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

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Key words: Risk factor, sports injury, re-injury, soccer, multivariate model

ABSTRACT

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 to injuries sustained** during the following season, and to compare injury risk and injury pattern between consecutive seasons.

Methods: The medical staffs of twelve 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 relationship between previous injury, anthropometric data and the risk of injury.

Results: The **training and match injury incidences** were similar between seasons; with **5.1** vs. **5.3** injuries/1000 training hours and **25.9** vs. **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 for **any injury in the following season** compared to non-injured players (Hazard Ratio **2.7**; **95% CI 1.7-4.3**, $p < 0.0001$). 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 relationship 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.**

INTRODUCTION

According to the van Mechelen model¹ 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) based on this information preventive strategies are introduced, and, 4) these strategies are evaluated by repeating step one.

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 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 relationship 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 In order 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: 1) **to study whether prospectively recorded injuries during one season are associated to injuries sustained during the following season**, and 2) to study the natural variation in injury risk and injury pattern between two consecutive seasons. Our hypotheses were that 1) previous injury is a **risk factor for** future injury, and 2) injury incidence and injury pattern **are similar between consecutive seasons**.

MATERIAL AND METHODS

Study sample and study period

In the first step of this study, all 14 teams in the Swedish top male 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 followed also 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 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 age 25±4, range 17-38 years; height 182±5, range 170-197 cm; weight 79±6, range 65-98 kg).**

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

Exposure registration

The development of the data collection procedure and data collection forms²² 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 physician and a 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 Orava²⁵ 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); and 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 season 2001, 28 players (11%) dropped out during the **season** (27 due to player transfer, one because of illness). In 2002, 33 players (13%) dropped out (26 due to transfer, three were downgraded to youth teams, 3 players quit because of injury and one due to illness). **Of the 197 players that participated both seasons, 18 dropped out during 2002.**

Statistical analyses

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 [$\text{incidence} / (e^{(1.96 \times \sqrt{1/\text{injuries}})})$, to $\text{incidence} \times (e^{(1.96 \times \sqrt{1/\text{injuries}})})$]. 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: 1) prospectively recorded injuries in season 2001; and 2) anthropometrics (age, height, weight and body mass index (BMI)). A Cox proportional hazard regression model was used to determine the relationship between the baseline variables and subsequent injury in the 2002 season. In this model, the time (hours of exposure) from 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, i.e. 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 statistically 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.

In addition, analyses were also carried out using the limb as unit of analysis²⁷ **when assessing previous injury as a risk factor for four specific injuries: hamstring injury** (overuse or muscle strain injury to the hamstring); **groin injury** (overuse or muscle strain injury to the groin); **knee joint trauma** (knee ligament or capsular sprain **and/or** traumatic meniscus or cartilage injury); and **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 78597 hours in 2001 (68849 training and 9748 match play) and 77270 in 2002 (66973 training and 10397 match play). **The mean training exposure was comparable between seasons but the match exposure was higher in season 2002** (Table 1). 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 season 2002** (Table 2). **Further, the rate of moderately severe injuries was lower during matches in season 2002** (Table 2). **Analysis of injury patterns showed minor differences between seasons** (Table 3). **The distribution of muscle strain injuries differed between seasons and also the relative percentages of back/trunk, thigh and lower leg injuries** (Table 3).

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 to 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 3). The relative risk of injury increased with the number of injuries a player had sustained during the previous season (Table 3). 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 3). **Due 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 (HR previous injury 2.7, 95% CI 1.7-4.3, 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 4).

Previous injury was a significant risk factor for groin injury in the univariate analysis (Table 4). All other variables (age, height, weight, BMI) had a $p>0.20$ and no multivariate analysis was made.

Previous injury and height were significantly associated with suffering a knee joint trauma in the univariate analysis, 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 4).

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 4).

