ORIGINAL ARTICLE

Previous injury as a risk factor for injury in elite football: a prospective study over two consecutive seasons

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Br J Sports Med 2006;**40**:767–772. doi: 10.1136/bjsm.2006.026609

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Accepted 12 June 2006
Published Online First 19 July 2006

Background: Previous injury is often proposed to be a risk factor for football injury, but most studies rely on players reporting their own medical history and are thus potentially subject to recall bias. Little is known about the natural variation in injury pattern between seasons.
Objectives: To study whether prospectively recorded injuries during one season are associated with injuries sustained during the following season, and to compare injury risk and injury pattern between consecutive seasons.
Methods: The medical staffs of 12 elite Swedish male football teams prospectively recorded individual exposure and time loss injuries over two full consecutive seasons (2001 and 2002). A multivariate model was used to determine the relation between previous injury, anthropometric data, and the risk of injury.
Results: The training and match injury incidences were similar between seasons (5.1 *v* 5.3 injuries/1000 training hours and 25.9 *v* 22.7/1000 match hours), but analysis of injury severity and injury patterns showed variations between seasons. Players who were injured in the 2001 season were at greater risk of any injury in the following season compared with non-injured players (hazard ratio 2.7; 95% confidence interval 1.7 to 4.3, $p<0.0001$). Players with a previous hamstring injury, groin injury, and knee joint trauma were two to three times more likely to suffer an identical injury in the following season, whereas no such relation was found for ankle sprain. Age was not associated with an increased injury risk.
Conclusions: This study confirmed previous results showing that previous injury is an important risk factor for football injury. Overall injury incidences were similar between consecutive seasons, indicating that an injury surveillance study covering one full season can provide a reasonable overview of the injury problem among elite football players in a specific environment. However, a prolonged study period is recommended for analyses of specific injury patterns.

According to the van Mechelen model,[1] prevention of sports injury can be seen as a four step sequence: (1) the extent of the injury problem is evaluated through injury surveillance; (2) injury risk factors and injury mechanisms are established; (3) on the basis of this information preventive strategies are introduced; (4) these strategies are evaluated by repeating step 1.

Studies that describe injury risk and injury pattern in football players at club level are typically conducted over one competitive season or one year,[2–11] and some include only part of a season.[12 13] Whereas injury incidence and injury pattern is known to vary within one season, little is known about the natural variation between seasons, even though this could affect comparisons between studies. Only a few published studies have included data from two or more seasons.[14–17]

The extent of the injury problem in football has thus been described in several studies, but there are few studies that have gone past the first step in the sequence of prevention. There are contradicting results in the literature regarding the commonly proposed risk factors for injury, which may partly be ascribed to inaccurate measuring tools or small sample size.[18] However, previous injury has consistently been identified as an important risk factor.[11 19 20] A weakness of most studies assessing the relation between previous injury and injury risk is that they rely on the player's own history of previous injury. It is well known that recall bias is a major concern when relying on retrospective self reporting of injuries in football, even for injuries occurring during the previous season.[21] To avoid the effects of recall bias when evaluating previous injury as a risk factor for football injury, we conducted this study over two consecutive seasons and relied on prospectively recorded data only.

The aims of the present study were to: (*a*) study whether prospectively recorded injuries during one season are associated with injuries sustained during the following season; (*b*) study the natural variation in injury risk and injury pattern between two consecutive seasons. Our hypotheses were that: (*a*) previous injury is a risk factor for future injury; (*b*) injury incidence and injury pattern are similar between consecutive seasons.

MATERIALS AND METHODS

Study sample and study period

In the first step of this study, all 14 teams in the top Swedish male football division were followed during the 2001 season.[8 9 12] The 12 teams that remained in the top division (two teams were relegated after the 2001 season) were also followed during the 2002 season. These 12 teams, followed prospectively for two full seasons (January 2001 to November 2002), were included in the analysis. All first team players were included during the first month of each season (January). There were 263 players in the 12 teams in 2001, and 262 players in 2002 (see table 1 for anthropometrics). For the risk factor analysis, only the 197 players who participated in both seasons were included (mean (SD) age 25 (4) years (range 17–38), height 182 (5) cm (range 170–197), and weight 79 (6) kg (range 65–98)).

