Canadian Academy of Sport and Exercise Medicine Position Statement: Neuromuscular Training Programs Can Decrease Anterior Cruciate Ligament Injuries in Youth Soccer Players

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INTRODUCTION

This Canadian Academy of Sport and Exercise Medicine (CASEM) position statement reviews the literature and concludes that youth soccer players and their coaches can decrease the incidence of anterior cruciate ligament (ACL) injuries of the knee through the implementation of neuromuscular training (NMT) programs. Furthermore, we propose a coordinated Canada-wide adoption of such injury prevention programs.

BACKGROUND INFORMATION

Close to a quarter of a million ACL injuries occur each year in Canada and in the United States.[1] Anterior cruciate ligament injuries are common in sports that involve sudden changes of direction, quick decelerations, and awkward landings after a jump.[2,3] Anterior cruciate ligament injuries usually result in prolonged postoperative recovery and time away from soccer to complete rehabilitation. There is often significant morbidity associated with ACL injuries as a result of long-term persistent symptoms and increased incidence of osteoarthritis later in life.[4–13] The injury, surgery, and rehabilitation process usually keeps an athlete out of competition for up to 1 year. The psychological effects can be profound. Fear of reinjury and loss of confidence can be major factors precluding an athlete's return to play.[5,14] The university athlete may also lose a year of school and possibly scholarship funding.

Multiple studies have demonstrated that these ACL injuries may be preventable.[15–18] The implementation of NMT programs has been shown to be of potential benefit in reducing ACL injuries in female soccer players.[15–18] However, recent research has shown that NMT programs can also be beneficial in reducing such injuries in male soccer players.[19,20] In this article, we will examine ACL injury prevention and describe strategies that can deliver these programs to all Canadian youth soccer players.

ANTERIOR CRUCIATE LIGAMENT INJURY RISK FACTORS AND GENDER DIFFERENCES

Female athletes, including soccer players, have a 4 to 8 times greater risk than male athletes of sustaining a noncontact ACL injury in multidirectional sports.[21–29] The reasons for this gender difference are likely multifactorial and may involve anatomical, hormonal, neuromuscular, and biomechanical differences.

Anatomical and Hormonal Risk Factors

Anatomical risk factors include a narrower intercondylar notch, smaller cross-sectional area of the ACL, and laxity

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of the knee joint.[23,25,30–32] Sex hormones may also act directly on the ACL, potentially changing its tensile strength. Studies indicate that a higher number of ACL injuries occur in the follicular phase of the menstrual cycle, but the relationship between hormone levels, ligamentous laxity, and injuries is not well understood.[33] Oral contraceptives may play a protective role in ACL injuries, but additional research is needed before hormonal manipulation can be recommended as a strategy for the prevention of injury.[34–36]

Neuromuscular and Biomechanical Risk Factors

Many studies have evaluated the differences in female and male athletes' movement patterns, strength, and proprioceptive abilities in an attempt to explain the higher incidence of noncontact ACL injuries in female athletes.[21,37–45] Female athletes perform movements at high risk for ACL injury, such as cutting and landing from a jump, with decreased flexion and increased valgus angles at the knee. These positions of the knee may contribute to additional strain on the ACL and therefore an increased risk of injury.[39,40,44] Prospective studies have identified deficits in core stability and control that were predictive of ACL injury in female but not male athletes.[46,47] Women experience higher cumulative deterioration of their isokinetic leg strength associated with knee flexion after intermittent high-intensity exercise, an inherent demand in soccer. Therefore, an exercise program that focuses on neuromuscular control of the trunk, hip, and knee may decrease noncontact ACL injuries in women.[41]

An outcome from the Hunt Valley II Meeting on ACL injury prevention was identification of the various components that influence dynamic joint loading, including central nervous system control, nerve–muscle interaction, and muscle and joint factors.[36] This consensus group recommended training proper technique in cutting and landing movements through such activities as gait training, agility drills, and plyometrics. The group also identified factors that may increase dynamic joint loading and strain on the ACL. These factors include fatigue, lowered torsional stiffness of the knee, muscle strength imbalance in the lower limb, unanticipated cutting or cutting, and landing with poor technique (ie, the knee in valgus). The group concluded that training can be used to reduce noncontact ACL injuries by modifying these components. For example, training exercises that improve the early recruitment and strength of the hamstring muscles may reduce anterior tibial translation and therefore reduce ACL strain during cutting activities and landing from a jump.[36]

