



ACL I – Risk Factors AAP Position Statement

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Anterior Cruciate Ligament Injuries: Diagnosis, Treatment and Prevention

- ACL injury risk in young athletes is likely multifactorial.
- Injury data from many fields demonstrate that numerous physical and psychological parameters affect ACL injury rates.



Genetics

- Genetic factors likely play a role.
- The genetic underpinnings of increased ACL injury have only recently begun to be examined



Hormones

- Hormonal factors also likely play a role.
- Results of studies investigating hormonal factors are both equivocal and controversial.
- The female knee appears to get slightly more lax on the order 0.5 mm, at mid-menstrual cycle.
- Injuries tend to cluster near the start of menses at the polar opposite time in the cycle.



Prior Injury

- One of the single best predictors of future ACL injury is prior ACL injury.
- One study found the incidence rate of ACL injury in athletes who had ACL reconstruction was 15 times greater than that of control subjects.
- Female athletes were 4 times more likely to suffer a second ACL injury in either knee and 6 times more likely to suffer a new ACL injury in the contralateral knee than male athletes.



Prior Injury

- Subsequent injuries to the contralateral ACL are twice as common as re-injury of the reconstructed ACL (11.8% vs 5.8%).
- Genetic, anatomic and neuromuscular factors likely play a role.



Age and Sex

- Although ACL injury rates increase with age in both sexes, girls have higher rates immediately following the growth spurt.
- It is likely that the increases in body weight, height and bone length during pubertal development underlie the mechanism of increased risk of ACL injury with increasing age.
- During puberty, the tibia and femur grow at a rapid rate.



Age and Sex

- This growth of the 2 longest levers in the human body translates into greater torques on the knee.
- Increasing height leads to a higher center of mass, making muscular control of this center of mass more challenging.
- Increasing body weight is associated with greater joint force that is more difficult to balance and dampen during high velocity athletic movements.



Age and Sex

- In pubertal boys, testosterone mediates significant increases in muscular power, strength and coordination, which affords them with greater neuromuscular control of these large body dimensions.
- Pubertal girls do not experience this same growth spurt in muscular power, strength and coordination, which likely explains their higher rates of ACL injuries compared with pubertal boys.



Age and Sex

- The fact that preadolescent athletes show no sex differences in ACL injury rates further supports this theory.



Anatomic/Anthropometric Factors

- Greater weight and body mass index (BMI) have been associated with increased risk of ACL injury.
- A study of military recruits found that body weight or BMI greater than 1 standard deviation above the mean was associated with 3.2 and 3.5 times greater risk of ACL injury.
- In a study of female soccer players older than 8 years, BMI was a significant risk factor for knee injury.



Anatomic/Anthropometric Factors

- An increased quadriceps angle (Q angle) has been postulated as a risk factor, but there have been no prospective clinical studies to investigate the relationship between quadriceps angle and ACL injury.
- A narrow intercondylar notch, where the ACL is housed, is proposed to increase ACL injury risk because a narrow notch tends to be associated with a smaller,



Anatomic/Anthropometric Factors

- weaker ACL and could cause increased elongation of the ACL under high tension.
- Some studies have shown that a narrow notch increases risk however other have shown no association.
- Subtalar joint overpronation has been associated with noncontact ACL injuries, likely because overpronation increases anterior translation of the



Anatomic/Anthropometric Factors

- tibia with respect to the femur, thereby increasing the strain on the ACL.
- Generalized joint laxity and knee hyperextension were found to significantly increase the risk for ACL injury in female soccer players.
- ACL injured patients have significantly more knee recurvatum at 10 and 90 degrees of hip flexion and an increased ability to touch palms to floor.



Anatomic/Anthropometric Factors

- Athletes with generalized joint laxity had a 2.7 times greater risk of ACL injury than did those without generalized laxity, and those with increased anterior-posterior laxity, as measured by a knee arthrometer, had an approximately 3 times greater risk of ACL injury than did those without increased anterior-posterior laxity.



Anatomic/Anthropometric Factors

- Joint laxity affects not only sagittal knee motion (hyperextension) but also coronal knee motion (valgus) which can strain the ACL and be related to increased risk in athletes.



