Prevention of Soccer-Related Knee Injuries in Teenaged Girls

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Background: Knee injuries end many careers among female soccer players. The number of injuries can be anticipated to increase because of the increasing popularity of the sport worldwide and the higher incidence of knee injuries among young females compared with males.

Methods: In a community-based intervention trial performed from February 1 through October 31, 2007, we sought to reduce the number of knee injuries among female soccer players aged 13 to 19 years (N=1506), representing 97 teams from 2 Swedish counties. A physical exercise program designed exclusively for female soccer players was combined with education of athletes, parents, and coaches to increase awareness of injury risk. The training program aimed to improve motor skills, body control, and muscle activation. New acute knee injuries, diagnosed by the physician, were the main outcome measure.

Results: Three knee injuries occurred in the intervention group and 13 occurred in the control group, corresponding to incidence rates of 0.04 and 0.20, respectively, per 1000 player hours. The preventive program was associated with a 77% reduction in knee injury incidence (crude rate ratio, 0.23; 95% confidence interval, 0.04-0.83). The noncontact knee injury incidence rate was 90% lower in the intervention group (crude rate ratio, 0.10; 95% confidence interval, 0.00-0.70). Adjustment for potential confounders strengthened the estimates. Forty-five of the 48 intervention teams (94%) reported a high adherence of at least 75%.

Conclusion: The incidence of knee injuries among young female soccer players can be reduced by implementation of a multifaceted, soccer-specific physical exercise program including education of individual players.

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SOCCER IS A DOMINANT CAUSE of sports-related injuries because of the large number of players.[1-3] Women's soccer, in particular, is increasing in popularity; between 2000 and 2006, the number of female soccer players increased by 19% to 26 million players worldwide.[1] The United States Soccer Federation alone has more than 1.6 million registered female soccer players.

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The most frequent and severe type of injury among soccer players is to the legs, especially the knees.[4,5] The anterior cruciate ligament (ACL) injury incidence is highest among young athletes.[6,7] Furthermore, female soccer players have a risk of ACL injury several times higher than that of men,[6,7] an observation partly explained by a combination of anatomical, hormonal, biomechanical, and neuromuscular differences between the sexes.[7] With the growing number of young female soccer players,[1] a rapid increase in the incidence of ACL injury can be anticipated. Knee injuries, and especially ACL ruptures, may have long-term consequences, including a long absence from soccer, incomplete recovery, and secondary osteoarthritis of the knee.[6]

Training programs for the reduction of knee injuries have been developed based on the notion that the risk of ACL injury could be reduced by improving motion patterns via neuromuscular and proprioceptive training.[7,8] When these programs were tested among young female soccer players, results have been conflicting.[9-13] Although one program resulted in a reduced injury rate,[9] all suffered from low compliance or did not report compliance with the program investigated.[9-13]

We hypothesized that an intervention program that was specifically designed to improve awareness of injury risk, maximize adherence, and promote proper motion patterns would reduce the incidence of knee injuries among female soccer players aged 13 to 19 years. The exercise portion was designed to be soccer-specific and easy to include during regular practice sessions at no cost.

