No Association Between Return to Play After Injury and Increased Rate of Anterior Cruciate Ligament Injury in Men's Professional Soccer

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Background: Studies have shown that previous injury, not necessarily anatomically related, is an important injury risk factor. However, it is not known whether a player runs an increased risk of anterior cruciate ligament (ACL) injury after returning to play from other injury types.

Purpose: To analyze whether professional soccer players are more susceptible to ACL injury after returning to play from any previous injury.

Study Design: Case-control study; Level of evidence, 3.

Methods: A total of 101 elite male soccer players suffering a first-time complete ACL injury between 2001 and 2014 were included and matched according to team, age, and playing position with control players who did not have a current injury (1:1 match). For each injured player, the 90-day period prior to the ACL injury was analyzed for injuries and compared with that of control players by using odds ratios (ORs) and 95% CIs.

Results: The odds of a player with an ACL injury sustaining a previous injury in the 90-day period did not differ significantly from that of controls (OR, 1.20; 95% CI, 0.66-2.17; $P = .65$). Testing the frequency of absence periods due to injury between the groups revealed that the odds of a player with an ACL injury having a previous period of absence due to injury did not differ compared with controls (OR, 1.14; 95% CI, 0.64-2.01; $P = .77$).

Conclusion: Players with ACL injury did not have a greater occurrence of absence due to injury in the 3 months preceding their ACL injury compared with matched controls. This indicates that previous injury of any type does not increase the risk of suffering an ACL injury.

Keywords: ACL; knee injury; ACL injury; ACL risk factors

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Injuries have a significant influence on performance in male professional soccer, and this underlines the importance of injury prevention to increase a team's chances of success.[1,3,4,13,14] A men's professional soccer team with a mean 25 players suffers approximately 1 anterior cruciate ligament (ACL) injury every 2 seasons.[25] ACL injuries are severe, causing a long temporary absence from the game for the player,[1] and are possibly career threatening.[21] It has previously been reported that the vast majority of male professional soccer players are able to return to play at the same level within 1 year after ACL injury.[25] However, returning to play after ACL injury leads to an increased risk of new knee injuries, including recurrent ACL injury.[24] It is not known whether injuries other than that of the ACL are associated with an increased risk of suffering an ACL injury.

Importantly, previous injury has been identified as an important risk factor for suffering a subsequent injury.[1,3,7,12,13,17] In a study from Iceland's top 2 divisions, Árnason et al[1] showed that soccer players who sustained a previous hamstring and groin strain, or knee and ankle sprain ran an increased risk of new injuries of the same type and at the same location. Engebretsen et al[7] showed that a history of acute groin injury and weak adductor muscles were significant risk factors for new groin injuries in the top 3 divisions in Norway. Hägglund et al[12] followed 12 Swedish male elite soccer teams and showed that a player with a previous hamstring injury, groin injury, and knee joint trauma was 2 to 3 times more likely to suffer an identical injury in the subsequent season. Factors such as remaining strength deficits, neuromuscular imbalance, and reduced flexibility may contribute to this increased risk after previous injury.[2,18] However, it has also been shown that previous injury is not necessarily anatomically related and may increase the risk of injury of another type and location.[13,17] For example, the risk of muscle injury in the lower extremities is increased by previous injury not only in the same muscle but also in other muscles in the lower extremities.[13] Nordström et al[17] showed that concussion increases the risk of subsequent other injury by approximately 50% in the following year in elite male soccer players. As injuries are strongly linked, it is important to identify risk factors associated with an increased risk of injury to establish prevention programs to prevent further injuries.[15]

The aim of this case-control study was to analyze whether male professional soccer players are more susceptible to sustaining an ACL injury after returning to play from any previous injury other than that to the ACL. The hypotheses were that ACL-injured players had suffered more injuries and had more periods of absence due to injury in the 90 days before the ACL injury compared with control players.

