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Mechanism of Anterior Cruciate Ligament Injuries in Soccer

Abstract

One hundred and thirteen patients, consecutively admitted to our clinic with an anterior cruciate ligament (ACL) rupture sustained while playing soccer, were surveyed and the mechanism behind their injury analyzed. The diagnosis was made arthroscopically or by instrumented laxity testing. The findings showed that the vast majority of the injuries were of the non-contact type and that very few were associated with foul play. No player positions were over- or underrepresented and goal keepers are apparently just as prone to ACL injury as their teammates. The findings of this study have helped our understanding of the mechanism behind ACL injuries in soccer and could be an aid to establishing future prophylactic measures. The findings also emphasize that certain injury mechanisms on the soccer field should alert the physician and draw his attention to a possible ACL injury.

Key words
Anterior cruciate ligament injury · ACL · soccer

Introduction

Over the past twenty years soccer has, with approximately two hundred million active players, become the world's major game [10]. Soccer is considered a relatively safe sport, but due to the large number of participants, it is responsible for a substantial number of injuries [6,12,14]. Fortunately, the majority of the injuries are of minor character [1,11,13].

Anterior cruciate ligament ruptures in soccer occur with incidences reported for a range of 0.06 to 3.7 per 1000 hours of active soccer playing [3,8,13]. Despite this relatively small risk for the individual player, because of its popularity soccer leads to an enormous number of ACL injuries.

The importance of the many ACL ruptures is further stressed by the finding that it is the injury that causes the longest lasting disability and is the most costly for the individual soccer player [9].

ACL ruptures among soccer players were described as primarily misdiagnosed in more than half of the cases in the study by Bjordal et al. [3]. This indicates that there is a need for higher alertness towards soccer-related ACL injuries among the team physicians and other medical personnel who examine the players after an injury.

While a tremendous effort has been put into the treatment of ACL injuries, only few studies have dealt with the prevention of ACL injuries in soccer [4].

A study of etiological factors provides the first step towards injury prevention, therefore the present study is designed to document and describe circumstances under which ACL injuries occur in soccer.

Material and Methods

In the study we analyzed pre-injury activity in soccer players who had an ACL rupture. We included patients taking part in an outdoor organized soccer match umpired by trained referees at the time of injury. The patients were consecutively included as

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they were admitted to our sports clinic. The time from injury to inclusion was 7 (mean, 0 – 41) days.

We handed out a questionnaire to all soccer players who were suspected to have sustained an ACL rupture playing soccer, at the time of injury (Fig. **1**). Enclosed was an introductory letter explaining the purpose of the study and guidelines for filling out the questionnaire. The soccer players were asked about their age, weight, height, years of experience, skill level, and dominating leg. They were asked to describe the circumstances under which the injury happened and where on the soccer field the accident occurred. Furthermore, they were requested to estimate the distance to the ball, opponents and team mates at the time of injury. Finally, they were asked to explain which foot was in contact with the surface and to which side they intended to move at the time of injury.

Previous injuries in ankle, knees, legs and hips, defined as an inability to play soccer for more than 2 weeks, were recorded.

We handed out questionnaires to 149 soccer players whom we suspected of having sustained an ACL injury. In that group we diagnosed an ACL rupture in 113 players, out of whom 105 filled out a sufficiently usable form. Patients with a partial ACL tear or an earlier ACL rupture, operated on or conservatively treated, were excluded from the study.

The diagnosis was made by a KT-1000 measurement confirmed by arthroscopy or MRI.

Chi-square test was used to analyze the numbers of injuries among goalkeepers, to compare the injuries in the two penalty boxes and the difference between injuries in opponents and the home field, between the first and second half and finally to compare earlier knee and ankle injuries in both legs of each player. A level of $p < 0.05$ was considered significant.

Results

Seven percent (7) of the injured were goalkeepers, who were not less likely to sustain an ACL injury than the rest of the players, assuming that there is an equal distribution among all of the team's players. The ratio of the different field players is dependent on the formation used by each team and therefore cannot be subject to statistical examination. Fifteen of the injured players

Name: Gender: Team: Age:

Please fill out this form. The information will be handled confidentially and will be available only for members of the study group at the Sports Clinic.

1. Experience with soccer: Years.
2. Weight: Kg
3. Height cm
4. Injured knee: Left: Right:
5. Dominant leg: Left: Right:
6. Level of soccer: Elite level; ___Lower levels:_____
7. Was a knee bandage used on now injured knee at time of this accident ? Yes ☐ No ☐
8. Was a knee bandage used on other knee at time of this accident? Yes ☐ No ☐
9. Previous ankle injury in same side as now injured knee? Yes ☐ No ☐
   (> 2 weeks inability to run)
10. Previous ankle injury in other side? Yes ☐ No ☐
    (> 2 weeks inability to run)
11. Have you had any previous injury in the now injured knee Yes ☐ No ☐
    (> 2 weeks inability to run)
    If yes describe: _____
    Use backside of paper if necessary
12. Have you had any surgery in the knee Yes ☐ No ☐
    (> 2 weeks inability to run)
    If yes describe: _____
    Use backside of paper if necessary
13. The injury occurred in first half of the game: ☐ Second half ☐
14. Approximately how many minutes of the match had surpassed at the time of injury min
15. At the time in quest. 14 your team was in the lead ☐ equal ☐ behind ☐
16. Your team was at the time in offensive ☐ defensive ☐ situation
17. You are Goalkeeper ☐ mainly offensive player ☐ mainly defensive player ☐

