Reducing The Risk Of ACL Injury In Female Athletes

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ABSTRACT

The Anterior Cruciate Ligament (ACL) is located behind the kneecap (patella) and connects the thigh bone (femur) to the shin bone (tibia). Stabilizing the knee joint is the primary responsibility of the ACL. Injuries that affect the ACL are three to five times more common in females than males. This is a result of anatomical, biomechanical, strength, and hormonal differences. The probability of potentially devastating tears to the ACL may be reduced in female athletes by an alternative warm-up program that focuses on muscle flexibility, strength, motor skill, and balance enhancement. Once the ACL has been torn, it becomes impossible to reattach or stitch the ligament back together. The blood supply in this area of the body is diminished and the tissue becomes nonviable. Reconstruction of the ACL involves attaching the ligament to another tendon from the hamstring, just below the knee. Although reconstruction and treatment of ACL injuries are available, much unnecessary pain, money, and time may be wasted during these procedures. It is important to be aware of the prevention methods available to reduce the possibility of potentially devastating tears to the ACL. These prevention methods include proper warm-up and avoiding activities that cause pain. Other preventive measures include incorporating balance exercises along with stretching and strengthening muscles near the ACL. Appropriate rest and recovery time are other important factors that may prevent ACL injuries. Quality footwear, strapping, or taping may provide an additional level of support to the knee joint and ACL.

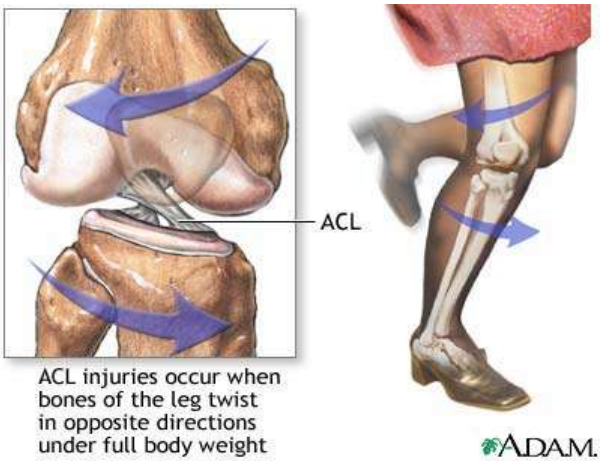
Keywords: Anterior Cruciate Ligament (ACL), Knee, Female, Injury, Hormones, Reconstruction, Warm-up, Prevention, and Athletes.

INTRODUCTION TO KNEE INJURIES

The Anterior Cruciate Ligament (ACL) is primarily responsible for stabilizing the knee joint. The most common age group for ACL injuries is 14 to 20. Of those injuries, 70 percent of ACL injuries are non-contact injuries *(Figure 1).* Female athletes are eight times more likely to suffer ACL injuries than males. Studies have found one in every fifty female high school athletes and one in every ten Division I college female athletes will tear an ACL (Jacobe, 2009). As more females participate in sports such as basketball and soccer, tears of the ACL have become more common. These sports require female athletes to perform various skills that require quick starts, stops, and turns. Research has found that the structures of male and female knee joints differ. These differences may have a greater effect on the female knee. Women's knees are different from males; their knee joint has a greater degree of extension (straightness) when performing certain maneuvers in running and changing directions when compared to males. Males tend to have a greater degree of flexion or bend in their knees (Jacobe, 2009). Other findings related to the differences in the knee joint by gender are that women tend to activate their hamstring considerably less than men during athletic maneuvers. Less activation of the hamstring muscles may cause stress on the knee specifically on the ACL (Jacobe, 2009).