METHODS

Study Population

This study is based on 101 male professional soccer players who suffered a first-time complete ACL injury. These players were randomly matched (1:1 match), using several matching criteria, against 101 control players where each control was matched from the same team based on the assumption that players in the same team have similar training activities, injury-prevention strategies, quality of fields, and rehabilitation strategies. The controls were studied during the same 90-day period as the paired players with ACL injury and were required to have participated in both training sessions and matches during this period. Since increased age has been found to be a significant risk factor for incurring new soccer injuries,[1] we used age as one of the main matching criteria. The controls were matched within ±3 years of age to the players with ACL injury as well as for playing position (defender and midfielder/forward); that is, players with ACL injury and their matched controls were either defenders or midfielders/forwards.

TABLE 1
Operational Definitions Used in the Study[a]

Training session	Team training that involves physical activity under the supervision of the coaching staff
Match	Competitive or friendly match against another team
Injury	Injury resulting from playing soccer and leading to a player being unable to participate fully in future training or match play (ie, time-loss injury)
ACL injury	First-time complete rupture of the ligament occurring either in isolation or associated with other concomitant injuries to the knee joint
Slight/minimal injury	Injury causing 0-3 days of absence from training and match play
Mild injury	Injury causing 4-7 days of absence from training and match play
Moderate injury	Injury causing 8-28 days of absence from training and match play
Severe injury	Injury causing >28 days of absence from training and match play
Injury incidence	Number of injuries per 1000 hours ((Σ injuries/Σ exposure hours) × 1000)

[a]ACL, anterior cruciate ligament.

Players with ACL injury and their matched controls came from 45 senior professional soccer teams from the top divisions in 11 European countries. The following cohorts were included: Union of European Football Associations (UEFA) Elite Club Injury Study 2001-2002 to 2013-2014 (12 seasons), English Premier League 2011-2012 to 2013-2014 (3 seasons), and the Swedish and Norwegian Premier Leagues 2010-2011 (2 seasons). The full methodology for and the development of these cohort studies have been reported elsewhere.[11] The study design underwent an ethical review and was approved by the UEFA Football Development Division and the Medical Committee.

Study Procedure

The collected information included playing exposure in the first and second teams as well as any national team duty.[11] The teams' medical staff recorded injuries using a standard injury form that provided information about the diagnosis and the nature and circumstances of injury. All injuries resulting in a player being unable to participate fully in training or match play (ie, time-loss injuries) were recorded. The player was regarded as injured until the team medical staff allowed full participation in training and availability for match selection (Table 1). All injuries were followed until the final day of rehabilitation. The Orchard Sports Injury Classification System was used to classify specific injuries.[20]

Inclusion and Exclusion Criteria

Players (cases and controls) were excluded if they had a history of previous partial or complete ACL injury. Only

complete ACL injuries, as determined by clinical investigation, magnetic resonance imaging (MRI), and/or surgery, recorded prospectively during injury surveillance were included, while partial ACL injuries, regardless of treatment, were excluded. Goalkeepers were also excluded from this study due to having a different injury pattern compared with field players.[5]

Statistical Analysis

Descriptive statistics were produced for the number of injuries, exposure, injury incidence, and number of injury periods within the 90-day study period. A matched and paired case-control study was carried out in which the matched pairs having at least 1 injury versus no injury during the 90-day period were analyzed. In the same way, the groups were compared for absence from play because of injury versus no absence during the 90-day period, including ongoing injury absence at the start of the 90-day period. The injury incidence was calculated as the number of injuries per 1000 hours. The results are presented as odds ratios (ORs), with the odds for the ACL-injured group divided by the odds for the control group. The Mantel-Haenszel method was used to calculate the OR, with a 95% CI. The significance level was set at $P < .05$.

To verify the exposure similarities, the difference in exposure between the injured players and controls was analyzed using the McNemar chi-square test. The quartiles in the McNemar test were based on the players with ACL injury and controls together. Consequently, the 25% of players with the lowest exposure were in the <25% quartile, and the same applied to the remaining quartiles.

RESULTS

All included players (N = 202) were between 18 and 37 years old, with a mean age of 25 ± 4.1 years for players with ACL injury and 25 ± 3.9 years for controls. Among players with ACL injury, there were 25 forwards, 45 midfielders, and 31 defenders, and among controls, there were 30 forwards, 40 midfielders, and 31 defenders. The similarity in exposure between injured players and controls is presented in Table 2. There were no statistically significant differences in training exposure ($P = .58$), match exposure ($P = .51$), or total exposure ($P = .92$) between injured players and controls, confirming our assumption that the groups had similar training conditions.