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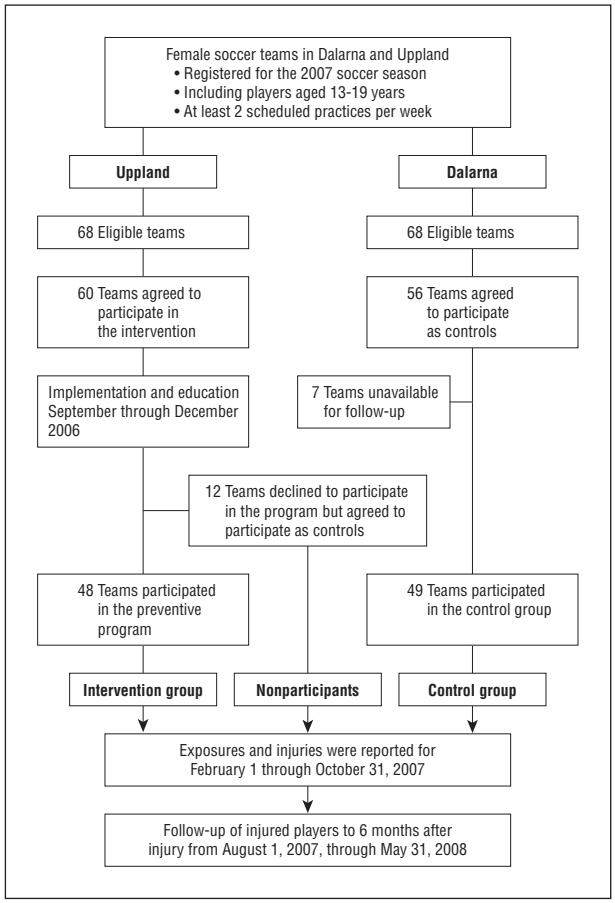

Figure. Flowchart of the study design.

METHODS

Using a regional approach with inclusion at the team level, teams in 2 Swedish counties (Uppland and Dalarna) were invited by mail to participate in the study if they were registered for participation in the 2007 female soccer season, had registered players between ages 13 and 19 years, and had at least 2 scheduled practices each week. A nonrandomized regional approach was chosen to reduce likely contamination effects from interaction between coaches or players changing teams or participating in regular regional, collective educational activities. Although not identical in population (323 270 in Uppland vs 275 618 in Dalarna) or population density (39.4 inhabitants per square kilometer vs 9.8 inhabitants per square kilometer),[14] the 2 counties are similar regarding the conditions for playing soccer: most trainings and matches are played on grass fields, there are both urban and rural areas where towns have more than 1 team, and smaller villages have larger recruiting areas and age spans in the same team.

The study design and recruitment of teams are illustrated in the **Figure**. The participation rate in the intervention group was 68% (48 of 70 eligible teams) and 72% (49 of 68 eligible teams) among controls. Reasons for nonparticipation at the invitation stage were, in most cases, uncertainty about team structure or management during the coming season. Most of the 12 teams that declined to participate after learning about the preventive program expressed skepticism regarding the usefulness of the program as the reason for nonparticipation, which suggests a different attitude toward preventive training.

The intervention was performed between February 1 and October 31, 2007, which covered the entire competitive soccer season (April 26 to October 31) and about 12 weeks of preseason training.

Data regarding matches and training were collected at the team level, as suggested by the FIFA (Fédération Internationale de Football Association) consensus statement.[15] Total exposure to soccer was calculated as the sum of practice and match exposure in player hours. Exposure to soccer practice (in player hours) was calculated as the number of players multiplied by the number of training sessions, training time (in hours), and mean practice attendance rate. Match exposure (in player hours) was calculated as the number of matches multiplied by match duration (in hours) and the number of players on the field. Collection of exposure data was facilitated by use of the attendance card that all teams in Sweden use routinely as a basis for economic compensation. Data on matches and match duration were checked against databases provided by the soccer associations or the separate tournaments and were updated with the official information if there was a discrepancy.

Level of intensity was categorized based on division or league: (1) (lowest) age 13 years, (2) ages 14 to 15 years, (3) ages 16 to 17 years, (4) women's division 5 and women's reserve division, (5) women's division 3 to 4, and (6) (highest) women's division 2 (the third-highest division in Swedish women's soccer).

The coaches, leaders, players, and the players' parents received written and oral information about the study. When an injury had occurred, consent was sought so that the investigator (A.K.) could interview the player about the circumstances of the injury. Written, informed consent for access to the injured player's medical records was given by their parents. Ethical approval was not required, as confirmed by the Regional Ethics Committee at Uppsala University.