Neuromuscular Factor

- Muscle strength and coordination have a direct effect on the mechanical loading of the ACL during sport movements.
- Poor neuromuscular control of the hip and knee and postural stability deficits have shown to be risk factors for ACL injury.
- Landing and pivoting sports involve a great deal of rapid deceleration and



Neuromuscular Factor

- acceleration movements that push and pull the tibia anteriorly and place the ACL under stress.
- This tibial translation can be modulated by hamstrings and quadriceps activity.
- In vivo studies who when subjects were asked to contract their muscles, knee laxity is reduced by 50% to 75%.
- Activation of the quadriceps before the



Neuromuscular Factor

- hamstrings, a pattern more frequently seen in females, increases the anterior shear force that directly loads the ACL and also could be related to increased dynamic valgus alignment at initial contact during cutting and landing maneuvers.
- Fatigue is often cited as a potential risk factor for ACL injury, there are relatively few published data to support or refute this.





Questions & Discussion



ACL II – Prevention Programs AAP Position Statement

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Bracing

- It is unlikely that prophylactic bracing can decrease the risk of ACL injury.
- The relative effects of 6 different brace designs on anterior tibial translation and neuromuscular function were studied in chronically unstable ACL-deficient patients.
- Bracing decreased anterior tibial translation in the range of 30% to 40% without the stabilizing contractions of the hamstrings, quadriceps or gastrocnemius muscles.



Bracing

- With muscle activation and bracing, anterior tibial translation was decreased between 70% and 85%. However, the braces slowed hamstrings muscle reaction time.
- A brace with a 5-degree extension stop decreased extension on landing.
- Knee bracing does not improve functional performance of subjects after ACL reconstruction and may actually reduce running and turning speed.



Bracing

- Functional bracing after ACL reconstruction has been studied using randomized controlled cohorts placed into braced or non-braced groups.
- The braced group was instructed to wear a functional knee brace for all cutting, pivoting or jumping activities for the first year after ACL reconstruction.
- There were no differences between groups in knee stability, functional testing, subjective knee scores, and range of motion or strength testing.



Bracing

- Investigators concluded that post-operative bracing did not change outcomes.
- Data are insufficient at this time to determine whether functional bracing decreases the risk of ACL injury or re-injury.



Neuromuscular Training Programs

- Although ACL injuries occur too quickly for reflexive muscular activation, athletes can adopt or “pre-program” safer movement patterns that reduce injury risk during landing or pivoting or unexpected loads or perturbations during sports movements.
- With sufficient neuromuscular control of knee position to avoid dynamic valgus, knee stability may be improved during competitive sport and the risk of ACL injury can be significantly reduced.



Neuromuscular Training Programs

- A collection of prospective cohort studies and randomized controlled trials have examined the effect of neuromuscular training programs on ACL, knee and other lower-extremity injuries in soccer, basketball, volleyball and handball.
- Some studies used only 1 or 2 types of exercises such as plyometric or balance exercises, and others applied a more comprehensive approach by including plyometrics (repetitive jumping exercises designed to build lower extremity strength and



Neuromuscular Training Programs

power), strengthening, stretching and balance training.

- Systematic examination of the data extracted from these studies leads to a few potentially valuable generalizations.
- Plyometric training combined with technique training and feedback to athletes regarding proper form were the common components of programs that effectively reduced ACL injury rates.



Neuromuscular Training Programs

- Balance training alone may not be sufficient to reduce ACL injury.
- Some of the effective programs did not include strength training, those that did were among the most effective at decreasing ACL injury rates.
- ACL injury reduction was greatest for soccer, and combined pre- and in-season training was more effective than pre- or in-season training alone.



Neuromuscular Training Programs

- With respect to age, the greatest reduction in injury risk was demonstrated for female athletes in their mid-teens (14-18 years) compared to those in their late teens (18-20 years) and adults (>20 years), with 72% risk reduction for those <18 years of age and 16% risk reduction for those > 18 years of age.
- This suggests the best window of opportunity for ACL injury risk reduction may be during early pubertal maturation, at or just before girls' neuromuscular risk factors start to become



Neuromuscular Training Programs

evident and ACL injury rates in girls dramatically increase.

- It is unknown whether neuromuscular training or other interventions can modulate the increased risk of early-onset degenerative knee arthritis after ACL injury.
- More information about specific evidence-based neuromuscular training programs can be found in the respective articles describing their study results.



Neuromuscular Training Programs

- The AAP has compiled a series of instructional videos for pediatricians, athletes and coaches who would like to learn more about neuromuscular training and preventive exercises.





Questions & Discussion
