Stress fractures in elite male football players

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ABSTRACT

The objective was to investigate the incidence, type and distribution of stress fractures in professional male football players. Fifty-four football teams, comprising 2,379 players, were followed prospectively for 189 team seasons during the years 2001 to 2009. Team medical staff recorded individual player exposure and time-loss injuries. The first team squads of 24 clubs selected by UEFA as belonging to the 50 best European teams, 15 teams of the Swedish Super League and 15 teams playing their home matches on artificial turf pitches were included. In total, 51 stress fractures occurred during 1,180,000 hours of exposure, giving an injury incidence of 0.04 injuries/1,000 hours**.** A team of 25 players can therefore expect one stress fracture every third season. All fractures affected the lower extremities and 78% the fifth metatarsal bone. Stress fractures to the fifth metatarsal bone, tibia or pelvis caused absences of three to five months. Twenty-nine percent of the stress fractures were re-injuries. Players that sustained stress fractures were significantly younger than those that did not. Stress fractures are rare in men's professional football but cause long absences. Younger age and intensive pre-season training appear to be risk factors.

INTRODUCTION

Football injuries are commonly divided into traumatic injuries with an acute onset and overuse injuries with a gradual onset (Ekstrand et al. 2003).

Traumatic injuries are caused by an external force on one specific occasion (for example, during a tackle or a burst of speed) exceeding the maximum durability of a tissue such as a ligament, a bone or a muscle tendon. Overuse injuries are caused by repetitive low-grade forces exceeding the tolerance of the tissues (Bahr 2009).

Examinations of the incidence and nature of traumatic injuries in football, as well as hypotheses about the mechanisms behind these injuries, are frequent (Andersen et al. 2004; Árnason et al. 1996; Ekstrand & Gillquist 1983; Ekstrand et al. 2009; Hawkins et al. 2001; Inklaar 1994; Walden et al. 2005; Walden et al. 2005; Woods et al. 2003), while detailed analyses of overuse injuries are lacking.

The reason for the sparseness of information about overuse injuries in football might be their vague and difficult definition, as well as the problem of evaluating the onset of these injuries (Bahr 2009).

Stress fractures result from repeated submaximal loads causing fatigue of the bone structure (Orava 1980; Warden et al. 2007).

Many theories have been proposed to explain the aetiology of stress fractures. These include repetitive stress (Bennell et al. 1996), rapid changes of load or changes of surface (Warden, Creaby 2007), and negative catabolism due to dieting (Sundgot-Borgen & Torstveit 2007).

There is limited scientific information about stress fractures in specific sports (Maquirriain & Ghisi 2007). As far as we know, there are no prospective studies describing the incidence and nature of stress fractures in elite men's football.

The aim of this study was to determine the incidence, type and distribution of stress fractures in professional male football players.

MATERIAL AND METHODS

Study period and participants

The study population consisted of three male, European cohorts: The UEFA Champions League cohort (UCL) , the Swedish Super League cohort (SWE), and the artificial turf cohort (ART) .

The UCL cohort was followed over eight consecutive seasons (2001 to 2009). Twenty-four teams from ten countries that had been playing in the UEFA Champions League regularly over the last decade were chosen by UEFA to participate in the study.

The 15 teams of the Swedish Super League (allsvenskan) were followed during the seasons 2001, 2002 and 2005, and a cohort of 15 elite teams from the two highest levels of play in eight different countries that played their home matches on third-generation artificial turf pitches were followed from 2003 to 2009.

The full methodology is reported elsewhere (Hägglund et al. 2005). All contracted players in the clubs' first teams were invited to participate in the study. Measured anthropometric data for these players as well as cohort characteristics are shown in Table 1. Exposure and injury data for players that left the study (due to transfers or for other reasons) were included for their time of participation. The players were informed about the study and agreed to participate by signing an informed consent form. The total cohort included 2,379 players, 189 team seasons and approximately 1,180,000 hours of exposure.

