

A Nationwide Follow-up Survey on the Effectiveness of an Implemented Neuromuscular Training Program to Reduce Acute Knee Injuries in Soccer Players

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Background: A cruciate ligament (CL) injury is a severe injury in soccer. Neuromuscular training programs have a well-documented preventive effect, but there are few studies on the effectiveness of such a program at a national level. The Swedish Knee Control Program (KCP) was found to be effective in preventing CL injuries in youth female soccer players. The KCP was implemented nationwide in Sweden in 2010.

Purpose: To evaluate the effectiveness of the Swedish KCP in reducing acute knee injuries in soccer players at a nationwide level.

Study Design: Descriptive epidemiology study.

Methods: All licensed soccer players in Sweden are covered by the same insurance company. Using this insurance database, around 17,500 acute knee injuries that were reported to the insurance company between 2006 and 2015 were included in the study. By matching the number of licensed soccer players with the number of reported injuries each year, the annual incidence of knee and CL injuries was able to be calculated. To evaluate the spread of the KCP nationally, a questionnaire was sent to all 24 Swedish district football associations (FAs) with questions regarding KCP education. The number of downloads of the KCP mobile application (app) was obtained.

Results: The incidence of CL injuries decreased during the study period for both male (from 2.9 to 2.4 per 1000 player-years) and female players (from 4.9 to 3.9 per 1000 player-years). The overall incidence of knee injuries decreased in both male (from 5.6 to 4.6 per 1000 player-years) and female players (from 8.7 to 6.4 per 1000 player-years). Comparing before and after the nationwide implementation of the KCP, there was a decrease in the incidence of CL injuries by 6% (rate ratio [RR], 0.94 [95% CI, 0.89-0.98]) in male players and 13% (RR, 0.87 [95% CI, 0.81-0.92]) in female players and a decrease in the incidence of knee injuries by 8% (RR, 0.92 [95% CI, 0.89-0.96]) and 21% (RR, 0.79 [95% CI, 0.75-0.83]), respectively ($P < .01$ for all). This trend corresponded to a reduction of approximately 100 CL injuries each year in Sweden. A total of 21 of 24 district FAs held organized KCP educational courses during the study period. The percentage of district FAs holding KCP courses was between 46% and 79% each year. There were 101,236 downloads of the KCP app.

Conclusion: The KCP can be considered partially implemented nationwide, and the incidence of knee and CL injuries has decreased in both sexes at a nationwide level.

Keywords: injury prevention; cruciate ligament; coach education; insurance data; nationwide implementation

Knee injuries are common among soccer players worldwide, regardless of age, sex, and playing level.^{4,24,29} The consequences of a severe knee injury, especially to the anterior cruciate ligament (ACL), entail a long absence from soccer and an increased risk of new injuries^{13,30} as well as long-term outcomes such as medical disabilities related to osteoarthritis.²⁵ Such a severe injury could also result in the

premature end of the soccer career.²⁹ Female players have a well-documented higher risk of knee injuries, especially ACL injuries,^{29,35} with a marked risk increase occurring during late puberty.³⁵ The most common ACL injury mechanism is a noncontact or indirect contact injury, for example, during sidestep and landing maneuvers.^{23,36} Thus, the prevention of knee injuries in soccer has mainly been focusing on neuromuscular training (NMT) programs.^{10,33}

An NMT program, the Knee Control Program (KCP), was developed in 2005 with the aim of reducing severe knee injuries among soccer players in Sweden. The KCP includes

The Orthopaedic Journal of Sports Medicine, 6(12), 2325967118813841

DOI: 10.1177/2325967118813841

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TABLE 1
Timeline of the Implementation of the Swedish KCP^a

| | KCP starts ^b | “Efficacy” of KCP in girl’s football ^c | | Follow-up implementation of KCP in districts ^d | | |
|--------------------|-------------------------|--|--|---|-------------------------|---|
| 2005 | 2008 | 2009 | 2010 | 2012 | 2013 | 2015 |
| KCP CD released | | | Nationwide implementation of KCP | KCP app released | New KCP DVD and book | KCP included in coach education curriculum |

^aKCP, Knee Control Program.

^bHagglund et al¹² (2009).

^cWalden et al³³ (2012).

^dLindblom et al¹⁹ (2014).

core muscle strengthening and stabilization; proprioceptive training; and dynamic stabilization with the knee, hip, and core aligned with the center of gravity. The program takes between 10 and 15 minutes to complete during an ordinary training session led by the coach. It should be implemented in players aged 10 to 12 years and performed at least 2 times a week.¹²

The KCP has been evaluated from an injury prevention perspective in female adolescent soccer players.³³ The results showed that the program was efficacious in reducing the ACL injury rate (64% reduction) in that population.³³ Importantly, the greatest reduction in injuries was identified in players in whom program compliance was high.¹¹ The subsequent implementation of the KCP within 8 (of 24) participating Swedish district football associations (FAs) was evaluated in a separate follow-up study 3 years later.¹⁹ Widespread reach and adoption among girls’ soccer coaches were identified, showing that they were familiar with the program and also used it to a high extent.¹⁹

The nationwide implementation of this KCP began in Sweden in 2010. Efforts to disseminate the program included information spread via websites and educational workshops for physical therapists, coaches, and soccer players nationwide. There were educational workshops in conjunction with national team games, incorporation of the KCP into the Swedish FA coach education curriculum, development of a freely downloadable smartphone application (app), and new instructional material with a book and DVD. Information was also presented via lectures and practical workshops at various conferences and coaching

seminars both nationally and internationally. The KCP has hereby been implemented in both female and male soccer in Sweden (Table 1).

