# Which Anterior Cruciate Ligament Prevention Programs are Effective in Decreasing Injury Rates and Improving Neuromuscular Indices in Female Athletes?

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INTRODUCTION: Anterior cruciate ligament (ACL) tears are common knee ligament injuries that have serious short- and long-term consequences. Approximately 250,000 ACL injuries occur in the US alone each year. ACL reconstruction does not always restore normal knee kinematics, despite advanced surgical procedures and rehabilitation. Authors have reported that 5-30% of patients who undergo ACL reconstruction will suffer a tear to either the reconstructed knee or contralateral knee upon return to sports activities. Multiple studies have demonstrated that female athletes have an increased risk of sustaining noncontact ACL injuries compared with male athletes in soccer, basketball, gymnastics, handball, and in military training. Although over 30 ACL prevention training programs have been described in the literature, few have been scientifically proven to decrease injury incidence rates and alter potentially dangerous neuromuscular movement patterns.

METHODS:

A review of the published literature using PubMed from 1995 to 2016 was performed to determine which ACL intervention programs have significantly decreased both the noncontact ACL injury rate and altered dangerous neuromuscular movement patterns in female athletes. Keywords included: knee ligament injury prevention, anterior cruciate ligament injury prevention, ACL intervention, neuromuscular retraining, and neuromuscular female athlete.

RESULTS:

Over 30 ACL intervention programs have been published since 1995. Nine reported the incidence of noncontact ACL injuries according to 1000 athlete-exposures (AE) in trained and control female athletes. Of these, only 3 effectively reduced the incidence of injury, all in high school athletes. The differences in the injury incidence rates between control and trained athletes were 0.21 and 0.03, respectively ($P = .03$), after Sportsmetrics; 0.48 and 0.10, respectively ($P = .04$), after Knee Injury Prevention Program (KIPP); and 0.49 and 0.09, respectively ($P < .0001$), after Prevent Injury and Enhance Performance Program (PEP). Kinematic and kinetic data were also reported upon completion of Sportsmetrics and PEP training. Sportsmetrics significantly improved lower extremity muscle strength and hamstrings:quadriceps ratio, decreased landing forces, decreased knee moments, improved lower limb alignment, and improved balance scores in several studies. PEP significantly improved lower extremity muscle strength and hamstrings:quadriceps ratio, decreased valgus knee moments, improved lower limb alignment, and increased knee flexion angles in separate studies.

Kinematic, kinetic, or balance data were reported upon completion of training in 23 other programs. Overall, improvements in some of these parameters were reported in 18 programs; however, the data were inconsistent. For instance, lower limb alignment on jumping tasks was studied in 8 programs and was improved (decrease in valgus) in only 2 studies. Landing forces were measured in 9 studies and were improved (reduction in vertical ground reaction forces) in just 3 studies. The effect of training on increasing knee flexion angles on landing from a jump was studied in 10 programs, of which 6 were effective.

DISCUSSION AND CONCLUSION:

Although over 30 ACL intervention programs have been published to date, only 2 have significantly decreased both the noncontact ACL injury rate and altered dangerous neuromuscular movement patterns in female athletes. Factors involved in the failure of other programs to be successful include short training duration sessions, unsupervised sessions, lack of compliance with training schedules, lack of increasing challenge in training exercises, failure to include plyometrics with body positioning instruction, and lack of comprehensive strength training (lower extremity, core, trunk). Clinicians interested in implementing ACL injury prevention training should be aware of these problems and select a proven program. Investigators interested in developing new programs should understand the components required to alter potentially dangerous movement patterns and increase lower extremity strength. Successful training requires a dynamic warm-up, supervised plyometrics, strength training for hamstrings/hip/core/trunk, and supervised agility training for cutting and pivoting motions.