High risk of new knee injury in elite footballers with previous anterior cruciate ligament injury

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High risk for new knee injury in anterior cruciate ligament injured elite footballers

Key words

Football, incidence, knee, prevalence
ABSTRACT

Background: Anterior cruciate ligament (ACL) injury is a severe event for a footballer, but it is unclear if the knee injury rate is higher after returning to football following ACL injury.

Objective: To study the risk for knee injury in elite footballers with a history of ACL injury compared to those without.

Method: The Swedish male professional league (310 players) was studied during 2001. Players with a history of ACL injury at the study start were identified. Exposure to football and all time loss injuries during the season were recorded prospectively.

Results: Twenty-four players (8%) had a history of 28 ACL injuries in 27 knees (1 re-rupture). These players had a higher incidence of new knee injury of any type than the players without ACL injury (4.2 ± 3.7 vs. 1.0 ± 0.7 injuries per 1000 hours, p=0.02). The risk for suffering a knee overuse injury was significantly higher regardless of whether the player (relative risk 4.8, 95% CI 2.0-11.2) or the knee (relative risk 7.9, 95% CI 3.4-18.5) was used as the unit of analysis. No interactive effects of age or any other anthropometric data were seen.

Conclusion: The risk for new knee injury, especially overuse injury, was significantly increased after return to elite football following ACL injury regardless of whether the player or the knee was used as the unit of analysis.
INTRODUCTION

Anterior cruciate ligament (ACL) injuries are not uncommon in football.\(^1\)-\(^5\) Apart from causing long temporary absence from the game,\(^1\)-\(^4\) ACL injury may also prevent return to football, at least at the same level as prior to the injury.\(^1\),\(^6\)-\(^7\) Furthermore, ACL injury considerably increases the risk for developing osteoarthrosis in the injured knee.\(^8\)-\(^10\)

Between 7-35% of all injuries in elite football are reported to be recurrent, depending on the study design and the definition of re-injury.\(^11\)-\(^14\) Previous injury is the strongest risk factor for new football-related ankle sprain,\(^5\),\(^15\)-\(^16\) and hamstring strain.\(^5\),\(^17\) In Australian Rules Football, previous ACL reconstruction has been shown to be the strongest risk factor for new ACL injury,\(^18\) but a similar study on ACL injuries in football is lacking. Although most practitioners would also argue that the risk for new knee injury is increased following an ACL injury, there is no scientific evidence to support this with regard to football players.

Traditionally, when analysing the effects of previous injury on the risk for new injury, the player has been used as the unit of analysis.\(^17\) In a hamstring strain model, however, it was proposed that the limb can be used as the unit of analysis instead, since the factors that contribute to re-injury such as decreased proprioception, reduced range of motion, scar tissue are probably more related to the injured limb and not the person.\(^17\)

The main purpose of this prospective study on Swedish male elite footballers during the 2001 season was to study the incidence of new knee injuries among players with and
without a history of ACL injury. Analyses were performed using the player or the knee as the unit of analysis, with the aim of comparing the two statistical models. The primary outcome was a new knee injury and our hypothesis was that the knee injury rate is higher in ACL-injured players/knees compared to ACL-healthy players/knees.
MATERIAL AND METHODS

Players from all 14 clubs in the Swedish professional league were studied prospectively during the 2001 season. The methodological design has been fully described in a previous study. All first team squad players were invited to participate voluntarily during the first month of the season (January). Players contracted at a later date were not included. Signed informed consent was obtained from all 310 players included and two players declined (Figure 1). Thirty-one players dropped out during the season (30 players due to transfer and one due to illness). Data for these players are included in the analyses for the entire time of their participation.

History of ACL injury, anthropometric data, player position and leg dominance were provided by the club medical staff at the start of the study. The kicking leg was regarded as dominant. Further details of past and present ACL injuries among the players including time of injury, injured side and treatment were obtained from three sources: (1) the players themselves; (2) the team doctors and the mandatory team medical records; and (3) the Folksam Insurance Company. All Swedish players from the age of 15 are insured with Folksam through their playing licence.