INTERVENTION

The objectives of the HarmoKnee preventive program are to increase overall awareness of injury risk, to provide a structured warm-up program, and to provide strengthening exercises aimed at achieving an improved motion pattern that produces less strain to the knee joint. The awareness component includes a theoretical seminar on the importance of preventing knee injuries directed to the player, her parents, and the team's leaders. The training program is implemented at a practice session during which athletes and coaches are trained in the correct way to perform and teach the exercises. The training program (**Table 1** and eAppendix [http://www.archinternmed.com]) includes 5 parts: warm-up, muscle activation, balance, strength, and core stability, all of which can be performed and integrated into the regular soccer practice sessions and require no additional equipment. It was emphasized that focus should be on performing the exercises with good quality and proper technique, not on the number of repetitions of each exercise. Implementation of the program took 4 months and was completed by the end of 2006. Teams were given a written training program, including pictures illustrating the correct and incorrect ways to execute the exercises. Upon request, an instructor (A.K. or K.A.) visited the teams. Teams were instructed to perform the program twice per week during preseason training (February 1-April 25) and once per week during the regular season (April 26-October 31). A monthly newsletter was mailed to the teams to maintain a high level of motivation and adherence to the program.

Coaches provided information on compliance with the program at the end of preseason training and at the end of the competitive season. The compliance for these periods was estimated by the coaches as less than 50%, at least 50%, at least 75%, or 100%.

Table 1. The HarmoKnee Preventive Training Program[a]

Exercise	Duration[b]
Warm-up	≥10 min
During each of the warm-up exercises we encouraged straight alignment hip-knee-foot; low center of gravity; lightly flexed knees; and soft and controlled landing. Optionally, ball and passing drills can be introduced where appropriate.	
Jogging	≥4-6 min
Backward jogging on the toes	Approximately 1 min
High-knee skipping: skip with an exaggerated motion by driving the left knee and the right arm toward the sky. Soft landing on the right foot. The sequence is repeated using the opposite leg and arm. No need to jump high or long.	Approximately 30 s
Defensive pressure technique: sliding slowly, zigzag backward.	Approximately 30 s
One and one: alternating forward zigzag running and pressure technique zigzag backward.	≥2 min
Muscle activation	Approximately 2 min
During each of the muscle activation exercises we encouraged carefully holding and contracting the muscle for approximately 4 s, focusing on "finding" your muscles. We recommend stretching only in cases of limited range of motion; stretching is not recommended for players with joint laxity.	
Activation of calf muscles	4 s for each leg/side
Activation of quadriceps muscles	4 s for each leg/side
Activation of hamstring muscles	4 s for each leg/side
Activation of hip flexor muscles	4 s for each leg/side
Activation of groin muscles	4 s
Activation of hip and lower back muscles	4 s for each leg/side
Balance	Approximately 2 min
Proper landing and take off in a jump is the most important movement in this exercise. We encouraged straight line hip-knee-foot; standing with feet shoulder-width apart; soft and controlled landing with flexed knees; freezing the landing before taking off again; and keeping a low body-center of gravity. Contract and hold stomach and buttocks during the whole exercise. Perform exercises slowly; no need to jump high.	
Forward and backward double leg jumps	Approximately 30 s
Lateral single leg jumps	Approximately 30 s
Forward and backward single leg jumps	Approximately 30 s
Double leg jump with or without ball (optional)	Approximately 30 s
Strength	Approximately 4 min
We encouraged soft and controlled landing; contracting stomach and buttocks; straight line hip-knee-foot.	
Walking lunges in place	Approximately 1 min
Hamstring curl (in pairs)	Approximately 1 min
Single-knee squat with toe raises	Approximately 1 min
Core stability	Approximately 3 min
We encouraged contracting stomach and buttocks; straight line through the body; if there is back pain, stop or modify the exercise (do not hold your breath).	
Sit-ups	Approximately 1 min
Plank on elbows and toes	Approximately 1 min
Bridging	Approximately 1 min

[a] All exercises were described in detail. Teams received a manual with written instructions and photographs in addition to practical education on how to correctly perform the exercises. Also see the eAppendix.
[b] Total program duration, approximately 20 to 25 minutes.