The number of injuries, exposure, and injury incidence during the 90-day period are presented and grouped according to injury severity in Table 3. The sum of all exposures in the 2 groups was similar, as were all the injury incidences.

A comparison between ACL-injured players and controls in terms of the number of injuries in the observed period is shown in Table 4. The odds of a player with ACL injury sustaining an injury in the 90-day period did not differ significantly from that of controls (OR, 1.20; 95% CI, 0.66-2.17; $P = .65$).

Testing the frequency of absence periods due to injury between groups (Table 5) revealed that the odds of a player

TABLE 2
Comparison of Exposure Between Players
With ACL Injury and Matched Controls[a]

| | Players With ACL Injury | | | |
| | <25% Quartile[b] | >25% and <75% Quartile[b] | >75% Quartile[b] | Total |
Controls				
Training exposure				
<25% quartile[b]	19	6	2	27
>25% and <75% quartile[b]	6	39	12	57
>75% quartile[b]	0	6	11	17
Total	25	51	25	101
Match exposure				
<25% quartile[b]	17	5	2	24
>25% and <75% quartile[b]	6	30	8	44
>75% quartile[b]	2	16	15	33
Total	25	51	25	101
Total exposure				
<25% quartile[b]	18	6	2	26
>25% and <75% quartile[b]	7	35	11	53
>75% quartile[b]	0	10	12	22
Total	25	51	25	101

[a]McNemar chi-square test. The table presents the number of pairs that matches the criteria specified in the row and column titles. For example, the first number, 19, is the number of pairs where both the ACL-injured player and control appear in the first quartile of amount of exposure. ACL, anterior cruciate ligament.
[b]Intervals of exposure (hours) within the 90-day period prior to ACL injury.

TABLE 3
Number of Injuries, Exposure, and Injury Incidence[a]

| | Players With ACL Injury | | | Controls | | |
Injury Type	n	Exposure	Incidence	n	Exposure	Incidence
Training injuries	16	5316	3.0	24	5206	4.6
Match injuries	26	1106	23.5	22	1234	17.8
Total injuries	42	6422	6.5	46	6440	7.1
Minimal injuries	9	6422	1.4	6	6440	0.9
Mild injuries	13	6422	2.0	11	6440	1.7
Moderate injuries	17	6422	2.6	20	6440	3.1
Severe injuries	3	6422	0.5	9	6440	1.4

[a]Incidence = number of injuries per 1000 hours. ACL, anterior cruciate ligament.

with ACL injury having an injury period did not differ compared with controls (OR, 1.14; 95% CI, 0.64-2.01; $P = .77$).

DISCUSSION

The principal findings in this study were that there were no differences in injury occurrence or absence due to any

TABLE 4
Number of Injuries in the 90-Day Period
Prior to ACL Injury[a]

	Players With ACL Injury		
	No Injury	≥1 Injury	Total
Controls			
No injury	43	24	67
≥1 injury	20	14	34
Total	63	38	101

[a]McNemar chi-square test. ACL, anterior cruciate ligament.

TABLE 5
Injury Within the 90-Day Period Prior to ACL Injury[a]

	Players With ACL Injury		
	No Injury	≥ 1 Injury	Total
Controls			
No injury	36	25	61
≥1 injury	22	18	40
Total	58	43	101

[a]McNemar chi-square test. ACL, anterior cruciate ligament.

injury other than ACL injury during the observed 90-day period between players who had suffered an ACL injury in a large-scale prospective injury surveillance project and players who had not. This novel information, that a player probably does not run an increased risk of suffering an ACL injury within a 3-month period after general injury, should be relevant and useful for taking care of players after injuries.

Previous Injury and Future Injuries

Waldén et al[24] showed that players who had a history of ACL injury 1 to 10 years earlier had a 4.2 times greater incidence of a new knee injury of any type compared with players without previous ACL injury. However, there was no increase in the incidence of total injuries of any type and any location or in lower limb injuries not related to the knee after ACL injury.

