximal activation of the quadriceps when compared to their male counterparts.

Muscle stiffness and strength may also affect the amount of anterior translation of the tibia on the femur and may increase the stress placed on the ACL. Muscle stiffness refers to the ability of a muscle to resist movement at the tibiofemoral joint (Hughes &

Watkins, 2006). Granata, Wilson, and Padua (2002) performed a study that investigated the muscle stiffness of the quadriceps and hamstrings in 12 male and 11 female subjects. The authors reported that females demonstrated decreased muscle stiffness for both the quadriceps and hamstrings in comparison to males (Granata et al., 2002). The findings of Granata et al. (2002) suggest that females may be less likely to protect the knee joint using the surrounding musculature, which may increase the incidence of ACL tears. Muscle strength may also play a role in influencing muscle stiffness. Lower extremity muscular strength, particularly of the hamstrings and quadriceps, have been found to be lower in females when compared to males. The lower muscular stiffness in females may be associated to a decrease in muscle strength (Hughes & Watkins, 2006).

Along with whole body and muscle activity patterns, muscle stiffness, and muscle strength, the ability of an individual to react to a situation affects the speed at which dynamic stability can be achieved, ultimately affecting the risk for injury (Beard, Dodd, & Trundle, 1994). Wojtys, Huston, Taylor, and Bastain (1996a) performed a study in which 16 males and 16 females were trained using either isokinetic, isotonic, or agility training, and a control group to determine which type of training most improved reaction time. Wojtys et al. (1996a) deduced that agility exercises yielded the highest improvement of reaction time. Aside from reaction time, muscular fatigue can play a role in non-contact ACL injuries because it causes a decrease in muscle activity (Chappell et al., 2005; Wojtys, Wylie, & Huston, 1996b). Chappell et al. (2005) studied the effects of fatigue on knee-joint kinetics and kinematics of ten male and ten female athletes during a drop-jump. The information collected revealed that both males and females increased anterior translation of

the tibia on the femur and decreased knee flexion while landing when fatigued. Chappell et al. (2005) also found that females increased the valgus angle of the knee while fatigued.

Wojtys et al. (1996b) also studied the effects of hamstrings and quadriceps fatigue on the anterior translation of the tibia on the femur and muscle reaction time in four female and six male subjects. The authors concluded that that recruitment patterns of the hamstrings and quadriceps did not change in the subjects when they became fatigued. However, a 32.5% increase in anterior translation of the tibia on the femur was noted when the athletes performed the fatigued test when compared to the non-fatigued test (Wojtys et al., 1996b). Both Chappell et al. (2005) and Wojtys et al. (1996b) demonstrated that muscular fatigue affects the anterior translation of the tibia on the femur, placing increased stress on the ACL, ultimately increasing the risk of ACL injuries.

### **Surgical Considerations for Anterior Cruciate Ligament Reconstruction**

In order to repair a torn ACL, an athlete may undergo reconstructive surgery to repair the damaged ligament and make him or her better able to compete at a high level. However, a surgical procedure may not be right for every patient that tears his or her ACL. Orthopedic surgeons have created certain criteria that a surgical candidate must meet in order to increase the chances of a successful surgical procedure, rehabilitation, and a safe return to pre-surgical levels of activity. Kisner and Colby (2007, p. 727) outlined both indications and contraindications for an ACL reconstructive surgery. Indications for ACL reconstruction include:

1. Disabling instability of the knee due to ACL deficiency caused by a complete or partial acute tear or chronic laxity.

2. Frequent episodes of the knee giving way (buckling) during routine activities of daily living (ADLs) despite a course of non-operative management.
3. A positive pivot-shift test because an ACL deficit is often associated with a lesion of other structures of the knee, such as the MCL, resulting in rotator instability of the joint.
4. Injury of the MCL at the time of ACL injury to prevent lax healing of the MCL.
5. High risk of reinjury because of participation in high-demand, high-joint-load activities related to work, sports, or recreational activities.

Contraindications, as outlined by Kisner and Colby (2007, p. 727) include, but are not limited to:

1. Relatively inactive individual with little to no exposure to work, sport, and recreational activities that place high demands on the knee.
2. Ability to make lifestyle modifications to eliminate high-risk activities.
3. Ability to cope with infrequent episodes of instability.
4. Advanced arthritis of the knee.
5. Poor likelihood of complying with postoperative restrictions and adhering to a rehabilitation program.

Once the orthopedic surgeon decides that the patient is a candidate for an ACL reconstruction, both the surgeon and patient must discuss the type of graft that will be used to reconstruct the torn ligament. The three most popular graft choices are the patellar tendon graft, the hamstring graft, both considered to be autografts, and the allograft (cadaver graft). The graft that is chosen should most closely reproduce the original ACL by providing similar biomechanical properties, allow for a secure fixation into the femur

and tibia, promote rapid healing, allow for integration into an accelerated rehabilitation protocol, and minimize donor site tissue death (Beasley et al., 2005). It should be noted that all of previous graft type criteria will not be met by one single graft option, but the graft choice that fulfills the most criteria for the individual should be selected.

Furthermore, the graft that is selected should be approved by both the patient and orthopedic surgeon, making sure that the patient understands both the advantages and disadvantages of each graft.

The use of the patellar tendon to reconstruct the ACL has been used since 1963, and is currently considered to be the “gold standard” for graft reconstruction (Beasley et al., 2005). Noyes, Butler, Grood, Zernicke, and Hefzy (1984) were the first to investigate an uninjured ACL and graft alternatives in terms of their structural and mechanical properties. It was found that an uninjured ACL can withstand 1725 Newtons (N) of force (Noyes et al., 1984). When comparing a patellar tendon graft, a single tendon hamstring graft, a quadriceps tendon graft, a tensor fascia lata graft, and an iliotibial band graft, Noyes et al. (1984) found that there was only one graft choice that was able to withstand the same, or more force than an uninjured ACL, and that graft choice was the patellar tendon. The patellar tendon demonstrated a 168% (2900 N) increase in tensile strength when compared to the tensile strength of an original ACL (Noyes et al., 1984). Advantages of the patellar tendon graft include, but are not limited to (Kisner & Colby, 2007, p. 727):

1. High tensile strength/stiffness, similar or greater than the ACL.
2. Secure and reliable bone-to-bone graft fixation with interference screws.
3. Rapid revascularization/biological fixation (6 weeks) at the bone-to-bone interface permitting safe, accelerated rehabilitation.

4. An ability to return to pre-injury, high-demand activities safely.

Disadvantages and complications of the patellar tendon graft may include (Kisner & Colby, 2007, p. 727):

1. Anterior knee pain in [the] area of [the] graft harvest site.
2. Pain during kneeling.
3. Extensor mechanism/patellofemoral dysfunction.
4. Long-term quadriceps muscle weakness.
5. Patellar fracture during graft harvest.
6. Patellar tendon rupture.

A second option for an ACL graft is the hamstring graft typically made up of the semitendinosus and gracilis tendons. With the evolution of the ACL reconstruction surgical procedure, the hamstring graft is now becoming more popular and has demonstrated improved surgical outcomes (Beasley et al., 2005). Typically, the hamstring graft is made up of two hamstring tendons, doubled over to create a quadrupled hamstring graft. Although Noyes et al. (1984) found the single hamstring tendon graft to be able to withstand forces of 838 N to 1216 N, Brown, Steiner, and Carson (1993) found that a quadrupled hamstring tendon graft can withstand forces almost three times greater than the forces that an original ACL can, demonstrating a tensile strength of 4108 N. Advantages of the hamstring tendon graft include, but are not limited to (Kisner & Colby, 2007, p. 728):

1. High tensile strength/stiffness greater than ACL with quadrupled graft.
2. No disturbance of epiphyseal plate in skeletally immature patient.
3. Evidence of hamstring tendon regeneration at donor site.

4. Loss of knee flexor muscle strength remediated by two years postoperatively.

Disadvantages and complications of the hamstring tendon graft may include (Kisner & Colby, 2007, p. 728):

1. Tendon-to-bone fixation devices are not as reliable as bone-to-bone fixation.
2. Longer healing time at tendon-bone interface.
3. Hamstring muscle strain during early rehabilitation.
4. Short- and long-term knee flexor muscle weakness.
5. Possible increased anterior knee translation that is not associated with functional limitations.

A third option for ACL reconstruction is the use of an allograft, or cadaver graft.

The most common allograft choices include the patellar tendon, hamstring tendons, anterior tibialis tendon, posterior tibialis tendon, and the Achilles tendon (Beasley et al., 2005). Advantages of an allograft include reduced surgical time, availability of any graft type or size, and the elimination of donor site tissue death (Beasley et al., 2005). These advantages lead to a less painful recovery for the patient and a more cosmetic appearance since there are no additional incisions needed to harvest the graft. Disadvantages of an allograft include disease transmission, poor immune system responses, adverse effects of processing and sterilization on the graft, slower remodeling and healing time, and an increased cost (Beasley et al., 2005). The risk of disease transmission was the most worrisome to orthopedic surgeons and patients alike, but over the past 30 years this risk has become almost obsolete. In the late 1980s, the transmission rate of the human immunodeficiency virus (HIV) was estimated to be less than one in 1.7 million allograft reconstructive surgeries (Buck, Malinin, & Brown, 1989). From 2000 to 2005, there were

over two million allografts used in ACL reconstructions and zero documented cases of viral infections disease transmissions (Woll, 2001). Currently, there are very strict screening programs and regulations to maintain sterile conditions for both viral and bacterial pathogens located in the allograft tissue.

With almost no risk of acquiring a bacterial or viral disease through the allograft, its popularity and use has increased as an ACL reconstruction graft choice. Shino, Nakata, Horibe, Inove, and Nakagawa (1993) performed a study which reviewed quadriceps strength and anterior translation in a group of 92 ACL reconstruction patients who have had a successful surgery and were 18 to 36 months post-operative. The study results indicated that older, less active patients were more likely to choose an autograft over an allograft. It was also observed that regardless of graft type (autograft or allograft), the reconstructed knee demonstrated increased anterior translation when compared to the healthy knee, but there were no differences in translation found between graft types (Shino et al., 1993). Lastly, results of the study showed that the patients who received an allograft demonstrated increased knee extension strength (quadriceps strength) in comparison to the patients who received an autograft for ACL reconstruction. This study reveals that similar results can be achieved regardless of the graft chosen to reconstruct the ACL (autograft versus allograft) and that excellent results can be achieved if the orthopedic surgeon is well acquainted and comfortable with the surgical technique and fixation procedure, and if proper rehabilitation practices are followed by the patient.

As with any surgery, there is the potential for risks and complications to occur during and after surgery. Such risks are uncommon but must be discussed as a part of the surgical decision. Graft impingement is a possible complication following surgery if the

drill holes that hold the new ACL were incorrectly placed into the tibia or femur. This may cause the repaired ACL to press against the bone as the knee moves through flexion and extension, restricting the normal movement pattern of the knee. Graft impingement typically makes it impossible to gain full extension, even with strict adherence to a rehabilitation protocol (Beasley et al., 2005). A second risk that may occur in the operating room involves an inappropriate graft length selection for the new ACL. This tends to occur more frequently with hamstring grafts than patellar tendon grafts, but nonetheless can lead to graft slippage and early failure (Kisner & Colby, 2007).

Once the surgical procedure has been completed, there are still a number of risk factors present that may impede the healing of the new ACL and slow the rehabilitation process. Deep vein thrombosis, or blood clots, can often develop in the deep veins of the lower legs following any surgery that requires a period of non-weight bearing and/or immobilization (Kisner & Colby, 2007). Most physicians take preventative measures to ensure that this condition does not occur by encouraging movement of the legs and the use of pressure stockings. In older patients, blood thinners may be prescribed prophylactically to help prevent deep vein thrombosis. Another risk that may be experienced after surgery is infection (Kisner & Colby, 2007). Although the risk is very low, it is important for the physician to discuss this with the patient. Antibiotics are taken before and after the surgery, and are also given intravenously during the surgical procedure. Proper care of the incisions by the patient is another means of keeping the risk of infection to a minimum. Stiffness may also occur after surgery, but this is decreased by instituting ROM exercises immediately following surgery. A continuous passive motion (CPM) machine may also be recommended by physicians following surgery to keep the knee moving during recovery.

It is often used for approximately two weeks after surgery (Kisner & Colby, 2007).

Anterior knee pain is another potential complication of surgery that may affect the rehabilitation process. This typically occurs at the site of the patellar tendon graft and may cause increased pain during functional activities (Kisner & Colby, 2007). Significant losses of ROM may occur as a result of muscle weakness (particularly of the quadriceps), a buildup of scar tissue in the intercondylar notch, or decreased patellar mobility (Kisner & Colby, 2007). Lastly, it is important to remember that graft failure may occur even in a seemingly successful surgical procedure. Graft failure is more likely to occur in the early months following the surgical procedure and is best prevented through strict adherence to the post-operative rehabilitation protocol, particularly in terms of an athlete's return to play criteria (Kisner & Colby, 2007).

### **Rehabilitation Following Anterior Cruciate Ligament Reconstructive Surgery**

After ACL reconstructive surgery, it is recommended that the patient undergo a minimum of six months of rehabilitation. The goal of ACL rehabilitation is to return the patient to his or her pre-injury level of activity without posing the risk of new injuries or degenerative changes within the knee. The success of the surgical procedure and the rehabilitation process is often identified through a return to a high level of athletic activity by orthopedic surgeons, sports medicine professionals, and patients alike (Kvist, 2004). By understanding the biomechanics of the knee joint, as well as the physiology of the healing processes in the body, a proper rehabilitation program can be constructed. The main priorities of ACL rehabilitation are to improve functional stability to a competitive level and decrease the risk for reinjury (Kvist, 2004). Typical rehabilitation programs focus on the affected limb and unaffected limb while incorporating good core strength and muscle

balance to promote whole body stabilization. Furthermore, Kvist (2004) states that functional stability of the knee is dependent on the dynamic muscle function, strength, and coordination, and also the proprioceptive ability of the athlete (Kvist, 2004). Many ACL rehabilitation programs focus on neuromuscular training as a way to enhance such coordination and proprioception (Kvist, 2004). Studies have shown that neuromuscular training has decreased the incidence of ACL injuries in athletes (Caraffa, Cerulli, Proietti, Aisa, & Rizzo, 1996; Hewett et al., 1999).

Over the past three decades, ACL rehabilitation protocols have changed dramatically. Conservative, or non-accelerated, rehabilitation of the past involved: Limitation of ROM, delayed weight bearing with full weight bearing at eight to ten weeks and returning to sports after nine to 12 months... The trend today is accelerated protocols with immediate training of ROM and weight bearing and return to sports within four to six months. (Kvist, 2004, p. 272)

Current protocols incorporate the immediate training of ROM, both actively and passively (through a clinician and/or with the help of a CPM). By beginning to work on ROM early in rehabilitation, the risk of graft stiffness can be decreased, while overall knee strength can be increased early on (Kvist, 2004).

Weight-bearing has also been encouraged early in the rehabilitation process, allowing pain, swelling, and the degree of extension loss to act as guides for the patient regarding the intensity of the rehabilitation process (Gerich, Lattermann, Fremerey, Zeichen, & Lobenhoffer, 1997; Maracci et al., 2003; Muellner, Alacamlioglu, Nikolic, & Schabus, 1998; Reat & Lintner, 1997). Weight-bearing immediately after ACL surgery also has been shown to decrease the incidence of anterior knee pain, particularly in those

patients who have chosen to use a patellar tendon graft (Beynnon, Johnson, Abate, Fleming, & Nichols, 2005).

