

## **ACL and the Female Athlete: Theoretical Causes and Prevention**

Today, female sports participation is at an all-time high. In 2000, more than 2.5 million high school girls and 145,000 college women competed in at least one sport (13). The popularity of women's sports rises each year and the competitive nature on the field is more intense. Unfortunately, however, more women are watching competition from the sidelines with knee injuries instead of standing on the playing field.

The infamous "pop" sound and the scream that follows. Those two sounds send shivers up the spines of victims of an Anterior Cruciate Ligament (ACL) tear. To the majority of athletes, an ACL tear requires reconstruction surgery and a challenging six to nine months of rehabilitation.

The commonality of ACL injuries among female athletes has athletic trainers, coaches and administrators concerned. Each year, one out of 100 high school female athletes and one of 10 college female athletes experiences an ACL injury (1,6,14,17). The National Collegiate Athletic Association (NCAA) reports that in any given year, approximately 2,200 collegiate female athletes are expected to rupture their ACL. Based on these statistics, research shows that women have a four to eight times higher incidence of knee injury than their male counterparts. One ACL surgery costs approximately \$25,000. Combined, high schools and colleges are spending over \$100 million per year on ACL reconstruction surgeries for female athletes (3,17).

Why are female athletes so susceptible to knee injuries? Many theories have surfaced from sports medicine research, and the most common stem from females' anatomical differences, muscular imbalances and variations in movement patterns.

### **Anatomical Differences**

In the knee joint, an intercondylar notch lies between the femoral condyles. The ACL moves within this notch, connecting the femur and the tibia, providing stability to the knee. The ACL prevents the tibia from sliding forward and rotating inward. The majority of women have a small notch, therefore restricting ACL movement. When movement is restricted, the femoral condyles can easily pinch the ACL within the joint, especially during twisting or hyperextended movements. This ultimately can result in a tear or rupture (2,11,12,16).

The femur meets the tibia at an angle called the Q angle. The width of the pelvis determines the size of the Q angle. Because women typically have a wider pelvis than men, their Q angles are larger. The average angle for females is 15 degrees and only 10 degrees for males. At this greater angle, forces are concentrated on the ligament for stability each time the knee rotates. This increases the rotational forces on the ACL, raising the probability of a tear. A large Q angle also results in a more pronated foot, further stressing the knee (2,8,11,12).

### **Muscular Imbalances**

The balance of muscle power and the recruitment pattern between the quadriceps and hamstrings is crucial to knee stability. Research shows that female athletes tend to have quadriceps to hamstrings muscle imbalances -- with the quadriceps as the dominating knee stability muscle. On the other hand, men have a better balance between quadriceps and hamstrings. They engage the hamstrings first when performing a movement, which actually decreases stress on the ACL. Therefore, the stability of the knee is more quadriceps-dominant (an ACL antagonist) in females and more hamstrings-dominant (an ACL agonist) in men (2,5,6,9,12,13,14,16).

Men and women engaging in the same activity with similar intensity put equal twisting and loading forces on the knee joint (11). Twisting, cutting and landing movements all stress the ACL to provide stability. As the quadriceps contract, additional stress is put on the ACL, increasing the risk of injury.

### **Variations in Movement Patterns**

Ninety-three percent of women's ACL injuries are classified as non-contact. These injuries are divided equally among the three main non-contact movements -- planting, cutting and straight-knee landings with hyper-extended knees (12). For unknown reasons, women tend to perform all these movements with straight legs. Straight-legged activities require the knees to absorb forces equal to four times an individual's body weight as well as encourage hyperextension of the knee joint. Hyperextending the knee is one of the major contributors to non-contact ACL injuries. Also, videos have shown that women tend to perform planting, cutting and landing movements by turning the knees inward, further exaggerating the Q angle stress on the ACL and therefore increasing risk of an ACL rupture (1,10)

### **Prevention**

How can the athletic community assist females to decrease the risk of an ACL tear? Obviously, anatomical attributes that increase the risk of ACL rupture cannot be altered. As a result, the focus for prevention has been on teaching athletes the correct motor patterns to prevent excessive stress on the ACL.

The most notable ACL prevention program was developed by Cincinnati Sportsmedicine, called Sportsmetrics. A total of 1263 athletes were divided into three groups: 366 females who participated in a 6-week pre-season training program, 463 females who did not participate in the program and 434

untrained males.

During the first few weeks, participants learned proper jumping and landing techniques that emphasized posture, knee stability and soft landings. Different jumps such as wall tucks, broad jumps, squat jumps and cone jumps were performed with increasing repetitions and time intervals. Athletes were trained to land on the balls of their feet with knees slightly bent, the chest over the knees and limited side-to-side motion.

Following the 6-week program, landing forces decreased by 22 percent and the quad to hamstring strength ratio increased from 50 percent to 66 percent -- which translates into less stress on the knee and ACL (2,7). Published in the American Journal of Sports Medicine, the study noted that the 366 females athletes who completed the program were about three times less likely to suffer an ACL injury than the non-trained females and only 1.3 times higher than the male athletes (7,14).

Laura Ramus, head athletic trainer for the WNBA's Detroit Shock, uses a variation of the Sportmetrics program to reduce knee injuries, incorporating proper jump and land techniques. Ramus' ultimate goal is to retrain the brain in jump mechanics to increase strength and improve performance. Since the program's inception in 1999, not one Shock player has suffered a knee injury (4).

Research presented at the 69th annual meeting of the American Academy of Orthopedic Surgeons showed that the risk of female ACL injuries may be cut by 88 percent with pre-season proprioceptive training. Dr. Bert Mandelbaum of the Santa Monica Orthopedic and Sports Medicine Research Foundation compared the rate of knee injuries in 1041 female soccer players enrolled in an ACL pre-season prevention program to 1902 players from the same league who did not enroll in the program. The program consisted of hamstring strengthening exercises, plyometrics and agility drills, concentrating on running, jumping and pivoting with bent knees. Following the season, the trained group only suffered two ACL injuries, compared to 32 in the non-trained group (15).

In addition to proprioception and plyometrics drills, many strength and conditioning coaches are focusing on isolated exercises to decrease the quadriceps to hamstrings muscular imbalance. Because strength in the hamstrings has been shown to protect the ACL from excessive strain, trainers hope that stronger hamstrings will engage quicker to assist with knee stabilization during pivoting, twisting, cutting and landing movements (4,5,12,16).

See a trend? The preliminary data above has shown that prevention programs -- including a series of proprioception, plyometrics, agility and strength training exercises -- greatly decrease females' risk of ACL tears. These types of exercises easily can be incorporated into warm-up and/or cool-down activities.

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