There is no national sports injury database in Sweden, but the Swedish FA has mandatory accident insurance with the insurance company Folksam, covering all organized soccer players in Sweden. The insurance covers costs associated with an injury, and if the injury results in life-long impairments, the player will also receive a nonrecurring amount in proportion to the assessed grade of permanent medical impairment.¹ The insurance company categorizes knee injuries as ACL, posterior cruciate ligament, or just “cruciate ligament” (CL) depending on the exactness of the diagnosis.

The objective of the present study was to evaluate the effectiveness of the implemented KCP among soccer players at a national level in Sweden. The primary aim was to investigate its effect on the incidence of acute knee injuries, particularly CL injuries, over time (2006-2015) using insurance data. The second aim was to evaluate the extent of KCP education and implementation nationwide. The hypothesis was that the national implementation of the KCP would be associated with a decrease in the incidence of knee and CL injuries nationwide.

METHODS

A retrospective cohort study was conducted of licensed soccer players in Sweden who sustained a knee injury from 2006 to 2015 and reported the injury to Folksam. The

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One or more of the authors has declared the following potential conflict of interest or source of funding: The database used in this study was from Folksam. M.Å. received salary support from the Swedish School of Sport and Health Sciences in collaboration with Folksam. M.H. has received grants from the Swedish Research Council (DNR 2015-02414). Folksam did not gain or lose financially in any way from the results of this study. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

Ethical approval for this study was obtained from the regional ethical committee (DNR 2012/1436-31/1).

definition of an injury for the purpose of the present study was “an acute knee injury resulting from a specific identifiable event, related to soccer activity, training, or competition organized by the Swedish FA or sports club” that was reported to Folksam. It is possible to report an injury to the insurance company within 3 years after the injury occurred or after the player became aware of the insurance (in rare cases, up to 10 years).² The diagnosis was most often made by a physician, especially regarding severe knee injuries, such as CL injuries, that might require magnetic resonance imaging or an arthroscopic examination. Less severe knee injuries that did not need to undergo magnetic resonance imaging or be examined by a medical doctor could, in rare cases, be examined by a physical therapist exclusively. In Sweden, patients (including soccer players) often consult a physical therapist as a first-line treatment specialist who can provide and report a diagnosis but who may refer the patient to an orthopaedic surgeon for consultation and further evaluation if deemed necessary, which is routine for severe injuries.

The insurance company’s database also contains free text on the management of the injury within the insurance company. If the administrator acquires new information regarding the injury—for example, a new diagnosis code—at a later stage, this will be updated within the text files in the database.² All diagnosis codes in the database, including the CL, were included in the analysis. The ACL as a specific diagnosis code was registered in 58% of the total CL injuries, the posterior cruciate ligament in 3%, the CL together with a ligament and/or meniscus injury in 26%, and an undefined CL in 13% of the total CL injuries. When a diagnosis code was missing from the investigated data set, or only reported as the location “knee” with no injury type or specific structure, the lead author (M.Å.) quality checked the information with the insurance administrator’s text files within the database and, if possible, updated the information within the data set.

Population

All soccer players, from the age of 15 years, are registered as licensed players within the Swedish FA. Players at all levels are represented, from beginners to the national level, but level of play is not registered within the insurance database.

Sweden is divided into 24 regional soccer districts (district FAs) of variable sizes, which are located throughout the country. All district FAs are responsible for educating soccer coaches at all levels of play. The district FAs are consequently responsible for the national implementation of the KCP among soccer players in Sweden.

The number of injuries and information regarding the injuries were extracted from the insurance database at the end of 2016. To generate reliable numbers of the incidence over time, the incidence rate for each year was adjusted to compensate for any late reporting of injuries to the insurance company. This was accomplished by reporting rate for 2006, in which the maximum amount of time for injury registration (10 years) had been reached. For example, 86% of knee injuries were reported within 1 year after the

injury occurred, and 93% were reported within 2 years after the injury occurred. For CL injuries, 81% were reported within 1 year and 91% within 2 years. The correction formula— $(1/\text{proportion of reporting rate}) \times \text{annual incidence}$ —was used for each investigated year. This adjustment was made for each sex and age group to calculate the injury incidences for the later years, in which the follow-up period was shorter (Table 2). Injury incidence was expressed as “injuries per 1000 licensed player-years,” further expressed as “1000 player-years.”¹

KCP Implementation

To evaluate KCP education and implementation nationwide, a questionnaire was sent by email to key people working with the KCP within each of the 24 district FAs in Sweden. Data were collected from May to June 2017. The first part of the questionnaire included general demographics such as contact information and position held in the district FA. The second part included specific items about policies regarding KCP education: is there a policy (official, unofficial), and is there an appointed position responsible for KCP education? The third part related to the number of KCP courses held each year and the sex of the players. Each district had 6 possible years of KCP education (2010-2015). To gain further knowledge about the spread of the KCP nationwide, we obtained the number of yearly downloads of the KCP app from its launch (eg, Google Play and App Store) in October 2012, when the app was released, to December 2015.