Lastly, the decision to allow athletes to return to unrestricted activity is based on much subjectivity from the orthopedic surgeon and sports medicine professionals. An athlete may consider a delay in the return to sport unnecessary and undesirable, however a premature return to sport that may injure the graft will also yield unnecessary and undesirable results (Kvist, 2004). In a literature review compiled by Kvist (2004), patients were typically allowed to begin light activities (running) around two to three months after surgery while a full return to contact sports typically occurred after six months (Kvist, 2004).

The exact criterion for return to sports is unknown, however Kvist (2004) mentions certain factors and criteria that influence a safe return to sports. Some of these factors include: muscle strength and performance, little to no pain or effusion, full ROM, passed functional and static knee stability tests, associated injuries (menisci, cartilage, other ligaments) have been healed, and that any and all psychological and social factors are not limiting the athlete in any way (Kvist, 2004). Sports medicine professionals often ensure that these criteria are met before the patient is allowed to return to a full level of activity. Furthermore, the actual time that it takes for an athlete to return to play is a secondary goal; the fulfillment of the previous criteria should be the primary goal of rehabilitation following ACL surgery.

In a review of more current studies of ACL reconstructive surgeries using patellar tendon grafts, the medical experts showed that an accelerated rehabilitation program produces similar clinical and functional outcomes when compared with a conservative

rehabilitation program. An accelerated program lasts approximately 19 weeks and allows weight bearing one week after surgery, no brace after week two, open kinetic chain exercises involving contraction of the quadriceps after week four, and a return to pre-injury activities at week 24. The conservative program lasts approximately 32 weeks and allows weight-bearing three weeks after surgery, no brace after week four, open kinetic chain activities involving contraction of the quadriceps after week 12, and a return to pre-injury activities at week 32 (Beynnon et al., 2005).

According to Marcacci et al. (2003), an approximate timeframe for a return to a full-level of activity could be any time between four to eight months post-operative. Maracci et al. (2003) surveyed 50 athletes that had undergone ACL surgery and were competing at a high level of athletic participation prior to injury and found that 40% returned to his or her pre-injury level of participation after four months, including nine soccer players who were able to participate in an official game. Another 40% of the athletes surveyed returned to activity sometime between four and six months, and the final 20% returned to athletic participation between six to eight months after surgery (Maracci et al., 2003). Return to play criteria may be decided by sports medicine professionals' subjective measures, while other sports medicine professionals may have more objective criteria that must be met such as muscle strength tests and performance tests (Keays, Bullock-Saxton, Newcombe, & Keays, 2003; Moller, Forssblad, Hansson, Wange, & Weidenhielm, 2001). It is important to remember that the most important criterion for returning to a full level of athletic participation should be the overall stability of the knee (Kvist, 2004).

As a general matter, each orthopedic surgeon has a specific rehabilitation protocol that should be followed, but it generally coincides to the four phases as listed in Table 1. Other procedures, such as meniscal repairs or articular cartilage damage, may slightly alter the duration of the four phases (Kisner & Colby, 2007; Starkey & Ryan, 2002).

Table 1. Four Phases of Rehabilitation

Phase 1 → 1 – 4 Weeks	Phase 2 → 5 – 8 Weeks	Phase 3 → 8 – 16 Weeks	Phase 4 → 17+ Weeks
Decrease Pain	ROM: 0° – 140°	ROM: WNL	Complete Functional Tests
Decrease Swelling	Single Leg Squat	Run 1+ Mile (Post-Week 12)	Return to Sport as Goals are Met
Protect the Graft	Ambulate 1 Mile	Sport or Activity Dependent Exercises	
Increase ROM	Minimal Pain	No Swelling	
WBAT	Stand for 1 Hour		

\*WBAT – Weight Bear as Tolerated

(Andrews, Harrelson, & Wilk, 2004; Kisner & Colby, 2007; Starkey & Ryan, 2002)

Furthermore, a typical rehabilitation protocol highlights many goals, exercises, rehabilitation progression criteria, suggested ROM measurements throughout the duration of the rehabilitation process, and brace/weight-bearing status of the patient (see Appendix A) (Andrews, Harrelson, & Wilk, 2004). It is important to emphasize that the protocol is only a guide, and that any rehabilitation protocol is always determined by the sports medicine professional and/or orthopedic surgeon.

### **Psychology of Rehabilitation Adherence**

As previously discussed, the rehabilitation process after ACL reconstructive surgery can be a long process that requires strict adherence to the rehabilitation protocol. Compliance to rehabilitation protocols has emerged as a new area of interest in the areas of sports medicine and sports psychology. Adherence to a rehabilitation protocol refers to the extent that an injured athlete complies with a sports medicine professional's instructions

regarding the rehabilitation protocol (Christakou & Lavalley, 2009). Research in this area has been used to identify factors that may aid the sports medicine professionals in determining how compliant his or her patient will be to a rehabilitation protocol. This research by Christakou and Lavalley (2009) has identified three different approaches that can be applied to rehabilitation adherence, including the protection motivation theory, the personal investment theory, and the cognitive appraisal models.

The protection motivation theory involves two different cognitive processes; the threat appraisal process and the coping appraisal process (Maddux & Rogers, 1975; Rogers, 1975; Rogers, 1983). The threat appraisal process involves the perception of how severe the harmful situation may be and how vulnerable the injured athlete is to that harm. The coping appraisal process involves the perception of how likely a course of action may reduce or prevent a threat and how likely the identified course of action can be performed by the individual. These two cognitive processes help to direct behavioral responses from the individual through explicit behavior and the inhibition of actions. Several studies have examined the protection motivation theory in regards to compliance to injury rehabilitation. Taylor and May (1996) examined the use of the protection motivation theory and its' ability to predict adherence to injury rehabilitation. It was found that athletes who had a higher understanding of their susceptibility to reinjury, a stronger belief in their ability to complete their rehabilitation, and an increased confidence in the prescribed rehabilitation exercises were more likely to adhere to their rehabilitation protocol.

Furthermore, Brewer et al. (2003) found that the benefits of rehabilitation, the patient's self-efficacy, and the patient's understanding of his or her susceptibility of reinjury were directly associated to rehabilitation adherence (Brewer et al., 2003). Lastly,

studies by Duda, Smart, and Tappe (1989) and Noyes, Matthews, Mooar, and Grood (1983) demonstrated that there was a positive association between the patient's beliefs in the effectiveness of the rehabilitation protocol and his or her compliance to that rehabilitation protocol. The previous studies demonstrate that the personal protection motivation theory can assist in the prediction of rehabilitation adherence. Adherence to a rehabilitation protocol is at its highest when athletes believe that there is a high threat to their health, the rehabilitation protocol will be effective, and the athletes themselves will be able to successfully complete the rehabilitation protocol (Christakou & Lavallee, 2009).

The personal investment theory states that motivation in certain situations can be determined by personal incentives (goals of a specific task), self-belief (thoughts and feelings), and perceived options (alternative behaviors that may motivate someone in a certain situation) (Christakou & Lavallee, 2009). Duda et al. (1989) looked at the relationship between personal incentives, self-beliefs, and perceived options in regards to rehabilitation compliance of 40 injured athletes and found that personal incentives were the least important predictors of rehabilitation adherence when compared to self-belief and perceived options. Furthermore, athletes who were poorly self-motivated and placed less emphasis on task incentives were more likely to miss appointments and not follow the rehabilitation protocols (Duda et al., 1989). Fields, Murphey, Horodyski, and Stopka (1995) completed a study regarding the personal investment theory and found that self-motivation was a factor in the adherence to rehabilitation protocols. Those who were more self-motivated were less likely to be distracted by outside factors that could prevent rehabilitation adherence. Fields et al. (1995) also found that those athletes completing rehabilitation protocols were more successful if they received social support. Overall, the

personal investment theory indicates that the understanding and adherence of the rehabilitation protocol is determined by individual characteristics and situations.

The last theory of rehabilitation compliance includes the models of cognitive appraisal, which state that post-injury behaviors are influenced by personal and situational emotional responses. Personal factors are unchangeable characteristics of the injured individual that affect his or her character, whereas situational factors refer to the athlete's perceptions of the rehabilitation protocol. Situational factors can interact with the personal factors to impact cognitive, emotional, and behavioral responses of an athlete's injury (Brewer et al., 2003).

Another factor in the cognitive appraisal model includes the sports medicine professional's expectations about the athlete's recovery; positive behavior by the sports medicine professional can be encouraging for an injured athlete and may increase rehabilitation adherence. Brickner (1997) observed that athletes who make negative associations with their injuries are more likely to experience emotional breakdowns which can have a negative impact on rehabilitation compliance (Brickner, 1997). Daly, Brewer, Van Raalte, Petitpas, and Sclar (1995) also found that cognitive appraisal was positively related to emotional disturbance, while emotional disturbance was negatively related to adherence to rehabilitation protocols. The cognitive appraisal model has been shown to have a direct effect on the approach that injured athletes take towards their rehabilitation protocol and are therefore, associated with behavioral responses, such as rehabilitation adherence (Christakou & Lavalley, 2009).

Based on the previous research, it is reasonable to assume that the partnership formed through the rehabilitation process between sports medicine professionals and

athletes is an important one. Athletes may find it difficult to follow their rehabilitation protocol because of cognitive, emotional, and/or behavioral issues. However, sports medicine professionals can help athletes to understand that rehabilitation is an effective way to overcome their injury and return to play if the rehabilitation adherence is achieved (Christakou & Lavallee, 2009). Rehabilitation protocols should be designed on an individual basis while focusing on the athlete's needs. Progress should be monitored and made visible to the athlete in order to help maintain a high level of motivation (by utilizing the protection motivation theory and personal investment theory) throughout the entire process. There are many different means through which sports medicine professionals can increase adherence to a rehabilitation protocol which include (but are not limited to) education, communication, social support, thought stoppage, enhancement of the athlete's beliefs, the use of short-term goals, and by enhancing the athlete's pain tolerance.

Educating athletes about their injury and what it means for their future is an important first step in the rehabilitation process (Fisher, 1999; Fisher, Scriber, Matheny, Alderman, & Bitting, 1993). It is important for athletes to have a good understanding of his or her injury and the rehabilitation process in order to believe that it will be effective. By using principles from the protection motivation theory, sports medicine professional can give important information about the rehabilitation protocol and reasons why selected exercises are performed in order to best elicit a commitment to the rehabilitation protocol (Christakou & Lavallee, 2009). Furthermore, by explaining how much control an athlete has over the rehabilitation process may also aid in compliance (Christakou & Lavallee, 2009).

In regard to the cognitive appraisal models, the sports medicine professional must play a role in directing the injured athletes' emotions in a positive direction. Sports medicine professionals should explain to athletes that negative feelings towards an injury are normal and athletes should be encouraged to express their feelings (Christakou & Lavallee, 2009). Sports medicine professionals may also assist athletes to reassess the injury at different times during the rehabilitation protocol so that a negative emotional response is less extreme (Christakou & Lavallee, 2009). Open lines of communication between the sports medicine professional and the injured athlete, as well as good listening skills can positively affect the self-belief of the athlete. Through the protection motivation theory, sports medicine professionals should use active listening, build a rapport with the athlete, and redirect questions with answers which demonstrate the control an athlete has over the situation (without making judgments) (Fisher et al., 1993; Gordon, Milios, & Grove, 1991; Worrell, 1992).

Social support is another means through which adherence to rehabilitation protocols can be met. A solid social support system lies within the basis of the personal investment theory. Furthermore, social support can be a situational variable through the cognitive appraisal models that have been shown to positively affect rehabilitation compliance (Brewer et al., 2003). Lastly, social support can also influence the protection motivation theory in regards to the threat and coping appraisal processes if the athlete realizes that they are less vulnerable to reinjury and complete the rehabilitation protocol (Christakou & Lavallee, 2009). Both the personal investment theory and the cognitive appraisal models demonstrate that minimizing the physical and psychological distance that an injured athlete has between their sport and incorporating the injured athlete into practices and/or meetings

may be methods to increase rehabilitation adherence (Fisher, 1999). Sports medicine professionals may be encouraged to perform rehabilitation exercises at practice instead of isolating the athlete, place the injured athlete in touch with athletes who have been successful in rehabilitation, and suggest continued attendance to sporting events are all ways that the injured athlete is still able to feel as though he or she is a part of that team (Brewer et al., 2000). Utilizing the previous ideas may be good ways to improve motivation and increase the compliance of rehabilitation protocols.

Thought stoppage is a way for athletes to recognize that they are experiencing negative thoughts about their injury and allows them to turn the negative thoughts into positive thoughts (Brewer et al., 2000; Wilder, 1994). The cognitive appraisal model indicates that an injury could be a threat to an athlete's well-being. Those who experience a negative understanding of an injury may subsequently have negative thoughts about the injury, possibly leading to emotional disturbance and non-compliance towards the rehabilitation protocol (Christakou & Lavallee, 2009). Enhancing an athlete's beliefs is yet another way to create a more positive attitude for athletes regarding their rehabilitation protocol. The personal investment theory demonstrates how beliefs about the meaning of rehabilitation can determine whether or not an athlete is compliant; athletes need to have a positive attitude and be encouraged to remain optimistic (Fisher, 1999). Furthermore, the protection motivation theory is used to help athletes cope with their injury and the rehabilitation process, with the ultimate goal of keeping the athlete optimistic about the recovery process. Sports medicine professionals must explain to athletes that the rehabilitation protocol they are following is the most appropriate and specific means to treat the injury and can also be utilized as a means of reinjury prevention.

Goal setting is a motivational tool used to increase the degree of effort for achieving a goal, increase the focus of rehabilitation, increase performance, and increase adherence to the rehabilitation protocol (Brewer et al., 2003; Kyllö & Landers, 1995). Creating achievable goals can create positive expectations and beliefs that short- and long-term goals can be accomplished, therefore enhancing personal motivation and adherence to the rehabilitation protocol (Christakou & Lavalley, 2009). Furthermore, if an athlete believes that he or she can attain a goal by following the rehabilitation protocol, the more likely the athlete will comply to the rehabilitation protocol. According to both the protection motivation theory and the cognitive appraisal model, setting short- and long-term goals and informing athletes if they have (or have not) reached their goals may be beneficial ways to help athletes overcome injuries and return to competition in a timely manner.

The final way to enhance rehabilitation adherence may be to enhance the athlete's pain tolerance. Pain is both emotional and sensory and plays a part in the athletic experience, regardless of the health status of the athlete (International Association for the Study of Pain, 1986). Pain tolerance has been positively related to rehabilitation adherence as some athletes may refrain from his or her rehabilitation protocol if they cannot tolerate the amount of pain experienced. Fisher, Domn, and Wuest (1988) found that athletes who adhered to their rehabilitation protocols were able to tolerate the pain better than those athletes who did not adhere to their rehabilitation protocols. Sports medicine professionals and athletes agree that acknowledging the pain and focusing the attention on something other than pain are important factors in rehabilitation adherence (Fisher et al., 1993). Duda et al. (1989) and Fisher et al. (1988) observed that the more aware athletes were regarding

the likelihood of pain during rehabilitation, the higher the athletes' tolerance for pain was and the more likely the athlete was to adhere to the rehabilitation protocol.

With an understanding regarding the theoretical approaches to rehabilitation adherence and implementing strategies to increase rehabilitation compliance, the psychological and physical aspects of the injury can be addressed. Athletes may be able to achieve maximal benefits from the rehabilitation process if the sports medicine professional that he or she is working with understands and addresses the psychological and physical aspects of the injury. Sports medicine professionals can better help athletes adhere to injury rehabilitation programs by utilizing goal setting, positive and effective lines of communication, and understanding what motivates individual athletes (Christakou & Lavallee, 2009).

