Dynamic Chiropractic

CHRONIC / ACUTE CONDITIONS

Anterior Cruciate Ligament Injuries in Female Athletes

Manuel Duarte, DC, DABCO, DACBSP, CSCS

Anterior cruciate ligament (ACL) injuries occur with a four-to-six times greater incidence in female athletes than male athletes playing the same landing and cutting sports such as basketball, soccer, football, handball and volleyball.[1] This curious rise of ACL injuries in women, combined with an increase in female participation at all levels of sports, has resulted in intense investigation of the mechanisms responsible for the gender disparity in these debilitating injuries. Injury to the ACL is expensive, often requiring surgical repair, months of rehabilitation, and additional costs including loss of sport participation and scholarship funding, long-term disability and a significant increase in the risk of developing osteoarthritis. The athlete pays a high physical, mental, emotional and economic price for this severe injury.[2]

Over the years, there have been many theories attempting to explain the fundamental cause of the gender difference in ACL injury rates. The causes responsible for increased risk are probably multifactorial in nature and include extrinsic, intrinsic and neuromuscular risk factors. Video analysis has demonstrated ACL injury mechanisms in basketball that include the athlete landing uncontrolled in a high-risk movement pattern (referred to as the "position of no return"). This posture includes the low back being forward-flexed and rotated, hips adducted and internally rotated, knees almost straight and valgus, tibia rotated, foot out of control, and weight forward on the ball of the foot. Compare this with landing in the "safe" position, which means the low back posture is maintained in a normal lordosis, hips are flexed and neutral, knee is flexed, tibia is in a neutral position, feet are in control and center-balanced in a midfoot stance.[3]

Extrinsic Mechanisms of Injury (Controllable)

It has been reported that 70 percent of ACL injuries are noncontact and 30 percent are contact.[4] Boden determined most ACL injuries occurred at foot strike with the knee close to full extension during quick deceleration or landing maneuvers.[5] Olsen concluded ACL injury occurred when the knee was in a position of forced valgus collapse with the knee close to full extension combined with tibial internal rotation. Olsen was able to demonstrate consistent mechanisms of ACL injury in female athletes; these included valgus, extended knee and widened stance.[6]

Bracing: It is unknown whether preventative bracing of the knee can decrease the risk of ACL injury. Boden conducted a small study on bracing and found only 2 percent of ACL injuries occurred while the leg was braced.[5] Bracing decreases anterior tibial translation by 29 percent to 39 percent without the stabilizing contractions of the hamstrings, quadriceps or gastrocnemius muscles. With muscle activation and bracing, anterior tibial translation decreased between 70 percent and 85 percent.

However, the use of braces consistently slows hamstring-muscle reaction times. Wu found knee bracing did not improve functional performance after ACL reconstruction and concluded that bracing actually slowed down running and turning.[7] Most data at this time indicate the current use of braces cannot prevent injury.

Shoe-surface interaction: A study that monitored noncontact ACL injuries in the National Football League for five years concluded that more ACL injuries occurred on natural grass than on an artificial surface and more than 95 percent occurred on a dry field.[8] Cold weather was associated with a lower risk of knee injuries as compared with hot weather. ntrinsic Mechanisms of Injury (Uncontrollable)

Anatomical: Since women have a wider and slightly different-shaped pelvis than men, this can lead to an increased quadriceps angle, which could correlate to increased injury rates. At the same time, other researchers have found Q-angle measurements do not appear to be predictive of either knee valgus or ACL injury risk during movement.[9]

Decreased notch width: Another well-documented anatomical variation is that female athletes have smaller femoral notch widths relative to the size of the ACL than male athletes. Emerson has hypothesized that a narrow intercondylar notch leads to a smaller, weaker ACL.[10] A narrow notch could cause increased lengthening of the ACL under high tension. It should be noted that a small notch is associated with a small ACL and is not gender-specific. Other reports do not demonstrate any relationship between notch width and injury.[1]

Increased general joint laxity: The female athlete has increased general joint laxity relative to her male counterpart. ACL-injured patients have increased genu recurvatum and an increased ability to touch their palms to the floor. Joint laxity not only occurs in the sagittal plane, but also with coronal knee motion (valgus), which can strain the ACL and increase injury risk in female athletes.[5]

Increased muscle (hamstring) flexibility: Boden, et al., found that the hamstring muscles were significantly more lax in ACL-injured athletes compared with controls.[5] Lax hamstrings may lead to a delay in the hamstrings' muscle activation, which results in an absence of co-contraction between the quadriceps and hamstrings for a period of time in early initial contact of the gait cycle.[11] Increased hamstring flexibility could be a potential contributor to increased ACL injury.