Outcomes

The primary outcome was the incidence of reported CL injuries, and the secondary outcome was the incidence of all acute knee injuries. The primary outcome for KCP education and implementation was the numbers of educational workshops and downloads of the mobile app.

Statistical Analysis

Data were statistically analyzed using Excel 2013 (Microsoft) and SPSS for Windows version 21.0 (IBM). The total injury incidence was calculated as the total number of acute knee and CL injuries separately, reported to Folksam, and divided by the total number of licensed soccer players (obtained from the Swedish FA). Data included nominal variables and were analyzed descriptively with incidences of injury with means, SDs, and 95% CIs. The incidence of CL and knee injuries for different sexes, age groups, and study years were analyzed and followed over time. The incidence of CL and knee injuries before and after the nationwide implementation of the KCP was calculated with 5-year aggregated data for years 2006-2010 and 2011-2015 and compared with a rate ratio (RR), and significance was assessed by using the *Z* test.¹⁶ Data included the total population of licensed soccer players in Sweden.

Items in the questionnaire were presented descriptively with frequencies and proportions. To calculate the total possible education years, the 24 soccer districts were multiplied

TABLE 2
Incidence of CL and Knee Injuries Before and After Adjusting for Late Reporting of Injuries^a

| Reported CL Injuries | | | | | | | | | |
|-------------------------------|---|--------|-------------|--------------------------------------|--------|---|----------------|---------------------------|--------|
| Time From Injury to Reporting | Proportion of Injuries Reported to Folksam ^b | | Injury Year | Original Calculated Injury Incidence | | Formula to Adjust for Late Reporting of Injury ^c | | Adjusted Injury Incidence | |
| | Male | Female | | Male | Female | Male | Female | Male | Female |
| <10 years | 100% | 100% | 2006 | 2.9 | 4.9 | (1/1) × 2.9 | (1/1) × 4.9 | 2.9 | 4.9 |
| <9 years | 100% | 100% | 2007 | 3.1 | 6.2 | (1/1) × 3.1 | (1/1) × 6.2 | 3.1 | 6.2 |
| <8 years | 100% | 99% | 2008 | 2.8 | 5.1 | (1/1) × 2.8 | (1/0.99) × 5.1 | 2.8 | 5.1 |
| <7 years | 100% | 99% | 2009 | 2.9 | 4.9 | (1/1) × 2.9 | (1/0.99) × 4.9 | 2.9 | 5.0 |
| <6 years | 99% | 99% | 2010 | 2.3 | 4.7 | (1/0.99) × 2.3 | (1/0.99) × 4.7 | 2.4 | 4.8 |
| <5 years | 99% | 99% | 2011 | 2.7 | 5.1 | (1/0.99) × 2.7 | (1/0.99) × 5.1 | 2.7 | 5.2 |
| <4 years | 97% | 98% | 2012 | 2.6 | 4.1 | (1/0.97) × 2.6 | (1/0.98) × 4.1 | 2.7 | 4.2 |
| <3 years | 94% | 97% | 2013 | 2.6 | 4.4 | (1/0.94) × 2.6 | (1/0.97) × 4.4 | 2.7 | 4.6 |
| <2 years | 91% | 92% | 2014 | 2.3 | 4.2 | (1/0.91) × 2.3 | (1/0.92) × 4.2 | 2.5 | 4.5 |
| <1 year | 80% | 83% | 2015 | 2.0 | 3.3 | (1/0.80) × 2.0 | (1/0.83) × 3.3 | 2.4 | 3.9 |