Female hormones, such as estrogen and progesterone, play a role in ACL injuries and as a result increased hormone production during the menstrual cycle may increase the number of ACL injuries. A greater number of female athletes sustain ACL injuries on days one and two of their menstrual cycle, when their hormones are at their highest (Slaughterbeck, 2002). The likelihood of potentially devastating tears to a knee ligament, such as the ACL,

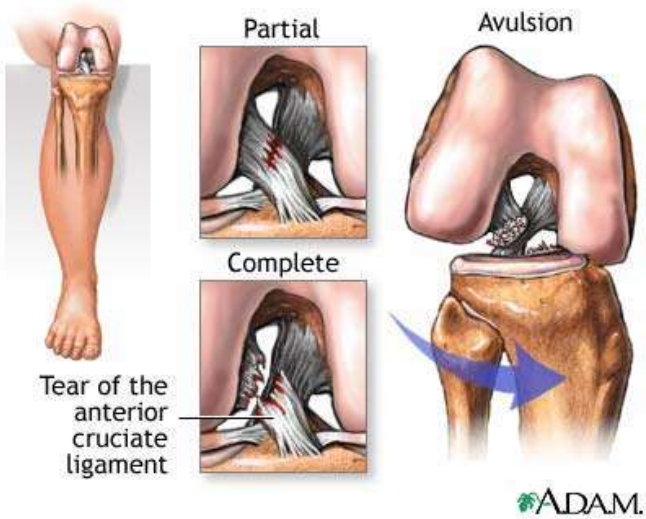
may be reduced in female athletes by an alternate warm-up program that focuses on improving balance, motor skill movements, muscle flexibility, and strength (Gilchrist, 2008).



(Figure 1: Chen, 2008).

ACL PROBLEMS IN FEMALE ATHLETES: CAUSES AND PREVENTION

To prevent ACL injuries, female athletes must learn how ACL injuries occur. These injuries may include extreme stretching, partial tearing, or a complete tearing of the ACL. Knee injuries are a common hazard for female athletes who compete in basketball, volleyball, soccer, or other sports where knees are subjected to turning, twisting, and jerking. Sports injuries (*Figure 2)* such as ACL tears, rips, or stretches may be found in contact or non-contact sports. Contact tears result from a blow to the side of the knee common in sports such as soccer. In basketball and skiing, athletes are required to combine quick stops and directional changes or landing from a jump, which produce excessive tension in the knee joint. Females tend to injure their ACL more frequently than males while participating in similar athletic activities. When comparing vulnerability of injury between males and females following ACL reconstruction surgery, women have a greater risk of injury. These injuries include knee laxity, ACL graft rupture, and other less successful outcomes after ACL reconstruction as compared with males in similar ACL restoration (Jacobe, 2009).

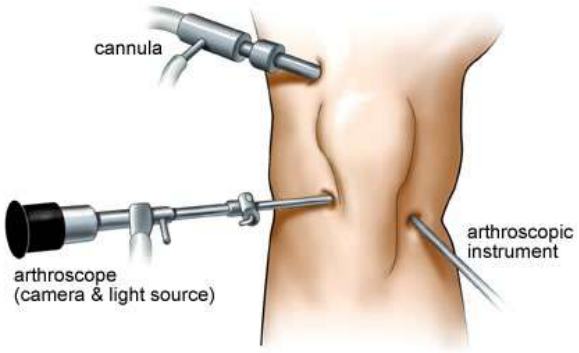


(Figure 2: Chen, 2009)

ACL injuries are three to five times more common in female athletes than male (Keyser, 2008). This is a result of anatomical, biomechanical, strength, and hormonal differences. An example of an important anatomical gender difference is the bones of female knees have less room around the ACL than male knees causing it to be more prone to injury. Other biomechanical differences include how girls and boys differ when landing from their jumps. Girls tend to land with their knee joint extended (straight), while boys' knees tend to be more flexed (bent) when landing. Strength differences by gender include girls with a higher quadriceps-to-hamstring strength ratio than males. The female knee joint may be more susceptible to injury, because the quadriceps muscles in the anterior thighs are stronger in females than the hamstrings in the posterior of the females' legs. This factor may increase tension on the knee joint, including the ACL. The hormonal differences between males and females may affect the outcome of ACL injuries. During various phases of the menstrual cycle, female ligaments may be weaker, which may put the ACL at a greater risk for injury (Keyser, 2008).