Table 1 near here

Study procedure and validity

The development and validation of the protocols and methodology used in the present study have been described previously (Hägglund, Waldén 2005). The study design followed the consensus on definitions and data collection procedures in studies of football injuries outlined by FIFA (Fuller et al. 2006) and UEFA (Hägglund, Waldén 2005). Baseline data was collected once yearly, at the start of the season. Individual player exposure in training and matches was registered by the clubs on a standard exposure form. This included exposure on the first and second team, as well as the national team, for all players and was returned on a monthly basis. The team medical staffs were responsible for recording each injury immediately after the event on standard injury forms, which were sent to the study group each month together with the exposure forms. The injury forms provided information on the date, type and location of each injury, whether it was a re-injury or not and whether the team doctors had classified the injury as traumatic or due to overuse. To reduce bias and inconsistencies in data collection, all clubs were provided with a manual containing information about the study design and definitions, together with explanatory examples and scenarios

The definitions applied in the study are shown in Table 2. All injuries resulting in a player being unable to fully participate in training or match play (i.e. time-loss injuries) were recorded, and the player was considered injured until the team medical staff allowed full participation in training and availability for match selection. Injuries were categorised under four degrees of severity based on the number of days' absence. All injuries were followed until the final day of rehabilitation. Stress fractures are defined according to Bennell et al (Bennell, Malcolm 1996) as: "partial or complete fractures of bone that result from the repeated application of a stress less than that required to fracture bone in a single loading situation". The diagnostic criteria for stress fractures were as follows (Maquirriain & Ghisi 2007): no history of related trauma, pain associated with exercise and relieved by rest, localised bone tenderness and pain on bone loading, as well as confirmation of the diagnosis by radiographic, isotopic or magnetic resonance imaging.

The study design underwent an ethical review and was approved by the Ethical Committee of Linköping University, the UEFA Football Development Division and the UEFA Medical Committee.

Table 2 near here

Analyses

ANOVA was used for group comparisons of continuous normally distributed data. The chi-square test was used for comparison of proportions between groups and for pairwise comparisons. Injury incidence was calculated as the number of injuries per 1,000 player hours. The significance level was set at $p<0.05$.

RESULTS

Exposure

A total of 1,180,000 exposure hours were registered (673,000 hours for the UCL cohort, 232,000 hours for the Swedish Super League and 274,000 hours for the artificial turf cohort), see Table 1. On average, teams in the UCL cohort had 23 training sessions and 6 matches per month, and around 230 training sessions and 55-60 matches over a season.

Incidence and frequency of stress fractures

A total of 51 stress fractures were registered (31 in the UCL cohort, 10 in the Swedish Super League and 10 in the artificial turf cohort) in 40 players, see Table 1. The stress fractures represented 0.5% of all injuries (0.6% in the UCL cohort and the Swedish Super League and 0.4% in the artificial turf cohort). The incidence of stress fractures was 0.04/1,000 exposure hours (0.05 in the UCL cohort and 0.04 in the Swedish Super League; artificial turf cohort: ns). As the mean total exposure time for a team of 25 players is about 8,000 hours per season, a team can expect a stress fracture every third season.

Location of stress fractures

All stress fractures affected the lower extremities. As seen in Table 3, 78% of the fractures affected the fifth metatarsal bone, while 12% were tibia stress fractures and 6% pelvic stress fractures.

Table 3 near here

Injury severity

All except three stress fractures were severe (causing absence of >28 days). As a mean, stress fractures to the fifth metatarsal bone and tibia caused absences of three months from full football training and match play and stress fractures to the pelvis around four to five months (Table 3).

Re-injuries of stress fractures

Re-injuries constituted 29% of all stress fractures and they caused significantly longer absences than non re-injuries (120 v 86 days, $p<0.05$). The re-injury rate was significantly lower in the UCL cohort than in the Swedish Super League and the artificial turf cohort (19 v 30 and 60%, $p<0.05$). The re-injury rate was high for pelvic and tibia stress fractures (66 v 50%) and lower for fifth metatarsal fractures (25%). No correlation was found between re-injury rate and age, body weight, height or BMI (body mass index).

Players with more than one stress fracture

Nine players sustained more than one stress fracture. Six players sustained re-fractures of the fifth metatarsal bone, five of them within two months and one after a year from the end of the rehabilitation of the index injury . Another player sustained three re-fractures of a metatarsal five fracture during a two year period. One player sustained a re-fracture of a pelvic stress fracture and another player of a bilateral stress fracture to the tibia. None of the players sustained several stress fractures with different locations.