CONTROL GROUP

Teams in the control group were asked to continue with their regular training and warm-up without any restrictions. Before the start of the study period, control teams were promised that they would be educated in the prevention program if the prevention proved beneficial.

OUTCOMES

All new acute knee injuries that occurred from February 1 through October 31, 2007, served as the main outcome measure. These injuries were defined as injuries to the knee following a trauma that made the player seek medical care. Owing to the severity of the injuries, all players seeking medical care were referred to local hospitals, where eventually all injuries were diagnosed according to extended *International Classification of Diseases, 10th Revision* codes[16] by orthopedic physicians not involved with the study. All orthopedic medical hospital records were scrutinized to ascertain injury type. Uncertain diagnoses received a second opinion or further investigation by magnetic resonance imaging or diagnostic arthroscopy when necessary. Two ACL reinjuries (1 in the control and 1 in the intervention group) and 1 knee distortion that was never diagnosed by a physician (in the control group) were disregarded as outcomes. The player's coach reported each injury to the study investigator (A.K.), who then contacted the player for an interview. Injured players were observed 6 months after the injury, through May 31, 2008. We performed subgroup analyses using noncontact injuries (as reported by the injured player) and soccer-specific injuries (excluding injuries occurring during nonsoccer activities) as outcomes. Other outcomes analyzed were long-term injuries (not having regained full activity 6 months after injury) and degree of injury severity. We defined injury severity based on days absent from soccer as minor (1-7 days), moderate (8-28 days), and major (>28 days).[17] We also added a fourth category: severe injury (>8 weeks absence from soccer).

STATISTICAL ANALYSES

Statistical analyses were performed using Stata statistical software, version 10.1 (StataCorp, College Station, Texas). Differ-

Table 2. Team Characteristics[a]

Characteristic	Intervention Group	Control Group	*P* Value[b]
No. of teams	48	49	NA
No. of players	777	729	NA
Age, y	14.7 (12.7-18.6)	15.0 (13.0-17.6)	.13
Training occasions	60 (35-93)	65 (35-105)	.21
Total No. of training occasions	2394	2877	NA
Training attendance rate	0.75 (0.54-0.90)	0.72 (0.50-1.00)	.57
Matches	27 (12-56)	22 (13-70)	.16
Total No. of matches	1096	1096	NA
Competitive matches	23 (12-48)	19 (10-57)	.05
Total No. of competitive matches	980	937	NA
Training matches	3 (0-8)	3 (0-13)	.37
Total No. of training matches	116	159	NA
Match to training ratio	0.44 (0.22-0.82)	0.38 (0.16-0.82)	.04
Match exposure, player hours	317 (180-700)	280 (169-1130)	.28
Total match exposure, player hours	13 387	14 713	NA
Training exposure, team, player hours	1320 (588-3038)	1114 (306-4212)	.03
Total training exposure, player hours	53 594	51 793	NA
Soccer exposure, player hours	1622 (808-3568)	1420 (712-4951)	.06
Total soccer exposure, player hours	66 981	66 505	NA
Level of intensity, No. of teams			
1 (Lowest)	9	11	.60
2	20	18	
3	3	4	
4	10	11	
5	6	4	
6 (Highest)	0	1	

Abbreviation: NA, not applicable.
[a] Data are given as median (range) unless otherwise indicated.
[b] *P* value for the difference between the intervention and control groups.

ences in means and proportions between groups were tested using the Wilcoxon rank-sum test and Fisher exact test, respectively. Injury rates per 1000 player hours and injury rate differences and ratios with 95% confidence intervals (CIs) were calculated using the ir command in Stata.[18(pp243-244)] The CIs for the unadjusted rate ratios were calculated using the exact method.[18(pp253-254)] The proportion of number of matches to number of training sessions, intensity, mean age of the players, and number of players on the team were considered as potential confounders in Poisson regression analysis. Standard errors from Poisson regression were adjusted for nonindependence of teams within clubs using the clustered sandwich estimator.[19] Players older than 19 years who took part in the study (n=56) were excluded from the statistical analyses.

