Anterior Cruciate Ligament Injuries in the Female Athlete

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ABSTRACT

The normal anterior cruciate ligament (ACL) is critical to knee joint stability, especially for athletes in cutting sports. Rupture of the ACL can be a devastating, if not career-ending, injury for a young athlete because of the resultant instability and increased risk of meniscal and chondral damage. Considerably more girls and women than ever before now participate in athletics. Some epidemiologic data show that female athletes may sustain a higher incidence of ACL injuries than male athletes. Risk factors that may be responsible for these increased injury rates are reviewed. History and physical examination are most important in establishing the diagnosis of ACL injury, although ancillary diagnostic imaging is helpful if the extent of injury is in question. Treatment options, including various surgical reconstructions and rehabilitation, are discussed, with attention to the specific concerns of the female athlete. With appropriate diagnosis and treatment, the ACL-injured athlete may now anticipate full return to function and athletic competition.

INTRODUCTION

Gaining a historic perspective of women in sports is both interesting and important. Men have been participating in organized sports for millennia. Unfortunately, women only really emerged on the athletic scene a few decades ago. Women were actually forbidden to observe the Olympic games in ancient times, under punishment of death. For many centuries, including the early twentieth century, the only sporting activity women were allowed was to watch the men compete. Part of the difficulty was wardrobe. When women were forced to wear dresses at all times, active sports participation was nearly impossible. In the 1920s, such pioneers as Gertrude Ederle and Sonja Henie did much to increase the popularity and acceptance of women athletes. Wearing of pants gradually became more acceptable for female athletes, and more women became active in athletics, although huge social obstacles still blocked their way. In the United States, women are not treated equally under the Constitution, but in 1972, Title IX passed, mandating equality for women’s sports in government-supported schools. True implementation of Title IX has been a long time coming, and lawsuits are still being filed for noncompliance.

By the early 1970s, the study of sports medicine began to make great advances, and almost all research centered on male athletes. Women were considered by many physicians to be too dainty and unaggressive to rupture their anterior cruciate ligaments (ACLs). Although it took over 3000 years from the first Olympic
Marathon to have a women’s marathon at the Olympic Games, the timeline of women’s sports is now growing at an exponential rate. We are just beginning to seriously investigate sports medicine issues for female athletes.

**EPIDEMIOLOGY**

Participation of females in sports has exploded in the last 25 years since Title IX was initiated. Ten times as many high school girls participate in competitive sports as compared to 1972. In the same time period, the number of boys participating has actually declined (Fig. 1). Along with the boom in participation has come a parallel increase in knee injuries. Since the mid-1970s, a number of researchers have documented increased ACL and patellofemoral joint injuries in females not explained solely by the increased numbers of participants.1-3

The National Collegiate Athletic Association (NCAA) has compiled data on athletic injuries in intercollegiate sports that provide a national cross-section of detailed documentation of high rates of knee injuries among certain female athletes.4 Football still carries the highest rate of knee injuries, as expected (2.04 injuries per 1000 exposures), but women’s gymnastics (1.85 per 1000) and soccer (1.76 per 1000) carry a higher rate of knee injuries than comparable men’s sports, even higher than wrestling (1.68 per 1000), a contact sport.

Arendt and Dick closely examined the NCAA data for basketball and soccer.5 They believe comparisons between men’s and women’s teams are valid because of similar rules, equipment, and playing conditions. The numbers are alarming. A female college basketball player is 4.1 times as likely to tear her ACL as is a male basketball player; and a female soccer player is 2.4 times as likely. In addition to basketball and soccer, women volleyball players, skiers, and gymnasts are at higher risk than their male counterparts for knee injuries.6,7 Malone et al. compared men’s and women’s College Division I Basketball players in various conferences.8 In each conference, women’s teams had considerably higher percentages of athletes sustaining ACL tears (Fig. 2).

**RISK FACTORS FOR ACL INJURY**

In recent years, it has been well established that female athletes in certain sports are at much higher risk of ACL injury than males. The important question to ask is: Why? If we can understand why so many young women athletes go down with torn knee ligaments, we may be able to find ways to prevent it. Potential causative factors can be grouped into two

![Bar chart showing the number of participants (both male and female) in high school sports in 1972 and 1996.](chart.png)

**FIG. 1.** National Federation of State High School Associations data on numbers of participating high school athletes in the United States.
areas, extrinsic and intrinsic. Extrinsic refers to possible external causes, things in the surrounding environment that may influence injury rates. Intrinsic refers to internal or anatomic differences that might be responsible.