| Reported Knee Injuries | | | | | | | | | |
|-------------------------------|---|--------|-------------|--------------------------------------|--------|---|----------------|---------------------------|--------|
| Time From Injury to Reporting | Proportion of Injuries Reported to Folksam ^b | | Injury Year | Original Calculated Injury Incidence | | Formula to Adjust for Late Reporting of Injury ^c | | Adjusted Injury Incidence | |
| | Male | Female | | Male | Female | Male | Female | Male | Female |
| <10 years | 100% | 100% | 2006 | 5.6 | 8.7 | (1/1) × 5.6 | (1/1) × 8.7 | 5.6 | 8.7 |
| <9 years | 100% | 100% | 2007 | 6.3 | 10.2 | (1/1) × 6.3 | (1/1) × 10.2 | 6.3 | 10.2 |
| <8 years | 100% | 100% | 2008 | 5.4 | 8.8 | (1/1) × 5.4 | (1/1) × 8.8 | 5.4 | 8.9 |
| <7 years | 100% | 100% | 2009 | 5.6 | 9.1 | (1/1) × 5.6 | (1/1) × 9.1 | 5.7 | 9.1 |
| <6 years | 100% | 99% | 2010 | 4.8 | 8.2 | (1/1) × 4.8 | (1/0.99) × 8.2 | 4.9 | 8.2 |
| <5 years | 99% | 99% | 2011 | 5.4 | 8.0 | (1/0.99) × 5.4 | (1/0.99) × 8.0 | 5.4 | 8.0 |
| <4 years | 98% | 99% | 2012 | 5.4 | 6.9 | (1/0.98) × 5.4 | (1/0.99) × 6.9 | 5.5 | 7.0 |
| <3 years | 96% | 97% | 2013 | 5.1 | 7.4 | (1/0.96) × 5.1 | (1/0.97) × 7.4 | 5.4 | 7.6 |
| <2 years | 93% | 93% | 2014 | 4.4 | 6.2 | (1/0.93) × 4.4 | (1/0.93) × 6.2 | 4.8 | 6.7 |
| <1 year | 86% | 87% | 2015 | 4.0 | 5.6 | (1/0.86) × 4.0 | (1/0.87) × 5.6 | 4.6 | 6.4 |

^aCL, cruciate ligament.

^bReported until year 2016, with injury year of 2006.

^c(1/proportion of reporting rate) × incidence.

by 6 possible years, with a total 144 possible years of education.

RESULTS

The total number of registered CL injuries was 9318, of which 5756 occurred in male players and 3562 in female players, during the study period (2006-2015). The annual mean number was 932 ± 84 CL injuries (female, 356 ± 41; male, 576 ± 50). In male players, the mean incidence was 2.7 ± 0.2 CL injuries per 1000 player-years (95% CI, 2.71-2.71) and in female players it was 4.8 ± 0.6 CL injuries per 1000 player-years (95% CI, 4.84-4.84). The mean RR between sexes was 1.8 ± 0.2 (95% CI, 1.79-1.79).

In total, there were 17,513 knee injuries reported to the insurance company: 11,527 for male players and 5986 for female players. The annual mean number was 1751 ± 151

knee injuries (female, 599 ± 61; male, 1153 ± 100). The mean incidence of knee injuries was 5.4 ± 0.5 per 1000 player-years (95% CI, 5.34-5.35) for male players and 8.1 ± 1.2 per 1000 player-years (95% CI, 8.09-8.10) for female players, resulting in a mean RR between sexes of 1.5 ± 0.1 (95% CI, 1.51-1.51).

The mean age for CL injuries was 24 ± 6 years in male players and 20 ± 5 years in female players, and the mean age for knee injuries was 24 ± 7 years in male players and 20 ± 6 years in female players.

Time Trend

There was a decrease in the incidence of CL and knee injuries in both sexes during the study period (Table 2 and Figure 1). When analyzing the mean injury incidence before and after the nationwide implementation of the KCP (2006-2010 compared with 2011-2015), there was a decrease in CL injuries by 6% (RR, 0.94 [95% CI, 0.89-