Female participants in intercollegiate soccer and basketball have been reported to be three times more likely to tear their ACL than male athletes in the same sport. The incidence of serious knee injury in high school females has been reported to be five times higher than high school males. It is estimated that there are more than 100,000 ACL injuries in the United States each year. Fifty percent of those individuals sustaining an ACL injury require surgery. The cost of the ACL surgeries is estimated at one billion dollars (Kramer, Denegar, Buckley & Hertel, 2007).

Reconstruction of the ACL *(Figure 3)* consists of attaching the ligament to another tendon from the hamstring below the knee. As previously stated, it is impossible to reattach or stitch the ACL together once it is torn, because the blood supply is diminished and the tissue becomes nonviable.



(Figure 3: ACL Solutions, 2009)

CAN THE RISK OF ACL INJURIES BE REDUCED IN FEMALE ATHLETES?

The risk of potentially devastating tears to the ACL may be reduced in female athletes by an alternative warm-up program that focuses on stretching, strengthening, and improving balance when performing various movements (CDC, 2009). A University of Michigan study (Woijts, 2001) measured the muscle protection or rotational knee stiffness, present in young female athletes of the same size and sport. This study was designed to determine the susceptibility of ACL injuries in female athletes. The Michigan study examined 24 (12 male, 12 female) NCAA Division I athletes who competed in basketball, volleyball, and soccer. All three are "pivot" sports that, because of turning, twisting, and jerking, put players at high risk for injury to the ACL (Woijts, 2001). Male and female pairs were matched for age, height, weight, body mass index, shoe size, and activity level, making them all but equal except for gender. Female athletes were two to eight times more likely to tear their ACL than their male counterparts (Woijts, 2001) concluded that many females may not be able to achieve the same muscle tension across the knee joint as males. The study confirmed that males produced more knee tautness, and therefore, were better protected against ACL injuries.

Little is known about the association of lower extremity structural malalignment, or the failure of body parts to align normally. These lower extremity structural problems include flexibility patterns, generalized laxity, postural control, previous ankle sprain history, and the increased risk of ACL injuries in females. Females with a history of ACL injury are more likely to also have a history of prior ankle sprains and other structural alignments than females without a history of ACL injuries. In a controlled study(Kramer, Denegar, Buckley, & Hertel, 2007) 33 young adult females with a history of ACL injuries and 33 females with no history of knee injury provided their medical history for the knee and ankle injury study. In addition, the participants supplied 16 lower extremity measures. The factors most associated with ACL injury were greater generalized laxity, greater genu recurvatum or hyperextension of the knee, and decreased iliotibial band flexibility. There was also a significant association between the history of ACL injury and history of previous ankle sprain injury. Those with a history of ACL injury were more likely to have experienced a prior ankle sprain located on the same side of the body, also known as an ipsilateral ankle sprain. Increased generalized laxity, greater genu recurvatum, and decreased iliotibial band flexibility discriminated between females-with and females without history of ACL injury. Kramer et al. found a relationship linking previous ankle injury and ACL injury risk (2007).

RELATIONSHIP BETWEEN ACL INJURIES AND MENSTRUAL CYCLE

Investigators researched whether ACL injuries in female athletes occurred randomly or were correlated with a specific phase of the menstrual cycle (Slauterbeck, Fuzie, Smith, & Clark, 2002). Female athletes who sustained ACL injury were required to report their menstrual cycle days and provide saliva samples for sex-hormone determination. Salivary sex-hormone profiles of participants were assessed to confirm their self-reported menstrual histories. A total of 38 female athletes (20 college athletes, 15 high school athletes, 1 middle school athlete, and 2 recreational students with recent ACL injuries participated in the study over a three-year period. Athletes with recent ACL injuries completed a questionnaire defining the injury, the last menstrual cycle, prior knee injury, school, and type of birth control used (if any.) Each subject provided a saliva sample within 72 hours of injury. Saliva samples were placed into sealed containers and frozen (-20 C). Thirteen additional control samples were obtained from uninjured females to test the correlation between saliva and serum sex-hormone levels. Progesterone and estrogen were examined by radioimmunoassay, a scientific method used to test antigens, and hormone levels in the blood. Physical examination, magnetic resonance imaging, or surgery confirmed the injury in all subjects. The study's results determined that the correlations between saliva and serum estrogen and serum estrogen progesterone were 0.73 and 0.72. These correlations were based on a Pearson correlation between 0 and +1.Ten of the 27 athletes who reported their menstrual cycle at time of injury sustained an ACL injury immediately before or 1-2 days after the onset of menses. A significantly greater number of ACL injuries occurred on day 1 and 2 of the athlete's menstrual cycle. Salivary sex-hormone levels correlated with the reported cycle day (Slauterbeck, Fuzie, Smith, Clark, 2002)