RESULTS

Of 1506 girls enrolled in the study, 777 (52%) participated in the intervention group and 729 (48%) in the control group. Details on training and matches for the teams are presented in **Table 2**. During preseason training, 3 teams in the intervention group reported 50% adherence to the program, 36 teams reported 75% adherence, and 9 teams reported 100% adherence. When the regular season had started, 1 team (in the lowest division) reported less than 50% compliance with the program, whereas the rest of the teams reported full compliance.

The match to training ratio was higher among intervention teams than among controls (*P*=.04). No major differences were noted regarding mean age, number of players on each team, number of training sessions, number of matches, mean attendance rate, or intensity of play (Table 2).

During follow-up, 16 new acute knee injuries occurred, with 5 diagnosed as ACL injuries. None of the ACL injuries occurred in the intervention group. Eleven of the injuries occurred in noncontact situations, such as when landing from a jump or while changing direction (**Table 3**).

Participation in the training program was associated with a 77% lower incidence of any knee injury and 90% lower incidence of knee injuries in noncontact situations. These associations were independent of the number of players on each team, age, match to training ratio, and intensity of play (**Table 4**). If the analysis was limited to teams that complied with the intervention, estimates were somewhat strengthened: rate ratio for any injury in the intervention group compared with controls was 0.17 (95% CI, 0.02-0.75) and for noncontact injury was 0.11 (0.002-0.77). The corresponding adjusted estimates were 0.11 (95% CI, 0.02-0.50) and 0.06 (0.01-0.48).

The rate of injury was not only lower among teams participating in the preventive program but the injuries that did occur were also less severe. Although all 3 injuries in the intervention group were categorized as major injuries (1 had a patella luxation and the other 2 had an unspecific knee distortion diagnosis), all 3 players regained full activity within 6 months after the injury (Table 3). Most injuries among the control participants were severe, and only 4 of the 13 injured players re-

Table 3. Injury Characteristics

	No. of Injuries	
	Intervention Group	Control Group
Any knee injury	3	13
Contact injury	2	3
Noncontact injury	1	10
Diagnoses		
Knee distortion	2	1
Lateral collateral ligament injury	0	2
Medial collateral ligament injury	0	1
Medial meniscus injury	0	1
Patella luxation	1	3
ACL injury	0	3
ACL and medial meniscus injury	0	2
Activity at time of injury		
Soccer training	1	4
Soccer match	2	6
Nonsoccer activity	0	3
Field surface[a]		
Natural grass	2	9
Artificial grass	1	1
Injury severity		
Minor/moderate	0	0
Major	3	2
Severe	0	11
Regained full activity 6 mo after injury	3	4

Abbreviation: ACL, anterior cruciate ligament.
[a] Surface at time of injury for injuries occurring during soccer activity.

Table 4. Knee Injury Incidence Rate, Rate Difference, and Rate Ratio

	Intervention Group	Control Group
No. of knee injuries	3	13
Rate, injuries/ 1000 player hours[a]	0.04	0.20
Rate difference (95% CI)	−0.15 (−0.27 to −0.03)	1 [Reference]
Unadjusted RR (95% CI)	0.23 (0.04 to 0.83)	1 [Reference]
Adjusted RR[b] (95% CI)	0.17 (0.04 to 0.64)	1 [Reference]
No. of noncontact knee injuries	1	10
Rate, injuries/ 1000 player hours[a]	0.01	0.15
Rate difference (95% CI)	−0.14 (−0.23 to −0.04)	1 [Reference]
Unadjusted RR (95% CI)	0.10 (0.00 to 0.70)	1 [Reference]
Adjusted RR[b] (95% CI)	0.06 (0.01 to 0.46)	1 [Reference]

Abbreviations: CI, confidence interval; RR, rate ratio.
[a] Player hours exposed to soccer.
[b] Rate ratio adjusted for number of players on the team, age of the players, the ratio of number of matches to number of training sessions, and intensity; standard errors adjusted for clustering at the club level.

gained full activity within 6 months after the injury (difference vs intervention, $P = .06$).