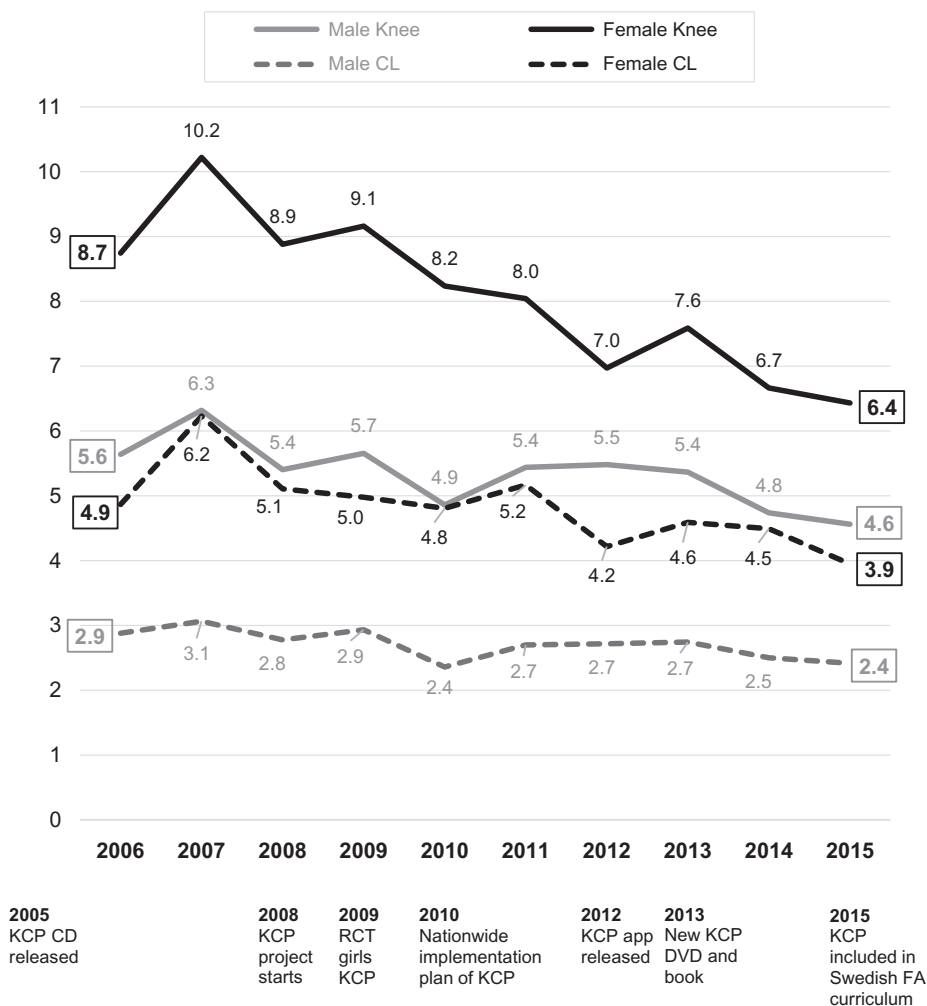


Figure 1. Incidence of knee and cruciate ligament (CL) injuries in male and female soccer players (per 1000 licensed player-years) in relation to the implementation of the Swedish Knee Control Program (KCP). FA, football association; RCT, randomized controlled trial.

TABLE 3
Incidence of Cruciate Ligament Injuries Before and After the Nationwide Implementation of the Swedish Knee Control Program

| Male | | | | Female | | | |
|------------------------------------|-----------|-----------|----------------|------------------------------------|-----------|-----------|-----------------|
| Year | Incidence | Year | Incidence | Year | Incidence | Year | Incidence |
| 2006 | 2.9 | 2011 | 2.7 | 2006 | 4.9 | 2011 | 5.2 |
| 2007 | 3.1 | 2012 | 2.7 | 2007 | 6.2 | 2012 | 4.2 |
| 2008 | 2.8 | 2013 | 2.7 | 2008 | 5.1 | 2013 | 4.6 |
| 2009 | 2.9 | 2014 | 2.5 | 2009 | 5.0 | 2014 | 4.5 |
| 2010 | 2.4 | 2015 | 2.4 | 2010 | 4.8 | 2015 | 3.9 |
| Mean ± SD | 2.8 ± 0.3 | Mean ± SD | 2.6 ± 0.1 | Mean ± SD | 5.2 ± 0.6 | Mean ± SD | 4.5 ± 0.5 |
| 95% CI | 2.7-2.9 | 95% CI | 2.5-2.7 | 95% CI | 4.9-5.4 | 95% CI | 4.3-4.7 |
| Reduction after implementation | | | | | | | |
| Absolute incidence reduction | | | 0.2 | Absolute incidence reduction | | | 0.7 |
| Percentage of reduction | | | 6 ^a | Percentage of reduction | | | 13 ^a |
| Estimated No. of injuries per year | | | 42 | Estimated No. of injuries per year | | | 55 |

^aP < .01.

TABLE 4
Incidence of Knee Injuries Before and After the Nationwide Implementation of the Swedish Knee Control Program

| Male | | | | Female | | | |
|------------------------------------|-----------|-----------|----------------|------------------------------------|-----------|-----------|-----------------|
| Year | Incidence | Year | Incidence | Year | Incidence | Year | Incidence |
| 2006 | 5.6 | 2011 | 5.4 | 2006 | 8.7 | 2011 | 8.0 |
| 2007 | 6.3 | 2012 | 5.5 | 2007 | 10.2 | 2012 | 7.0 |
| 2008 | 5.4 | 2013 | 5.4 | 2008 | 8.9 | 2013 | 7.6 |
| 2009 | 5.7 | 2014 | 4.8 | 2009 | 9.1 | 2014 | 6.7 |
| 2010 | 4.9 | 2015 | 4.6 | 2010 | 8.2 | 2015 | 6.4 |
| Mean ± SD | 5.6 ± 0.5 | Mean ± SD | 5.1 ± 0.4 | Mean ± SD | 9.0 ± 0.7 | Mean ± SD | 7.1 ± 0.7 |
| 95% CI | 5.4-5.7 | 95% CI | 5.0-5.3 | 95% CI | 8.7-9.3 | 95% CI | 6.9-7.4 |
| Reduction after implementation | | | | | | | |
| Absolute incidence reduction | | | 0.5 | Absolute incidence reduction | | | 1.9 |
| Percentage of reduction | | | 8 ^a | Percentage of reduction | | | 21 ^a |
| Estimated No. of injuries per year | | | 102 | Estimated No. of injuries per year | | | 147 |

^a*P* < .01.

0.98]; *P* < .01) in male players and by 13% (RR, 0.87 [95% CI, 0.81-0.92]; *P* < .01) in female players (Table 3). The incidence of knee injuries decreased by 8% (RR, 0.92 [95% CI, 0.89-0.96]; *P* < .01) in male players and by 21% (RR, 0.79 [95% CI, 0.75-0.83]; *P* < .01) in female players after the implementation of the KCP (Table 4).