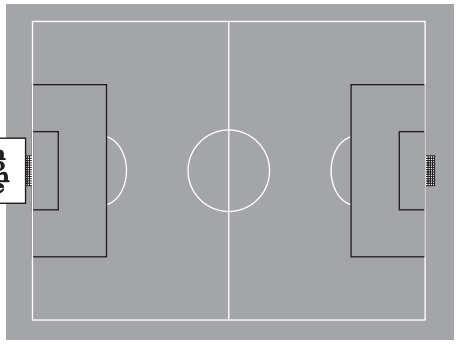
a

Fig. **1 a** and **b** Questionnaire handed out to all participants. The forms were translated from the Danish into English. *(continued)*

Fig. **1 b** *(continued)*

Mark the appropriate description(s) of your situation at time of accident

- ☐ No physical contact to other players
- ☐ The foot of the now injured side was planted in the ground
- ☐ If change, or intended change, of direction you turned towards now injured side
- ☐ If change, or intended change, of direction you turned towards uninjured side
- ☐ The ball was within one meter from you
- ☐ You were landing after heading or intending heading the ball
- ☐ You were landing on injured side
- ☐ You were landing on uninjured side
- ☐ You were being pushed at time of injury
- ☐ The situation prompted red ☐ or yellow card ☐
- ☐ You received penalty



Mark with **X** you position on the field at time of injury.

Mark with **O** the nearest opponent

Mark with × the position of the ball

If the questions do not cover your injury mechanism, please describe with your own words

b Please return the completed form

came from one of the three best leagues in Denmark; the others came from all levels of organized soccer in the country (Table **1**).

Fifty-nine percent (62) of all ACL injuries occurred on the opponents' half of the field.

There was no statistical difference between the numbers of players who were in a defensive role versus those in an offensive role at the time of injury.

Twenty-three percent (24) of the injuries took place inside the penalty box, of which 18 happened outside the opponents' goal and 6 outside the home goal. Activity inside the opponents' penalty box is therefore significantly more risky than in the home box, $p = 0.02$. The remaining 81 ACL injuries were evenly distributed throughout the soccer field. The largest number of injuries occurred during the second half, but the difference between the first and second half was not significant.

In twenty-six cases the injured player belonged to the leading team, whereas 50 were players on teams with an equal score as their opponents, and the rest (29) were on teams with fewer goals than the opponents' teams. In only 11 percent (11) of the situations that caused the ACL injuries did the referee give out either a yellow or red card. All 11 penalized players were from the opposing team. None of the injured players received a penalty at time of accident (Table **2**).

Table **1** Characteristics of ACL injured soccer players

n = 105	
Age	25.6 (16–45)
Goalkeepers	7
Strictly offensive players	28
Strictly defensive players	23
Elite level/lower levels	15/90
Favorite kicking leg injured	52

Thirty of the injured players were neither in contact with other players nor with the ball at the time of injury. Fifty-eight injuries happened in situations with ball contact but no contact to other players. Only seventeen sustained an ACL rupture while being

touched or actually pushed by another player at the time of injury (Table **3**).

Fifty-three percent (56) had intended to change their direction towards the side of their injured knee at the time the ACL was torn, while only 10 had intended to turn towards the uninjured side ($p < 0.01$). Twenty-six sustained their injury when landing after heading the ball, of whom twenty were being tackled by an opponent in the air, while not being in contact with the ground and thereby jeopardizing their landing. Nine landed on the injured leg not touched by other players. Thirteen of the 105 injured players had other explanations than the above mentioned or could not explain how the injury happened. All but one remembered the foot on the injured site as being in contact with the ground at time of injury (Table **4**).

Nineteen had had a previous injury other than an ACL injury in the now ACL-injured knee against five in the other knee. The difference is highly significant ($p = 0.004$) using Fischer's exact test. Earlier ankle injury was distributed equally between the same and the opposite side of the injured knee (Table **5**).