All teams documented individual exposure in minutes for all training sessions and matches with the club and national teams on a standard attendance record form. The club doctor was responsible for diagnosis and treatment of injuries. Injuries were reported on a standard injury card and defined as occurring during scheduled training sessions or matches causing the player to miss the next training session or match. The
injuries were divided into traumatic and overuse injuries. Traumatic injuries were characterised by acute onset and subdivided into sprains, strains, contusions, fractures, dislocations, joint injuries and other forms of traumatic injury such as wounds and concussions. Overuse injury was characterised by insidious onset without any known trauma. A recurrent injury was defined as a subsequent injury of the same type and location and occurring on the same side as the previous injury during the season.

The study was approved by the Ethics Committee of Linköping University, Sweden.

**Statistical analysis**

The players were divided into two groups: players with a history of ACL injury at the start of the study (ACL-injured group) and players without that history (ACL-healthy group). Group differences in anthropometric data and exposure were analysed using an unpaired t-test and in injury time loss using the Mann-Whitney U test. The ACL injury prevalence was calculated as the percentage of first team squad players having a history of ACL injury in January 2001. The injury incidence was calculated as the number of injuries per 1000 hours of exposure and expressed as mean ± standard deviation (SD). Group differences in injury incidence were analysed using the Wilcoxon signed rank test. The risk for suffering a knee injury using the player or the knee as unit of analysis was analysed using a Cox proportional hazards regression model and expressed as the relative risk with 95% confidence interval (95% CI) for the ratio. The difference between injured side and dominant side was analysed using the chi-square test. Comparison of the frequency of knee-injured players was analysed using Fischer’s exact test. The significance level was set at 5% (p<0.05).
RESULTS

History of ACL injury
Twenty-four players had a medical history of altogether 28 past or present ACL injuries (Table 1). Three players had suffered bilateral ACL injuries and one of them had also suffered a re-rupture 10 years after his first ACL tear. All ACL injuries (except the bilateral injuries of one player, both treated conservatively) were treated by ACL reconstruction. All ACL injuries except one had been reported to the Folksam Insurance Company.

Insert Tables 1 and 2 near here

There were no differences in anthropometric data between players with a history of ACL injury and players without (Table 2). Among the 23 players with known dominant leg (one player was ambidextrous), there was no difference in the number of ACL injuries between dominant and non-dominant sides (16 vs. 11 ACL injuries, p=0.55).

Risk exposure and injuries
Total exposure to football was 93,353 hours. The ACL-injured players had lower exposure than the ACL-healthy players and longer absence due to injury (Table 2). In total, 715 injuries were recorded and 625 (87%) were located to the lower limbs (Figure 1). Seventy percent of the injuries to the lower extremities in the ACL-injured group (38/54) affected a limb with a previous ACL injury.
The knee injuries incurred by the 24 ACL-injured players are shown in Table 3 and by the 286 ACL-healthy players in Table 4. Half of the players (n=12) with a history of ACL injury suffered at least one knee injury during 2001 which was a significantly higher proportion than the ACL-healthy group (50% vs. 21%, p=0.004). One overuse injury and three traumatic injuries in the contralateral healthy knee occurred in the ACL-injured group (Table 3). Ten players from eight different teams had ACL reconstruction during the 2000 season. Half of these players suffered altogether nine overuse injuries to their newly reconstructed knees during 2001 and one a secondary medial meniscus tear.

Insert Tables 3 and 4 near here

Risk for injury
The difference in knee injury incidence between players with and without a history of ACL injury was significant (4.2 ± 3.7 vs. 1.0 ± 0.7 injuries per 1000 hours, p=0.02). There was no difference between the groups in the incidence of total injuries (10.1 ± 9.3 vs. 7.6 ± 4.6 injuries per 1000 hours, p=0.08) or in lower limb injuries not related to the knee (5.4 ± 6.0 vs. 5.7 ± 3.6 injuries per 1000 hours, p=0.66).