All players were informed about the study by their team doctor, and signed informed consent was obtained.

Table 1 Anthropometric data for footballers followed in seasons 2001 and 2002

	2001 (n = 263)		2002 (n = 262)		
	Mean (SD)	Range	Mean (SD)	Range	p Value
Age (years)	25 (5)	17–38	25 (5)	17–39	0.83
Weight (kg)	79 (6)	65–98	79 (6)	65–98	0.36
Height (cm)	182 (5)	170–198	183 (6)	167–199	0.80

Exposure registration

The development of the data collection procedure and data collection forms[22] and their practical implementation[9 12] have been described in detail previously. A club representative (present at all sessions) recorded individual exposure on a standard form (sent in on a monthly basis) for all included players, during training sessions and matches (friendly and competitive). This included exposure with the first and second teams, as well as national teams. A training session was defined as any coach directed scheduled physical activity carried out with the team.

Injury registration and definitions

The club medical staff (usually a doctor and physiotherapist) immediately documented all time loss injuries that occurred during the study period on a standard form. Injury was defined as any injury occurring during a scheduled training session or match causing the player to miss the next training session or match.[23] A diagnosis was noted on each injury card. An injured player was defined as injured until the club medical staff cleared him for full participation in training and match play. An identical injury (same side, location, and type) that occurred after a player's return to full participation after an index injury was defined as a recurrence.[24] A recurrent injury occurring within two months of a player's return to full participation was defined as an early recurrence.

Injuries were categorised as overuse or traumatic (acute). The definition of overuse injury was modified from Orava[25] and defined as a pain syndrome of the musculoskeletal system with insidious onset and without any known trauma or disease that might have given previous symptoms. Injuries were also classified into four severity categories according to the length of absence from training sessions and matches: slight (1–3 days); minor (4–7 days); moderate (8–28 days); major (>28 days). The number of days of absence was calculated according to the calendar and checked for accuracy against the exposure registration form.

Dropouts

In the 2001 season, 28 players (11%) dropped out during the season (27 through player transfer, one because of illness). In 2002, 33 players (13%) dropped out (26 through transfer, three were downgraded to youth teams, and three players quit because of injury and one because of illness). Of the 197 players that participated in both seasons, 18 dropped out during 2002.

Statistical analysis

Comparison between seasons

Anthropometric data were normally distributed and groups compared using an unpaired Student's *t* test. The number of training sessions and matches, and exposure data were compared using the Mann-Whitney U test because of abnormal distribution. Injury incidence was calculated as the number of injuries per 1000 player hours and presented with 95% confidence intervals (incidence/$e^{(1.96 \times \sqrt{(1/\text{injuries})}}$ to incidence $\times$ $e^{(1.96 \times \sqrt{(1/\text{injuries})}}$). Injury incidences were compared between seasons using z-statistics.[26] Injury patterns were compared between seasons using the χ^2 test or Fisher's exact test for small numbers.

Risk factor analysis

The baseline variables used in the risk factor analysis in season 2002 were: (*a*) prospectively recorded injuries in season 2001; (*b*) anthropometrics (age, height, weight, and body mass index (BMI)). A Cox proportional hazard regression model was used to determine the relation between the baseline variables and subsequent injury in the 2002 season. In this model, the time (hours of exposure) from the start of the follow up period (January 2002) until the event (first injury) or the end of follow up is the main variable. The model also takes censorship into account—that is, abbreviated length of follow up for reasons other than injury. All baseline variables were assessed in a univariate analysis and all variables that were $p<0.20$ in the univariate model were entered into a multivariate model for further analysis. In the multivariate model, variables that were $p<0.05$ were considered significant. All analyses were carried out using the player as unit of analysis. It was decided a priori to adjust for age when assessing previous injury as a risk factor.