DISCUSSION

Previous injury and risk for 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 for 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 for injury. **Recurrent injuries will account for some of the association between previous injury and increased injury risk in general but in some cases the injuries will be anatomically unrelated. Remaining deficits in physical conditioning or proprioception, or altered movement patterns following a previous injury could provide a plausible link to an anatomically unrelated injury in a following season.** For instance, having a previous ACL-injury has been found to increase the risk for 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 that 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 threefold** increase in risk for 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 for re-injury regardless of time interval. This could be due to residual deficits in the previously injured joint or muscle that leave the player more liable to re-injury.

In contrast to other studies^{3,11,32} we found no association between previous **injury** and an increased risk for **ankle** sprain. One explanation could 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 could also be 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 under study weakness and strength).

Age and injuries

In contrast to one previous study on male elite players¹¹ we did not find an association between increased age and injury risk in general (although age was associated with risk for hamstring injury). **We used similar age categories as in the study by Árnason et al.¹¹ to facilitate comparisons but the analytic methods differed, which could possibly 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 to the findings by McGregor & Rae¹⁴ 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, e.g. climate, seasonal disposition, between seasons is unclear. Due to the World Cup in Korea/Japan the mid-season league match break (June) was prolonged in the 2002 season (7 vs. 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 injuries³⁵ and knee injuries³⁶ 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 regarding **many** other **common** injuries. Sherry & Best³⁹ 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 well sized compared to 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 between **20 and 48** injury cases. As discussed by Bahr & Holme²⁷, 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 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 sub-groups 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 due to variations in incidences between different seasons and in order to increase power of data analysis.

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Table 1. Anthropometric data and risk exposure in seasons 2001 and 2002.

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

Table 2. Injury incidences in seasons 2001 (n=263) and 2002 (n=262).

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

^a Injury incidence with 95% confidence interval

Significantly different from season 2001 at: * p<0.05; ** p<0.01; *** p<0.001 (z-statistics)

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

	Training				Match play				Total			
	2001		2002		2001		2002		2001		2002	
	N	%	N	%	N	%	N	%	N	%	N	%
<i>Injury type</i>												
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)
<i>Injury location</i>												
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)
<i>Total injuries</i>	349		352		252		236		601		588	

Significantly different from season 2001 at: * p<0.05; ** p<0.01; *** p<0.001 (χ^2 test, or Fisher's exact test)

Table 4. Risk factors for injury in 197 football players using a Cox proportional hazard regression model.

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

^a Reference group uninjured players^b Reference group intermediate group (mean ± 1SD)^c Relative risk for 1 measured unit increase

Table 5. Risk factors for the most common injury types in the Cox proportional hazard regression model using each limb as unit of analysis (n=394).

	n ^b	Univariate analysis ^d			Multivariate analysis		
		Hazard Ratio	95% CI	P-value	Hazard Ratio	95% CI	P-value
Hamstring injury ^a							
Previous injury	55	3.2	1.8-6.0	<0.001	3.5	1.9-6.5	<0.0001
Age (years) ^c		1.1	1.0-1.2	0.021	1.1	1.0-1.2	0.011
Groin injury							
Previous injury	48	2.4	1.2-4.6	<0.01			
Knee joint trauma							
Previous injury	28	3.1	1.3-7.6	0.011	3.1	1.3-7.6	0.011
Height (cm) ^c		1.05	1.0-1.1	0.13	1.05	1.0-1.1	0.13
Ankle sprain							
Previous injury	24	2.8	0.8-9.6	0.099	3.0	0.9-10.4	0.079
Age (years) ^c		0.9	0.8-1.0	0.12	0.9	0.8-1.0	0.061
Height (cm) ^c		1.1	1.0-1.2	0.16	1.0	0.9-1.1	0.89
Weight (kg) ^c		1.1	1.0-1.2	0.091	1.1	1.0-1.2	0.19

^a Accurate injury history available for 383 limbs

^b Number of previously injured limbs

^c Relative risk for 1 measured unit increase (continuous variables)

^d Only variables p<0.20 in the univariate analysis presented

What is already known on this topic	What this study adds
<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • Players that are injured during one season have an increased risk for injury in the following season • Having a previous hamstring injury, groin injury and knee joint trauma increased the risk for an identical injury in the same leg the following season, while no such relationship was observed for ankle sprain • Age was not identified as a risk factor for injury