When using the player as the unit of analysis, the risk for suffering a new knee injury was significantly higher among the 24 ACL-injured players than among the 286 ACL-healthy players (relative risk 3.4, 95% CI 1.8-6.3). The risk for incurring a traumatic knee injury was significantly higher among the ACL-injured players (relative risk 2.7, 95% CI 1.3-5.8) as well as for overuse injury (relative risk 4.8, 95% CI 2.0-11.2). When
using the knee as the unit of analysis (27 ACL-injured knees and 593 ACL-healthy knees) the risk for suffering a new knee injury was significantly higher in ACL-injured knees than in ACL-healthy knees (relative risk 4.5; 95% CI 2.3-8.8). The risk for incurring a knee overuse injury (relative risk 7.9, 95% CI 3.4-18.5) and a traumatic knee injury (relative risk 2.6, 95% CI 1.1-6.7) was also significantly higher in the ACL-injured knees. No interactive effects of age or any other anthropometric data were seen.
DISCUSSION

The principal finding in this study was that the risk for suffering a new knee injury, especially overuse injury, was significantly higher in players with a history of ACL injury than in players without. The higher risk for knee injury was seen regardless of whether the player or the knee was used as the unit of analysis.

Risk for injury

When studying the effects of previous injury on the risk for new injury, the unit of analysis has traditionally been the player.\textsuperscript{17} However, factors such as decreased proprioception, reduced range of motion or scar tissue after an injury may be regarded as more related to an injured limb than to the person. It has therefore been proposed that the limb can be used as the unit of analysis instead.\textsuperscript{17} However, bilateral proprioceptive deficits have been observed even after unilateral ACL injury,\textsuperscript{20} and there is also some evidence that a genetic predisposition influences the risk for tearing the ACL.\textsuperscript{21} It could therefore be argued that some factors associated with ACL injury are more related to the person than the injured limb.

The risk for suffering a new knee injury in this study was significantly higher in the group of players with a history of ACL injury, and this difference was seen regardless of whether the player or the knee was used as the unit of analysis. This finding suggests that either of the two methods can be applied and using the limb instead of the person could be an attractive alternative when studying uncommon injury types. The higher risk for knee injury was especially pronounced for overuse injury, but no further sub-
analyses were meaningful due to a limited number of injuries for each injury subtype. However, ACL-injured players may be more prone to suffer from synovitis or osteoarthritis, but perhaps not from contusion or iliotibial syndrome etc.

When using a Cox proportional hazards regression model, exposure time is the main variable. The method takes into account that playing time can vary greatly between different players in the squad, but requires that individual exposure is documented. It also takes censorship into account, i.e. shortened follow-up for reasons other than injury (for example illness or transfer). Furthermore, potential confounding risk factors can be included in the analysis. One example is age, since increase in age has been found to be a significant risk factor for incurring new football injuries. However, no interactive effects from age or any other anthropometric variables were seen in this study. Another advantage is that the effect of many recurrent injuries to a few players is avoided. As seen from Tables 3 and 4, recurrent injuries constituted 24% of all knee injuries during the season. However, the higher risk for suffering an overuse injury among the players with a history of ACL injury was significant in spite of filtering the recurrent overuse injuries.