Analyses were also carried out using the limb as unit of analysis[27] when previous injury was assessed as a risk factor for four specific injuries: hamstring injury (overuse or muscle strain injury to the hamstring); groin injury (overuse or muscle

Table 2 Risk exposure for footballers followed in seasons 2001 and 2002

	2001 (n = 263)		2002 (n = 262)		
	Mean (SD)	95% CI	Mean (SD)	95% CI	p Value
Season exposure					
Training sessions					
No/team	241 (18)	229 to 253	228 (10)	222 to 235	0.078
No/player	186 (52)	179 to 192	179 (49)	173 to 185	0.019
Matches					
No/team	41 (3)	39 to 43	46 (30	45 to 48	<0.001
No/player	29 (11)	28 to 30	32 (13)	30 to 33	<0.001
Exposure (hours/player)					
Total	299 (84)	289 to 309	295 (84)	285 to 305	0.45
Training	262 (73)	253 to 271	255 (71)	247 to 264	0.13
Matches	37 (15)	35 to 39	40 (18)	38 to 42	0.038
Weekly exposure (team)					
Trainings/week	5.7 (0.4)	5.4 to 6.0	5.5 (0.2)	5.4 to 5.7	0.27
Matches/week	1.0 (0.1)	0.9 to 1.0	1.1 (0.1)	1.1 to 1.2	<0.001
Activities/week	6.7 (0.4)	6.4 to 6.9	6.7 (0.2)	6.5 to 6.8	0.86

CI, Confidence interval.

Table 3 Injury incidences in seasons 2001 (n = 263) and 2002 (n = 262)

	Training				Match play				Total			
	2001		2002		2001		2002		2001		2002	
	N	Incidence	N	Incidence	N	Incidence	N	Incidence	N	Incidence	N	Incidence
All injuries	349	5.1 (4.6 to 5.6)	352	5.3 (4.7 to 5.8)	252	25.9 (22.8 to 29.2)	236	22.7 (20.0 to 25.8)	601	7.6 (7.1 to 8.3)	588	7.6 (7.0 to 8.3)
Traumatic	186	2.7 (2.3 to 3.1)	193	2.9 (2.5 to 3.3)	193	19.8 (17.2 to 22.8)	163	15.7 (13.4 to 18.3)*	379	4.8 (4.4 to 5.3)	356	4.6 (4.2 to 5.1)
Overuse									222	2.8 (2.5 to 3.2)	232	3.0 (2.6 to 3.4)
Early recurrent injuries	95	1.4 (1.1 to 1.7)	72	1.1 (0.9 to 1.4)	38	3.9 (2.8 to 5.4)	35	3.4 (2.4 to 4.7)	133	1.7 (1.4 to 2.0)	107	1.4 (1.1 to 1.7)
Injury severity												
Slight	127	1.8 (1.6 to 2.2)	133	2.0 (1.7 to 2.4)	54	5.5 (4.2 to 7.2)	80	7.7 (6.2 to 9.6)	181	2.3 (2.0 to 2.7)	213	2.8 (2.4 to 3.2)
Minor	76	1.1 (0.9 to 1.4)	83	1.2 (1.0 to 1.5)	87	8.9 (8.9 to 7.2)	82	7.9 (6.4 to 9.8)	163	2.1 (1.8 to 2.4)	165	2.1 (1.8 to 2.5)
Moderate	113	1.6 (1.4 to 2.0)	94	1.4 (1.1 to 1.7)	84	8.6 (7.0 to 10.7)	51	4.9 (3.7 to 6.5)**	197	2.5 (2.2 to 2.9)	145	1.9 (1.6 to 2.2)**
Major	33	0.5 (0.3 to 0.7)	42	0.6 (0.5 to 0.8)	27	2.8 (1.9 to 4.0)	23	2.2 (1.5 to 3.3)	60	0.8 (0.6 to 1.0)	65	0.8 (0.7 to 1.1)
Injury type/diagnosis												
Strain	65	0.9 (0.7 to 1.2)	79	1.2 (0.9 to 1.5)	76	7.8 (6.2 to 9.8)	33	3.2 (2.3 to 4.5)***	141	1.8 (1.5 to 2.1)	112	1.4 (1.2 to 1.7)
Sprain/joint injury	49	0.7 (0.5 to 0.9)	58	0.9 (0.7 to 1.1)	41	4.2 (3.1 to 5.7)	42	4.0 (3.0 to 5.5)	90	1.1 (0.9 to 1.4)	100	1.3 (1.1 to 1.6)
Groin injury	54	0.8 (0.6 to 1.0)	66	1.0 (0.8 to 1.3)	36	3.7 (2.7 to 5.1)	38	3.7 (2.7 to 5.0)	90	1.1 (0.9 to 1.4)	104	1.3 (1.1 to 1.6)
Hamstring injury	26	0.4 (0.3 to 0.6)	50	0.7 (0.6 to 1.0)**	40	4.1 (3.0 to 5.6)	25	2.4 (1.6 to 3.6)*	66	0.8 (0.7 to 1.1)	75	1.0 (0.8 to 1.2)
Knee joint trauma	22	0.3 (0.2 to 0.5)	31	0.5 (0.3 to 0.7)	22	2.3 (1.5 to 3.4)	24	2.3 (1.5 to 3.4)	44	0.6 (0.4 to 0.8)	55	0.7 (0.5 to 0.9)
Ankle sprain	25	0.4 (0.2 to 0.5)	25	0.4 (0.3 to 0.6)	16	1.6 (1.0 to 2.7)	17	1.6 (1.0 to 2.6)	41	0.5 (0.4 to 0.7)	42	0.5 (0.4 to 0.7)

