The Female Athlete: Entitled to Compete, Predetermined to Tear Her Anterior Cruciate Ligament?

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Introduction

Young people—men and women—should be encouraged to compete in organized athletics. The numbers of participants in high school sports has continued to grow. In 1971 the National Federation of State High School Associations reported the number of participants as 294,015 girls and 3,666,917 boys [1]; 33 years later, the number of girls participating in sports was 2,865,299 and boys was 4,038,253. For 2003-2004 participants in girl's basketball numbered 457,986 and for boys numbered 544,811. The largest number of participants was in boy's football at 1,032,682, followed by basketball. Soccer ranked fifth for girls with 309,032 participants, and fifth for boys with 349,785 players.

As a multisport high school athlete and swimmer, I was discouraged from but determined to continue swimming in college in the early 1970s. I persisted and tried out for the Olympics in 1972 and 1976. I was unsuccessful in making the US Olympic team; however, standing on the starting blocks at the Olympic trials, I felt as though I was on top of the world—confident and even a bit cocky. The opportunity to swim at the college level allowed me to have the structure for excellence in the classroom, respect from my teammates, and support from family, friends, and fans. I am a big believer in equal opportunity for boys and girls, and men and women, to compete in sports.

The Title IX Educational Amendment Act was passed in 1972, requiring that federally funded schools not discriminate on the basis of sex in the provision of any educational activity, including athletics [2]. Other Title IX requirements that male and female athletes receive the same benefits of athletic participation, specifically equipment, uniforms, access to weight rooms and training facilities, equal practice facilities, same size and quality locker room, competition facilities, same quality coaches, opportunity to play same quality opponents, receive the same awards and awards banquets, and have cheerleading and band performances at girls' games. The numbers of male and female collegiate athletes are equalizing. Now, 33 years after Title IX, college female athletes number 160,650 and male athletes number 216,991 for all National Collegiate Athletic Association (NCAA) Divisions (Table I). The ratio of men to women for all sports is 1.35. If the 59,640 football players are eliminated, the ratio is 0.98 [3].

Unfortunately, with the opportunities to compete in sport comes the price of injury, specifically the anterior cruciate ligament (ACL) tear, which is the topic of this commentary. The NCAA instituted an injury surveillance system in 1989 in which injury rates are recorded per 1000 athlete exposures [3]. Over a 14-year period from 1989 to 2003, injury documentation reveals an alarmingly high rate of ACL tears in female athletes. The average ratio of injury of women to men is 3.4 in basketball and 2.8 in soccer. This is despite earlier competition in sport, improved coaching, and awareness of the nature of ACL injuries. When a female athlete asks why she tore her ACL, we must find more answers for her.

Noncontact Anterior Cruciate Ligament Tear Risk Factors

The different categories of risk factors include structural, biomechanical, hormonal, and neuromuscular [4–7]. Participants at research retreats have published views and consensus statement on what we know, what we don't know, and where do we go from here [8–11]. Fortunately, the factors that are changeable or extrinsic are thought to contribute significantly to ACL tear. Ryder *et al.* [12] have emphasized the importance of study design and methods to identify the incidence rates in sports trauma. In a prospective study on competitive alpine skiers, ACL injury was two times greater in women compared with men. In this study, significant risk factors for ACL injury were female sex, knee hyperextension, and increased leg length ratio. In a review of the literature, Murphy *et al.* [13] listed categories as *extrinsic*: level of competition, skill level, shoe type, ankle bracing, and playing surface; and *intrinsic*: age, sex, phase of menstrual cycle, previous injury and inadequate rehabilitation, aerobic fitness, body size, limb dominance, flexibility, (generalized joint laxity, ankle and knee joint laxity, muscle tightness, range of motion), muscle strength imbalance, reaction time, limb girth, postural stability, anatomic alignment,

Table 1. 2002–2003 NCAA participants, overall numbers and sex ratios, with and without men's football

	Women	Ratio M:W	Men	Men playing football	Ratio M (football):W	Men w/o football	Total
Division I	68,679	1.3	87,019	25,243	0.9	61,776	155,698
Division II	30,701	1.5	46,067	13,938	1.0	32,129	76,768
Division III	61,270	1.4	83,905	20,459	1.0	63,446	145,175
Total	160,650	1.4	216,991	59,640	1.0	157,351	377,641

NCAA—National Collegiate Athletic Association.
(*Data from* the NCAA Injury Surveillance System [3].)

and foot morphology. There were five extrinsic factors and 14 intrinsic factors. Of the 19 factors analyzed, six were clear ACL injury risk factors. The ACL injury risk factors were intrinsic (narrower femoral notch), and extrinsic (female sex, incurring previous ACL injury followed by inadequate rehabilitation, competing in games compared with practice, and wearing edge-style cleats compared with other cleat designs [13].