The fact that half of the players who had ACL reconstruction during 2000 incurred at least one overuse injury shortly after their comeback suggests that the first months after return to football are of specific concern. A short interval between the final rehabilitation date and a subsequent time loss due to knee symptoms might also indicate inadequate rehabilitation and premature return. Traditionally, return to contact sports is allowed around 6 months after ACL reconstruction. However, at this time significant
thigh muscle strength deficits often exist as well as reduced performance evaluated by the one-leg jump test.\textsuperscript{22} It is also well-known that standardised criteria for return to sports after ACL injury are missing.\textsuperscript{22-23}

Except for premature return to football, there could be several other possible explanations for the high rate of overuse injuries in knees with a reconstructed ACL: (1) the transition from complete rehabilitation to full participation in collective training and matches may result in pure overloading of still not healed or remodelled tissues; (2) after their long convalescence the players may be more motivated to show their coach that their performance is adequate for a position in the initial line-up, which might result in higher play intensity; (3) even if satisfactory mechanical stability is achieved after ACL reconstruction, the knee may still suffer from altered kinematics and diminished proprioception;\textsuperscript{20, 24-25} and (4) ACL injury is often combined with concomitant bone bruising and lesions to other intraarticular structures such as menisci or joint cartilage,\textsuperscript{26} which could make the joint more vulnerable to loads that were tolerated before the ACL injury. However, the history of previous or concomitant meniscus and joint cartilage lesions was not recorded and the influence of these joint injuries on the risk for subsequent knee injury is therefore not clear from this study. Finally (5), it is also possible that some players may be injury prone due to an aggressive playing style or high risk-taking behaviour etc. However, we found no evidence that ACL-injured players were more prone to suffer injuries to the lower limbs that were not related to the knee (p=0.66).
Consequences of ACL injury

Tear of the ACL is a severe injury for a footballer and the injury may prevent return to football, at least at the same level as prior to the injury.\textsuperscript{1,3,6-7} In one Swedish follow-up, no elite player still played football at elite level seven years after ACL injury.\textsuperscript{7} In contrast, five players in our study played elite football at least seven years after their ACL injury. This may reflect a satisfactory outcome, but could also be regarded as knee abuse with a high risk for secondary joint injury and development of osteoarthrosis.\textsuperscript{8-10} The high rate of subsequent knee injuries after ACL injury is a worrying find and the problem may be even greater since the frequency of ACL-injured players that were able to play with a painful knee without any loss of exposure is unclear using the present study design. Clearly, future studies in this field are needed if we are to give proper advice to players regarding their short- and long-term knee prospects.

Insurance claims data

From the age of 15, all Swedish football players are insured with Folksam through their mandatory playing licence. In this study, all ACL injuries except one were reported to the insurance company. It thus seems that in Sweden insurance claims data are epidemiologically reliable for estimating the occurrence of ACL injury at the elite level. Whether this is true at lower levels, for other severe knee injuries or in other team sports is, however, unclear.

Methodological considerations

This study, conducted on a homogenous population of elite footballers, investigated the risk for injury in a group of 24 players with a history of ACL injury in altogether 27
knees and compared this with the 593 ACL-healthy knees (572 knees of the 286 ACL-healthy players and 21 knees of the 24 ACL-injured players). The principal limitation of the study is the small sample of ACL-injured players. In another study on 83 surgically verified ACL tears occurring during official matches in Australian Rules Football, a significantly higher risk (tenfold) for graft re-rupture during the first year after ACL reconstruction was reported.\textsuperscript{18} After the first year, the risk was still increased fourfold, but distributed fairly evenly between the reconstructed and the contralateral healthy knee. In our study, only one contralateral ACL tear and no re-rupture was identified during the one-year study period. Thus, to specifically study the re-rupture rate after ACL reconstruction in football, a considerably larger study sample and/or a longer observation period would be necessary.

The second principal limitation of this study is that most injuries were clinically diagnosed by the club medical staff and the degree of inter-rater reliability is unclear. However, magnetic resonance imaging (MRI) or arthroscopy was performed in a certain number of the knee injuries, but no standard criteria for referral to MRI or arthroscopy were formulated and it is therefore possible that there are differences in access to these diagnostic procedures. It is also possible that players with a history of ACL injury may have a lower threshold to seek medical attention due to symptoms from their knees compared with their ACL-healthy counterparts.