Variations in injury incidence over a season

The distribution of stress fractures over the season varied between the cohorts. For the UCL cohort, the total risk of sustaining a stress fracture was significantly higher during the pre-season preparation period in July and August than during the competitive season in September to May (0.078 v 0.039/1000 h, $p<0.05$). For the SWE and ART cohorts, there was no significant variation in injury incidence over the season.

Anthropometric data and injury risk

The players that sustained stress fractures were significantly younger than those that did not (mean age 23 v 25 years, $p> 0.001$). Eighty per cent of the players that sustained stress fractures were under 26 years of age (compared with 54% in the non-injured group). No differences were seen between the groups concerning body weight, height or BMI.

DISCUSSION

A rare injury but with a long absence

The principal finding in this study was that stress fractures are rare in elite male football players, representing only 0.5% of all injuries. The incidence of stress fractures being 0.04/1,000 hours of football exposure means that an elite team with 25 players in their A squad can expect only one stress fracture every third season. However, these injuries could still cause considerable problems for the individual players and the team. Since the healing time is long, these injuries normally result in three to five months of absence from football.

The majority of stress fractures in elite football players affect the fifth metatarsal bone

It has been suggested that the sites of occurrence of stress fractures in athletes are activity-related and that specific anatomical sites are endemic to certain sports (Lee 2009; Maquirriain & Ghisi 2006; Ranawat et al. 2003). All the stress fractures registered in this study affected the lower extremities and four out of every five were fifth metatarsal fractures. One injury mechanism in sports involving rapid changes in direction and speed, as seen in football, may be the many bending moments applied to the fifth metatarsal..

Re-injuries are common

In the present study, the rate of re-injury of stress fractures was found to be 29%. The re-injury rate was lower for the UCL cohort. One possible explanation for the difference might be that top-level clubs in Europe have greater medical support, providing for more personalised rehabilitation of injured players. Still, one might speculate that improvements in controlled rehabilitation, with functional tests before returning to team training and match play, might reduce the risk of re-injury even more (Fuller & Walker 2006).

The re-injury rate was especially high for pelvic and tibia stress fractures and lower for fifth metatarsal fractures. The reason might be that treatment and rehabilitation procedures are better established for fifth metatarsal fractures (Kavanaugh et al. 1978; Mindrebo et al. 1993) than for pelvic and tibia stress fractures, which are considered to be difficult-to-treat injuries (Varner et al. 2005; Verrall et al. 2008).

Re-injuries of stress fractures caused significantly longer absences than non-re-injuries, which is in accordance with previous findings (Waldén et al. 2005).

Higher risk during pre-season preparation

In the majority of European leagues, an autumn-spring season is used, with competitive league matches in principle from September to May. The pre-season period (July and August) is predominantly devoted to intensive physical training with few matches, which could explain the finding that the total risk of stress fractures as well as stress fractures during trainings were higher in the UCL cohort during this period than during the competitive season. In the SWE and ART cohorts, there was no difference in the injury risk of stress fractures between the different parts of the season. The majority (25/30)of the teams in the SWE and ART cohorts played in leagues where a spring-autumn season is used, providing the teams with a longer pre-season period (3-4 months) and a possibility of avoiding stress fractures and other overuse injuries by having a longer preparation period for strengthening of the tissues.

Stress fractures more common in younger players

The players that sustained stress fractures in our study were significantly younger than those that did not. This finding is in accordance with other studies of stress fractures in athletes (Dameron 1975; Kavanaugh, Brower 1978; Maquirriain & Ghisi 2006).

Risk factors for stress fractures in male football players

Several risk factors for stress fractures in football have been proposed: repetitive stress (Warden, Creaby 2007), rapid changes of load or changes of surface (Ekstrand & Gillquist 1983; Ekstrand & Nigg 1989; Warden, Creaby 2007) and negative catabolism due to low energy availability (Sundgot-Borgen & Torstveit 2007; Torstveit & Sundgot-Borgen 2005).