Three of the injuries occurred during nonsoccer activities: 1 during a handball game, 1 in a school physical education class, and 1 in an alpine skiing competition. Excluding these 3 injuries did not change the interpretation of our results: the rate ratio for any injury (compared with controls) was 0.30 (95% CI, 0.05-1.16) and for noncontact injuries was 0.14 (0.03-1.10). The corresponding adjusted estimates were 0.25 (95% CI, 0.06-0.98) for any knee injury and 0.09 (0.01-0.64) for noncontact injury. All but 2 injuries occurred when playing on natural grass (Table 3).

In a sensitivity analysis, we kept as cases the 3 injuries that did not meet our inclusion criterion of being incident injuries (2 ACL reinjuries and 1 knee distortion without a physician's diagnosis). The interpretation of the results did not change when these injuries were included. Analyses were also performed with training exposure or match exposure only used as a denominator rather than the total soccer exposure time. The estimates were similar to those presented for total soccer exposure.

Among the 227 players on the 12 teams educated in the intervention program but that did not participate in the study, 7 had knee injuries (injury rate, 0.32/1000 player hours), of which 6 occurred in noncontact situations. The rate ratio when the intervention group was compared with this group was 0.14 (95% CI, 0.02-0.61) for any knee injury and 0.05 (0.001-0.45) for noncontact injury. The corresponding adjusted estimates were 0.11 (95% CI, 0.02-0.65) and 0.12 (0.01-1.97). Similar to the control group, the injuries for these nonparticipating players were also more severe, with only 1 of 7 injured players regaining full activity within 6 months after injury (difference vs intervention, $P = .03$). There were 5 ACL injuries among nonparticipating teams.

COMMENT

The primary finding from this community-based intervention trial among young female soccer players in Sweden is the 77% reduction in acute knee injuries after participation in the preventive program. Injuries that did occur in the intervention group were less severe.

The incidence rate of acute knee injuries occurring in noncontact situations was reduced by 90%, and no ACL injuries occurred in the intervention group. This is important because these injuries often require long rehabilitation and frequently lead to permanently reduced function and early retirement from soccer.[6,20]

A physician (A.K.) in collaboration with an orthopedic surgeon (E.H.), a physiotherapist (K.A.), and elite soccer coaches in Sweden developed our training program specifically for female soccer players. The combination of existing soccer-specific agility exercises that require no additional equipment makes the program available to teams at no cost. The implementation of the intervention program is also unique in all its components: the involvement of many supportive people around the athlete, the emphasis on the importance of not overusing young talented players in matches, and the practical education of both coaches and athletes. The importance of including all these aspects in a successful preventive program has been highlighted in a steering document from the International Olympic Committee.[7]

Because the specificity of the exercises facilitates incorporation into the regular practice, little extra time is spent on additional training, which ensures the program will be well-received by coaches and players. This may explain the high compliance rates reported in our

study; only 3 teams reported compliance of less than 75%. Furthermore, at the end of the 2008 competitive season, ie, 1 year after the end of the study, the 48 teams in the intervention group were asked whether they had continued with the program. Of the 40 responding teams, 12 had been disbanded. Assuming that the 8 teams not responding had not continued with the program, 16 of 36 teams (44%) reported that they had spontaneously continued performing components of the exercise program and 7 teams (19%) reported using the entire exercise program. The program was continued despite the fact that none of the teams had knowledge of the study results.

The exercise component of our program focuses on motor skills and body control and prepares the neuromuscular system for sport-specific maneuvers. The training program stressed technique perfection for each exercise. Preventive programs in other injury-prone sports were also effective when all these factors were included.[8,21,22] In a cluster randomized study of female floorball players (mean age, 24 years), noncontact injuries to the legs but not to the knees were reduced by a multifactor training program.[21] A similar cluster randomized trial in handball players (mainly girls aged 15-17 years) demonstrated an 80% reduction of acute knee ligament injuries (rate ratio, 0.20; 95% CI, 0.06-0.70).[22] These 2 studies, however, included additional equipment, such as balance boards or mats, which increases the cost for the individual teams.