Increased anterior translation: One of the functions of the ACL is to limit the amount of tibial translation relative to the femur. The mechanism seems to be related to the natural laxity in female ligaments that allow the tibia to move anteriorly before the supporting muscles have an opportunity to control the movement. The hamstrings and quadriceps help decrease the amount of tibia movement during landing, rapid acceleration and deceleration movements.[12] Landing and pivoting motions during sports involve rapid deceleration and acceleration movements that push and pull the tibia anteriorly and place the ACL under stress.

Increased foot pronation and navicular drop: Women can also demonstrate greater joint laxity in the foot. This increased ligamentous laxity is a possible cause of increased navicular drop in women. Navicular drop could play a role in lower-extremity alignment and tibial translation.[13] Trimble reported that navicular drop was a significant postural predictor of tibial translation and suggested there was a relationship between increased subtalar joint pronation and increased anterior translation of the tibia.[14] Loudon concluded there was an association between noncontact ACL injuries and subtalar joint overpronation.[13] The information on navicular drop and its association between noncontact ACL injuries is limited and more work is needed in this area.

Estrogen effects on ACL injury incidence: Estrogen has been reported to be an underlying cause of increased female ACL injury rates. It has been reported that female soccer players demonstrated a higher incidence of serious injury during the luteal phase of the menstrual cycle just before menses.[15] There are contradictory data describing the effects of hormones on the mechanical properties of ligaments, and this is attributed to a lack of experimental control of the variables of relaxin and estrogen.

Neuromuscular Mechanisms (Partially Controllable)

Agonist-antagonist relationships: When the quadriceps and hamstring muscles coactivate, the knee may be protected against excessive anterior drawer, knee abduction and dynamic lower-extremity valgus. Deficits in strength and activation of the hamstrings limit the potential for co-contraction and decrease the protection of the ACL. If hamstring recruitment is high, the quadriceps can be highly activated, resulting in a moment of internal knee flexion, which is protective. Similar protection mechanisms apply against torsonial loading. Wojtys demonstrated maximal rotations of the tibia were greater in women than in men in both the relaxed and the active muscle state.[16] Therefore, women exhibited less muscular protection of the knee ligaments under internal rotation loading than did men. Valgus torques on the knee can significantly increase anterior tibial translation and load on the ACL, and are significant predictors of future ACL injury risk.

The position of the ankle is an important contributor to knee positioning. Increased ankle eversion is a potential factor related to greater ACL injury rates. Increased valgus knee stress, anterior tibial translation and increased loading on the ACL result from excessive eversion. Female athletes have demonstrated greater maximum ankle eversion than males during cutting maneuvers. This is related to a coupling of foot pronation and internal tibial rotation.[13]

Interventions for injury prevention: Effective intervention programs appear to be composed of similar neuromuscular components that provide a reduction in ACL injury rates in female athletes. Plyometric training combined with biomechanical analysis and technique training were common components in programs that reduced ACL injury rates. In-season training also seems to be a cost-effective and efficient method of achieving beneficial injury-prevention effects.[17]

Plyometrics trains muscles, connective tissue and the nervous system to effectively carry out the muscular stretch/shortening cycle and focuses on proper technique and body mechanics. A six-week preseason training program to reduce landing forces and increase hamstring power has proven effective in reducing ACL injuries.[3]

Analysis of movement biomechanics and education-enforced awareness of dangerous positions and mechanics of ACL injury have also been shown to decrease ACL injuries. Strength training, balance and core-stability training in and of themselves do not appear to add a preventive component. Improvements in strength and proprioception have some benefits, but they do not appear to be sufficient to reduce ACL injury risk.[17]

Although not specifically studied, ancillary interventions have been shown to reduce pronation, navicular dropand tibial rotation. These are factors previously mentioned as contributing to the development of altered mechanics related to an increased risk of ACL injuries in female athletes. The effect of in-shoe orthotics combined with the interventions of plyometrics, movement education, biomechanical enhancements and comprehensive training protocols is an area worthy of future investigation.

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