In a prospective study, lower extremity injuries in basketball and track athletes were documented after measurement of lumbopelvic or core stability. Males were significantly stronger in core measurements of hip abduction, external rotation, and back extension. However, athletes who did not sustain an injury back or lower extremity were significantly stronger in hip abduction and hip external rotation. Logistic regression analysis revealed that hip external rotation strength was the only useful predictor of injury status [14].

Age and growth also pose risks. In high school basketball, a greater number of girls tear an ACL than boys. At Kentucky Sports Medicine, 475 ACL reconstructions were performed in basketball athletes. Of the girls who underwent ACL reconstructions, 67% were high school age, whereas among boys, only 39% were high school age. Of these ACL reconstructions, the revision rate was 3%; 6% tore their opposite ACL (Unpublished data; Kentucky Sports Medicine, Lexington, KY).

Hewett *et al.* [15] and Myer *et al.* [16], in a series of 181 middle and high school soccer and basketball players, reported that after girls mature they land and jump differently than do boys, as measured kinematically and kinetically. Following the onset of pubertal growth spurt, girls change the way they land from a jump with greater maximal valgus angles of their dominant and nondominant lower extremities; this valgus alignment landing position places the ACL at risk.

Mechanism of Injury and Prevention Programs

A female basketball player was bumped while attempting to catch a pass, rebound, and take the ball back up for a shot. She felt like her brain was processing a lot of information and she landed awkwardly. She felt her knee collapse, give way, or buckle. She tore her ACL as she rebounded her missed shot and got ready to shoot the ball again (Fig. 1). She landed on one leg, out of balance, in an upright hip and knee position.

There is a safe way to land and a "position of no return" [5,6,17] (Fig. 2). The more flexed hip and knee and normal alignment landing position is safe. The good (agonist) muscle groups can control the knee. The good muscles at the hip are the abductors and external rotators, at the knee the hamstrings, and at the lumbar spine the extensors. In the "position of no return," the knee is in valgus with the femur internally rotated, tibia externally rotated, and forefoot pronated. The knees and hips are relatively extended, with limb malalignment, and knee in valgus. The agonist (good) muscles are not able to correct this awkward landing. Therefore, the antagonist (bad) muscles (hip flexors, abductors) allow the femur to continue internally rotating with the quadriceps musculature causes anterior tibial translation (Fig. 2). Aggressive quadriceps loading with the knee in slight flexion has been reported as a common position for ACL tears [18].

Bench basic research should rule! Advanced measurement techniques and computer modeling will allow us to define forces on the ACL and analyze joint position, bony anatomy, and muscular forces provided by the agonist and antagonist muscles. In addition, the bony geometry of the knee, including degree of tibial slope, notch, geometry, and distal femoral rotation, as it relates to hip anteversion and hip rotation can also be analyzed by computer modeling. Translation of basic research in the lab to movement patterns in the field is key. Prevention programs do appear to be reducing ACL injury rates, but the question remains what factors are being modified.

Programs reporting reduction of ACL injuries are alpine skiing [19], soccer (PEP program) [20], and volleyball and basketball program (Timothy E. Hewett, PhD, Cincinnati Children's Hospital Medical Center). Review texts [8], and web sites [21] with specifics of prevention programs are listed in the reference section.

Conclusions

The female athlete is entitled to compete, she deserves to compete. She is *not* predetermined to tear her ACL. She should know she risks an ACL tear in cutting sports and should prepare maximally for her sport. We need to instruct her on what she needs to do to protect herself.

The equality of opportunity for men and women to complete has not resulted in equal rates of ACL tear. Although we have better ways to reconstruct the ACL, return to the same