REDUCING ACL INJURY

Results suggested that dynamic neuromuscular training applied to a high-risk population of female athletes may decrease risk of ACL injury (Meyer, Ford, Hewitt, 2009). The following training techniques may increase female athletes' enjoyment of sports participation without long-term disabilities associated with sports knee injuries Plyometric training programs are recommended to reduce ACL injuries in female soccer players. This type of training may also be used as a warm-up prior to competition. Prevention of ACL injuries should be the first priority and one of the most important considerations in ACL injury. Methods to prevent ACL injuries should include a good warm up which is essential to ready the body for physical activities. A well structured warm up will prepare the heart, lungs, muscles, joints and mind for strenuous activity. Warm up tips include.

- **Avoid activities that cause pain**
  Develop an awareness of activities that cause pain or discomfort by either avoiding or modifying them.
- **Rest and Recovery**
  Rest is very important to assist the soft tissues of the body to recover from strenuous activity. Be sure to allow adequate recovery time between training sessions.
- **Balancing Exercises**
  Activities that challenge one's ability to balance and maintain balance, may improve-proprioception, which is the ability to know where your limbs are at any given time.

- **Stretch and Strengthen**
  To prevent ACL injury, it is important that the muscles around the knee be well conditioned. Athletes should work on the strength and flexibility of all muscle groups in the leg.
- **Footwear**
  Be aware of the importance of good footwear. A good pair of shoes will stabilize knees, provide cushioning for feet, knees, ~~etc,~~ and support the lower leg during running or walking.
- **Strapping**
  Strapping or taping may provide an added level of support and stability to weak or injured knees (Jacobe, 2009).

CONCLUSION

ACL injuries occur most often just before or on day 1 or 2 of a female's menstrual cycle. This suggests that ACL injuries are not random, but occur more often around the time of menses, when circulating sex-hormone levels are low and progesterone levels begin to elevate. In the female athletic population, salivary sex hormone profiling is associated with serum profiling and adequately identifies the menstrual cycle phase at the time of injury. Therefore, salivary sex hormone profiling is an effective technique to identify the relationships between injury and hormone patterns in female athletes.

ACL injuries in females were found in those who suffered from generalized laxity, greater hyperextension of the knee, and less iliotibial band flexibility. In addition, a kinetic chain relationship may exist between previous ankle sprain injuries and risk for ACL injury. As there is a relationship between previous ankle injuries and ACL injuries, ankle rehabilitative programs may need to add components of ACL prevention programs to their practices.

Female athletes may exhibit more than one neuromuscular imbalance of ligament dominance, quadriceps dominance, or overall leg dominance. Active neuromuscular training assessment provides a method to extensively address and correct these neuromuscular imbalances. The correction of neuromuscular imbalance is important for both optimal biomechanics of athletic movements and to reduce the number of knee injuries in female athletes. Standardized jump-landing risk assessments should be administered to aid in preseason screening for potentially at-risk female athletes. These tests can be quickly and easily administered by clinicians. Additional revision on the effects of neuromuscular retraining on biomechanical performance and knee-injury frequency is the key to advancing programs dealing with the prevention of injury in women's athletics. While major strides have been made, continued sports injury risk screening advancements are necessary. Screening tests should include the integration of high-risk sports movements and maturational assessment.

Future research should be conducted to determine the relationship between female injury (if any) and the use of various oral contraceptives.

AUTHOR INFORMATION

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