### **Psychology of Sports Injuries**

The injury process is very dynamic and changes in both magnitude and direction over time, playing a role in the return to sport as previously discussed. Walker, Thatcher, and Lavallee (2007) observed that previous literature has demonstrated an athlete's response to injury, but has not examined what the injury actually means to the athlete. A study by Granito (2001) addressed the meaning of athletic injuries by focusing on the perspectives of athletes and sports medicine professionals alike. It was found that there were seven different factors that influenced the participants' interpretation of an injury: (1) personal factors, (2) effects on relationships, (3) sociological aspects, (4) physical factors, (5) daily hassles, (6) feelings associated with the injury, and (7) rehabilitation (Granito, 2001). Granito's (2001) findings suggest that there are many different factors that influence an athlete's perceptions of an injury and need to be addressed on an individual

level by the sports medicine professional. Grindstaff, Wrisberg, and Ross (2010) investigated the meaning of an athlete's injury further via a phenomenological approach. Phenomenology is a way to give a direct description of a human experience as it is lived, and it is believed that an injury to an athlete appears to be an experience that creates the most sense of personal meaning (Grindstaff et al., 2010).

Grindstaff et al. (2010) interviewed five NCAA Division I athletes at three different time periods after an injury had occurred (7 days, 15 to 20 days, and at least 30 days) before the athlete was allowed to return to play. The authors found that each athlete experienced something different during the injury, and that the experiences of the athletes varied throughout the rehabilitation process. Grindstaff et al. (2010) categorized the meaning of the injury experience into four major themes: (1) perspective, (2) emotion, (3) coping, and (4) relationships. In regards to perspective, athletes experienced both positive and negative reactions to their injuries, and also had a greater understanding and appreciation for actions of his or her coach (feedback, instruction, discipline). Emotion demonstrated the importance of the cognitive appraisal theory and identified it as a factor in guiding an athlete's response to injury. It also demonstrated the effectiveness of sports medicine professionals and their ability to allow athletes to open up regarding their thoughts about the injury and rehabilitation process. Coping was related to the various ways that athletes tried to manage or overcome the challenges and difficulties of the injury. The fourth theme, relationships, looked at the many ways athletes interacted with others during the injury and rehabilitation process. Relationships were identified as the most significant aspect of the rehabilitation experience. This study provided an insight into the meaning of injury to athletes, and also provided four common themes that fit all of the

athletes that were interviewed during the duration of the study (Grindstaff et al., 2010).

Sports medicine professionals are now able to better understand the meaning of injuries for their athletes.

Mann, Grana, Indelicato, O'Neill, and George (2007) examined the extent to which orthopedic physicians encounter and discuss psychological issues with the athletes that they treat. The study also evaluated the physicians' perceptions of the availability and usefulness of sports psychologists. Mann et al. (2007) found that physicians most often discussed fears of reinjury, fears of surgery, and lack of patience in terms of recovery with their patients; stress, anxiety, and burnout were three of the most common non-injury related topics discussed by orthopedic physicians. Orthopedic physicians discussed non-injury related psychological issues the least with their patients, while only 19% of all responding orthopedic physicians felt that there were an adequate number of sports psychologists in their geographical area. Seventy-five percent of the responding orthopedic physicians stated that they almost never referred athletes to sports psychologists for injury-related issues, while 66% of orthopedic physicians stated that they rarely or never referred athletes to sports psychologists for non-injury related issues. Of the responding orthopedic physicians, most were considered to be moderately effective in working with athletes regarding psychological issues. The authors concluded that there was an increased need for communication between orthopedic physicians and the mental health community. Also, orthopedic physicians should become more aware and/or have increased access to mental health professionals who are trained in the area of sport psychology (Mann et al., 2007).

As previously mentioned, a way to identify a successful surgery is through a successful return to the pre-injury level of activity by the athlete. However, there is little

research that has examined psychosocial issues with athletes who desire a full return to activity (Podlog & Eklund, 2009). For example, Kvist et al. (2005) found that reinjury anxiety was a psychological hindrance for athletes who were returning to sport after ACL reconstruction. Kvist et al. (2005) addressed a specific factor associated with a recovery outcome, but there has not been much research done on the perceptions of a successful return to sport after an injury.

The purpose of a study by Podlog and Eklund (2009) focused on the self-determination theory (SDT) and how it related to an athlete's perceptions of a successful return to sport after an injury. The SDT focuses on the effects of self-determination on human behavior, health, and well-being. The extent to which athletes feel self-determined is based upon the degree to which the environment satisfies their basic needs for competence (proficiency in certain tasks), autonomy (behaviors are personally supported), and relatedness (social connection with others) (Kilpatrick, Hebert, & Jacobsen, 2002; Ryan & Deci, 2000). Research regarding the SDT has also found that there are a wide range of performance, well-being, and social development benefits (Ryan & Deci, 2000). The results of the Podlog and Eklund (2009) study stemmed from the conversations with 12 athletes from Australia and Canada who were interviewed 40 times over a six to eight month period. The results of the study indicated that the SDT played a large role in determining an athlete's perceptions of a successful return to sport.

### **Fear of Reinjury Post Anterior Cruciate Ligament Reconstruction**

A study by Kvist et al. (2005) examined the question regarding the fear of reinjury and if it was a significant factor in patients who had undergone an ACL reconstruction and were returning to a previous level of activity. The authors surveyed 84 patients who had

undergone an ACL reconstruction at a hospital in Sweden between January, 1998 and December, 1999. The patients that met the inclusion criteria (ages 16-35, unilateral injury, no previous ACL reconstruction, no further knee injury) were sent three different questionnaires to gather data. The questionnaires included the Tampa Scale of Kinesiophobia (TSK), the Knee Injury and Osteoarthritis Outcome Score (KOOS), and a general questionnaire designed by the researchers. The TSK consisted of 17 statements which aimed to quantify a fear of reinjury due to movement and physical activity (Kvist et al., 2005). Each statement was rated on a scale of one to four and the total score was found by adding the scores of the 17 statements; the higher the score, the greater the fear of reinjury. The KOOS was a self-administered questionnaire originally made for patients with osteoarthritis or that have suffered an ACL injury. The KOOS consisted of questions regarding pain, symptoms, function in daily living, function in sport and recreation, and knee-related quality of life (Kvist et al., 2005). A lower score on the KOOS was subjectively linked to an increase in knee problems. The general questionnaire included questions about pain at the time of injury, return to pre-injury level of activity, reasons for not returning to activity, and training programs in order to return to sports. A total of 62 patients returned all of the surveys and were used in the study (34 males, 28 females: 74% response rate).

Linear relationships were formed by comparing the TSK to the KOOS, as well as the TSK to “pain at the time of injury” and the TSK to “age”. Other testing measures were analyzed using statistical software. The results of the study showed that 53% of the patients returned to their pre-injury activity level three to four years after ACL reconstruction (Kvist et al., 2005). It should be noted however, that the rate of returning to

contact sports was lower than the rate of those who returned to non-contact activities. Twenty-four percent of the patients who did not return to their pre-injury activity level reported that the cause was due to a fear of reinjury. In the study, patients who returned to their pre-injury level expressed a lower fear of reinjury when compared to those patients that did not return to their pre-injury level as indicated by the TSK. Furthermore, the patients that exhibited a greater fear of reinjury also displayed a decreased knee-related quality of life score based on the KOOS. The fear of movement that the patients assumed could cause reinjury was a psychological factor that affected the patients' return to a previous level of activity (Kvist et al., 2005). All of these results indicate that a greater focus on the psychological aspects of injury during rehabilitation may help athletes to return to their previous level of activity.

Chmielewski et al. (2008) performed a study similar to Kvist et al. (2005) whose purpose was to measure the levels of fear of movement/reinjury at different times during ACL reconstruction rehabilitation. The study included 97 subjects (60 males, 37 females) that were divided into three groups: less than 90 days postoperative (39 subjects), 91 to 180 days postoperative (31 subjects), and 181 to 372 days postoperative (27 subjects). Dividing the subjects into three different groups allowed the researchers to determine the fear of movement/reinjury at different timeframes during the ACL rehabilitation process (Chmielewski et al., 2008). Subjects were excluded from the study if they had a bilateral knee injury, an ACL injury and another knee injury, previous surgery on the same knee, a chronic knee injury, were greater than one year postoperative, or had failed to fill out self-report questionnaires (Chmielewski et al., 2008).

The self-report questionnaire was distributed by the University of Florida and Shands Orthopedics and Sports Medicine Institute to all patients at the initial evaluation and at subsequent four-week intervals until the completion of rehabilitation (Chmielewski et al., 2008). The questionnaire consisted of a shortened version of the TSK (TSK-11), the International Knee Documentation Committee (IKDC) subjective form, and the Medical Outcomes Study 8-Item Short-Form Health Survey (SF-8). The TSK-11 is a shorter version of the TSK used to quantify pain-related fear of movement/reinjury, while the IKDC measures a patient's knee symptoms and functional limitations, and the SF-8 is a more generalized survey to help determine the overall physical and mental quality of life of the individual (Chmielewski et al., 2008). Chmielewski et al. (2008) reported that the fear of movement/reinjury was lower as the time after surgery increased, and was inversely related to the subjects' functional levels. They also found that the fear of movement/reinjury contributed to functional levels the most when the subjects were most likely to begin a return to their respective sports.

### **Knee Injury and Osteoarthritis Outcome Score (KOOS) and Tampa Scale of Kinesiophobia (TSK)**

The KOOS was designed as a knee-specific questionnaire and developed to assess the patients' opinions about their knee and its associated problems. The KOOS evaluates both short- and long-term consequences of a knee injury by measuring five scored subscales: pain, other symptoms, function in daily living, function in sport and recreation, and knee-related quality of life (Roos & Lohmander, 2003). Since traumatic knee injuries can also cause injuries to other structures (meniscus, ligaments, cartilage), the development of osteoarthritis increases throughout the lifespan after a traumatic knee injury occurs. The

KOOS allows clinicians to follow their patients after a traumatic knee injury and monitor changes in symptoms and overall function of the knee. The questionnaire was developed in 1995 by Roos and colleagues at the Department of Orthopedics at Lund University in Sweden and at the University of Vermont. It has been validated on several different populations of different ages and activity levels who have undergone a knee surgery due to some type of knee complaint (Roos & Lohmander, 2003). The English version of the KOOS was validated on patients ages 18 to 46 that were undergoing ACL reconstruction (Roos, E., Roos, M., Lohmander, Ekdahl, & Beynnon, 1998b) and a Swedish version of the KOOS was validated on patients ages 16 to 79 that were undergoing knee arthroscopy (Roos, E., Roos, M., Ekdahl, & Lohmander, 1998a). The KOOS is scored using a Likert scale

and all items have five possible answer options scored from zero (no problems) to four (extreme problems) and each of the five scores is calculated as the sum of the items included. Scores are transformed to a zero to 100 scale, with zero representing extreme knee problems and 100 representing no knee problems as common in orthopedic assessment scales and generic measures. (Roos & Lohmander, 2003, p. 3)

The TSK was originally created for patients with musculoskeletal pain and aimed to quantify the fear of reinjury due to movement and physical activity (Vlaeyen & Linton, 2000). Kinesiophobia is defined as “an excessive, irrational and debilitating fear of physical movement and activity resulting from a feeling of vulnerability to painful injury or reinjury” (Kvist et al., 2005, p. 394). Kinesiophobia causes injured athletes to avoid any type of activity that places them in situations in which reinjury can occur, making them fear

returning to sports and other activities (Vlaeyen et al., 1995). The TSK consists of 17 statements regarding subjective experiences of the injury and physical activity and is scored on a four-point Likert scale. The sum of the statements yields a score from zero to 51, with a higher score indicating more fear (Vlaeyen & Linton, 2000; Vlaeyen, Kole-Snijders, Boeren, & Van Eek, 1995). “The reliability and the validity of the questionnaire were acceptable when tested on patients with acute and chronic musculoskeletal pain and in volunteers who participated in an aerobic exercise program especially designed for people with back problems” (Kvist et al., 2005, p. 394). The use of the TSK has not been validated for use in determining a patient’s fear of reinjury after undergoing ACL reconstructive surgery and subsequent rehabilitation; however, the TSK was used by Kvist et al. (2005) for that purpose.

After examining the literature regarding the prevalence of knee injuries, it is fair to assume that injuries to the ACL occur at a rather high rate, and even more so in female athletes. In order to make a full return to sport after an athlete suffers from an ACL injury, a lengthy rehabilitation process, typically lasting six months to one year, is often necessary to provide adequate stability of the knee joint during athletic activities. The current research also shows that the injury itself and the rehabilitation process involves some degree of psychological intervention by the orthopedic surgeon and/or sports medicine professionals. On that note, there appears to be an increased interest in the psychology of rehabilitation and injuries and how they play a role in an athlete’s return to sport. In particular, the fear of reinjury in patients who have suffered an ACL tear, have undergone reconstructive surgery and the required rehabilitation protocol, and are ready to return to activity was of special interest to Chmielewski et al. (2008) and Kvist et al. (2005).

## METHODS

The purpose of this study was to determine if a fear of reinjury and degree of current knee pain, as measured by the Tampa Scale of Kinesiophobia (TSK) and Knee Injury and Osteoarthritis Outcome Score (KOOS) respectively, were associated with a collegiate athlete's decision to return to sport after suffering from an anterior cruciate ligament (ACL) injury, having reconstructive surgery, and performing rehabilitation. The secondary purpose of this study was to determine if the scores on the TSK varied among the athlete's pain at time of injury, age at time of injury, an athlete's return to a pre-injury level of activity, National Collegiate Athletic Association (NCAA) divisions, gender, graft type, mechanism of injury, and months since the time of the injury. The tertiary purpose of this study was to determine if gender or the KOOS-Pain score affected an athlete's return to pre-injury level of activity. The study was needed to determine if the fear of re-injury is a limiting factor in a full return to sport in NCAA Divisions I, II, and III. Research questions for the study were as follows:

1. Did the fear of reinjury and degree of current knee pain relate to an athlete's decision to return to sport after suffering from an ACL reconstructive surgery and rehabilitation?
2. Was there a relationship between the TSK and KOOS scores?
3. Was there a relationship between the TSK scores and the athlete's level of pain at the time of injury?
4. Was there a relationship between the TSK scores and the athlete's age at the time of injury?

5. Was there a difference between TSK scores among athletes from NCAA Division I, II, and III schools?
6. Was there a gender difference with regard to TSK scores?
7. Did TSK scores differ between graft choice (patellar tendon, hamstring, or cadaver)?
8. Did TSK scores differ between with respect to the mechanism of injury (contact or non-contact)?
9. Did TSK scores differ considering the time lapse since the occurrence of an ACL injury?
10. Was there a relationship between gender and an athlete's return to a pre-injury level of activity?
11. Was there a relationship between the KOOS-Pain score and an athlete's return to a pre-injury level of activity?

### **Participants**

The subjects for this study were selected from a group of 273 NCAA-sanctioned Division I, II, or III colleges or universities. Study participants were college-aged athletes who have participated in or were currently participating in NCAA sanctioned athletics during their college career. Additionally, each participant's medical history indicated an ACL tear, subsequent surgical reconstruction within a time period of one to six years prior to completion of the survey, and no additional knee injuries since the ACL reconstruction surgical event. Further, each participant must have been cleared by a physician for a full return to activity.

### **Pilot Study**

A pilot study was conducted to ensure the SurveyMonkey™ questionnaire functioned without technical problems. The pilot study was utilized to increase the validity and reliability of the survey instruments targeted for this study. The pilot study was sent to professionals in the field of athletic training and education in order to improve content validity and construct validity for the entire SurveyMonkey™ questionnaire, which included a general questionnaire, the TSK, and the KOOS. A Cronbach alpha of 0.77 to 0.81 was found for the TSK. The pilot study was also sent to students who met the eligibility requirements for the study, but were not NCAA athletes, to again test for both content validity and construct validity. Pilot study participants were excluded from the actual study.

