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Anterior Cruciate Ligament Injuries in Female Athletes

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Anterior cruciate ligament (ACL) tears are common sports-related injuries, with more than 120 000 reported annually in the US.¹ Complete ACL ruptures may cause both acute and chronic physical and psychological morbidity, such as anterior knee pain, osteoarthritis, fear of reinjury, and time missed from sports and physical activity, and they are associated with substantial



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health care costs. Despite modern surgical techniques, only 65% of all athletes return to preinjury level of sport after an ACL rupture and only 55% return to competitive sport.² Males are 1.7 (95% CI, 1.2-2.3) times more likely than females to return to preinjury level of competitive sport after an ACL rupture.²

A 2019 meta-analysis of 36 observational studies reported that female athletes participating in contact sports (such as basketball or soccer) have a significantly higher incidence of ACL rupture during an athletic exposure (defined as a practice session or a competitive event) than males playing the same sports (1.88 vs 0.87 per 10 000 exposures; risk ratio, 3.0 [95% CI, 2.7-3.34]).³ In a population-based historical cohort study, the incidence of ACL rupture decreased for males from 96 per 100 000 person-years in 1990-1994 to 70.9 per 100 000 person-years in 2005-2010 ($P < .001$), while the incidence for females did not change significantly (52.1/1 000 000 person-years in 1990-1994 vs 50.9/1 000 000 person-years in 2005-2010 [$P = .33$]).⁴

Certain risk factors contributing to sex-based ACL injury risk are nonmodifiable, including anatomic and hormonal differences. Compared with males, females have a relatively wider pelvis and shorter femur. However, the role these factors play in ACL injuries is uncertain because these differences in static alignment do not correlate with dynamic stability or ACL injury risk.⁵ The female sex hormones estrogen and relaxin contribute to decreased strength and increased laxity of ligaments; however, with regard to ACL ruptures, the association of these hormone levels or blunting of hormonal fluctuations with therapeutic use of oral contraceptives remains uncertain.⁵ There is no current role for active manipulation of hormones to prevent ACL rupture.

Sex-based ACL injury risk has modifiable risk factors, including neuromuscular strength (such as differences in relative strength between the hamstrings and quadriceps muscle groups) and the biomechanics of dynamic motion at the knee (which is influenced by substantially less gluteal muscle activation during landing in females compared with males), that contribute to increased risk of ACL injury in females.⁵ These differences in activation and strength of large muscle groups around the hip and knee result in different dynamic landing patterns when running, jumping, or pivoting. Compared with males, females typically exhibit increased hip internal rotation and both excessive valgus motion and torque at the knee when landing from a jump. This results in less control and stability of the knee during landing and directional change,

which leads to increased stress on the ACL and an increased risk of ACL injury.⁵

Interventions that address these modifiable risk factors in female athletes can decrease ACL injury risk. A 2019 systematic review and meta-analysis of 18 clinical trials (27 231 participants) of neuromuscular training programs (which correct imbalances between hamstring and quadriceps strength), plyometric training (which improves the ability to generate rapid muscle forces over shorter periods of time), balance exercises, and stretching routines vs no similar training reported these prevention programs were associated with reduced risk of ACL injury from 1 in 54 (1.85%) to 1 in 111 (0.9%) female athletes.⁶

Biological sex-based explanations may not fully explain the discrepancy between the difference in ACL risk and outcomes in female and male athletes.⁷ For example, during childhood, girls may be exposed to different play activities than boys, which can affect the development of muscular strength and physical skills. During their sporting lives, females might have access to inferior-quality sporting grounds and training facilities for physical activity compared with boys.⁷ Although requiring additional research, the differential social and cultural experience of females may influence the risk of ACL injuries during training and competition and may affect treatment and rehabilitation outcomes after an injury.⁷

Surgical reconstruction is the recommended treatment for most ACL ruptures, especially for individuals who intend to return to a physically demanding sport. ACL reconstruction is typically performed arthroscopically, using a graft to replace the torn ACL. The graft options include native iliotibial band, hamstring, quadriceps, or patellar tendon (autograft) and cadaver tendons (allograft). Some studies have reported inferior results when allografts or hamstring grafts are used in young and highly active patients, but no high-level evidence identifies a clearly superior graft option for females in general.⁸

In a meta-analysis of 8 observational studies (2518 patients), graft failure risk was similar among females (5.4%) and males (4.6%) (relative risk, 0.93 [95% CI, 0.51-1.42]), and no sex-based difference was found in anterior knee pain and osteoarthritis after reconstruction (relative risk, 1.0 [95% CI, 0.91-1.11]; absolute rates not reported).⁹ However, a 2023 systematic review and meta-analysis (242 observational studies; 123 687 patients) found that females self-reported worse functional outcome measures in the first 10 years after ACL injury across 4 different validated scales and scores that included knee instability, locking, swelling, limping, stair climbing, squatting, and overall activity levels.¹⁰

Conclusions

Female athletes have higher risks of sustaining an ACL rupture and lower odds of returning to sport than male athletes. However, ACL injury prevention programs are effective for female athletes and can be implemented with minimal cost. The global attention on the Olympics is an opportunity to deliver this message.

ARTICLE INFORMATION

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