Since only two players did not agree to participate, it is highly unlikely with any selection bias due to the inclusion procedure. The players with a history of ACL injury are, however, to be regarded as “survivors” and the number of players who have retired
or settled for a career at a lower level of play during the preceding decade is unknown. The prevalence rate of 8% should also be interpreted as a minimum figure, since it may be possible that some players are able to play with undiagnosed ACL injury. However, the risk for overlooking a total ACL rupture at the professional level is, in our opinion, minimal since all traumatic knee swellings are routinely examined by magnetic resonance imaging (MRI) and/or arthroscopy. Likewise, newly contracted players are also routinely medically screened for past and present injuries. However, the risk for overlooking or misdiagnosing an ACL injury might be greater at lower levels of play where the clubs have less medical support.¹⁷
ACKNOWLEDGEMENTS

The authors gratefully acknowledge the involved clubs and Lars-Inge Svensson, Folksam Insurance Company, for help with data collection. Valuable comments on the manuscript given by Toomas Timka (MD, PhD) and Joanna Kvist (PT, PhD) are also appreciated as well as the help of biostatistician Karin Borg (PhD) for statistical advice and Peter Cox (MD) for correcting the text.

The study was financially supported by UEFA (Union of European Football Associations), the Swedish Football Association and the Swedish Sports Confederation (Sports Research Council).
INFORMATION BOX

What is already known on this topic

- ACL injury is a severe injury with a high risk for developing osteoarthrosis.
- The risk for recurrent injury in elite football is high.
- Previous injury is the strongest risk factor for new football injury.

What this study adds

- The risk for suffering a football-related knee injury was significantly associated with a history of ACL injury.
- Analyses using the player or the knee as the unit of analysis gave similar results.
REFERENCES


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Table 1. History of ACL injury in 310 players as recorded in January 2001

<table>
<thead>
<tr>
<th>Injury year</th>
<th>Injuries</th>
<th>Injured side</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>1</td>
<td>1 right</td>
<td>ACL reconstruction</td>
</tr>
<tr>
<td>1993</td>
<td>1</td>
<td>1 right</td>
<td>Conservative treatment</td>
</tr>
<tr>
<td>1994</td>
<td>3</td>
<td>3 right</td>
<td>ACL reconstruction</td>
</tr>
<tr>
<td>1995</td>
<td>3</td>
<td>2 right and 1 left</td>
<td>ACL reconstruction</td>
</tr>
<tr>
<td>1996</td>
<td>2</td>
<td>1 right and 1 left</td>
<td>ACL reconstruction</td>
</tr>
<tr>
<td>1997</td>
<td>2</td>
<td>2 right</td>
<td>ACL reconstruction</td>
</tr>
<tr>
<td>1998</td>
<td>1</td>
<td>1 left</td>
<td>ACL reconstruction</td>
</tr>
<tr>
<td>1999</td>
<td>4</td>
<td>1 right and 3 left</td>
<td>ACL reconstruction</td>
</tr>
<tr>
<td>2000</td>
<td>11</td>
<td>7 right and 4 left</td>
<td>10 ACL reconstruction (1 revisional) and 1 conservative treatment</td>
</tr>
</tbody>
</table>

Total 28 18 right and 10 left knees 26 ACL reconstructions and 2 conservative treatments
Table 2. Anthropometric data, risk exposure and injury time loss during 2001

<table>
<thead>
<tr>
<th>Variable</th>
<th>ACL-injured (N = 24)</th>
<th>ACL-healthy (N = 286)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>25 ± 4</td>
<td>25 ± 5</td>
<td>p = 0.62</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>183 ± 6</td>
<td>182 ± 6</td>
<td>p = 0.87</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>81 ± 6</td>
<td>79 ± 6</td>
<td>p = 0.32</td>
</tr>
<tr>
<td>Training (hours)</td>
<td>233 ± 79</td>
<td>266 ± 72</td>
<td>p = 0.03</td>
</tr>
<tr>
<td>Match (hours)</td>
<td>32 ± 13</td>
<td>38 ± 15</td>
<td>p = 0.06</td>
</tr>
<tr>
<td>Injury time loss (days)</td>
<td>24 ± 50</td>
<td>13 ± 31</td>
<td>p = 0.01</td>
</tr>
</tbody>
</table>
Table 3. Knee injuries during 2001 in 24 players with a history of ACL injury