Previous injury, not necessarily anatomically related, is an important risk factor for a new injury.[13,17,19,23] For example, Hägglund et al[13] showed that a history of previous injury to other lower extremity muscle groups increased the rate of quadriceps and calf injury by 68% to 91%, a finding not previously reported in soccer. In addition, Nordström et al[17] recently reported that concussion increases the rate of subsequent injury of any type by approximately 50% in elite male soccer players.

Previous Injury and Future ACL Injury

Previous studies have shown an increased rate of anatomically related reinjuries. There has also been an association noted between previous injury and subsequent

anatomically nonrelated injuries.[13,17] To the best of our knowledge, however, there are no studies that have investigated the influence of previous injury other than ACL injury and the subsequent occurrence of ACL injury. The hypothesis in the present study was based on the assumption that remaining muscle strength deficits and/or muscle imbalance from a previous injury and insufficient time for tissue healing may explain an increased rate of reinjuries.[2,18]

In the current study, there was no association between previous injuries within the 90-day period preceding ACL injury and subsequent ACL injury. This novel finding is important when mapping the causes of ACL injury. In light of an unacceptably high reinjury rate in general,[6] this finding could also help to reassure the medical teams at the top European soccer clubs that they are doing well in reducing the effects of previous injuries that could possibly lead to an increased rate of ACL injury on return to play.

Risk Factors for ACL Injury

In a review, Sugimoto et al[22] indicated that specific biomechanical and neuromuscular characteristics may underlie an increased risk of ACL injury in male athletes. This has also been shown in female soccer players.[10] Differences in lower extremity biomechanics are observed in relation to anticipated versus unanticipated tasks, and these differences are influenced by foot positioning, playing surfaces, and fatigue status. Neuromuscular status, including fatigue, proprioception, muscle activation, and interjoint coordination, contributes to different lower extremity biomechanics.

This study indicates that there is no increased risk of ACL injury on returning to play from any other injury than ACL injury during the 90-day period, and it is possible to speculate that players with ACL injury did not have reduced functionality, as described here and in the review by Sugimoto et al.[22] One possible explanation is that the medical teams at this elite level are managing the rehabilitation process effectively so that the players have a well-developed fitness level when returning to play and thereby no increase in the risk of a subsequent ACL injury. This might not be true for lower level soccer.

There is evidence showing that a genetic predisposition strongly influences the risk of tearing the ACL.[16] Flynn et al[8] showed that participants with an ACL tear were twice as likely to have a close relative who had suffered an ACL injury compared with participants without an ACL injury. It could therefore be argued that some factors associated with the risk of ACL injury are more related to the person than to previous injuries, and one may speculate that they have torn their ACL earlier in life before they reached elite divisions of soccer.

Methodological Considerations

The main strength of this study is the large homogeneous sample of male professional soccer players followed prospectively for a long period using a standardized, recognized methodology.[9,11] In addition, the players with ACL

injury were carefully matched with controls of similar age and playing position from the same teams (1:1 match).

There are also some limitations to the present study. The cutoff of 90 days before ACL injury was determined more or less arbitrarily based on experience and not on previous studies. The rationale for choosing a 90-day period prior to ACL injury is that there needs to be enough time to include a reasonable number of injuries but not too much so as to reduce the possible effect of remaining strength deficits and neuromuscular imbalance, which may contribute to an increased risk after previous injury.[2,18] Moreover, if a longer period (eg, 6 or 12 months) were chosen, there might be a risk of a lack of complete data for players who had sustained an ACL injury early in their first season in the study or their controls. Furthermore, players were matched according to playing position as defender or midfielder/forward. With respect to the different demands and playing styles in soccer, it would have been more optimal to match controls with exactly the same playing position (eg, central defender, full-back, winger/midfielder, and so on), but we had to make compromises to enable matching with other criteria. We would also like to highlight that our study only describes the highest level of male soccer, and other results may be found for lower levels and for females.

CONCLUSION

This study showed that there were no differences in injury incidence or absence due to injury during the observed 90-day period between professional soccer players who suffered an ACL injury and players who did not.

ACKNOWLEDGMENT

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