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Prevention of Knee and Anterior Cruciate Ligament Injuries Through the Use of Neuromuscular and Proprioceptive Training: An Evidence-Based Review

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Clinical Question: Is neuromuscular and proprioceptive training effective in preventing knee and anterior cruciate ligament (ACL) injuries?

Data Sources: The authors searched CINAHL, Cochrane Central Register of Controlled Trials, MEDLINE/EMBASE, PubMed, and Web of Science databases from 1996 through December 2014 and limited the results to peer-reviewed manuscripts published in English. Search terms for all databases were *knee injury* OR *knee injuries*; OR *anterior cruciate ligament injury* OR *anterior cruciate ligament injuries*; OR *ACL injury* OR *ACL injuries*; OR *lower limb injury* OR *lower limb injuries* AND *prevention*.

Study Selection: Inclusion criteria were (1) English language, (2) published from 1996 through 2014, (3) the intervention used neuromuscular or proprioceptive training to prevent knee or ACL injuries, (4) human participants, (5) the incidence of knee or ACL injury was provided.

Data Extraction: For the articles that met the inclusion criteria, 2 authors worked independently using the Jadad scale to extract the first author, year of publication, title, sport type, participant sex, participant age, country in which the study was conducted, number of participants in the control and intervention groups, intervention characteristics or components, and knee or ACL injury outcome.

Main Results: A total of 24 studies with 1093 participants were included in this review. Intervention efficacy was determined from weighted incidence rate ratios. After the intervention of neuromuscular and proprioceptive training exercises, the incidence ratio (frequency of a disease or injury occurrence in a population over a specific time frame) was calculated at 0.731 (95% confidence interval = 0.614, 0.871) for knee injury and at 0.493 (95% confidence interval = 0.285, 0.854) for ACL injury. This indicated a link between neuromuscular and proprioceptive training programs and injury reduction. No significant correlation was present between more components added to training and a greater decrease in injury to either the knee or ACL.

Conclusions: Neuromuscular and proprioceptive training appeared to decrease the incidence of injury to the knee and specifically the ACL. However, no evidence suggested that a specific group of exercises was better than others.

Key Words: traumatic injuries, recurrence, injury prevention

COMMENTARY

Each year, more than 2 million anterior cruciate ligament (ACL) injuries are reported worldwide, with a greater prevalence in young female athletes.[1] Multiple modifiable and nonmodifiable risk factors (eg, biological, hormonal, biomechanical, and psychosocial) can influence an individual's susceptibility to knee injury.[2] Decreased neuromuscular control and high-risk movement biomechanics appear to be significantly influenced by abnormal trunk and lower extremity movement patterns.[3] Athletic trainers (ATs) commonly implement neuromuscular and proprioceptive training exercises in an attempt to correct high-risk movements and prevent ACL injuries. However, the literature supporting the use of neuromuscular-control training as an injury-prevention technique is conflicting. The authors of this meta-analysis[4] examined neuromuscular and proprioceptive training programs for the prevention of knee and ACL injuries. Of the 24 studies included, 20 studies provided data on knee injuries and 16 specifically on ACL injuries. To assess the methodologic quality of clinical trials and reduce bias, researchers can use the Oxford quality scoring system, also referred to as the Jadad scale.[5] The Jadad scale is a representative quality-assessment tool consisting of 3 factors: randomization (2 points), double blinding (2 points), and dropout rate (1 point). The maximum score is 5 points, and higher Jadad scores are associated with more conservative estimates of an intervention's efficacy. The authors also sought to determine the specific components of exercises that were most successful in preventing knee and ACL injuries. The technical components (range = 0–5) were summed to indicate whether programs with more components had better or worse outcomes. The components of neuromuscular control and proprioception on which the authors focused were balance training, plyometric (jump) training, strength and resistance training, running-technique training (combined technique training and running exercises [eg, shuttle run, bounding run]), and stretching.

The authors did not find a significant association between any single training component and injury prevention for either the knee in general or the ACL specifically. Intervention efficacy was determined from weighted incidence rate ratios (IRRs) using a random-effects model. *Incidence ratios* are measures of the frequency with which a disease occurs in a population over a specified time frame, typically 1 year. After intervention of the neuromuscular and proprioceptive training exercises, the summary IRR was estimated at 0.731 (95% confidence interval = 0.614, 0.871) for knee injury and 0.493 (95% confidence interval = 0.285, 0.854) for ACL injury, indicating a protective effect between neuromuscular and proprioceptive prevention programs and injury reduction. This was surprising as neuromuscular and proprioception exercises are typically termed *ACL injury-prevention programs* rather than *knee-injury prevention programs*. It is interesting that the analysis did not demonstrate a significant association between any single training component and injury prevention, either for knee injury or for ACL injury. The results suggested that the specific components of the injury-prevention program were not as key as the time of implementation. Interventions started in the preseason (IRR = 0.237) were better at preventing knee injuries ($P = .0016$) than those started during the season (IRR = 0.754), and they had a protective, though nonsignificant effect on ACL injuries. More training (eg, more components) was not associated with better outcomes ($P = .55$), nor were different training components associated with fewer ACL injuries. Ultimately, the researchers confirmed that neuromuscular and proprioceptive training prevented both knee and ACL injuries.

This meta-analysis had 4 noteworthy limitations. Different neuromuscular and proprioceptive exercise programs used different components, which limited the researchers' ability to detect differences in the effectiveness of the training components. Further investigation is needed to determine which training programs are homogeneous, thereby allowing for better statistical and clinical comparisons. The authors did not cite any research on the use of multifaceted interventions including video or technical feedback, which have been shown to be effective in reducing both hamstrings and ACL injuries.[6] In addition, a clear statistical bias has been observed in studies conducted on this type of training. In the meta-analysis, 63% of the investigations focused on female athletes, making it difficult to generalize between sexes. Although there is no one-size-fits-all knee or ACL injury-prevention program, ATs should continue to incorporate neuromuscular and proprioceptive exercises in their injury-prevention regimens. To prevent athletes' knee injuries, ATs should use a combination of components: balance training, plyometric training, strength and resistance training, running-technique training (combined technique training and running exercises [eg, shuttle run, bounding run], and stretching). Regardless of the athlete's sex or sport, ATs should work with coaches to find specific neuromuscular and proprioceptive exercises that can be incorporated into each practice session.

Athletes expect ATs to help them prevent knee and ACL injuries. Neuromuscular and proprioceptive training programs have been demonstrated to reduce knee and ACL injuries. Athletic trainers should consider the injury-prevention techniques they currently use and combine them with neuromuscular and proprioceptive training techniques that can be performed both preseason and in-season. Because no particular neuromuscular or proprioceptive training technique was associated with a reduction in knee or ACL injury, ATs can select the components they believe are most appropriate for each athlete, regardless of sex or sport. Further research needs to be conducted to identify the specific components of neuromuscular and proprioceptive training that contribute to the prevention of knee and ACL injuries.

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