Injury incidence is given with 95% confidence interval. Significant difference from the 2001 season is shown: *p<0.05; **p<0.01; ***p<0.001 (z-statistics).

strain injury to the groin); knee joint trauma (knee ligament or capsular sprain and/or traumatic meniscus or cartilage injury); ankle sprain (ligament or capsular sprain to the ankle).

The study was approved by the ethics committee of the University of Linköping, Sweden.

RESULTS

Risk exposure and injuries in consecutive seasons

The overall exposure to football was 78 597 hours in 2001 (68849 training and 9748 match play) and 77 270 in 2002 (66 973 training and 10 397 match play). The mean training exposure was comparable between seasons but the match exposure was higher in 2002 (table 2). There were 601 injuries recorded from 196 players (75%) in the 2001 season, and 588 injuries from 199 players (76%) in the 2002 season. The overall injury incidence in training and match play did not differ between the two seasons, but the rate of traumatic match injuries was lower in 2002 (table 3). Further, the rate of moderately severe injuries was lower during matches in the 2002 season (table 3). Analysis of injury patterns showed minor differences between seasons (table 4). The distribution of muscle strain injuries differed between seasons and also the relative percentages of back/trunk, thigh, and lower leg injuries (table 4).

Risk factors for football injury in general

Of the 197 players that participated in both seasons, 151 (77%) sustained at least one injury in the 2001 season. Eighty seven per cent (131 of 151) of the players with an injury in the first season were injured during the 2002 season compared with 48% (22 of 46) of the players with no injury during the preceding season. Univariate Cox regression analysis showed that players with an injury during the 2001 season had an almost threefold risk of suffering an injury in the 2002 season (table 5). The relative risk of injury increased with the number of injuries that a player had sustained during the previous season (table 5). None of the anthropometric variables (age, height, weight, BMI) were significantly associated with injury in the 2002 season. Even so, age adjusted analysis was carried out and showed that previous injury was still a significant risk factor for injury (table 5). Owing to a disproportional distribution of dropouts during 2002 between previously injured and uninjured players (12 of 44 uninjured; 16 of 153 injured), a hazard ratio was calculated for previous injury adjusted for dropouts, and this showed no interactive effects of dropout rates: 2.7, 95% confidence interval 1.7 to 4.3, $p<0.0001$.

Risk factors for specific injury types

Previous injury and age were significant risk factors for hamstring injury in the univariate analysis and were included in a multivariate model (height, weight, and BMI all had a $p>0.20$). Both previous hamstring injury and increasing age were significant risk factors in the multivariate model (table 6).

Previous injury was a significant risk factor for groin injury in the univariate analysis (table 6). All other variables (age, height, weight, BMI) had a $p>0.20$, and no multivariate analysis was performed.

Previous injury and height were significantly associated with suffering a knee joint trauma in the univariate analysis, and all other variables (age, weight, BMI) had a $p>0.20$. In the multivariate analysis, only previous knee joint trauma was found to be a significant risk factor (table 6).

Previous injury, age, height, and weight were all associated with ankle sprain in the univariate analysis (BMI $p>0.20$). In the multivariate model, there was a tendency towards an increase in risk for ankle sprain in the previously injured leg and a decrease in risk for ankle sprain with increasing age, but none of the variables reached statistical significance (table 6).