### **Recruitment of Study Participants**

Twenty-five percent of the colleges and universities from each NCAA division were randomly selected from the NCAA database titled “NCAA Membership by Division.” A stratified random selection of schools was achieved using Research Randomizer ([www.randomizer.org](http://www.randomizer.org)). Schools were entered into a Microsoft Excel 2010 spreadsheet, as listed in the NCAA database for each NCAA division. If schools were undergoing a transition from one NCAA division to another, they were entered into Microsoft Excel 2010 according to their reclassified division. Schools were then selected according to the Research Randomizer results. Eighty-six schools from Division I (345 total), 76 schools from NCAA Division II (303 total), and 111 schools from NCAA Division III (445 total) were selected to participate in this study.

Emails were sent to supervising athletic trainers of each selected NCAA institution asking for their assistance through the distribution of an informational letter to potential study participants (See Appendix B). Discretion was left to the supervising athletic trainer with regard to the distribution of the informational letter to potential participants (See Appendix C) (i.e. email, printed handout, posting on a bulletin board, etc.). A reminder email with the same information/content as the initial contact letter was sent to supervising athletic trainers one week following the initial date of contact and two weeks following the initial date of contact.

The informational letter provided student-athletes with a link allowing them to access the informed consent and SurveyMonkey™ questionnaire. Once the student-athlete entered the SurveyMonkey™ link into the URL bar of their web browser, they were directed to an informed consent page. After reading the informed consent (Appendix D) and selecting the option at the bottom of the page that states, “I am agreeing to participate in this study,” and clicking “Next,” it was assumed that the participant gave consent to participate in the study. The SurveyMonkey™ questionnaire (Appendix E) utilized for this study consisted of questions taken from the TSK and KOOS survey instruments, as well as a general questionnaire for collection of limited demographic data from each participant. Each participant was asked to complete the survey to the best of his/her knowledge. The questionnaire took approximately 12 to 15 minutes to complete.

An incentive was offered to the supervising athletic trainers who were contacted to distribute the informational letter to potential study participants (student-athletes). Each student-athlete that participated in the study represented an opportunity for the supervising athletic trainer to randomly be selected to win a Nintendo® Wii™ gaming system for their

respective college/university – a gaming system that could potentially be utilized in their athletic training facilities as a physical rehabilitation aid device.

An incentive was also provided to the group of potential participants (student-athletes) who ultimately respond to the SurveyMonkey™ questionnaire associated with the study. If the student-athlete agreed to participate in the study and complete the survey, he/she was eligible to win one of eight \$25 BestBuy® gift cards through a random drawing that included a pool of others who have also participated in the study. Study participants had an opportunity to sign up for the offered incentives by completing the survey and acknowledging their desire to enter the drawing with the final question of the SurveyMonkey™ questionnaire. The random drawings for a Nintendo® Wii™ gaming system and the eight BestBuy® gift cards took place approximately one week following the conclusion of all data collection. All eligible parties (for each drawing) had his/her name or institution written onto a piece of paper and concealed by folding the paper a few different times. The names were then put into a box, mixed well, and drawn by an uninterested party.

To ensure that the privacy of participant information is protected, identifying information from the SurveyMonkey™ questionnaire (in the form of initials/names, email addresses, institution identification, etc.) was deleted from the survey database following the completion of data analysis and recognition of the random drawing winners. Data collection and storage was performed through an encrypted online website using a SurveyMonkey™ instrument that required a username and password to see any identifiable information as provided by all study participants. The SurveyMonkey™ account was a private account that only the principal or co-investigator had rights to access. Data analysis

was performed and stored on the co-investigator's password protected computer – a computer that complies with North Dakota State University (NDSU) Information Technology Services (ITS) standards. The laptop computer and backup hard drive where data can be accessed was stored at both the principal or co-investigators home and office. This study was approved by the NDSU Institutional Review Board (IRB).

### **Instruments**

The TSK was a questionnaire designed to quantify the fear of reinjury associated with movement and physical activity. It consisted of 17 items that are scored on a four-point Likert scale (strongly agree, agree, disagree, strongly disagree). An answer of “strongly disagree” received one point, “disagree” received two points, “agree” received three points, and “strongly agree” received four points. Adding the inverted individual scores of items 4, 8, 12, and 16 provided a sum score from 0 to 51; the higher the score, the greater the fear of reinjury. Eight statements were rephrased according to a previous study by Kvist et al. (2005), in which the TSK has been validated. Specifically, ‘pain’ was changed to ‘knee trouble’ in statements 4, 8, and 12, to ‘trouble’ in statement 11, and to ‘get injured’ in statement 17. Statement 10 was changed from ‘Simply being careful that I do not make any unnecessary movements is the safest thing I can do to prevent my pain from worsening’ to ‘Simply being careful that I do not make any unnecessary movements is the safest thing I can do to prevent my injured leg from worsening.’ In statement 15, ‘injured’ was changed to ‘injured again’. Statement 16 was changed from ‘Even though something is causing me a lot of pain, I don’t think it’s actually dangerous’ to ‘Even though my injured knee is causing me a lot of pain, I don’t think it’s actually dangerous’”

(Kvist et al., 2005, p. 394). Appendix F provides a sample of the TSK that was used in this study.

The KOOS was a questionnaire consisting of 42 questions created for patients who have osteoarthritis or have experienced an ACL rupture (Roos & Lohmander, 2003). The KOOS consisted of five different categories: pain, symptoms, function in daily living, function in sport and recreation, and knee-related quality of life (Roos & Lohmander, 2003). Responses to the questions were intended to reflect symptoms or experiences that have been noticed in the past week. Five options were provided for each question. The participant was directed to select the word that was most applicable. Participant descriptor options consisted of “Never, Rarely, Sometimes, Often, or Always” for questions that addressed knee symptoms and “None, Mild, Moderate, Severe, or Extreme” for questions that addressed stiffness, pain, function in daily living, function in sport and recreation, and knee-related quality of life. A copy of the KOOS that was used in this study can be found in Appendix G.

The KOOS was scored by assigning a value of 0 to 4 to each answer, summing up the total score of each subscale, and then dividing by the pre-determined possible maximum score for the scale. A score ranging from 0 to 100 was calculated for each category. In orthopedics, a scale ranging from 0 to 100 is used most often, with zero indicating extreme problems and 100 indicating no problems (Roos & Lohmander, 2003). The KOOS scoring system has been normalized in order to meet orthopedic standards. The normalizing equation that must be used took the total score for a category and multiplied it by 100, then subtracted that value from 100, and finally divided it by a pre-assigned number. The numbers were as follows for each category: 36 for pain, 28 for symptoms, 68

for function in daily living, 20 for function in sport and recreation, and 16 for knee-related quality of life. Appendix H contains an example of a scoring sheet that was used to score the KOOS. Lastly, a general questionnaire was used to gather demographic information about the participants as well as more specific information about the ACL injury that was not addressed by the TSK or KOOS.

### **Data Analysis**

Frequency tables were created for number of months since ACL injury (1 to 12, 13 to 24, 25 to 36, 37 to 48, 49 to 60, 61 to 72), NCAA Division, a return to pre-injury level of activity, mechanism of injury, graft type, age, pain at time of injury, TSK score, and for each subscale of the KOOS (Pain, Symptoms, ADLs, Sports and Rec, and QOL). The Pearson Correlation was used to determine the relationship between the TSK and all five of the KOOS subscales (Pain, Symptoms, ADLs, Sports and Rec, and QOL). The Pearson Correlation was also used to determine the relationship between the TSK and the age at time of injury. The Spearman Correlation was used to determine the relationship between the TSK and the pain experienced at the time of the ACL injury. The Fisher Exact test was used to determine the significant difference between gender and the return to a pre-injury level of activity. An independent t-test was used to determine significant differences among or between the TSK and a return to a pre-injury level of activity, the TSK and gender, the TSK and mechanism of injury (contact or non-contact), and the KOOS -Pain and a return to pre-injury level of activity. A one-way analysis of variance (ANOVA) was used to determine the significant difference between the TSK and NCAA Division and the TSK and months since ACL injury. The Kruskal Wallis test was used to determine the significant difference between the TSK and graft type. The Alpha level for statistical

analysis testing was set at  $p < 0.05$ . The SAS® statistics program, version 2.9.1, was used for all statistical analysis for this study.

## RESULTS

The purpose of this study was to determine if a fear of reinjury and degree of current knee pain, as measured by the Tampa Scale of Kinesiophobia (TSK) and Knee Injury and Osteoarthritis Outcome Score (KOOS) respectively, were associated with a collegiate athlete's decision to return to sport after suffering from an anterior cruciate ligament (ACL) injury, having reconstructive surgery, and performing rehabilitation. The secondary purpose of this study was to determine if the scores on the TSK varied among the athlete's pain at time of injury, age at time of injury, an athlete's return to a pre-injury level of activity, National Collegiate Athletic Association (NCAA) divisions, gender, graft type, mechanism of injury, and months since the time of the injury. The tertiary purpose of this study was to determine if gender or the KOOS-Pain score affected an athlete's return to pre-injury level of activity. Conducting this study might also help determine if the fear of re-injury was a limiting factor in a full return to sport in NCAA Divisions I, II, and III.

Descriptive results from the study are shown in Tables 2 through 7. The data collected came from a total of 19 different NCAA institutions (7.0%). The breakdown for NCAA Divisions that participated in this study are shown in Table 2: five NCAA Division I institutions (5.8%), three NCAA Division II institutions (3.5%), and 11 NCAA Division III institutions (9.9%).

Table 2. Response Rate by Division (Institution)

<b>NCAA Division I</b>	5.8% (n = 5)
<b>NCAA Division II</b>	3.5% (n = 3)
<b>NCAA Division III</b>	9.9% (n = 11)
<b>Total</b>	7.0% (n = 19)

A total of 49 subjects (14 males (28.6%) and 35 females (71.4%)) completed the SurveyMonkey™ questionnaire in its entirety and were used for data analysis. The NCAA

Division I institutions yielded 12 total participants (24.5%), NCAA Division II institutions yielded three total participants (6.1%), and NCAA Division III institutions yielded 34 total participants (69.4%). The NCAA Division I participants included two males and 10 females, and accounted for 14.3% and 28.6% respectively of the total gender response rate. The NCAA Division II participants no males and three females, and accounting for 0.0% and 8.6 % respectively of the total gender response rate. The NCAA Division III participants included 12 males and 22 females, accounting for 85.7% and 62.9% respectively of the total gender response rate. The results of NCAA Division Responses are shown in Table 3.

Table 3. NCAA Division Responses by Gender

	<b>Males</b>	<b>Females</b>	<b>Total</b>
<b>NCAA Division I</b>	14.3% (n=2)	28.6% (n=10)	24.5% (n=12)
<b>NCAA Division II</b>	0.0% (n=0)	8.6% (n=3)	6.1% (n=3)
<b>NCAA Division III</b>	85.7% (n=12)	62.9% (n=22)	69.4% (n=34)

The average age for subjects was 21, but ranged from 18 to 24. The median “pain at time of injury” was 7, but ranged from 0 to 10 (none to extreme, respectively). Seven males (50.0%) and 22 females (62.9%) stated that the mechanism of their ACL injury was non-contact in nature, and resulted in a total of 29 non-contact injuries (59.2%), as opposed to 20 contact injuries (40.8%). These results are illustrated in Table 4.

Table 4. Mechanism of Injury by Gender

	<b>Males</b>	<b>Females</b>	<b>Total</b>
<b>Contact</b>	50.0% (n = 7)	37.1% (n = 13)	40.8% (n = 20)
<b>Non-Contact</b>	50.0% (n = 7)	62.9% (n = 22)	59.2% (n = 29)

In regard to graft types used in during the reconstructive ACL surgery, for males, eight (57.1%) ACLs were reconstructed using the patellar tendon, five (35.7%) ACLs were

reconstructed using the hamstring tendon, and one (7.1%) ACL was reconstructed using a cadaver graft. For females, 17 (48.6%) ACLs were reconstructed using the patellar tendon, 11 (31.4%) ACLs were reconstructed using the hamstring tendon, and six (17.1%) ACLs were reconstructed using a cadaver graft. When looking at the entire group of participants (n = 49), one female could not remember the type of graft she had (2.0%), 25 (51.0%) ACLs were reconstructed using the patellar tendon, 16 (32.7%) ACLs were reconstructed using the hamstring tendon, and seven (14.3%) ACLs were reconstructed using a cadaver graft. The results for graft type and gender are illustrated in Table 5.

Table 5. Graft Type by Gender

	<b>Males</b>	<b>Females</b>	<b>Total</b>
<b>I can't remember</b>	0.0% (n = 0)	2.9% (n = 1)	2.0% (n = 1)
<b>Patellar Tendon</b>	57.1% (n = 8)	48.6% (n = 17)	51.0% (n = 25)
<b>Hamstring</b>	35.7% (n = 5)	31.4% (n = 11)	32.7% (n = 16)
<b>Cadaver</b>	7.1% (n = 1)	17.1% (n = 6)	14.3% (n = 7)

Eight male participants (57.1%) and 30 females (85.7%) (for a total of 38 participants (77.6%)) stated that they have returned to their pre-injury level of activity.

Study participants were asked to state the number of months since the injury to their ACL had occurred, which are displayed in Table 6. Their responses were then divided into six different categories for data analysis: 1 to 12 months, 13 to 24 months, 25 to 36 months, 37 to 48 months, 49 to 60 months, and 61 to 72 months. For males, eight (57.1%) responded 1 to 12 months post-ACL injury, four (28.8%) responded 13 to 24 months post-ACL injury, and two (14.3%) responded 49 to 60 months post-ACL injury. For females, five (14.3%) responded 1 to 12 months post-ACL injury, 12 (34.3%) responded 13 to 24 months post-ACL injury, eight (22.9%) responded 25 to 36 months post-ACL injury, five (14.3%) responded 37 to 48 months post-ACL injury, one (2.9%) responded 49 to 60

months post-ACL injury, and four (11.4%) responded 61 to 72 months post-ACL injury. In regard to the total number of participants ( $n = 49$ ), 13 (26.5%) responded one to 12 months post-ACL injury, 16 (32.7%) responded 13 to 24 months post-ACL injury, eight (16.3%) responded 25 to 36 months post-ACL injury, five (10.2%) responded 37 to 48 months post-ACL injury, three (6.1%) responded 49 to 60 months post-ACL injury, and four (8.2%) responded 61 to 72 months post-ACL injury.

Table 6. Months Since ACL Injury

Months	Males	Females	Total
1-12	57.1% (n=8)	14.3% (n=5)	26.5% (n=13)
13-24	28.8% (n=4)	34.3% (n=12)	32.7% (n=16)
25-36	0.0% (n=0)	22.9% (n=8)	16.3% (n=8)
37-48	0.0% (n=0)	14.3% (n=5)	10.2% (n=5)
49-60	14.3% (n=2)	2.9% (n=1)	6.1% (n=3)
61-72	0.0% (n=0)	11.4% (n=4)	8.2% (n=4)

The average score on the TSK was  $32.4 \pm 6.5$  for males ( $n = 14$ ) and  $32.0 \pm 5.8$  for females ( $n = 35$ ), while the overall average score on the TSK was  $32.1 \pm 5.9$  ( $n = 49$ ). The KOOS was scored based on five different subscales: Pain, Symptoms, ADLs, Sports and Rec, and QOL. For males ( $n = 14$ ), the average scores on the KOOS were as follows:  $88.1 \pm 6.8$  for KOOS-Pain,  $56.4 \pm 11.7$  for KOOS-Symptoms,  $95.2 \pm 5.4$  for KOOS-ADLs,  $73.2 \pm 15.0$  for KOOS-Sports and Rec, and  $67.9 \pm 19.4$  for KOOS-QOL. For females ( $n = 35$ ), the average scores on the KOOS were as follows:  $83.0 \pm 14.0$  for KOOS-Pain,  $54.2 \pm 12.9$  for KOOS-Symptoms,  $92.6 \pm 8.3$  for KOOS-ADLs,  $73.1 \pm 17.1$  for KOOS-Sports and Rec, and  $69.1 \pm 21.5$  for KOOS-QOL. For the total group of participants ( $n = 49$ ), the average scores on the KOOS were as follows:  $84.5 \pm 12.5$  for KOOS-Pain,  $54.8 \pm 12.5$  for KOOS-Symptoms,  $93.4 \pm 7.6$  for KOOS-ADLs,  $73.1 \pm 16.4$  for KOOS-Sports and Rec, and  $68.8 \pm 20.7$  for KOOS-QOL. The results of the KOOS are listed in Table 7.