Table **2** Localisation on the soccer field and match characteristics at time of ACL injury

n = 105	
Opponents' field/home field	62/43
Defensive/offensive role at time of injury	38/50
Injury in penalty box – opponents/home	18/6
First/second half	40/65
Team leading/equal/behind	26/50/29
Foul play by opponent penalized by red or yellow card	11
Foul play by injured player	0

Table **3** Relation to ball and opponent at time of injury

n = 105	
No contact with ball or other player	30
Contact to ball but not to other players	58
Physical contact with other player	17

Table **4** Soccer players' activity at the time of injury

n = 105	
Running, intention of turning to (later) injured side	56
Running, intention of turning to uninjured side	10
Landing after heading and pushed while in the air	12
Landing after heading but not pushed	14
No clear mechanism	13
Foot on injured site with ground contact	104

Table **5** Previous injury (defined as more than 2 weeks absent from soccer)

n = 105	
Injury same knee	19
Other knee	5
Ankle same side	21
Ankle other side	16

Discussion

Soccer is an exciting team game that requires only inexpensive playing equipment. Its widespread popularity is reinforced by tremendous exposure from the media. The game is a contact sport where the players are allowed to tackle the shoulder directly to put the opponent off balance. Furthermore, soccer is characterized by speed, sidestepping, cutting, landing and abrupt stopping. During these movements the knee can be close to the "out of control situation" and therefore is potentially at risk for the ACL.

This study describes the circumstances under which ACL injuries occur during soccer. The players were questioned shortly after their injury and none of the questioned players had difficulties remembering the circumstances under which the injury took place. In comparison with the observations on injury mechanisms made in the study by Bjordal et al. [3], where the time from injury to registration was longer, we consider our registrations valid.

The design of this study, which is descriptive by nature, does not allow us to do statistical calculations on incidence-related figures. It is however relevant to do statistics on certain answers from the players.

None of the player positions were over- or under-represented. It is noteworthy that goalkeepers do not seem to have a lower risk for injury than the field players, although they have less ball contact than their teammates.

Further, the offensive and defensive players were almost equally represented in the material (Table **1**). This differs from the findings of Bjordal [3], who found higher risks for offensive players.

One would expect that if fatigue was a factor in ACL injuries, there would be an overrepresentation of injuries during the second half of the game. The number of ACL injuries were highest in the second half, but the number was not significantly different from that of the first half. We conclude that if fatigue does predispose to ACL injury, it is not detectable with numbers of persons used in this study.

One third of soccer injuries other than ACL ruptures are caused by foul play [7,14]. In our study ACL injuries were associated with

foul play in only one tenth of the cases. A significant reduction in ACL injuries therefore cannot be expected by trying to reduce unsporting behaviour.

It has been shown that the most frequent mechanism behind soccer injuries, in general, is collision with another player. Collision accounts for about thirty percent of all accidents, whereas 16 percent of all injuries were caused by kicks from an opponent in the study by Inklaar [13]. Our study shows that the mechanism behind ACL rupture differs from that of other soccer-related injuries because only a small fraction of the injured players had contact with another player at the time of the accident. We therefore conclude that tackling and kicking do not contribute significantly to ACL ruptures in soccer.

The low number of body-contact related ACL injuries corresponds to what is seen in basketball [2], Australian ruled football, where three out of four are nonc-ontact injuries [17] and team handball where 95 percent are non-contact injuries [16].

Others have found that tackling was responsible for almost half of all ACL injuries [3], whereas we found that only 18% (17 cases) had physical contact to another player at the time of injury. The explanation might be that Bjordal's [3] material was collected before 1994, when a new regulation was introduced mandating a warning to a player who was tackling from behind. The differences between our findings therefore could be a result of the new rules and hopefully a lower incidence of ACL ruptures in soccer.

Internal rotation of the tibia combined with a semi flexed knee at foot strike during landing was described by McNair [15] as the prominent mechanism behind the ACL lesion. This was confirmed by Ebstrup et al. [5], who found, by studying video clips of ball games, that cutting maneuvers where the femur is externally rotated combined with valgus load predispose to ACL rupture. We found significantly more players turning toward the side of the injured knee at the time of accident. This leads us to expect that if the players were trained to do cutting moves by using the opposite leg, pushing the body in the desired direction, instead of crossing over the knee on the same side as the direction change, this would decrease the risk for an ACL injury.

Also landing after heading is a risky activity. Being pushed in the air further increases the risk. Often in these situations the players are being pushed by opponents or teammates who simultaneously are trying to head the ball. Landing is jeopardized and the femur can be rotated if the knee is only semi flexed. We suggest that players are trained in landing technique where both legs are used for landing and they are taught to flex the knee more during foot strike.

We noticed a surprisingly and significantly high number of earlier injuries in the now ACL damaged knee compared to the uninjured knee. The finding can be explained in either of two ways. The players could have had an unrecognized partial or total ACL lesion or the knee could have had another lesion, i.e. an MCL lesion predisposing to the ACL lesion. We recommend that soccer players with a previous knee injury are examined by an experienced physician in order to get a proper diagnosis before the start of the season.

There was a high number of previous ankle injuries among the ACL injured soccer players, but the methodology of the study does not allow us to draw any conclusion about a predisposing factor for ACL lesions. We did not obtain information about whether the players actually wore any ankle straps at the time of injury. However, there were no differences on the side with respect to the subsequent ACL injury.

The most important findings in our study are that the mechanisms behind ACL lesions in soccer can be described predominantly as non-contact and that two distinctive actions (change of direction and landing after heading) are responsible for 95% of the cases. We also found that a non-specific previous lesion is associated with ACL lesion in the same knee.

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