EVIDENCE FOR NEUROMUSCULAR TRAINING PROGRAMS IN REDUCING ANTERIOR CRUCIATE LIGAMENT INJURY RISK

Over the past decade, there has been conflicting evidence to support the effectiveness of NMT training programs in reducing the incidence of ACL injury.[15–18,48–50] However, a series of meta-analyses now exist to support NMT programs. In 2006, Hewett et al[51] reviewed 6 studies and found that balance training was not effective by itself but only when combined with other types of training. Grindstaff et al conducted a review of original research studies that compared NMT programs with control programs to determine the number of noncontact ACL injuries per event exposure or hours of playing time. Five studies met the inclusion criteria. The authors estimated the crude incidence rate ratio for intervention versus comparison groups to be 0.30 [95% confidence interval (CI), 0.26-0.61].[52] In other words, a 70% reduction in the incidence of ACL injuries was observed in the NMT group compared with the control group.

Yoo et al[22] evaluated the effectiveness of ACL injury prevention programs by performing a meta-analysis of 7 prospective cohort studies. Their study concluded that NMT prevention programs were effective at reducing the risk of ACL injury in female athletes. Training was more effective at decreasing ACL injury risk in subjects younger than 18 years of age and for subjects who played soccer compared to handball. Additionally, preseason and in-season training had higher injury prevention efficacy than either preseason or in-season training alone. Their analysis identified that plyometric, strengthening, and balance exercises are essential for a successful training program that can serve to prevent injuries and enhance performance.

A systematic literature review and meta-analysis authored in 2012 by Sadoghi et al sought to determine whether a particular NMT program offered superior protection when compared to other programs.[19,20] The heterogeneity of the 14 NMT studies that were analyzed prevented the authors from choosing "the best" training program to prevent ACL injuries. However, all of the interventions that reduced ACL injuries had prevention programs that included exercises with a neuromuscular focus and were performed for at least 10 minutes, 3 times a week. Furthermore, their review provided strong evidence in support of ACL injury prevention program effectiveness, with a risk reduction of 52% in the female athletes and 85% in the male athletes.[19,20] This meta-analysis supports our recommendation for NMT programs to be implemented across genders.

A 2012 systematic review and meta-analysis by Gagnier et al[53] included 8 cohort (observational) studies and 6 randomized trials, involving a total of approximately 27 000 participants. The random-effects meta-analysis yielded a pooled rate-ratio estimate of 0.485 (95% CI, 0.299-0.788; $P = 0.003$), indicating a lower ACL injury rate in the intervention groups. However, there was appreciable heterogeneity of the estimated effect across studies. The authors found that various types of neuromuscular and educational interventions seem to reduce the incidence of ACL injuries by approximately 50%, but the estimated effect varied appreciably among studies.

In a meta-analysis that focused on female athletes, Myer et al[54] suggested an optimal age window exists to maximize the positive effects of NMT programs in young female athletes. The authors found a 72% risk reduction in female athletes 18 years of age or younger, but only a 16% reduction for those older than 18 years. They concluded that the optimal time to initiate an NMT program is during early adolescence, before the changes in mechanics that increases injury risk occur.[54]

THE FIFA 11+

Fédération Internationale de Football Association (FIFA) is the international governing body of association football (soccer). Since 2003, FIFA has promoted injury prevention exercises. The 11+ exercises can be viewed at

http://f-marc.com/11plus/exercises/.[55] The "11+" was developed by a group of international experts from FIFA's Medical Assessment and Research Centre (F-MARC), the Oslo Sports Trauma Research Center, and the Santa Monica Sports Medicine Foundation.

CONSIDERATIONS FOR IMPLEMENTATION

Although the effectiveness of specific ACL injury prevention programs has been demonstrated, compliance and uptake of the programs may be a critical factor in decreasing ACL injuries overall.[18,56] Finch[56] suggests that athletes, coaches, and sports administrators will only adopt injury prevention strategies if certain criteria are met. They need to be convinced that the proposed strategies will actually prevent injuries, will not change the nature or enjoyment of the sport, will enhance rather than negatively affect performance, and are easy to do.[56,57] Exercises are often designed as structured warm-up programs to ensure that all players use the program regularly.[58] In youth soccer, coaches are often the decision makers regarding the implementation of injury prevention programs. Coaches are less likely to implement injury prevention programs if they are not soccer specific or take too much time away from regular practice.[18] To be effective, ACL injury prevention training programs must accomplish 2 goals: (1) ameliorate known risk factors, and (2) be adopted by coaches and athletes and performed on a consistent and ongoing basis.