Table 4 Injury patterns in the 2001 (n = 262) and 2002 (n = 263) seasons

	Training		Match play		Total	
	2001	2002	2001	2002	2001	2002
Injury type						
Overuse	163 (47)	159 (45)	59 (23)	73 (31)	222 (37)	232 (39)
Strain	65 (19)	79 (22)	76 (30)	33 (14)***	141 (23)	112 (19)
Sprain/joint injury	49 (14)	58 (16)	41 (16)	42 (18)	90 (15)	100 (17)
Contusion	41 (12)	33 (10)	52 (21)	57 (24)	93 (15)	90 (15)
Fracture	6 (2)	4 (1)	11 (4)	12 (5)	17 (3)	16 (3)
Dislocation	4 (1)	2 (<1)	2 (<1)	3 (1)	6 (<1)	5 (<1)
Other	21 (6)	17 (5)	11 (4)	16 (7)	32 (5)	33 (6)
Injury location						
Head/face/neck	5 (1)	3 (<1)	11 (4)	15 (6)	16 (3)	18 (3)
Upper extremity	9 (3)	7 (2)	6 (2)	4 (2)	15 (2)	11 (2)
Back/trunk	32 (9)	29 (8)	11 (4)	21 (9)*	43 (7)	50 (9)
Hip/groin	57 (16)	69 (20)	39 (15)	41 (17)	96 (16)	110 (19)
Thigh	60 (17)	85 (24)*	78 (31)	46 (19)**	138 (23)	131 (22)
Knee	60 (17)	65 (18)	32 (13)	43 (18)	92 (15)	108 (18)
Lower leg	64 (18)	30 (9)***	35 (14)	30 (13)	99 (16)	60 (10)**
Ankle	35 (10)	33 (9)	23 (9)	22 (9)	58 (10)	55 (9)
Foot	27 (8)	31 (9)	17 (7)	14 (6)	44 (7)	45 (8)
Total injuries	349	352	252	236	601	588

Values are number (%). Significant difference from the 2001 season is shown: *p<0.05; **p<0.01; ***p<0.001 (χ^2 test or Fisher's exact test).

DISCUSSION

Previous injury and risk of injury

The principal finding of this study, relying on prospectively recorded data only, was that previous injury was identified as an important risk factor for injury in football players, which is consistent with the results of previous studies.[11 19 20] Players that were injured in the 2001 season had an increased risk of any injury in the preceding season. This observation is in agreement with the findings of Dvorak *et al*[19] and Kucera *et al*,[20] and, similar to these studies, we found that the more previous injuries a player had suffered, the greater was the risk of injury. Recurrent injuries account for some of the association between previous injury and increased injury risk in general, but in some cases the injuries are anatomically unrelated. Remaining deficits in physical conditioning or proprioception, or altered movement patterns after a previous injury may provide a plausible link to an anatomically unrelated injury in a following season. For instance, having a previous anterior cruciate ligament injury has been found to increase the risk of new knee injury, especially overuse injury.[28] Other player characteristics such as risk taking behaviour and various psychological factors are probably equally important,[29] especially for players

Table 5 Risk factors for injury in 197 football players using a Cox proportional hazard regression model