Table 7. KOOS

	<b>Males</b>	<b>Females</b>	<b>Total</b>
<b>Pain</b>	88.1 ± 6.8 (n=14)	83.0 ± 14.0 (n=35)	84.5 ± 12.5 (n=49)
<b>Symptoms</b>	56.4 ± 11.7 (n=14)	54.2 ± 12.9 (n=35)	54.8 ± 12.5 (n=49)
<b>ADLs</b>	95.2 ± 5.4 (n=14)	92.6 ± 8.3 (n=35)	93.4 ± 7.6 (n=49)
<b>Sport/Rec</b>	73.2 ± 15.0 (n=14)	73.1 ± 17.1 (n=35)	73.1 ± 16.4 (n=49)
<b>QOL</b>	67.9 ± 19.4 (n=14)	69.1 ± 21.5 (n=35)	68.8 ± 20.7 (n=49)

After statistical analysis, there was a weak negative correlation ( $r = -0.4235$ ,  $p < 0.05$ ) between the TSK score and the KOOS-Pain, as shown in Figure 1.

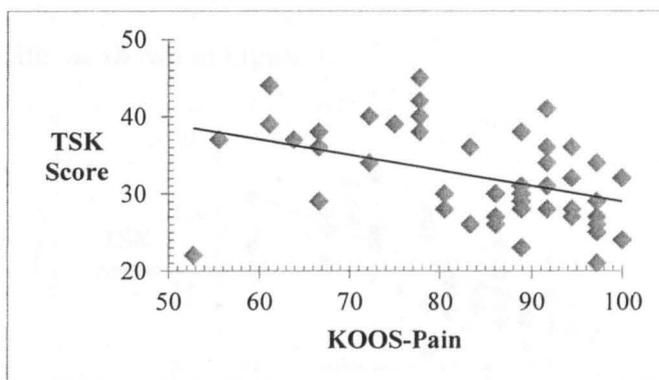


Figure 1. Correlation Between TSK Score and KOOS-Pain

In addition, there was a negative correlation ( $r = -0.5067$ ,  $p < 0.05$ ) between the TSK score and the KOOS-ADLs, as shown in Figure 2.

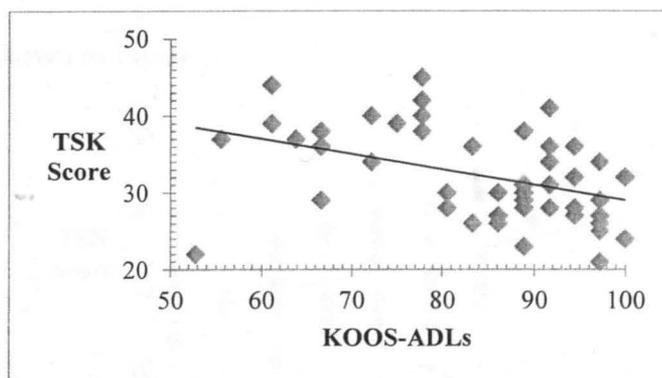


Figure 2. Correlation Between TSK Score and KOOS-ADLs

A negative correlation ( $r = -0.4693$ ,  $p < 0.05$ ) between the TSK score and KOOS-Sports and Rec was found, as shown in Figure 3.

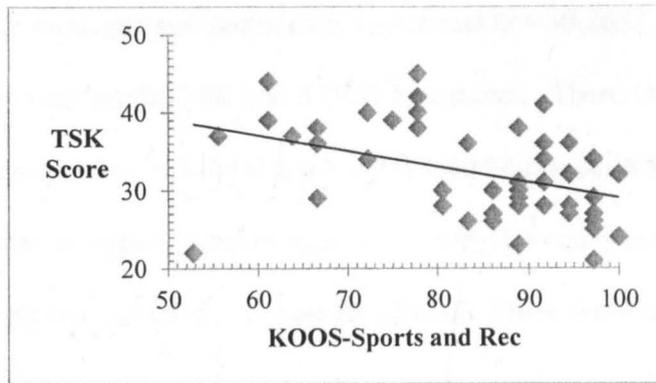


Figure 3. Correlation Between TSK Score and KOOS-Sports and Rec

A strong negative correlation ( $r = -0.7154$ ,  $p < 0.05$ ) was found between the TSK score and KOOS-Quality of Life, as shown in Figure 4.

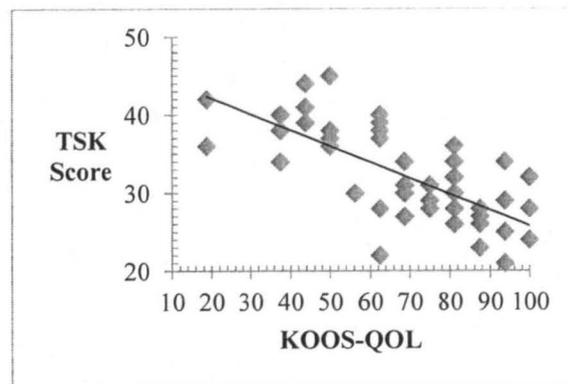


Figure 4. Correlation Between TSK Score and KOOS-QOL

A positive correlation ( $r = 0.4608$ ,  $p < 0.05$ ) was found between the TSK score and age at time of injury, as shown in Figure 5.

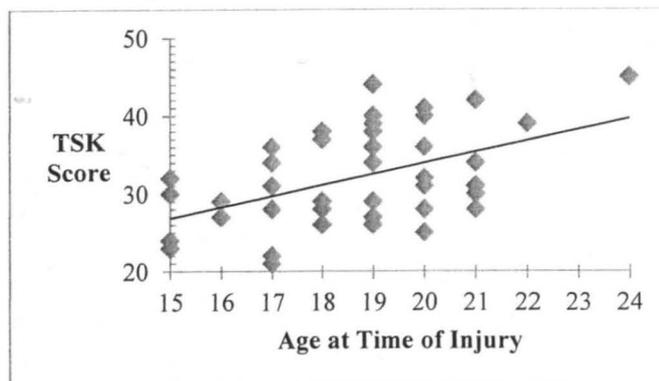


Figure 5. Correlation Between TSK Score and Age at Time of Injury

There was a weak and not statistically significant ( $r = -0.2632$ ,  $p > 0.05$ ) correlation found between the score on the TSK and KOOS-Symptoms. There was a very weak and not statistically significant ( $r = -0.00543$ ,  $p > 0.05$ ) correlation found between pain at time of injury. There was no significant difference ( $p > 0.05$ ) between the scores on the TSK and athletes from NCAA Division I, II, and III schools. There were no significant differences ( $p > 0.05$ ) found between TSK scores with regard to gender, graft type, mechanism of injury (contact or no contact), or months since the time of the ACL injury. Lastly, there were no significant differences between gender or KOOS-Pain and an athlete's return to a pre-injury level of activity.

## **DISCUSSION, CONCLUSION, AND FURTHER RESEARCH**

The purpose of this study was to determine if a fear of reinjury and degree of current knee pain, as measured by the Tampa Scale of Kinesiophobia (TSK) and Knee Injury and Osteoarthritis Outcome Score (KOOS) respectively, were associated with a collegiate athlete's decision to return to sport after suffering from an anterior cruciate ligament (ACL) injury, having reconstructive surgery, and performing rehabilitation. The secondary purpose of this study was to determine if the scores on the TSK varied among the athlete's pain at time of injury, age at time of injury, an athlete's return to a pre-injury level of activity, National Collegiate Athletic Association (NCAA) divisions, gender, graft type, mechanism of injury, and months since the time of the injury. The tertiary purpose of this study was to determine if gender or the KOOS-Pain score affected an athlete's return to pre-injury level of activity. The study was needed to determine if the fear of re-injury is a limiting factor in a full return to sport in NCAA Divisions I, II, and III.

### **Discussion**

The results of this study were higher than other studies in comparison to the percent of athletes who felt that they had returned to a pre-injury level of activity. In the current study, 77.6% of NCAA student-athletes participating in this study stated that they had returned to a pre-injury level of activity, in comparison to Kvist et al. (2005) where only 53% of the patients had returned to their pre-injury level of activity three to four years post-ACL reconstruction and rehabilitation. Although the populations are different in the current study (athletes) and the Kvist et al. (2005) study (general population), the return to a pre-injury on a national level among athletes tends to be closer to that found in by Kvist et al. (2005), Agel et al., 2005, Arendt & Dick, 1995, and Mihata et al., 2006. It is possible

that those athletes who stated that they have not yet returned to a pre-injury level of activity are currently participating in NCAA athletics, but are cleared by a physician. The athlete may have a subjective feeling that their level of play is not equivalent to what it was prior to the injury. It should also be noted that the results of the current study did not assess reasons for not returning to a pre-injury level of activity for the participants. Likewise, the rate of returning to contact sports in comparison to non-contact sports was not assessed.

In a previous study conducted by Herman et al. (2008), it was found that nearly 80% of ACL tears tend to be non-contact in nature. However, in the current study, only 59.2% of ACL injuries were non-contact in nature, while the remaining 40.8% of injuries were the direct result of contact with another player. The results of the current study were much lower than that of the Herman et al. (2008) study in regards to non-contact injuries. The results may be much closer to the results of Herman et al. (2008) if there was an increased response rate by the NCAA collegiate population. This result may also reflect the physicality of collegiate sports; the fact that there are such a high percentage of contact injuries may be attributed to an increase focus on speed, strength, power, and agility training, which ultimately allows cause more force during a contact hit, potentially causing an increase in contact ACL injuries.

Furthermore, females are four to six time mores likely to suffer an ACL injury than their male counterparts. In the current study, females accounted for 71.4% of the total response rate. This may be attributed to the fact that there are a greater number of NCAA female athletes that have suffered an ACL injury in comparison to males, as found by Arendt and Dick (1995), Agel et al., (2005), and Mihata et al., (2006). In the current study, males demonstrated an equal number of contact ACL injuries and non-contact ACL

injuries. Females, however, demonstrated that approximately two-thirds of the ACL injuries occurred as a result of a non-contact mechanism of injury, while one-third of the ACL injuries occurred as a result of a contact mechanism of injury. The fact that females demonstrated a greater percentage of non-contact injuries in comparison to their male counterparts is consistent with previous literature. Although the study does not examine specific reasons for each female athlete who suffered a non-contact injury, the assumption can be made that the non-contact ACL injuries were a result of one or more of the aforementioned causes of non-contact ACL injuries; an increased Q angle, a narrower intercondylar notch width, increased joint laxity, biomechanical issues (decreased knee flexion, increased knee valgus angle, greater knee extension moment, and increased ground reaction force), quadriceps dominance, an increase in total lower extremity muscle activation, a decrease in muscle stiffness, and/or a decrease in lower extremity muscle strength (Hughes & Watkins, 2006).

The scores on the TSK for the current study were higher than those recorded for the Kvist et al. (2005) study. The Kvist et al. (2005) study demonstrated overall scores on the TSK of  $17 \pm 6$ , while the current study's scores were  $32.1 \pm 5.9$ . This score is meant to represent the fear of reinjury on a scale of 0 to 51, with a higher score indicating a greater fear of reinjury (Vlaeyen & Linton, 2000; Vlaeyen et al., 1995). The overall score on the TSK does not indicate exact reasons as to why the athlete may or may not display a fear of reinjury. It is also important to remember that the TSK has not been validated for use in determining a patient's fear of reinjury after undergoing ACL reconstructive surgery and subsequent rehabilitation; however, the TSK was used by Kvist et al. (2005) for that purpose, after which the current study was modeled.

In regard to the scores on the TSK for the current study, the rehabilitation protocols had the potential to be very different for each participant, even though the underlying principles of the protocols may have been similar. The exact means through which the rehabilitation protocols were administered and the different exercises that each sports medicine professional may have implemented potentially could have caused an increase in scores on the TSK in comparison to the Kvist et al. (2005) study. It is possible that a greater focus on the psychological aspects of the injury during the rehabilitation process may have decreased the scores on the TSK.

Furthermore, the different psychological techniques as discussed by Cristakou and Lavallee (2009) used to increase rehabilitation adherence (protection motivation theory, personal investment theory, and cognitive appraisal models), the relationships formed between the participants and the sports medicine professionals, the different levels of education received by the participants, social support systems, and types of goals set by participants may all be areas that were or were not utilized by different individuals who participated in the study. Kvist et al. (2005) mentioned that patients who are forced to confront their fears of reinjury are more likely to return to a pre-injury level of activity in regard to those who avoid the problem. It is possible that the incorporation of different psychological techniques may have played a role in the outcome of the patient's rehabilitation and ultimate return to a pre-injury level of activity, potentially increasing the scores on the TSK in comparison with the Kvist et al. (2005) study. The last factor that may have led to higher scores on the TSK in the current study versus the scores found in the Kvist et al. (2005) study is the fact that the sample group for the current study involved

NCAA athletes. These athletes generally perform complex athletic movements on a regular basis and participate in much more physical activity than the general public.

The KOOS study was designed as a knee-specific questionnaire and developed to assess the patients' opinions about their knee and its associated problems within the week prior to taking the survey. The "scores are transformed to a zero to 100 scale with zero representing extreme knee problems and 100 representing no knee problems" (Roos & Lohmander, 2003, p. 3). The scores on the KOOS were ultimately very similar to those recorded in the study by Kvist et al. (2005). The score for the KOOS-Pain, KOOS-ADLs, and KOOS-QOL subscales in the current study provided the same mean as the Kvist et al. (2005) study. The KOOS-Symptoms subscale in the current study yielded a lower mean (by 20 points) in comparison to the Kvist et al. (2005) study, while the KOOS-Sport/Rec subscale yielded a higher mean (by 11 points) than the Kvist et al. (2005) study. The fact that the KOOS-Symptoms subscale in the current study was so much lower than that of the Kvist et al. (2005) study may be attributed to the sample group studied. Again, athletes perform a good number of complex athletic movements on a regular basis and consistently participate in much more physical activity than the general public, ultimately exacerbating the participants' symptoms.

The results of the current study also showed significant relationships between the TSK and KOOS-Pain ( $r = -0.4235$ ,  $p < 0.05$ ) and KOOS-QOL ( $r = -0.7154$ ,  $p < 0.05$ ). These significant relationships were also found in the Kvist et al. (2005) study. For these associations, those that scored higher on the TSK, indicated fewer problems (higher score) in regards to current knee pain and an overall quality of life. Furthermore, the current study revealed significant correlations between the TSK and KOOS-ADLs ( $r = -0.5067$ ,  $p$

< 0.05), TSK and KOOS-Sports/Rec ( $r = -0.4693$ ,  $p < 0.05$ ), and TSK and Age at Time of Injury ( $r = 0.4608$ ,  $p < 0.05$ ). The authors of Kvist et al. (2005) study did not find the previous correlations significant in their study. Data collected in the current study also showed no relationships between the score on the TSK and KOOS-Symptoms, pain at time of injury, a return to pre-injury level of activity, division, gender, graft type, mechanism of injury (contact or non-contact), or months since the time of ACL injury. With regard to the significant relationship found between the TSK and Age at Time of Injury, those who were injured at an earlier age displayed a lower score on the TSK, indicating a lower fear of reinjury. This significant relationship may be directly related to the months since the time of the ACL injury. For example, if an ACL injury occurred at a younger age (in high school), the athlete would have completed the survey with an increased number of months since the time of the ACL injury, as opposed to an athlete who suffered an ACL tear while in college (the number of months since the time of the ACL injury would be less). With regard to the number of months since the time of the ACL injury, the one way ANOVA statistical testing was run on six different groups (zero to 12 months, 13 to 24 months, 25 to 36 months, 37 to 48 months, 49 to 60 months, and 61 to 72 months), and was found to be not statistically significant. However, had the months since the time of the ACL injury been grouped differently, the results may have yielded a significantly higher difference (or a significantly stronger relationship), therefore providing a more concrete reason with regard to statistical differences between the score on the TSK and the age at time of injury.