In Canada, the governing bodies for soccer include the Canadian Soccer Association (CSA) nationally and a provincial soccer association for each province. To be successful, the CSA and the provincial soccer associations must support an injury prevention program at the governance (board) level and at the technical (coaching) levels of administration. Such support should include an injury prevention component within the various coaching certification courses. This injury prevention component would provide the rationale and practical information on how to implement an injury prevention warm-up. The introduction of this training should be at the community level coaching courses and then would increase in detail and complexity in more advanced coaching courses. A "train the trainers" model would be employed, having a qualified health care professional deliver this module of the coaching program. The module would include practical demonstrations of the injury prevention exercises, a question and answer period, and DVDs and handouts demonstrating the same exercises for the coaches. Players could access this information on the CSA Web site where professional and national team players could be observed doing the program.

In a meta-analysis, Sugimoto et al[59] found that the incidence of ACL injury was lower in studies with good compliance with NMT programs than in studies with poor compliance. To improve compliance, coaches need to be educated about the potential performance benefits, in addition to the effectiveness for injury prevention.[58,60] Indeed, recent studies show that the coach is the key partner ensuring high player adherence to the program.[61–63] In addition to injury prevention, Reis et al[64] showed that the "11+" can be used as an effective conditioning means for improving physical fitness and technical performance of youth futsal (officially recognized as 5-a-side indoor soccer) players. Compliance will be further enhanced by ensuring that the programs delivered are time efficient (ie, included as part of the preexisting warm-ups), cost effective (ie, no additional equipment), and soccer specific.[18,56] Team or group training remains the most feasible means of implementing injury prevention training, especially in youth sports. Qualified health care professionals can monitor teams for frequency, content, and quality of delivery of the programs on the field. They can also provide a resource for the coaches regarding questions, correction, and feedback. We recommend that the costs of implementing these programs be shared among the governing body, soccer leagues, and teams. An appendix is posted on the CASEM Web site and provides information regarding how 1 Canadian community has implemented a youth soccer NMT program. It is not yet clear which components of the current FIFA "11+" protocols are most effective at preventing ACL injuries. However, there is sufficient evidence for us to recommend that all Canadian youth soccer teams institute such training programs now.

TABLE. Strength of Recommendation Grades[65]

Strength of Recommendation	Basis of Recommendation
A	Consistent, good quality, patient-oriented evidence
B	Inconsistent, or limited quality, patient-oriented evidence
C	Consensus, disease-oriented evidence, usual practice, expert opinion, or case series for studies of diagnosis, treatment, prevention, or screening

RECOMMENDATIONS

The Canadian Academy of Sport and Exercise Medicine makes the following recommendations with respect to ways in which youth soccer players and their coaches can decrease the incidence of ACL injuries. The Table shows the definition of scoring recommendations, which are based on those reported by Ebell et al[65]

1. All Canadian youth soccer players should engage in exercise programs that incorporate neuromuscular, proprioceptive, agility, and strength training in their routine practice and warm-ups (Strength of Recommendation = A).
2. These NMT programs should be commenced at least by the early teenage years (Strength of Recommendation = A).
3. During the performance of the ACL injury prevention program in training, the coaches and trainers should give effective feedback on the performance of the drills, and players should learn from watching each other perform the tasks (Strength of Recommendation = B).
4. National and provincial soccer governing bodies should develop age-specific ACL injury prevention programs and monitor these programs for effectiveness based on the latest available evidence (Strength of Recommendation = B).
5. Soccer teams should collaborate with a qualified health or physical education professional in the institution of an ACL injury prevention program for the team's training sessions (Strength of Recommendation = A).

6. Professional organizations of sport medicine physicians, physiotherapists, chiropractors, athletic therapists, and physical education teachers can lead by encouraging their members to provide appropriate educational sessions and educational materials to soccer teams (Strength of Recommendation = C).
7. Ongoing research to refine these programs according to the current evidence-based best training practices is essential (Strength of Recommendation = B).
8. Ongoing understanding, development, and refinement of implementation strategies are needed to improve compliance and uptake of the prevention programs (Strength of Recommendation = A).

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