Are ACL Tears Preventable in the Female Athlete?

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Introduction

In 1972, legislation known as Title IX of the Educational Amendments was passed. Title IX prohibits institutions that receive federal funding from practicing gender discriminations in educational programs or activities, including athletics. Since that time, women's sports have advanced tremendously. Currently, more than 2.36 million girls participate in high school sports, compared with 300,000 in 1972, representing an increase of approximately 800%.

> *No person in the United States shall, on the basis of sex, be excluded from participation in, be denied the benefits of, or be subject to discrimination under any educational programs, or activity receiving federal financial assistance.*
>
> *From the Preamble to Title IX of the Educational Amendments of 1972*

The level of professionalism and competition among female athletes is rising exponentially, and so are the physical demands placed on them, resulting in more injuries. As a result, the medical community's challenge is to study the effects of these physical demands and then recommend new concepts for training, policies for institutions, and protocols for rehabilitation for this select population. For instance, it is estimated that there are 80,000 anterior cruciate ligament (ACL) tears in the United States annually, and women incur ACL injuries 2 to 8 times more frequently than males.[1-3] The reason for this gender discrepancy still eludes the medical community. So the question this article seeks to answer is, how do we prevent tears from occurring?

Anatomy and Physiology of the ACL

The ACL is the primary stabilizer of the femur on the tibia and serves to prevent the tibia from rotating and sliding forward during agility, jumping, and deceleration activities. Directly behind the ACL is the posterior cruciate ligament (PCL). Alternatively, the PCL prevents the tibia from sliding to the rear.

The ACL can be injured or torn in a number of different ways. The most common mechanism --- frequently occurring in football, basketball, and soccer --- is that of a sudden pivoting or cutting maneuver. In addition, most ACL injuries occur with no contact to the injured player. In fact, of all ACL injuries reported, 70% are non contact injuries.[4]

How Do We Address This Problem?

A consensus group consisting of physicians, physical therapists, and athletic trainers met in Hunt Valley, Maryland, in June 1999 to discuss the epidemic increases in

ACL injuries. In order to determine the etiology and mechanism of ACL injuries, they conducted a literature review to define potential risk factors. The intrinsic and extrinsic risk factors are thought to include anatomic, hormonal, environmental, and biomechanical mechanisms.

Anatomically, females demonstrate a greater Q angle (angle created by the intersection of a line drawn from the anterosuperior iliac spine to the center of the patella with a second line drawn from the center of the tibial tuberosity to the center of the patella), femoral anteversion, tibial torsion, and greater pronation at the subtalar joint compared with their male counterparts. Athletes who demonstrate excessive subtalar pronation and tibial internal rotation impart more stress on the ACL.[5] In addition, the actual width of the femoral notch has been examined. Two prospective studies have shown that there is a correlation between notch width index (NWI) and ACL injury. [6, 7] However, Souryal and associates [7] have found no gender difference in NWI and rate of ACL injury. There is no conclusive evidence that directly links any one anatomical risk factor with an increased incidence of ACL injury.

Hormones may contribute to the high incidence of ACL tears in female athletes by increasing ligament laxity. Some studies have indicated that there are estrogen receptors on the ACL ligament, suggesting that ACL tears occur with higher frequency in the ovulatory phase (days 10-14) of the menstrual cycle. [8] However, Arendt and colleagues [9] determined that there was a correlation between an increase in ACL injury and the follicular phase (days 1-9). On the contrary, other studies have shown no connection between menstrual phase and time of injury. Karageanes and colleagues [10] found no significant change in ACL laxity when comparing measurements taken in the follicular, ovulatory, and luteal phases. In addition, women on birth control regimens (hormonal replacement) are not exempt from ACL injury. Another argument against this theory is that estrogen receptors are present on other ligaments (such as uterosacral and shoulder capsular), [11] so this does not fully explain the increase in ACL injury. Further studies with larger sample sizes and clear methodology for hormone sampling are necessary to clearly examine whether any correlation exists between hormones and the rate of ACL injury.

The consensus group determined that the most important component in the prevention of ACL injuries is neuromuscular control and proprioception (the ability to know where your joint is in relation to your body). This has been shown to play a crucial role in joint stability.[12] If an athlete performs activities to increase neuromuscular awareness, an overall protective effect may result from the heightened balance, coordination, and muscular strength. Through proper biomechanical training, the ACL will also be protected from excessive external and internal forces generated around the knee joint, thereby decreasing the number of ACL tears overall.

Methods

The Santa Monica Orthopaedic and Sports Medicine Research Foundation, through a grant from the Amateur Athletic Foundation of Los Angeles, designed the

PEP Program: *P revent inury and E nhance P erformance*. It is a soccer-specific prevention program, designed by physical therapists, and athletic trainers in response to the recent increase in the number of ACL injuries found in soccer. The program is a comprehensive alternative warm-up that consists of avoidance techniques, stretching, strengthening, plyometrics (jumping drills), and soccer-specific exercises. The program strongly emphasizes proper technique by offering verbal and visual cues for each component of the program. It takes approximately 15 to 20 minutes to complete and can be performed on the field without any additional equipment.

Female soccer teams between the ages of 14 and 18 are enrolled in the intervention program. The athletes perform the prevention program 2 to 3 times per week in direct replacement of their traditional warm-up program. Throughout the study, data are collected on the female athletes to determine the efficacy of the program in its efforts to decrease the incidence of ACL injuries.

In the first 2 years of the study, female soccer players from a soccer league in Southern California were enrolled in the study. The enrolled athletes (cases) performed the warm-up program 2 to 3 times a week for 12 weeks. The control group continued to do the standard warm-up that their team routinely performed. In the case study group, there was an overall 88% reduction in the incidence of ACL tears during the first-year and a 74% reduction during the second year compared with the age- and skill-matched control group (Table 1). This study will continue into 2003; biomechanical analysis will be conducted to validate the prevention efforts and learn more about the mechanism of injury.

Conclusion

The results of this study are promising secondary to the large number of subjects involved in the program. However, we recognize the fact that the study design does innately have its limitations. This study is nonrandomized, so some of the success of the prevention program may be due to a sample selection bias. We are planning to continue this study in a randomized nature with a younger population.

The increased incidence of ACL tears in female athletes has been problematic for the medical community as we struggle to ascertain the true mechanism of injury and develop a comprehensive method to decease the number of injuries in this high-risk population. However, it is encouraging to see various ACL prevention programs successfully diminishing the number of ACL injuries incurred. These include, but are not limited to, the Cincinnati Sportsmetrics Program (Hewitt and associates, 1996)[13] and the Vermont ski program.[14] Future research must focus on defining the mechanism of injury and developing additional programs for prevention, and strong biomechanical validation studies are needed to determine their effectiveness.

Tables

Table 1. Cases and Controls in ACL Prevention Program

Controls Enrolled Athletes (Cases)				
Year of Study	2000	2001	2000	2001
# of players	1041	844	1905	1913
# of teams	52	45	95	112
# of ACL tears	2	4	32	35
Injuries per athlete	0.2	0.47	1.7	1.8

Overall decrease in ACL injury:
(1.7 – 0.2) / 1.7 * 1000 = 88% in 2000
(1.8 – 0.47) / 1.8 * 1000 = 74% in 2001

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