In the current study, it was hypothesized that TSK scores would be affected by a higher, more intense level of competition found in NCAA Division I athletics. Another suspicion not substantiated by the investigators of this study was that the score on the TSK

would differ between genders. Since a majority of the ACL injuries that occurred in females were a result of a non-contact mechanism of injury in studies performed by Arendt and Dick (1995), Agel et al. (2005), and Mihata et al. (2006), it was hypothesized that there would be a significant relationship between the score on the TSK and gender, particularly among females. This suspicion was based on the fact that non-contact injuries generally occur as a result of different passive and dynamic stabilizers and not as a result of direct contact. Since it is not clear what types (if any) of education the female participants had received during or after the rehabilitation process, it is possible the study participants were participating in ACL prevention programs. Their participation in that type of education would be directed at correcting imperfections of the dynamic knee stabilizers, with the anticipation of preventing another injury to the ACL and ultimately decreasing the fear of reinjury in female study participants.

The ultimate purpose of this study was to determine if a fear of reinjury and degree of current knee pain were associated with a collegiate athlete's decision to return to sport after suffering from an ACL injury, having reconstructive surgery, performing rehabilitation, and being cleared by a physician for participation in athletic activity. There were no efforts made to find reasons or to justify why athletes may possess a fear of reinjury after an ACL tear, reconstruction, and rehabilitation. Factors that were not evaluated, but are relevant to ACL tears and a fear of reinjury include the correction of possible causes of the ACL tear, such as the width of the intercondylar notch and biomechanical factors. Some of the biomechanical factors can include movement patterns, muscle activity patterns, muscle stiffness, muscle strength. Some additional factors can include the surgeon's familiarity with the graft type used, the time between the injury and

the ACL reconstructive surgery, the exact rehabilitation protocol followed by the sports medicine professional, the exact duration of the participant's rehabilitation, different psychological techniques utilized by sports medicine professionals, the ability of the athlete to regain a position on the athletic team, and the overall support system of the athlete.

### **Conclusions**

The study results indicate that the participants' fear of reinjury was only significantly related to an athlete's degree of current knee pain ( $r = -0.4235$ ,  $p < 0.05$ ) and overall quality of life ( $r = -0.7154$ ,  $p < 0.05$ ) after suffering from an ACL tear, reconstructive surgery, and rehabilitation. Results of the study also noted statistical significance between the participants' fear of reinjury and KOOS-ADLs ( $r = -0.5067$ ,  $p < 0.05$ ) and KOOS-Sports/Rec ( $r = -0.4693$ ,  $p < 0.05$ ). Third, the study data showed a statistical significance between the fear of reinjury and the participants' age at the time of the injury to the ACL ( $r = 0.4608$ ,  $p < 0.05$ ). The data collected for this study revealed no statistical significance between the participants' fear of reinjury and pain at time of injury, division, gender, graft type, mechanism of injury, and months since time of injury. Furthermore, the current study results indicated that there was no statistical significance between degree of current knee pain and the participant's return to a pre-injury level of activity.

The information collected with this study demonstrated that NCAA athletes, regardless of division, do, in fact, possess a high fear of reinjury. Although this fear of reinjury was found to be unrelated to a return to pre-injury levels of activity in this study, improvements in rehabilitation processes and implementation of different psychological strategies by orthopedic surgeons and sports medicine professionals may help to decrease

or eliminate the fear of reinjury in those athletes that are being treated for injuries to the ACL.

### **Limitations**

Limitations of this study included self-reporting by the study participants, a small sample size, inability of the supervising athletic trainer to contact all qualified participants, and a low participation rate. Self-reporting might have led to over- or under-reporting, ultimately affecting the results of the data. This study also included a very specific population of college athletes. Therefore, findings of this study resulted in a small sample size and are not generalizable toward other populations. Furthermore, the small sample size greatly affected the number and types of statistical analysis that could be performed with the data. An increase in the number of responses would have allowed ANOVA testing with respect to a variety of comparisons between variables. A low response rate from the participants of one or more NCAA divisions, or from the male gender most likely skewed the results. Supervising athletic trainers who distributed the survey might have impacted the response rate of the survey, especially in situations where there was limited access to all eligible participants. Additionally, the survey instrument used for this study did not reveal reasons why the participant did not return to his or her pre-injury level of activity, aside from the fear of reinjury.

### **Further Research**

Due to the poor response rate of the current study, additional study in this area should be conducted again, but possibly at a different time of year. The timing of the current study data collection fell during the NCAA tournaments for winter sports. It was suggested that the study should be conducted during summer months or sporadically during

different times throughout the year, allowing athletes of different seasons plenty of access to the supervising sports medicine professional as well as a substantial amount of time to complete the study. Further research should emphasize acquiring larger sample sizes, making the study more generalizable to the collegiate athlete population. Lastly, further prospective research should look to combine psychological variables as well as functional and biomechanical variables in order to fully examine why patients return or fail to return to a pre-injury level of activity.

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## APPENDIX A

### Anterior Cruciate Ligament Rehabilitation Protocol (Andrews et al., 2004)

#### Preoperative Phase

##### *Goals*

- Diminish inflammation, swelling, and pain
- Restore normal ROM (especially knee extension)
- Restore voluntary muscle activation
- Provide patient education to prepare patient for surgery

*Brace*—Elastic wrap or knee sleeve to reduce swelling

*Weight Bearing*—As tolerated with or without crutches

##### *Exercises*

- Ankle pumps
- Passive knee extension to 0°
- Passive knee flexion to tolerance
- Straight leg raises (three-way, flexion, abduction, adduction)
- Quadriceps Setting
- Closed kinetic chain exercises: minisquats, lunges, step-ups

*Muscle Stimulation*—Electrical muscle stimulation to quadriceps during voluntary quadriceps exercises (4 to 6 hours per day)

##### *Neuromuscular/Proprioception Training*

- Eliminate quad avoidance gait
- Retro stepping drills
- Joint repositioning on Sports RAC
  - Passive/active reposition at 90, 60, and 30°
  - Closed kinetic chain squat/lunge repositioning on screen

*Cryotherapy/Elevation*—Apply ice 20 minutes of every hour, elevate leg with knee in full extension (knee must be above heart)

##### *Patient Education*

- Review postoperative rehabilitation program
- Review instructional video (optional)
- Select appropriate surgical date

#### **I. Immediate Postoperative Phase (Day 1 to Day 7)**

##### *Goals*

- I. Restore full passive knee extension
- II. Diminish joint swelling and pain
- III. Restore patellar mobility
- IV. Gradually improve knee flexion
- V. Reestablish quadriceps control
- VI. Restore independent ambulation

##### **Postoperative Day 1**

*Brace*—EZ Wrap brace/immobilizer applied to knee, locked in full extension during ambulation of Protonics

*Weight Bearing*—Two crutches, weight bearing as tolerated

*Exercises*

- Ankle pumps
- Overpressure into full, passive knee extension
- Active and passive knee flexion (90° by day 5)
- Straight leg raises (flexion, abduction, adduction)
- Quadriceps isometric setting
- Hamstring stretches
- Closed kinetic chain exercises: minisquats, weight shifts

*Muscle Stimulation*—Use muscle stimulation during active muscle exercises (4 to 6 hours/day)

*Continuous Passive Motion*—As needed, 0 to 45/50° (as tolerated and as directed by physician)

*Ice and Evaluation*—Ice 20 minutes out of every hour and elevate with knee in full extension

### **Postoperative Days 2 to 3**

*Brace*—EZ Wrap brace/Immobilizer, locked at 0° extension for ambulation and unlocked for sitting, etc.

*Weight Bearing*—Two crutches, weight bearing as tolerated

*Range of Motion*—Remove brace, perform ROM exercises 4 to 6 times a day

*Exercises*

- Multiangle isometrics at 90 and 60° (knee extension)
- Knee extension 90-40°
- Overpressure into extension (knee extension should be at least 0° to slight hyperextension)
- Patellar mobilization
- Ankle pumps
- Straight leg raises (three directions)
- Minisquats and weight shifts
- Quadriceps isometric setting

*Muscle Stimulation*—Electrical muscle stimulation to quads (6 hours/day)

*Continuous Passive Motion*—0 to 90°, as needed

*Ice and Elevation*—Ice 20 minutes out of every hour and elevate leg with knee in full extension

### **Postoperative days 4 to 7**

*Brace*—EZ Wrap brace/immobilizer, locked at 0° extension for ambulation and unlocked for sitting, etc.

*Weight Bearing*—Two crutches, weight bearing as tolerated

*Range of Motion*—Remove brace to perform ROM exercises 4 to 6 times per day. knee flexion 90° by day 5, approximately 100° by day 7

*Exercises*

- Multiangle isometrics at 90 and 60° (knee extension)
- Knee extension 90 to 40°
- Overpressure into extension (attain complete extension)
- Patellar mobilization (5 to 8 times daily)

- Ankle pumps
- Straight leg raises (three directions)
- Minisquats and weight shifts
- Standing hamstring curls
- Quadriceps isometric setting
- Proprioception and balance activities

*Neuromuscular training/proprioception*—Open kinetic chain passive/active joint repositioning at 90 and 60°; closed kinetic chain squats/weight shifts with repositioning on sports RAC

*Muscle Stimulation*—Electrical muscle stimulation (continue 6 hours daily)

*Continuous Passive Motion*—0 to 90°, as needed

*Ice and Elevation*—Ice 20 minutes of every hour and elevate leg with knee in full extension

## **II. Early Rehabilitation Phase (Weeks 2 to 4)**

*Criteria to Progress to Phase II*

1. Quad control (ability to perform good quad set and straight leg raising)
2. Full passive knee extension
3. Passive ROM 0 to 90
4. Good patellar mobility
5. Minimal joint effusion
6. Independent ambulation

*Goals*

- Maintain full passive knee extension (maintain complete extension)
- Gradually increase knee flexion
- Diminish swelling and pain
- Muscle control and activation
- Restore proprioception/neuromuscular control
- Normalize patellar mobility

### **Week Two**

*Brace*—Continue locked brace for ambulation

*Weight Bearing*—As tolerated (goal is to discontinue crutches 10 to 14 days postoperatively)

*Passive Range of Motion*—Self ROM stretching (4 to 5 times daily), emphasis on maintaining full, passive ROM

*KT 2000 Test*—(15-lb anterior-posterior test only)

*Exercises*

- Muscle stimulation to quadriceps exercises
- Isometric quadriceps sets
- Straight leg raises (four planes)
- Leg press (0 to 60°)
- Knee extension 90 to 40°
- Half squats (0 to 40°)
- Weight shifts
- Front and side lunges
- Hamstring curls standing (active ROM)

- Bicycle (if ROM allows)
- Proprioception training
- Overpressure into extension
- Passive ROM from 0 to 100°
- Patellar mobilization
- Well leg exercises
- Progressive resistance extension program—start with 1 lb. progress 1 lb per week

#### *Proprioception/Neuromuscular Training*

- Open kinetic chain passive/active joint repositioning at 90, 60, and 30°
- Closed kinetic chain joint repositioning during squats/lunges
- Initiate squats on tilt board; use sports RAC with repositioning

#### *Swelling control*—Ice, compression, elevation

#### **Week Three**

*Brace*—Discontinue locked brace (some patients use ROM brace for ambulation)

*Passive Range of Motion*—Continue ROM stretching and overpressure into extension (ROM should be 0 to 100/105°)

#### *Exercises*

- Continue all exercises as in week 2
- Passive ROM 0 to 105°
- Bicycle for ROM stimulus and endurance
- Pool walking program (if incision is closed)
- Eccentric quadriceps program 40 to 100° (isotonic only)
- Lateral lunges (straight plane)
- Front step-downs
- Lateral step-overs (cones)
- Stair-stepper machine
- Progress proprioception drills, neuromuscular control drills
- Continue passive/active reposition drills on sports RAC (closed and open kinetic chain)

### **III. Progressive Strengthening/Neuromuscular Control Phase (Weeks 4 to 10)**

#### *Criteria to Enter Phase III*

1. Active ROM 0 to 115°
2. Quadriceps strength 60% > contralateral side (isometric test at 60° knee flexion)
3. Unchanged KT 2000 test bilateral values (+1 or less)
4. Minimal to no joint effusion
5. No joint line or patellofemoral pain

#### *Goals*

- Restore full knee ROM (0 to 125°)
- Improve lower extremity strength
- Enhance proprioception, balance, and neuromuscular control
- Improve muscular endurance
- Restore limb confidence and function

*Brace*—No immobilizer or brace, may use knee sleeve to control swelling/support

#### *Range of Motion*

- Self ROM (4 to 5 times daily using the other leg to provide ROM), emphasis on maintaining 0° passive extension
- Passive ROM 0 to 125° at 4 weeks

*KT 2000 Test*—Week 4, 20 lb anterior and posterior test

#### **Week 4**

##### *Exercises*

- Progress isometric strengthening program
- Leg press (0 to 100°)
- Knee extension 90 to 40°
- Hamstring curls (isotonic)
- Hip abduction and adduction
- Hip flexion and extension
- Lateral step-overs
- Lateral lunges (straight plane and multiplane drills)
- Lateral step-ups
- Front step-downs
- Wall squats
- Vertical squats
- Standing toe calf raises
- Seated toe calf raises
- Biodex stability system (balance, squats, etc.)
- Proprioception drills
- Bicycle
- Stair-stepper machine
- Pool program (backward running, hip and leg exercises)

##### *Proprioception/Neuromuscular Drills*

- Tilt board squats (perturbation)
- Passive/active reposition open kinetic chain
- Closed kinetic chain repositioning on tilt board with sports RAC
- Closed kinetic chain lunges with sports RAC

#### **Week 6**

*KT 2000 Test*—20- and 30- lb anterior and posterior test

##### *Exercises*

- Continue all exercises
- Pool running (forward) and agility drills
- Balance on tilt boards
- Progress to balance and ball throws
- Wall slides/squats

#### **Week 8**

*KT 2000 Test*—20- and 30- lb anterior and posterior test

##### *Exercises*

- Continue all exercises listed in weeks 4 to 6
- Leg press sets (single leg) 0 to 100° and 40 to 100°
- Plyometric leg press

- Perturbation training
- Isokinetic exercises (90 to 40°) (120 to 240°/sec)
- Walking program
- Bicycle for endurance
- Stair-stepper machine for endurance
- Biodex stability system
- Sports RAC neuromuscular training on tilt board and Biodex stability

### **Week 10**

*KT 2000 Test*—20 and 30 lb and manual maximum test

*Isokinetic Test*—Concentric knee extension/flexion at 180 and 300°/sec

#### *Exercises*

- Continue all exercises listed in weeks 6, 8 and 10
- Plyometric training drills
- Continue stretching drills
- Progress strengthening exercises and neuromuscular training