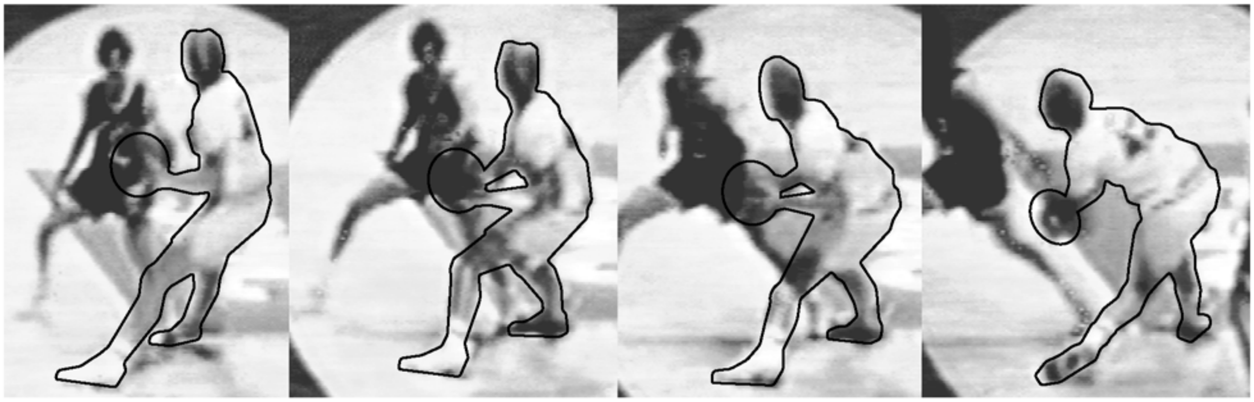

Figure 1. The mechanism of an anterior cruciate ligament (ACL) tear is captured on video. Injury to the left knee as observed from the back and left side of the athlete. The athlete has just rebounded and stops to change direction to avoid the defending player. She lands in an upright position with less knee and hip flexion and a forward-flexed lumbar spine. After the ACL fails, she falls forward and knee valgus rotation and flexion increase. She is unable to upright herself and regain pelvis control to avoid ACL injury. (Copyright 2000, M.L. Ireland; with permission.)

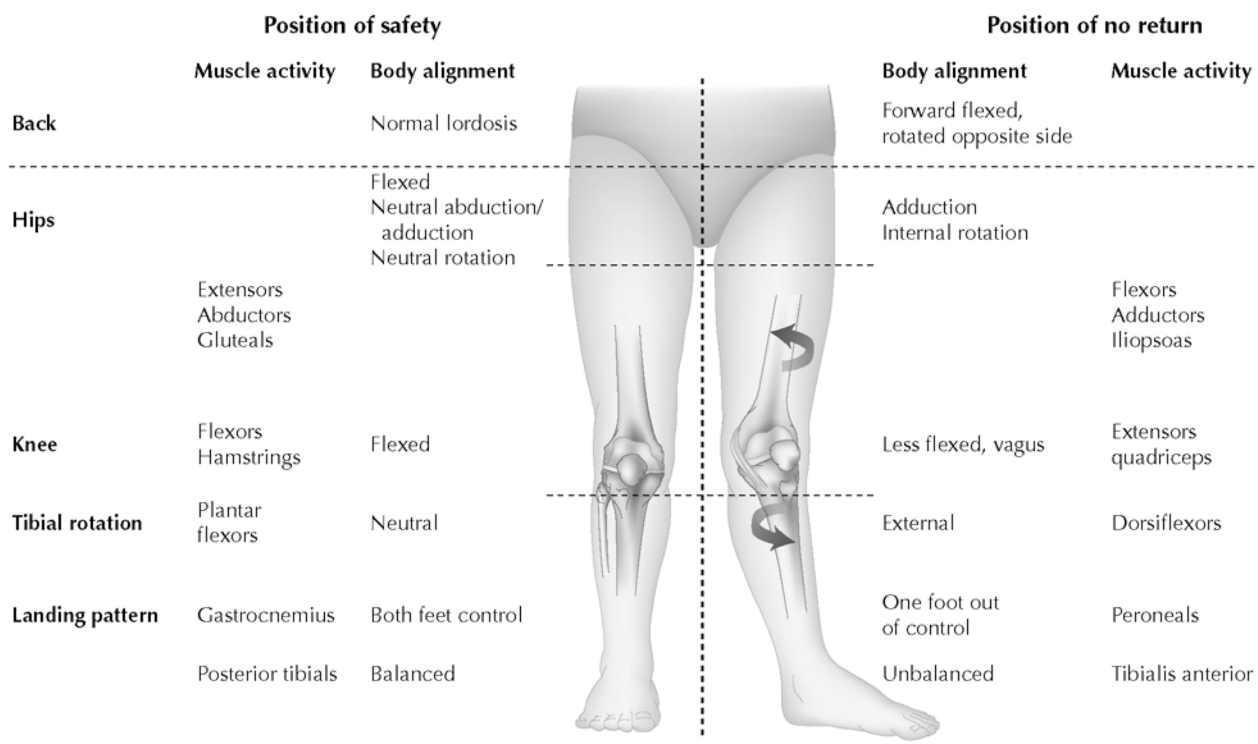

Figure 2. This diagram shows the "position of no return." This term refers to an awkward out-of-control landing with the leg pronated in valgus angulation, the body more upright, and the leg in pronation and rotation, and the knee in valgus angulation, which places the ACL at risk of tearing. The safety position is more flexed, with the body over legs, and more balanced. ACL— anterior cruciate ligament. (Copyright 2000, M.L. Ireland; with permission.)

sport of injury should occur only when the athlete is ready—confident, agile, and strong—after ACL reconstruction. Patients should be followed long term to assess their function and risk of developing arthritis. We must identify the high-risk individual and intervene. We must draw our focus as medical professionals to reduce the rate of noncontact ACL tears. The benefits given to her by competition at the collegiate level, including an education, confidence to compete in the workplace, and relationships developed through sports greatly outweigh an ACL injury. She may cheer "Be the Man" from the stands, but she gets even more fired up to hear "Be the Woman" as she competes.

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