One of the extrinsic factors that has been implicated is coaching differences between men's and women's sports. This is essentially impossible to quantify as there are infinite variables involved. One interesting item compares salaries for Division I head basketball coaches across the nation. According to a 1994 survey by the Chronicle of Higher Education, coaches of women's teams are still paid only 59 cents on the dollar as compared with men's coaches. The average base salary for the head coach of a women's team was $44,961, whereas the men's coaches earned $76,566 annually. Compensation does not necessarily correlate with quality, experience, and expertise, but there is a definite possibility that the ability to recruit top coaches may be at least partly related to the compensation offered. When one looks at the total budget for women's versus men's sports, the discrepancy is even higher. Despite Title IX, funding for women's Collegiate Division I sports is about 40% compared with men's sports. Does lack of financial support necessarily lead to more injuries? Do inferior equipment and athletic shoes, bumpy playing fields, and less individual coaching attention contribute to injuries? We do not yet have the data to answer these questions.

Other possible extrinsic injury factors are conditioning and muscular strength. Poor conditioning has been shown numerous times in the literature to be a risk factor for musculoskeletal injury in general. With the tremendous rise in the number of female sports participants, including novice girls, conditioning may be a significant factor. More study in this area is warranted, but it would not hurt to encourage proper training and conditioning of our young women athletes in the interim. Differences in thigh muscle strength between genders has been studied, and some investigators believe that females rely more on ligamentous stability of the knee whereas males rely more on muscle. The hamstrings (HS) are the agonist for the ACL. They pull the tibia posteriorly on the femur. Conversely, the quadriceps are the ACL antagonist. Huston and Wojty's suggest that the females are more quadriceps dominant, and Moore and Wade showed that some women have decreased HS/quadriceps ratios. This muscle balance may predispose to ACL injury or cause more functional instability after ACL rupture. Conclusive evidence of whether muscle strength or the HS/quadriceps ratio is correlated with ACL injury risk is still lacking, however. Encouraging HS strengthening in young female athletes could be helpful in preventing ACL injuries, but further study is warranted.

The shoe-surface interface has long been studied in male athletes; and its importance is
well documented in the sports medicine literature. Long-cleated shoes used on artificial or dry turf may provide too much traction, at times causing ACL rupture. There is a higher incidence of ACL tears in sports where athletes wear cleats instead of court shoes, but this still does not explain gender differences in similar sports. We assume females and males have similar shoes and playing surfaces, but if $40 instead of $100 is provided in the athletic budget for shoes or for playing field maintenance, we cannot necessarily make this assumption. Frey is beginning to draw attention to gender differences in foot anatomy, alignment, and gait.12 Unfortunately, the athletic shoe industry still continues to manufacture and market shoes for women designed for men’s feet, only in smaller sizes and pastel colors. The athlete’s shoe is the critical link that transmits ground reaction force in noncontact injuries, which inevitably tears the ACL.

The majority of ACL tears are caused by noncontact mechanisms. Arendt and Dick have shown that nearly all ACL tears in female athletes result from noncontact injuries.5 The usual history is a sudden plant to cut in the opposite direction, a sudden stop and pivot turn, or landing on a straight knee. Two studies have looked at volleyball injuries in Division I colleges.13,14 Most injuries occurred in games, not practice, especially later in the season. Most players were hurt jumping or landing, and all injuries were noncontact injuries. More detailed study into the shoe/surface interface as it applies specifically to female athletes must be accomplished.

Knee braces have never been definitely shown to mechanically prevent ACL injury or prevent reinjury in an ACL-deficient knee, despite manufacturer’s claims. Holding the ankle rigid with a brace or ski boot, in fact, has been thought to possibly increase the incidence of knee ligament injuries. The foot and ankle when rigidly held by brace or tape may transmit injury forces to the knee ligaments.15 Thus, prophylactic taping of all basketball players’ ankles and relationship of this practice to knee ligament injuries is also an area that deserves further investigation.