There was no decrease in the incidence of CL injuries in players aged 15 to 17 years. In female players, there was a decrease in the incidence of CL injuries in players >18 years of age (6%-53% decrease) and in male players >20 years of age (0%-27%).

Nationwide Implementation of the KCP

The response rate from the district FAs was 100%. Twenty-one of 24 of the districts (89%) held at least 1 KCP educational workshop from the nationwide implementation of the program (2010) to the end of the study period (2015), and 3 of 24 did not undertake any KCP education. One of these 3 latter districts used another type of strengthening and NMT program to prevent injuries, and 1 district carried out KCP education only with the official “district soccer team.” There was no reporting on the extent of this training.

During the study period, the district FAs arranged KCP courses in 60% of the 144 possible years of education (mean number of years of education, 14 ± 4). The percentage of districts carrying out KCP education for each year is displayed in Figure 2. KCP educational workshops were held for ≥4 years (of a possible 6 years) in 58% of the district FAs, and 75% held educational workshops for ≥3 years. Approximately 80% of the courses were primarily aimed at female soccer teams, 9 district FAs only included female teams, and more than 50% of the educational workshops included adolescent female players (<18 years of age). Half of the district FAs did not have, or did not know of, any guidelines regarding education, information, and implementation of the KCP within their district FAs; 21% (5/24) had

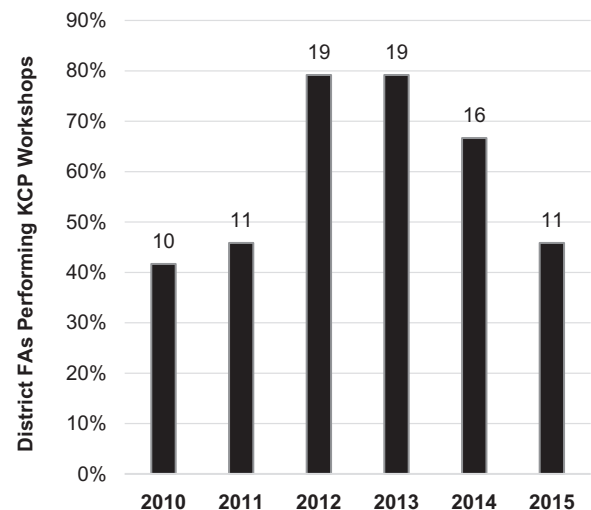


Figure 2. Number and proportion (%) of the 24 district football associations (FAs) that held Knee Control Program (KCP) educational workshops each year.

written formal guidelines, while 29% (7/24) had informal guidelines, and 50% (12/24) did not know.

There were a total of 101,236 downloads of the KCP mobile app (from the App Store and Google Play) from 2012 to 2015 (mean each year, 25,309 ± 10,415) (Figure 3).

DISCUSSION

The main result from this study is that CL and acute knee injuries reported to the insurance company Folksam among licensed Swedish soccer players nationwide decreased from 2006 to 2015, especially in female players. To the best of our knowledge, this is the first study to evaluate the incidence of CL and knee injuries over a 10-year period that includes all licensed soccer players—adolescent, amateur, and professional—from a whole nation. This makes this study unique.

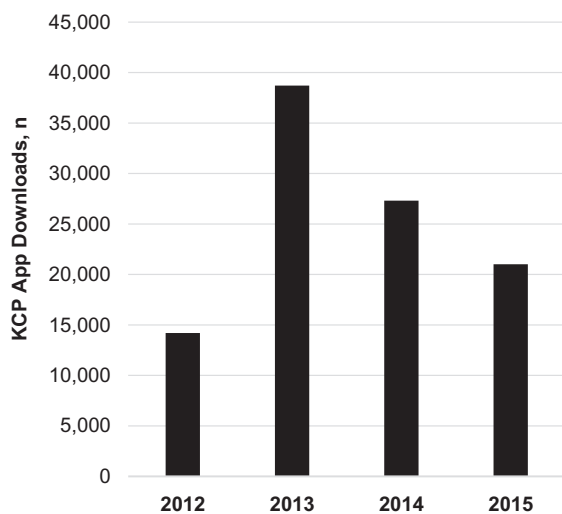


Figure 3. Number of downloads of the Knee Control Program (KCP) app each year.

A nationwide prevention campaign in Switzerland used telephone interviews of a representative sample of Swiss amateur coaches to collect data on injuries as well as knowledge and implementation of the NMT program FIFA 11+ (introduced by the Fédération Internationale de Football Association [FIFA]). Teams that instituted the FIFA 11+ had an 11.5% lower incidence of match injuries and a 25.3% lower incidence of training injuries compared with teams that did not perform the exercises.¹⁵ In a study from Belgium, the authors used insurance data to evaluate the implementation of the FIFA 11+, together with a “bad weather policy,” among all licensed soccer players in the nation over a 10-year period, and they found a 21% reduction in the total injury rate.³ Neither of the 2 studies evaluated the incidence of CL injuries specifically. In professional European soccer players, no decrease in ACL injuries was observed between 2001 and 2015, and it was speculated that poor adoption of evidence-based knee-protective exercises could be the reason for this in professional players.³⁴ Other ligament injuries, such as to the collateral ligament of the knee and lateral ligament complex of the ankle, have shown a slight decrease.^{4,20} In the present study, information about the level of play was not recorded in the database; thus, it was not possible to evaluate this factor.