### **IV. Advanced Activity Phase (Weeks 10 to 16)**

#### *Criteria to Enter Phase IV*

- Active ROM 0 to 125° or greater
- Quad strength 75% of contralateral side. knee extension flexor-extensor ratio 70% to 75%
- No change in KT 2000 values (comparable with contralateral side, within 2 mm)
- No pain or effusion
- Satisfactory clinical examination
- Satisfactory isokinetic test (values at 180°)
  - Quadriceps bilateral comparison 75%
  - Hamstrings equal bilateral
  - Quadriceps peak torque/body weight 65% at 180°/sec (males) 55% at 180°/sec (females)
  - Hamstrings/quadriceps ratio 66% to 75%
  - Hop test (80% of contralateral leg)
  - Subjective knee scoring (modified Noyes system), 80 points or better

#### *Goals*

- Normalize lower extremity strength
- Enhance muscular power and endurance
- Improve neuromuscular control
- Perform selected sport-specific drills

#### *Exercises*

- May initiate running program (weeks 10 to 12)
- May initiate light sport program (golf)
- Continue all strengthening drills
  - Leg press
  - Wall squats
  - Hip abduction/adduction
  - Hip flexion/extension
  - Knee extension 90 to 40°

- Hamstring curls
- Standing toe calf
- Step-down
- Lateral step-ups
- Lateral lunges
- Neuromuscular training
- Lateral step-overs (cones)
- Lateral lunges
- Tilt board drills
- Sports RAC repositioning on tilt board

#### **Weeks 14-16**

- Progress program
- Continue all drills above
- May initiate lateral agility drills
- Backward running

#### **V. Return to Activity Phase (Weeks 16 to 22)**

##### *Criteria to Enter Phase V*

1. Full ROM
2. Unchanged KT 2000 test (within 2.5 mm of opposite side)
3. Isokinetic test that fulfills criteria
4. Quadriceps bilateral comparison (80% or greater)
5. Hamstring bilateral comparison (110% or greater)
6. Quadriceps torque/body weight ratio (55% or greater)
7. Hamstrings/quadriceps ratio (70% or greater)
8. Proprioceptive test (100% of contralateral leg)
9. Functional test (85% or greater of contralateral side)
10. Satisfactory clinical exam
11. Subjective knee scoring (modified Noyes system) (90 points or better)

##### *Goals*

- Gradual return to full-unrestricted sports
- Achieve maximal strength and endurance
- Normalize neuromuscular control
- Progress skill training

*Tests*—KT 2000, Isokinetic, and Functional tests before return

##### *Exercises*

- Continue strengthening exercises
- Continue neuromuscular control drills
- Continue plyometrics drills
- Progress running and agility program
- Progress sport specific training
  - Running/cutting/agility drills
  - Gradual return to sports drills

#### **6-Month Follow-up**

- Isokinetic test
- KT 2000 test

- Functional test

**12-Month Follow-up**

- Isokinetic test
- KT2000 test
- Functional test

## APPENDIX B

### Letter to Supervising Athletic Trainers

Greetings Supervising Athletic Trainer.

I am a graduate student at North Dakota State University, working toward completing my master's degree thesis that involves a survey study regarding the fear of reinjury in NCAA athletes following an anterior cruciate ligament (ACL) injury, reconstructive surgery, and rehabilitation. Your institution has been randomly selected to participate in this study only 25% of all NCAA institutions will be invited to participate. Anything you are able to do to help me with the following request would be much appreciated.

I am asking you to please distribute the attached informational letter to potential study participants. Distribution of this informational letter is certainly at your discretion (i.e. email, printed handout, posting on a bulletin board, etc.). Study participants must be NCAA collegiate athletes who are currently, or have in the past, participated in college athletics, and have suffered an ACL tear within the past one to six year. It is also important that the athletes have had no other knee injuries since the ACL reconstruction surgical event, have completed the required rehabilitation, have been cleared by a physician, and have returned to full activity.

Athletes electing to participate in this study will be given the opportunity to identify your college/university as one who created an opportunity for them to participate in this study. As an incentive for creating that opportunity for your student-athletes, you will be eligible to win a Nintendo® Wii™ for your athletic training room, a device that could be used for injury rehabilitation purposes. A random drawing will be held at the conclusion of our data collection period. If even one athlete from your institution chooses to participate, you will be given an opportunity to randomly be drawn for the Nintendo® Wii™ gaming system.

Your athletes will also be offered an incentive for completing the study. By participating in the study and completing the survey regarding the fear of reinjury, each athlete will be eligible to randomly win one of eight \$25 BestBuy® gift cards through a process similar to the one described above. An opportunity will be presented at the completion of the study for each athlete to provide contact information if they desire to enter their name in the random drawing for one of the eight \$25 BestBuy® gift cards.

Again, as mentioned above, anything you can do to help distribute this informational letter to potential study participants would be very much appreciated! Keep in mind that the deadline to complete the survey is set for **Sunday, April 3, 2011**, at which time data will be summarized and the opportunity for the random drawings will be terminated. Please feel free to contact me with any questions that you may have and good luck with your current and upcoming sports seasons.

Sincerely,

Nicole Salvesen, ATC, CSCS  
Graduate Student – North Dakota State University  
[Nicole.M.Salvesen@ndsu.edu](mailto:Nicole.M.Salvesen@ndsu.edu)  
701-730-6251

## APPENDIX C

### Letter to Participants

Greetings Student-Athlete,

I am a graduate student at North Dakota State University working on completing my thesis regarding the fear of reinjury in NCAA athletes after suffering from an anterior cruciate ligament (ACL) tear, reconstructive surgery, and rehabilitation. Your supervising athletic trainer has distributed this letter to you because you are a potential candidate for the research study that I am conducting. I would greatly appreciate it if you would take about 12 to 15 minutes to complete a brief, confidential survey about your level of fear regarding reinjury to your ACL. Additionally, you will be asked to complete a short biographical survey that will be used for demographical purposes only.

You are being asked to participate in this study because you are a current NCAA collegiate athlete who is currently, or has in the past, participated in college athletics and has suffered an ACL tear within the past one to six years. It is also important that you have had no other knee injuries since the ACL reconstruction surgical event, have completed the required rehabilitation, have returned to full activity, and have been cleared by a physician. If you do not meet these criteria, please disregard this letter.

If you agree to participate in this study and complete the survey, you will be eligible to win one of eight \$25 BestBuy® gift cards through a random drawing that will include a pool of others who have also participated in this study. An opportunity will be presented at the completion of the study for you to enter in your name and an email address where you can be contacted at if your name was selected through the random drawing.

Please enter the link below into the URL address bar of a web browser; keep in mind that the link is case sensitive. If entering the link onto the URL address bar of a web browser does not work, please contact me by email and I will electronically send you a link that you can click on to help you access the survey. If you would prefer a hard copy of the survey, just let me know and I will mail one to you as soon as possible. Keep in mind that the deadline to complete the survey is set for **Sunday, April 3, 2011**, at which time data will be summarized and the opportunity for the random drawings will be terminated. Again, your cooperation is very much appreciated! Please feel free to contact me with any questions and good luck with your upcoming season.

<https://www.surveymonkey.com/s/fearofreinjuryNCAAathletes>

Sincerely,

Nicole Salvesen, ATC, CSCS  
Graduate Student – North Dakota State University  
[Nicole.M.Salvesen@ndsu.edu](mailto:Nicole.M.Salvesen@ndsu.edu)  
701-730-6251

## APPENDIX D

### Informed Consent

#### **North Dakota State University**

Health, Nutrition & Exercise Science  
NDSU Dept. 2620  
P.O. Box 6050  
Fargo, ND 58108

You are invited to participate in a research study that examines the fear of reinjury with NCAA athletes following an anterior cruciate ligament (ACL) tear injury, reconstruction of the ACL injury, and any subsequent rehabilitation of that ACL injury. With your agreement to participate in the study, an online survey becomes available with questions regarding the aforementioned. Not agreeing to participate in this study allows you to close the browser, terminating your involvement with the study.

The purpose of this study is to determine if a fear of reinjury and the athlete's current knee pain are associated with an athlete's decision to return to sport after suffering from an ACL injury, reconstructive surgery, and rehabilitation. You have been asked to participate in this study because you are an NCAA collegiate athlete who is currently, or has in the past, participated in college athletics and has suffered an ACL tear within the past one to six years. Other additional important criteria includes that you have had no other knee injuries since the ACL reconstruction surgical event; that you have completed the required rehabilitation; that you have returned to full activity; and that you have been cleared to play sport again by a physician. If you do not meet all of the noted criteria, please exit the browser window at this time. However, if you do meet the criteria to participate in this study, please continue reading.

The survey for this study involves minimal (or no) risk of or for discomfort. The survey will take approximately 12 to 15 minutes to complete. Your responses may help athletic trainers better understand the fear of reinjury following an ACL tear injury event, which in turn might help athletic trainers treat their patients with improved rehabilitation techniques, and ultimately help their athletes return to activity with a reduced fear of reinjury. By agreeing to participate in this study, you also will be eligible to win one of eight \$25 BestBuy® gift cards via a drawing that will include others participating in this study. The final question of the survey allows you to enter your name (for the drawing) and your email address so that you can be contacted if your name is drawn as one of the winning participant names.

Please note that every effort will be made to keep all information obtained about you confidential by the principal and co-investigator throughout the duration of the study.

however, some of the information may be reported in summary form if the study results are requested by participating institutions and/or requested by you. Your decision to participate in this study is very much appreciated, but is completely voluntary.

You may withdraw from participating in this study at any time throughout the course of the study, knowing that your withdrawal will not adversely affect your standing at your institution or cause a loss of benefits to which you might otherwise be entitled to. There is no penalty of any kind for either non-participation or withdrawal at any time. The demographic information requested for this study will be used to sort, group, and summarize collected data. The first, middle, and last initials from your name will be used solely to eliminate collection of duplicate data.

Study summary results may be requested by contacting Nicole Salvesen at [Nicole.M.Salvesen@ndsu.edu](mailto:Nicole.M.Salvesen@ndsu.edu) or Dr. Albrecht at [Jay.Albrecht@ndsu.edu](mailto:Jay.Albrecht@ndsu.edu) after July, 2011. If you have any questions or problems during the study, please feel free to email Ms. Salvesen or Dr. Albrecht. For questions about your rights as a research participant, or to report a complaint about the research, you may contact the NDSU Human Research Protection Program at 701.231.8908 or [ndsu.irb@ndsu.edu](mailto:ndsu.irb@ndsu.edu). In advance, thank you for your participation.

## APPENDIX E

## SurveyMonkey™ Questionnaire

## Fear of Reinjury: A Survey of NCAA Athletes Post ACL Reconstruction and

## 1. Informed Consent

NORTH DAKOTA STATE UNIVERSITY  
Health, Nutrition & Exercise Science  
NDSU Dept. 2620  
P.O. Box 6050  
Fargo, ND 58108

You are invited to participate in a research study that examines the fear of reinjury with NCAA athletes following an anterior cruciate ligament (ACL) tear injury, reconstruction of the ACL injury, and any subsequent rehabilitation of that ACL injury. With your agreement to participate in the study, an online survey becomes available with questions regarding the aforementioned. Not agreeing to participate in this study allows you to close the browser, terminating your involvement with the study.

The purpose of this study is to determine if a fear of reinjury and the athlete's current knee pain are associated with an athlete's decision to return to sport after suffering from an ACL injury, reconstructive surgery, and rehabilitation. You have been asked to participate in this study because you are an NCAA collegiate athlete who is currently, or has in the past, participated in college athletics and has suffered an ACL tear within the past one to six years. Other additional important criteria includes that you have had no other knee injuries since the ACL reconstruction surgical event, that you have completed the required rehabilitation, that you have returned to full activity, and that you have been cleared to play sport again by a physician. If you do not meet all of the noted criteria, please exit the browser window at this time. However, if you do meet the criteria to participate in this study, please continue reading.

The survey for this study involves minimal (or no) risk of or for discomfort. The survey will take approximately 12 to 15 minutes to complete. Your responses may help athletic trainers better understand the fear of reinjury following an ACL tear injury event, which in turn might help athletic trainers treat their patients with improved rehabilitation techniques, and ultimately help their athletes return to activity with a reduced fear of reinjury. By agreeing to participate in this study, you also will be eligible to win one of eight \$25 BestBuy™ gift cards via a drawing that will include others participating in this study. The final question of the survey allows you to enter your name (for the drawing) and your email address so that you can be contacted if your name is drawn as one of the winning participant names.

Please note that every effort will be made to keep all information obtained about you confidential by the principal and co-investigator throughout the duration of the study, however, some of the information may be reported in summary form if the study results are requested by participating institutions and/or requested by you. Your decision to participate in this study is very much appreciated, but is completely voluntary.

You may withdraw from participating in this study at any time throughout the course of the study, knowing that your withdrawal will not adversely affect your standing at your institution or cause a loss of benefits to which you might otherwise be entitled to. There is no penalty of any kind for either non-participation or withdrawal at any time. The demographic information requested for this study will be used to sort, group, and summarize collected data. The first, middle, and last initials from your name will be used solely to eliminate collection of duplicate data.

Study summary results may be requested by contacting Nicole Salvesen at [Nicole.M.Salvesen@ndsu.edu](mailto:Nicole.M.Salvesen@ndsu.edu) or Dr. Albrecht at [Jay.Albrecht@ndsu.edu](mailto:Jay.Albrecht@ndsu.edu) after July, 2011. If you have any questions or problems during the study, please feel free to email Ms. Salvesen or Dr. Albrecht. For questions about your rights as a research participant, or to report a complaint about the research, you may contact the NDSU Human Research Protection Program at 701.231.8908 or [ndsu.hrb@ndsu.edu](mailto:ndsu.hrb@ndsu.edu). In advance, thank you for your participation.

**\* 1. By clicking yes, I am agreeing to participate in this study.**

Yes

**Fear of Reinjury: A Survey of NCAA Athletes Post ACL Reconstruction and****2. Demographic Information****\* 1. Name of Institution:**  
**2. Initials:**

(Your initials will remain confidential and will be used to prevent duplicate results from being analyzed.)

  
**\* 3. Sex:** Male Female**\* 4. Year in College:** 1st 2nd 3rd 4th 5th**\* 5. Age:**  
**\* 6. Sport(s) currently participating in at the collegiate level:**  
**\* 7. Age at time of ACL injury:**  
**\* 8. Time (in months) since ACL injury:**

**Fear of Reinjury: A Survey of NCAA Athletes Post ACL Reconstruction and**

\* 9. Type of graft used in ACL reconstruction surgery:

- Hamstring Graft  
 Patellar Tendon Graft  
 Cadaver Graft  
 Other  
 I can't remember

\* 10. Did your ACL injury occur from (check one):

- Contact  
 Non-Contact  
 I can't remember

\* 11. Sport(s) you were participating in at the time of your ACL injury:

\_\_\_\_\_ 5  
\_\_\_\_\_ 6

\* 12. On a scale of 0 (none) to 10 (extreme), please rate the amount of pain felt during the time of your ACL injury.

- 0 None  
 1  
 2  
 3  
 4  
 5  
 6  
 7  
 8  
 9  
 10 Extreme

\* 13. Have you returned to your pre-injury level of activity?

- Yes  
 No

## Fear of Reinjury: A Survey of NCAA Athletes Post ACL Reconstruction and

### 3. TSK - Fear of Reinjury

\* 1. Please answer the following statements as they best apply to you today.