No previous soccer-specific preventive programs have included all components deemed important for successful results.[7] Preventive programs including some of these components yielded conflicting results. A neuromuscular and proprioceptive training program in a cohort study of female soccer players aged 14 to 18 years reduced the ACL injury incidence by 88% during the first year and by 74% during the second year.[9] However, the authors did not report how well the participants adhered to the program. The program was further tested in a cluster randomized trial in which no reduction in injury rates was observed.[12] The results from training programs using balance boards alone are contradictory.[8] Female soccer players participating in a balance-board exercise program that had previously shown a reduction of ACL injuries among men[23] found no reduction in injury rates.[10] No protection against lower extremity injuries has been observed using warm-up or stretching programs.[8] Recently, a warm-up program was tested in a cluster randomized trial of 15- to 16-year-old female soccer players.[13] The program reduced the risk of severe injuries of any type but could not demonstrate a specific effect on acute knee or ankle injuries. Nor was there an effect on acute injuries occurring in noncontact situations.[13] When visited during training sessions, players seemed not to focus on achieving the intended benefit, a behavior ascribed to the age of the players.[13] Anecdotally, we experienced the opposite at our team visits and in feedback from coaches; the players, regardless of age, performed the exercises with full focus. We credit this behavior to the individual education of the players. Sex differences in motion patterns are established between ages 12 and 16 years.[24-26] It may be easier to prevent knee injuries with exercise programs if they are implemented for younger players who have not yet established their motion patterns.[27] Ages as low as 6 to 10 years have been suggested.[7] Future studies should evaluate the possibility of implementing our intervention program among younger players.

Our intervention program is multifaceted and addresses many aspects of injury risk. Training programs may confer additive performance-enhancement effects, and the effects of different strengthening exercises may be synergistic in the female athlete.[28] Further studies including individual data on performance for each aspect of our program before and after intervention would help determine the effect of specific components.

The objective injury ascertainment made by orthopedic physicians is a major strength of our study. Because we used a pragmatic[29] and broad approach, including teams with young players at all levels, the results presented could have direct relevance to many female soccer teams.

The community-based intervention design was chosen over individual and cluster randomized designs to minimize contamination effects that would otherwise be likely to occur by transfer of players and coaches between clubs and at regional educational activities. The regions were chosen to be as similar as possible with special regard to the availability and structure of female youth soccer. The main limitation of our study design is that exposure data were not obtained at the individual level. Thus, we cannot determine whether the girls who suffered a knee injury participated more in matches or training than did those who did not suffer such an injury. The method of collecting data at the team level has been suggested by FIFA as a feasible procedure in studies of soccer injuries because many studies will otherwise be too costly and complicated to ever be performed.[15] The low number of injuries and the crude and possibly biased measurement of compliance are also limitations to our study. In spite of this, we demonstrate a protective effect of the intervention program, and our estimates were strengthened when teams reporting low compliance were excluded from our analyses.

Soccer players with a previous ACL injury are at a several-fold higher risk of reinjury.[30,31] Therefore, all injured players were asked about previous injuries, and only new knee injuries were included in our analyses.

Teams participating in the present study could be more prone to work in a preventive manner with knee injuries. If teams in the control group did engage in preventive training, it was not identical to our intervention program, which is not yet publicly available. Any training causing protective effects among controls would result in weaker estimates for the effect of our preventive program.

CONCLUSION

In conclusion, we present a multifaceted, soccer-specific prevention program that combines education, proper motion patterns, strength, and balance, without using special equipment. Participation in the program reduced the incidence of knee injury by 77% and noncontact injury by 90% among female soccer players aged 13

to 19 years. The high compliance rate in this study suggests that the program is easy to implement and incorporate into regular soccer practice.

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