In several controlled studies with different soccer populations, NMT programs have been found to reduce the incidence of knee¹⁰ and ACL injuries.³³ A large-scale cluster randomized controlled trial, which included 230 female youth soccer clubs and more than 4500 players (aged 12-17 years), was performed in 2009 in 8 district FAs in Sweden.³³ The study showed that the intervention group teams that used the KCP had a 64% lower rate of ACL injuries compared with the control group teams that performed their regular training.^{11,33} Based on this study, a structured education program to educate coaches and soccer players in the KCP has been implemented nationwide in Sweden since 2010. The results from the present study

indicate that this implementation has had a preventive effect on the rate of CL and knee injuries, although causation cannot be attributed. Many factors that may influence the incidence of injuries, such as the amount of exposure to soccer, duration and frequency of training or matches, game intensity, and previous injuries, among others,^{14,26,35} were not able to be quantified in the present study. Neither was compliance to and use of the program among soccer players reported. To our knowledge, 1 district FA implemented a similar NMT program, but no other structured injury prevention measures were implemented in Swedish soccer nationwide during the study period, and there was no accompanying general decrease in other soccer-related injuries reported to the insurance company that could explain the decrease in the incidence of CL and knee injuries. Neither was there any decrease in the incidence of knee and CL injuries in other team sports during the same time period (eg, team handball and floorball) when using the same insurance data (M. Åman, unpublished data, 2018).

There was a greater decrease in the total incidence of knee and CL injuries in female players compared with male players in the present study. The program was initially evaluated in young female players, and the results received great attention in the media. Thus, it is possible that the program was implemented earlier and adopted to a greater extent among female coaches. This was also supported by the district FA questionnaire result showing that approximately 80% of the courses were for female teams, especially adolescent players (<18 years of age).

There was no decrease in knee and CL injuries in the 15- to 17-year age group, which is concerning because this is a high-risk group for such injuries.³⁵ There are no comparable studies confirming this, but a population-based study in Australia showed a general increase in the ACL injury rate in children and adolescents, particularly in female participants, with over half of the injuries occurring during sports activities.²⁷ According to the Swedish National Knee Ligament Register, the rates of ACL reconstruction among children in Sweden have increased since 2014, with 75% of them occurring in female patients.⁷ It is possible that awareness of CL injuries among this age group has increased and more CL injuries have been diagnosed.³¹ In Sweden, young players (<18 years of age) most often have inexperienced coaches, usually a parent, while older soccer players have more experienced coaches with more coaching education. Inexperienced coaches might not implement the KCP to the same extent as the more experienced coaches. The older players and their coaches may also have carried out the KCP for a longer time and had greater awareness and confidence in the necessity of KCP training.

The present study showed that 21 of 24 district FAs had undergone KCP education to some extent during the 2010 to 2015 period. An earlier study by Lindblom et al¹⁹ evaluated the implementation aspects of the Swedish KCP (in 2012) with a questionnaire to 799 coaches (coaching female teams) 3 years after the Swedish KCP randomized controlled trial study period. They found that the reach and adoption of the KCP was high among coaches, showing that they were familiar with the program (91%-99%) and also

used it to a high extent (72%-74%).¹⁹ The Swedish FA had formal written policies regarding the implementation of the KCP, and 2 of 8 district FAs (25%) had informal guidelines.¹⁹ In the present study, 29% of the 24 district FAs had informal guidelines, and 21% had written policies, which indicate that now, 4 years later, more district FAs have policies and guidelines regarding KCP implementation and education. Since 2015, it has been clearly stated in the Swedish FA curriculum that the KCP should be included in training sessions from the age of 9 years (www.fogis.se). Unfortunately, there is often a discrepancy between what is reported by sports bodies at any level and what is regularly implemented in practice.⁶

Only 1 district FA had not undertaken any KCP education at all. One district FA stated that it used another form of an NMT program with the goal to reduce knee injuries, and 1 district FA used the KCP only to train and educate the more talented players in the “district soccer team.” All this suggests that KCP training is used in soccer district FAs nationwide, even if not uniformly undertaken throughout the country. The reason why some district FAs did not carry out any education in the KCP is unknown, but since 2015, it has been strongly recommended for all district FAs to educate coaches in the KCP. Facilitators for the coach implementation of NMT programs have been identified as largely practical in nature, such as time, accessibility to the program, and instructional resources.^{22,28} An interview study of coaches’ experiences of using the Swedish KCP suggested that support from district FAs and the club (eg, by practical workshops and annual follow-ups) and other coaches on the team, more possibilities to vary and tailor the KCP to the needs of the team (eg, based on age group or proficiency), and easy access to the KCP were facilitators for program adoption and use.¹⁸

The KCP is easily available on websites (Swedish FA and Folksam) and by using internet search engines. The most accessible way to find and use the KCP is to download it onto a smartphone or other multimedia device. It has been shown that using a mobile app leads to similar compliance to prevention programs compared with using written materials.³² Between 2012 and 2015, there were more than 100,000 downloads of the KCP app nationwide in Sweden. However, downloading the app may not correlate with usage of the KCP.