Univariate analysis	n	Hazard ratio	95% CI	p Value
Categorical variables*				
Previous injury	151	2.7	1.7 to 4.3	<0.0001
1–2 previous injuries	80	2.2	1.4 to 3.6	0.0013
3–4 previous injuries	38	3.0	1.7 to 5.3	<0.0001
⩾5 previous injuries	33	5.1	2.9 to 9.0	<0.0001
Categorical variables†				
Age >1SD below mean (⩽21 years)	43	1.2	0.8 to 1.8	0.38
Age >1SD above mean (⩾31 years)	29	1.2	0.8 to 1.9	0.36
Height >1SD below mean (⩽176 cm)	27	0.8	0.5 to 1.2	0.27
Height >1SD above mean (⩾188 cm)	29	0.7	0.5 to 1.2	0.21
Weight >1SD below mean (⩽72 kg)	26	0.8	0.5 to 1.2	0.27
Weight >1SD above mean (⩾86 kg)	32	0.9	0.6 to 1.4	0.74
BMI>1SD below mean (⩽22 kg/m^2)	47	1.0	0.7 to 1.5	0.96
BMI >1SD above mean (⩾26 kg/m^2)	30	1.3	0.8 to 1.9	0.29
Continuous variables†				
Previous injury	151	1.2	1.1 to 1.3	<0.0001
Age (years)	197	1.0	1.0 to 1.0	0.80
Height (cm)	197	1.0	1.0 to 1.0	0.98
Weight (kg)	197	1.0	1.0 to 1.0	0.52
BMI (kg/m^2)	197	1.1	0.9 to 1.2	0.29
Multivariate analysis	**n**	**Age adjusted hazard ratio**	**95% CI**	**p Value**
Previous injury (categorical)*	151	2.7	1.7 to 4.3	<0.0001
1–2 previous injuries	80	2.2	1.4 to 3.6	0.0014
3–4 previous injuries	38	3.0	1.8 to 5.3	<0.0001
⩾5 previous injuries	33	5.2	2.9 to 9.0	<0.0001
Previous injuries (continuous)‡	151	1.2	1.1 to 1.3	<0.0001

*Reference group uninjured players.
†Reference group intermediate group (mean (1SD)).
‡Relative risk for 1 measured unit increase.
BMI, Body mass index.

Table 6 Risk factors for the most common injury types in the Cox proportional hazard regression model using each limb as unit of analysis (n = 394)

		Univariate analysis†			Multivariate analysis		
	n*	Hazard ratio	95% CI	p Value	Hazard ratio	95% CI	p Value
Hamstring injury‡							
Previous injury	55	3.2	1.8 to 6.0	<0.001	3.5	1.9 to 6.5	<0.0001
Age (years)¶		1.1	1.0 to 1.2	0.021	1.1	1.0 to 1.2	0.011
Groin injury							
Previous injury	48	2.4	1.2 to 4.6	<0.01			
Knee joint trauma							
Previous injury	28	3.1	1.3 to 7.6	0.011	3.1	1.3 to 7.6	0.011
Height (cm)¶		1.05	1.0 to 1.1	0.13	1.05	1.0 to 1.1	0.13
Ankle sprain							
Previous injury	24	2.8	0.8 to 9.6	0.099	3.0	0.9 to 10.4	0.079
Age (years)¶		0.9	0.8 to 1.0	0.12	0.9	0.8 to 1.0	0.061
Height (cm)¶		1.1	1.0 to 1.2	0.16	1.0	0.9 to 1.1	0.89
Weight (kg)¶		1.1	1.0 to 1.2	0.091	1.1	1.0 to 1.2	0.19

*Number of previously injured limbs.
†Only variables p<0.20 in the univariate analysis presented.
‡Accurate injury history available for 383 limbs.
¶Relative risk for 1 measured unit increase (continuous variables).

who are repeatedly injured, and these aspects warrant further attention.

Having a previous hamstring injury, groin injury, and knee joint trauma was associated with a two to three fold increase in risk of an identical injury in the same leg. This correlates with the findings of Árnason *et al*,[11] who identified previous injury as the main risk factor for suffering a hamstring strain, groin strain, and knee sprain in 306 elite male footballers in Iceland. The reported recurrence rates of hamstring injury (12–43%),[4 12 16 30 31] groin injury (31–50%),[4 12 16] and knee sprain (30–40%)[4 16] are high. In the present study, 22% and 18% of the injuries were early recurrences with an identical injury within two months. Many of the early recurrent injuries could probably be attributed to inadequate rehabilitation or premature return to play after the initial injury, but it is evident that some injuries may increase the risk of re-injury regardless of time interval. This may be due to residual deficits in the previously injured joint or muscle that leave the player more liable to re-injury.

In contrast with other studies,[3 11 32] we found no association between previous injury and an increased risk of ankle sprain. One explanation may be that the medical staffs working in elite football clubs are well aware of optimal treatment and secondary prevention strategies for these injuries. It is possible that this is also the reason why ankle injury is no longer the most common injury in elite football, as shown in some recent studies.[10 12 17] However, we must also consider the lack of power in our study (discussed further below).