A potential intrinsic cause of ACL injury risk is knee joint laxity. Nicholas believed that loose-jointed football players were at risk for knee ligament injuries,16 although a number of other researchers found no relationship between joint laxity and risk for injury.17–20 Although it is generally assumed that females are more loose jointed, no differences in knee laxity based on gender have been found with actual measurements.21,22

Limb alignment is slightly different in females than in males because of the wider pelvic ring. The Q-angle, a measure between the anatomic axis of the femur and tibia, is generally larger in females. A high Q-angle has been associated with increased patellofemoral problems, which on intensive study has not been shown to be related to ACL injury.23,24

Another intrinsic factor possibly affecting ACL injury risk is intercondylar notch width. The notch is located on the distal femur and is normally over 17–18 mm in width. Both cruciate ligaments originate from the inside surfaces of the intercondylar notch. After the ACL is torn, the notch may fill in with osteophytes and become narrowed. A number of studies show an association between narrow notches and ACL injuries, but a causal effect is not clear.25–31 One study showed that females’ notches are smaller than males,26 whereas others have shown no difference.25,28 LaPrade and Burnett reported no association between ACL injuries and the notch size between men and women.25 Measurement of notch width in relation to ACL size showed no correlation between small notches and thinner ACL’s.32 The tensile strength of normal ACLs related to body weight and functional loads between men and women has not been evaluated.

The final intrinsic factor possibly related to ACL injury is the effect of hormones. Relaxin is released in pregnant women just before delivery to loosen ligaments at the pelvic outlet. Lutter and Lee believe relaxin increases the risk of ligamentous injury in pregnant women.33 Few women 8 or 9 months pregnant participate in aggressive cutting and jumping sports, however, so it is doubtful that this significantly influences ACL injury rates. What is not known is the effect on the ACL of the normal hormone cycles in nonpregnant women or the role of estrogen receptors on the ACL.
CASE REPORT

The patient is a 15-year-old Native American female high school basketball player who injured her knee in the fourth quarter of a game. She went to stop and cut left and felt her right knee pop and give way. She had immediate global knee pain and swelling within the first 2 hours and inability to bear weight or return to the game. Her examination revealed a large effusion, limited range of motion, lateral joint line tenderness, and a positive Lachman's test (Fig. 3). Lachman's test is performed with the knee in 15 degrees of flexion. One hand stabilizes the femur, and the other attempts to translate the tibia anteriorly. A positive Lachman's test is more than a few millimeters of tibial translation anteriorly with a poor or absent end point. It is the most reliable test for ACL insufficiency.

This patient had no significant varus/valgus instability. Her drawer sign was negative, as often occurs with an acute ACL tear, large knee effusion, and possible displaced meniscal tear. On the acute injury examination, the pivot shift and McMurray's sign often are not adequately evaluated secondary to guarding and limited motion. The patient's radiographs were negative as is most commonly the case with isolated ACL injury.

The diagnosis was acute ACL tear and probable lateral meniscus tear. Because the history and physical examination were straightforward and diagnostic, additional imaging was not required. If the diagnosis is unclear or treatment recommendations would change based on associated injuries, MRI can be a helpful adjunct in selected cases. Treatment consisted of rest, ice, compression, elevation, and early physical therapy for range of motion and prevention of thigh muscle atrophy. Once the patient regained full range of motion and muscle tone 5 weeks later, she was brought to the operating room for reconstruction.

Some controversy exists over the timing and type of ACL reconstruction, but my preference in such a young athlete with a potentially repairable meniscus tear is early reconstruction with bone-patellar tendon-bone autograft. The graft is harvested from the central third of the patellar tendon and tagged with heavy sutures through drill holes. Any meniscal trimming or repair is accomplished. The old ruptured stump of ACL is resected, and notchplasty is accomplished to slightly enlarge the intercondylar notch. Using arthroscopic technique, bone tunnels are drilled through the femur and tibia at the previous points of ACL attachment. The graft is pulled into position with a pin through which the holding suture is threaded.

FIG. 3. Lachman's test for ACL deficiency.

FIG. 4. The bone-patellar tendon-bone graft is pulled into position within the femoral and tibial tunnels.
Although some risk factors may have been identified, there is little information to identify individual athletes at risk for tearing their ACLs. Further prospective, longitudinal studies specific to women are needed before we can develop worthwhile preventive strategies. Areas needing more intensive research include coaching/technique differences between men's and women's sports, muscle balance and relation to ACL injury risk, the shoe-surface interface, shoe fit for female athletes, the role of bracing/taping, and anatomic/hormonal risk factors. These are your daughters, your sisters, your friends, and your patients out there breaking barriers in sport. Sometimes, they blow out their knees in the process. It is the responsibility of every medical care provider working with young women athletes to know how to identify, diagnose, and treat these ACL injuries. Efforts for further research should be strongly supported, as well as work to level the playing field for our girls, young and old.

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