The present study is a descriptive epidemiology study that retrospectively examined more than 17,500 knee injuries among licensed soccer players in Sweden and analyzed the results on a population level. Only injuries that were reported to the insurance company were captured in the database and could be analyzed in the study; thus, the true magnitude and burden of knee and CL injuries might be even greater than that presented here. Forssblad et al⁸ found that 74% of ACL injuries resulting in surgical procedures were reported to the insurance company in a Swedish county. They did not perform the same comprehensive quality check as in the present study. There may be several factors that influence the injury reporting rate to the insurance company, such as a lack of knowledge among players and coaches or choosing to use another insurance company. If the player reports the injury to another

insurance company (where he or she has a personal insurance agreement), this insurance company is required to inform the player to also report the injury to Folksam.

Serious knee injuries leading to permanent medical impairment, such as CL injuries, are more likely to be reported to the insurance company because it provides financial compensation to the player, regardless of whether the player has more than 1 agreement with different insurance companies. The medical diagnosis of knee injuries often takes time; hence, the registration and/or diagnosis of the injury might be delayed. The players have 3 years (in rare cases, up to 10 years) to report an injury to the insurance company, and thereby, an adjustment of the injury incidence numbers for each year was performed in the present study. Even if this approach gave an approximation of the incidence, it was necessary so as to achieve more accurate figures of incidence over time. Neglecting this calculation, any decrease in the incidence of CL and knee injuries could have been explained by not all injuries having been reported to the insurance company in later years.

It is known that compliance with the KCP is essential to achieve a reduction in the injury risk.¹¹ However, there was no information available regarding an individual player’s KCP training data in this study. Instead, data regarding the numbers of coach/player courses and downloads of the KCP mobile app were used to quantify the nationwide implementation of the KCP.

The decrease in the incidence of CL injuries by 13% in female players and 6% in male players can be equated with a reduction of approximately 100 CL injuries per year. No cost effect was calculated within the present study, but this finding would lead to reduced health care costs for society and also better health for the player both in the short and long term. The monetary value for health care costs associated with 1 CL reconstruction surgery has been estimated at approximately US\$3000 to US\$4000 (25,000-35,000 SEK),⁷ and it is higher when considering postoperative medical care and rehabilitation. When including sick leave, reduced lifelong physical activity, and a higher risk of future medical care (eg, knee replacement due to osteoarthritis or cardiovascular diseases), the total costs for society are much higher. The monetary cost for the Swedish FA regarding KCP education in Sweden is approximately US\$10,000 (~80,000 SEK) each year. This means that the costs associated with nationwide KCP education each year are less than the costs for just 1 CL injury. Studies attempting to calculate costs associated with soccer CL injuries have shown that the injury-related costs (health care and non-health care costs) were reduced in adult male amateur soccer players after implementation of an NMT program mainly because of a lower proportion of knee injuries.¹⁷ In youth soccer players, the implementation of an NMT program has led to a considerable reduction (43%) in health care costs.²¹

The fact that there was no decrease in the incidence of CL and knee injuries among young players (<18 years of age) is concerning and needs further investigation. It is important to continue these intervention efforts to maintain and increase the use of the KCP, especially among young players. Further studies should also continue to follow time

trends in knee and CL injuries among soccer players as well as KCP implementation.

The limitations of the study may be that time exposed to soccer, level of play, and other confounding variables such as natural or artificial turf, weather conditions, and contact versus noncontact injuries are not registered within the insurance database. More time exposed to soccer entails a higher risk of soccer-related injuries,⁹ and many previous studies have evaluated injury rates with “injuries/1000 hours of exposure.”^{4,5,10,33} Young, talented players who participate in additional matches with teams other than their own, often at a higher level, may have a greater risk of acute knee injuries.²⁶ There are also studies showing that adolescent female players with low soccer participation have an increased risk of injuries.^{4,13} There is no obvious reason to believe that the average hours of soccer exposure per player in Sweden would have changed over the observed period; thus, the incidence rate per 1000 player-years is held to be valid. Also, the weather and soccer turf conditions did not differ considerably during the study period.

CONCLUSION

The Swedish KCP can be considered partially implemented nationwide because 21 of 24 district FAs educate coaches and soccer players in the program. The incidence of knee and CL injuries has decreased significantly in both sexes nationwide during the observed period and specifically when comparing the 5-year period before versus after the large-scale nationwide implementation of the education program.

ACKNOWLEDGMENT

The authors thank Lena Lindquist, Folksam, and Helena Stigson, associate professor at Karolinska Institutet and Folksam, for technical help with the database.

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