Age and injuries

In contrast with one previous study on male elite players,[11] we did not find an association between increased age and injury risk in general (although age was associated with risk of hamstring injury). We used similar age categories to those in the study of Árnason *et al*[11] to facilitate comparisons, but the analytical methods differed, which may explain this discrepancy.

Injury incidences and injury patterns in consecutive seasons

The injury incidence and injury pattern in the present study are comparable to previous studies at elite level.[3 4–6 8–12 16 33] Overall training and match injury incidences did not differ between the two seasons, so it seems that an injury surveillance study covering one full football season can provide a reasonable overview of the injury problem among elite football players in a specific environment. However, analysis of injury patterns revealed variations between seasons—for instance, in the rate of muscle strains and hamstring injuries. This correlates with the findings of McGregor and Rae[14] and McGregor *et al*,[15] who reported variations in the rate of thigh injuries and muscle tears over different seasons in a Scottish premier football team. Whether this reflects natural variations in injury patterns between seasons or differences in the study environment—for example, climate, seasonal disposition—between seasons is unclear. Because of the World Cup in Korea/Japan, the mid-season league match break (June) was prolonged in the 2002 season (7 *v* 2 weeks). This could have provided the teams with a possibility to let otherwise highly exposed players rest and recover, possibly resulting in a decrease in muscle strains observed during matches in the 2002 season. Possible variations in injury patterns between seasons should be taken into account when comparing data between different studies. A prolonged study period is recommended for studies analysing specific injury patterns.

Injury prevention

There is convincing evidence that football injuries in general can be prevented using multimodal intervention programmes.[23 34] In addition, specific interventions targeted at hamstring injuries[35] and knee injuries[36] have been successful in preventing these injuries. However, less is known about how to prevent recurrence of injury specifically. Balance board training and bracing have been shown to reduce the rate of ankle sprains in previously injured ankles,[37 38] but there is limited evidence on many other common injuries. Sherry and Best[39] showed a reduction in the recurrence rate of hamstring injuries in athletes undergoing a rehabilitation programme focusing on trunk stabilisation exercises, but comparable studies are lacking in a football population. The high recurrence rate of football injuries clearly indicates that secondary prevention of recurrence is a key point in reducing the overall incidence of injury.

Study weakness and strength

Although our study is a good size compared with many similar studies, limited sample size is a potential weakness. In our overall analysis of previous injury, we had 153 injured subjects, and in the analysis of the four most common injuries we had 20–48 injury cases. As discussed by Bahr and Holme,[27] about 20–50 injury cases are required to detect moderate to strong associations in a risk factor study, whereas small to moderate associations would need about 200 injured subjects. Applying the formula suggested by Schmoor *et al*[40] for assessment of a

What is already known on this topic

- Previous injury is the most important risk factor for football injury
- Multivariate analyses are recommended for risk factor studies of sports injuries but few studies have applied analytical methods that account for exposure time

What this study adds

- Players who are injured during one season have an increased risk of injury in the following season
- Having a previous hamstring injury, groin injury, and knee joint trauma increased the risk of an identical injury in the same leg the following season, whereas no such relation was observed for ankle sprain. Age was not identified as a risk factor for injury

previous injury as a risk factor for ankle sprain using a univariate Cox proportional hazard regression, we find that our study lacks the power for this analysis (required sample size 5885 players for power $1-\beta = 0.90$). A problem with sample size was also evident when comparing various injury subgroups between seasons, where the number of injuries in some categories are small. An obvious strength of our study design is that it relied only on prospectively recorded data, and we therefore avoided the risk of recall bias that is evident when relying on self reporting of previous injury.

CONCLUSIONS

Using prospectively recorded data only, the present study confirmed previous results showing that previous injury is an important risk factor for football injury. Overall injury incidences were similar between consecutive seasons, indicating that an injury surveillance study covering one full season can provide a reasonable overview of the injury problem among elite football players in a specific environment. However, a prolonged study period may be required to analyse specific injury patterns because of variations in incidence between different seasons and in order to increase power of data analysis.

ACKNOWLEDGEMENTS

We gratefully acknowledge UEFA (Union of European Football Associations), the Swedish Football Association, the Swedish Sports Confederation (Sports Research Council), and Praktikertjänst AB for financial support of the study. We greatly appreciate the cooperation of the participating clubs.

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Competing interests: none declared

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