	Strongly Disagree	Disagree	Agree	Strongly Agree
1. I am afraid that I might injure myself if I exercise.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2. If I were to try to overcome my knee trouble, my pain would increase.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3. My body is telling me I have something dangerously wrong.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4. My knee trouble would probably be relieved if I were to exercise.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5. People are not taking my medical condition seriously enough.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6. My accident has put my body at risk for the rest of my life.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7. Pain always means I have injured my body.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8. Just because something aggravates my knee pain does not mean it is dangerous.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9. I am afraid that I might injure myself accidentally.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10. Simply being careful that I do not make any unnecessary movements is the safest thing I can do to prevent my injured leg from worsening.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
11. I would not have this much trouble if there were not something potentially dangerous going on in my body.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
12. Although my knee trouble is painful, I would be better off if I were physically active.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
13. Pain lets me know when to stop exercising so that I do not injure myself.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
14. It is really not safe for a person with a condition like mine to be physically active.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
15. I cannot do all of the things normal people do because it's too easy for me to get injured again.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
16. Even though my injured knee is causing me a lot of pain, I don't think it's actually dangerous.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
17. No one should have to exercise when he/she could get injured.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

## Fear of Reinjury: A Survey of NCAA Athletes Post ACL Reconstruction and

### 4. KOOS - Symptoms and Stiffness

This portion of the survey asks for your view about your knee. This information will tell us how you feel about your knee and how well you are able to perform your usual activities. Answer each question by selecting the appropriate answer, only one answer for each question. If you are unsure about how to answer a question, please give the best answer you can.

**\* 1. These questions should be answered thinking of your knee SYMPTOMS during the LAST WEEK.**

	Never	Rarely	Some times	Often	Always
S1. Do you have swelling in your knee?	<input type="radio"/>				
S2. Do you feel grinding, hear clicking, or any other type of noise when your knee moves?	<input type="radio"/>				
S3. Does your knee catch or hang up when moving?	<input type="radio"/>				
S4. Can you straighten your knee fully?	<input type="radio"/>				
S5. Can you bend your knee fully?	<input type="radio"/>				

**\* 2. The following questions concern the amount of JOINT STIFFNESS you have experienced during the LAST WEEK in your knee. Stiffness is a sensation of restriction or slowness in the ease with which you move your knee joint.**

	None	Mild	Moderate	Severe	Extreme
S6. How severe is your knee joint stiffness after just waking in the morning?	<input type="radio"/>				
S7. How severe is your knee stiffness after sitting, lying, or resting later in the day?	<input type="radio"/>				

## Fear of Reinjury: A Survey of NCAA Athletes Post ACL Reconstruction and

### 5. KOOS - Pain

\* 1. The following question concerns your experience with knee pain.

	Never	Monthly	Weekly	Daily	Always
P1. How often do you experience knee pain?	<input type="radio"/>				

\* 2. What amount of KNEE PAIN have you experienced the LAST WEEK during the following activities?

	None	Mild	Moderate	Severe	Extreme
P2. Twisting/pivoting on your knee	<input type="radio"/>				
P3. Straightening knee fully	<input type="radio"/>				
P4. Bending knee fully	<input type="radio"/>				
P5. Walking on flat surface	<input type="radio"/>				
P6. Going up or down stairs	<input type="radio"/>				
P7. At night while in bed	<input type="radio"/>				
P8. Sitting or lying	<input type="radio"/>				
P9. Standing upright	<input type="radio"/>				

## Fear of Reinjury: A Survey of NCAA Athletes Post ACL Reconstruction and

### 6. KOOS - Activities of Daily Living (ADL)

\* 1. The following questions concern your **PHYSICAL FUNCTION**. By this we mean your ability to move around and to look after yourself. For each of the following activities, please indicate the **DEGREE OF DIFFICULTY** you have experienced in the **LAST WEEK** due to your knee.

	None	Mild	Moderate	Severe	Extreme
A1. Descending stairs	<input type="radio"/>				
A2. Ascending stairs	<input type="radio"/>				
A3. Rising from sitting	<input type="radio"/>				
A4. Standing	<input type="radio"/>				
A5. Bending to floor or picking up an object	<input type="radio"/>				
A6. Walking on flat surface	<input type="radio"/>				
A7. Getting in and out of a car	<input type="radio"/>				
A8. Going shopping	<input type="radio"/>				
A9. Putting on socks	<input type="radio"/>				
A10. Rising from bed	<input type="radio"/>				
A11. Taking off socks	<input type="radio"/>				
A12. Lying in bed (turning over, maintaining knee position)	<input type="radio"/>				
A13. Getting in and out of the bathtub or shower	<input type="radio"/>				
A14. Sitting	<input type="radio"/>				
A15. Getting on and off of the toilet	<input type="radio"/>				
A16. Heavy domestic duties (moving heavy boxes, scrubbing floors, etc.)	<input type="radio"/>				
A17. Light domestic duties (cooking, dusting, etc.)	<input type="radio"/>				

**Fear of Reinjury: A Survey of NCAA Athletes Post ACL Reconstruction and****7. KOOS - Function, Sports, and Recreational Activities**

\* 1. The following questions concern your PHYSICAL FUNCTION when being active on a HIGHER LEVEL. The questions should be answered thinking of what DEGREE OF DIFFICULTY you have experienced during the LAST WEEK due to your knee.

	None	Mild	Moderate	Severe	Extreme
S P1: Squatting	<input type="radio"/>				
S P2: Running	<input type="radio"/>				
S P3: Jumping	<input type="radio"/>				
S P4: Twisting/pivoting on your injured knee	<input type="radio"/>				
S P5: Kneeling	<input type="radio"/>				

## Fear of Reinjury: A Survey of NCAA Athletes Post ACL Reconstruction and

### 8. KOOS - Quality of Life

\* 1. The following question concerns your awareness regarding your knee problem.

Q1. How often are you aware of your knee problem?

Never	Monthly	Weekly	Daily	Constantly
<input type="radio"/>				

\* 2. The following question concerns any modifications to your life style that you have made to avoid potentially damaging activities to your knee.

Q2. Have you modified your lifestyle to avoid potentially damaging activities to your knee?

Not at all	Mildly	Moderately	Severely	Totally
<input type="radio"/>				

\* 3. The following question concerns your possible lack of confidence in your knee.

Q3. How much are you troubled with lack of confidence in your knee?

Not at all	Mildly	Moderately	Severely	Extremely
<input type="radio"/>				

\* 4. The following question concerns any difficulty with your knee that you may have.

Q4. In general, how much difficulty do you have with your knee?

None	Mild	Moderate	Severe	Extreme
<input type="radio"/>				

**Fear of Reinjury: A Survey of NCAA Athletes Post ACL Reconstruction and****9. Thank You**

Thank you very much for participating in your study. Your time is greatly appreciated.

Since you have completed the study, you will now be given the opportunity to enter a random drawing to win 1 of 8 gift cards to BestBuy. This portion of the survey will allow you to enter in the required information stating that you would like to enter the drawing and also provide contact information should you win.

If you do not wish to enter the drawing, please close the browser window at this time.

If you would like to enter the drawing, please click "YES" below.

Thank you again for your participation.

**\* 1. I would like to enter the random drawing.**

YES

No

**Fear of Reinjury: A Survey of NCAA Athletes Post ACL Reconstruction and****10. Drawing Information**

**\* 1. Please provide the following information so that you and/or your supervising athletic trainer can be contacted should lucky winners in the random drawings!**

**Name:** \_\_\_\_\_

**Email Address:** \_\_\_\_\_

**Institution:** \_\_\_\_\_

**Fear of Reinjury: A Survey of NCAA Athletes Post ACL Reconstruction and****11. Thanks Again For Your Help!**

Please close your browser window at this time or click the "Done" button below. Your survey has been completed and your results have been saved.

## APPENDIX F

## Modified Tampa Scale of Kinesiophobia

(Vlaeyen et al., 1995)

1 = Strongly Disagree

2 = Disagree

3 = Agree

4 = Strongly Agree

1. I am afraid that I might injure myself if I exercise.	1	2	3	4
2. If I were to try to overcome my knee trouble, my pain would increase.	1	2	3	4
3. My body is telling me I have something dangerously wrong.	1	2	3	4
4. My knee trouble would probably be relieved if I were to exercise.	1	2	3	4
5. People are not taking my medical condition seriously enough.	1	2	3	4
6. My accident has put my body at risk for the rest of my life.	1	2	3	4
7. Pain always means I have injured my body.	1	2	3	4
8. Just because something aggravates my knee pain does not mean it is dangerous.	1	2	3	4
9. I am afraid that I might injure myself accidentally.	1	2	3	4
10. Simply being careful that I do not make any unnecessary movements is the safest thing I can do to prevent my injured leg from worsening.	1	2	3	4
11. I would not have this much trouble if there were not something potentially dangerous going on in my body.	1	2	3	4
12. Although my knee trouble is painful, I would be better off if I were physically active.	1	2	3	4
13. Pain lets me know when to stop exercising so that I do not injure myself.	1	2	3	4
14. It is really not safe for a person with a condition like mine to be physically active.	1	2	3	4
15. I cannot do all of the things normal people do because it's too easy for me to get injured again.	1	2	3	4
16. Even though my injured knee is causing me a lot of pain, I don't think it's actually dangerous.	1	2	3	4
17. No one should have to exercise when he/she could get injured.	1	2	3	4

## APPENDIX G

**Knee Injury and Osteoarthritis Outcome Score**

(Roos &amp; Lohmander, 2003)

## Knee Injury and Osteoarthritis Outcome Score, English Version

**Instructions:** This survey asks for your view about your knee. This information will tell us how you feel about your knee and how well you are able to perform your usual activities. Answer each question by circling the appropriate answer, only one answer for each question. If you are unsure about how to answer a question, please give the best answer you can.

**Symptoms:**

These questions should be answered thinking of your knee symptoms during the **last week**.

S1. Do you have swelling in your knee?

Never          Rarely          Sometimes          Often          Always

S2. Do you feel grinding, hear clicking or any other type of noise when your knee moves?

Never          Rarely          Sometimes          Often          Always

S3. Does your knee catch or hang up when moving?

Never          Rarely          Sometimes          Often          Always

S4. Can you straighten your knee fully?

Never          Rarely          Sometimes          Often          Always

S5. Can you bend your knee fully?

Never          Rarely          Sometimes          Often          Always

**Stiffness:**

The following questions concern the amount of joint stiffness you have experienced during the **last week** in your knee. Stiffness is a sensation of restriction or slowness in the ease with which you move your knee joint.

S6. How severe is your knee joint stiffness after first wakening in the morning?

None          Mild          Moderate          Severe          Extreme

S7. How severe is your knee stiffness after sitting, lying or resting later in the day?

None          Mild          Moderate          Severe          Extreme

**Pain:**

P1. How often do you experience knee pain?

Never          Monthly          Weekly          Daily          Always

What amount of knee pain have you experienced the **last week** during the following activities?

P2. Twisting/pivoting on your knee?

None          Mild          Moderate          Severe          Extreme

P3. Straightening knee fully

None          Mild          Moderate          Severe          Extreme

P4. Bending knee fully

None          Mild          Moderate          Severe          Extreme

P5. Walking on flat surface

None          Mild          Moderate          Severe          Extreme

P6. Going up or down stairs

None          Mild          Moderate          Severe          Extreme

P7. At night while in bed

None          Mild          Moderate          Severe          Extreme

P8. Sitting or lying

None          Mild          Moderate          Severe          Extreme

P9. Standing upright

None          Mild          Moderate          Severe          Extreme

**Activities of Daily Living (ADL):**

The following questions concern your physical function. By this we mean your ability to move around and to look after yourself. For each of the following activities, please indicate the degree of difficulty you have experienced in the **last week** due to your knee.

A1. Descending stairs

None	Mild	Moderate	Severe	Extreme
------	------	----------	--------	---------

A2. Ascending stairs

None	Mild	Moderate	Severe	Extreme
------	------	----------	--------	---------

A3. Rising from sitting

None	Mild	Moderate	Severe	Extreme
------	------	----------	--------	---------

A4. Standing

None	Mild	Moderate	Severe	Extreme
------	------	----------	--------	---------

A5. Bending to floor or picking up an object

None	Mild	Moderate	Severe	Extreme
------	------	----------	--------	---------

A6. Walking on flat surface

None	Mild	Moderate	Severe	Extreme
------	------	----------	--------	---------

A7. Getting in and out of a car

None	Mild	Moderate	Severe	Extreme
------	------	----------	--------	---------

A8. Going shopping

None	Mild	Moderate	Severe	Extreme
------	------	----------	--------	---------

A9. Putting on socks

None	Mild	Moderate	Severe	Extreme
------	------	----------	--------	---------

A10. Rising from bed

None	Mild	Moderate	Severe	Extreme
------	------	----------	--------	---------

A11. Taking off socks

None	Mild	Moderate	Severe	Extreme
------	------	----------	--------	---------

A12. Lying in bed (turning over, maintaining knee position)

None	Mild	Moderate	Severe	Extreme
------	------	----------	--------	---------

A13. Getting in and out of the bathtub or shower

None	Mild	Moderate	Severe	Extreme
------	------	----------	--------	---------

A14. Sitting

None	Mild	Moderate	Severe	Extreme
------	------	----------	--------	---------

A15. Getting on and off of the toilet

None	Mild	Moderate	Severe	Extreme
------	------	----------	--------	---------

A16. Heavy domestic duties (moving heavy boxes, scrubbing floors, etc.)

None	Mild	Moderate	Severe	Extreme
------	------	----------	--------	---------

A17. Light domestic duties (cooking, dusting, etc.)

None	Mild	Moderate	Severe	Extreme
------	------	----------	--------	---------

### **Function, Sports, and Recreational Activities:**

The following questions concern your physical function when being active on a higher level. The questions should be answered thinking of what degree of difficulty you have experienced during the **last week** due to your knee.

SP1. Squatting

None	Mild	Moderate	Severe	Extreme
------	------	----------	--------	---------

SP2. Running

None	Mild	Moderate	Severe	Extreme
------	------	----------	--------	---------

SP3. Jumping

None	Mild	Moderate	Severe	Extreme
------	------	----------	--------	---------

SP4. Twisting/pivoting on your injured knee

None	Mild	Moderate	Severe	Extreme
------	------	----------	--------	---------

SP5. Kneeling

None	Mild	Moderate	Severe	Extreme
------	------	----------	--------	---------

**Quality of Life (QOL):**

Q1. How often are you aware of your knee problem?

Never	Monthly	Weekly	Daily	Constantly
-------	---------	--------	-------	------------

Q2. Have you modified your lifestyle to avoid potentially damaging activities to your knee?

Not at all	Mildly	Moderately	Severely	Totally
------------	--------	------------	----------	---------

Q3. How much are you troubled with lack of confidence in your knee?

Not at all	Mildly	Moderately	Severely	Extremely
------------	--------	------------	----------	-----------

Q4. In general, how much difficulty do you have with your knee?

None	Mild	Moderate	Severe	Extreme
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## APPENDIX H

**Knee Injury and Osteoarthritis Outcome Score  
Scoring Sheet**  
(Roos & Lohmander, 2003)

**Instructions:**

Assign the following scores to the boxes:

None	Mild	Moderate	Severe	Extreme
0	1	2	3	4

Missing Data: If two choices are circled, that which indicated the more severe problem is chosen.

Missing data are treated as such: one or two missing values are substituted with the average value for that subscale. If more than two items are omitted, the response is considered invalid and no subscale score is calculated.

Sum up the total score of each subscale and divide by the possible maximum score for the scale.

Please use the formulas provided for each subscale.

$$1. \text{ PAIN:} \quad 100 - \frac{\text{Total score P1-P9} \times 100}{36} = 100 - \frac{\quad}{36} = \underline{\quad}$$

$$2. \text{ SYMPTOMS:} \quad 100 - \frac{\text{Total score S1-S7} \times 100}{28} = 100 - \frac{\quad}{28} = \underline{\quad}$$

$$3. \text{ ADL:} \quad 100 - \frac{\text{Total score A1-A17} \times 100}{68} = 100 - \frac{\quad}{68} = \underline{\quad}$$

$$4. \text{ SPORT\&REC:} \quad 100 - \frac{\text{Total score SP1-SP5} \times 100}{20} = 100 - \frac{\quad}{20} = \underline{\quad}$$

$$5. \text{ QOL:} \quad 100 - \frac{\text{Total score Q1-Q4} \times 100}{16} = 100 - \frac{\quad}{16} = \underline{\quad}$$