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Injuries</th>
<th>ACL-injured knee</th>
<th>Recurrent injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capsular sprain</td>
<td>1</td>
<td>0</td>
<td>No</td>
</tr>
<tr>
<td>ACL tear</td>
<td>1</td>
<td>0</td>
<td>No</td>
</tr>
<tr>
<td>MCL tear</td>
<td>2</td>
<td>2</td>
<td>One recurrent injury to one player</td>
</tr>
<tr>
<td>Meniscus lesion</td>
<td>2</td>
<td>2</td>
<td>No</td>
</tr>
<tr>
<td>Chondral lesion</td>
<td>1</td>
<td>0</td>
<td>No</td>
</tr>
<tr>
<td>Giving way</td>
<td>2</td>
<td>2</td>
<td>No</td>
</tr>
<tr>
<td>Synovitis</td>
<td>10</td>
<td>9</td>
<td>Four recurrent injuries to three players</td>
</tr>
<tr>
<td>Osteoarthrosis</td>
<td>4</td>
<td>4</td>
<td>Four recurrent injuries to one player</td>
</tr>
<tr>
<td>Distal hamstring tendinosis</td>
<td>1</td>
<td>1</td>
<td>No</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>24</strong></td>
<td><strong>20</strong></td>
<td><strong>Nine recurrent injuries to five players</strong></td>
</tr>
</tbody>
</table>

ACL: Anterior Cruciate Ligament; MCL: Medial Collateral Ligament
Table 4. Knee injuries during 2001 in 286 players without a history of ACL injury

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Injuries</th>
<th>Recurrent injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capsular sprain</td>
<td>4</td>
<td>No</td>
</tr>
<tr>
<td>ACL tear</td>
<td>3</td>
<td>No</td>
</tr>
<tr>
<td>PCL tear</td>
<td>2</td>
<td>No</td>
</tr>
<tr>
<td>MCL tear</td>
<td>22</td>
<td>Three recurrent injuries to three players</td>
</tr>
<tr>
<td>LCL tear</td>
<td>1</td>
<td>No</td>
</tr>
<tr>
<td>Meniscus lesion</td>
<td>9</td>
<td>No</td>
</tr>
<tr>
<td>Contusion</td>
<td>9</td>
<td>No</td>
</tr>
<tr>
<td>Popliteus strain</td>
<td>1</td>
<td>No</td>
</tr>
<tr>
<td>Synovitis</td>
<td>11</td>
<td>Five recurrent injuries to two players</td>
</tr>
<tr>
<td>Osteoarthrosis</td>
<td>2</td>
<td>One recurrent injury to one player</td>
</tr>
<tr>
<td>Bursitis</td>
<td>2</td>
<td>No</td>
</tr>
<tr>
<td>Patellofemoral pain syndrome</td>
<td>11</td>
<td>Seven recurrent injuries to four players</td>
</tr>
<tr>
<td>Patellar tendinosis</td>
<td>8</td>
<td>One recurrent injury to one player</td>
</tr>
<tr>
<td>Iliotibial band syndrome</td>
<td>3</td>
<td>One recurrent injury to one player</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>88</strong></td>
<td><strong>18 recurrent injuries to 12 players</strong></td>
</tr>
</tbody>
</table>

ACL: Anterior Cruciate Ligament; PCL: Posterior Cruciate Ligament; MCL: Medial Collateral Ligament; LCL: Lateral Collateral Ligament
Figure 1. Study profile for 310 players with and without a history of ACL injury