Our finding that stress fractures were more common in the UCL cohort during the pre-season preparation period supports the theory of repetitive stress as a risk factor for stress fractures since the pre-season period is mainly devoted to physical training involving repetitive stress. Further, this intensive training period follows a period of rest between seasons: the change of loads between these periods might be a risk factor as well. Also, the change of load when moving from an academy environment or a lower level of play might be an explanation for our finding that the risk of stress fractures is higher in young players.

It has been suggested that the cause of the female athlete triad (disordered eating, menstrual dysfunction and osteoporosis) might be an energy deficit due to low energy intake in combination with high energy expenditure in training and matches (Sundgot-Borgen & Torstveit 2007; Torstveit & Sundgot-Borgen 2005). Data from the Norwegian elite athletes showed that female athletes who were diagnosed with stress fractures had a lower body fat percentage and higher total lean mass than athletes without stress fractures (Øyen et al., 2009). In this study we found no difference in body weight and BMI between players sustaining and not sustaining stress fractures. However, energy deficit could still be a risk factor for stress fractures in male football players too. The use of BMI is only a surrogate measure of energy deficiency. One might speculate as to whether our finding of an increased risk of stress fractures in young players, especially during the pre-season period, could partly be due to nutritional factors, with insufficient energy intake in combination with high energy expenditure due to intensive training.

Why so few sport-specific investigations of stress fractures?

To our knowledge, this is the first study investigating stress fractures in elite men's football. A possible explanation for the lack of sport-specific investigations of stress fractures might be the debated definition, the differences in diagnostic criteria and the problem of evaluating the onset of these injuries.

In this study, we used the time-loss definition of injury, the most common definition used in prospective cohort studies of football injuries. By using the time-loss definition, the most relevant traumatic injuries are captured, i.e. those that directly influence ability to take part in training and matches (Bahr 2009).

However, stress fractures and other overuse injuries have a gradual onset and it is sometimes difficult to establish when the injury occurred. As pointed out by Bahr (Bahr 2009), the symptoms of a stress fracture could have a sudden onset although the injury may actually be the result of a long-term process. Further, stress fractures and other overuse injuries might be underestimated by using the time-loss definition, since according to this definition a pain problem is only recognized as an injury as long as the injury is causing absence from training and matches. Players might continue to participate in training and matches but still have plenty of problems. However, the risk of underestimation is less at elite level since these teams normally have high-quality medical staff.

Methodological considerations

The collection of data followed the international consensus agreements on procedures for epidemiological studies of football injuries recommended by FIFA and UEFA (Fuller, Ekstrand 2006; Hägglund, Waldén 2005). In these papers, the strengths and limitations of injury surveillance studies such as this one are thoroughly discussed. Nevertheless, the obvious strength of this study is the plentiful, homogenous material on professional male players in Europe and the fact that the study is based on an injury recording system specifically developed to address the issue under review. Another advantage of studies at elite level is that official match data and other exposure data are frequently published on the UEFA website as well as the websites of the clubs. Our exposure data is believed to be accurate since they were regularly verified against official reports found on websites, in newspapers, etc.

A limitation of studies of stress fractures and other overuse injuries is that separated data of injury occurrence in trainings and matches would be less robust. In contrast to traumatic injuries which have a sudden onset, overuse injuries have, by definition, an insidious onset. Even if a player interrupts a match due to an overuse injury, that does not mean that the match play caused the injury, the cause might very well be an intensive training period before that match and vice versa.

Perspectives

There is limited research assessing stress fractures and other overuse injuries in football. We have shown that stress fractures are rare in professional men's football but when they occur, they cause long absences. Younger age and intensive pre-season training appear to be risk factors. Our hypothesis is that a change of load is the most probable explanation of stress fractures in male footballers, but dieting could be a confounding factor. Clearly, further studies are needed to evaluate the possible mechanisms behind stress fractures in football. Direct measurement of loads on players as well as studying of the effect of change of surfaces during a season would be of interest. To evaluate if energy deficit could be a factor involved, an analysis of nutrition of the players and measurements of their body fat and lean body mass would be desirable.

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Table 1. Player and cohort characteristics

	UCL[1]	SWE[1]	ART[1]
No. of teams (team seasons[2])	24 (105)	15 (35)	15 (49)
No. of players (player seasons[2])	1210 (2698)	508 (774)	661 (1201)
Player anthropometrics[3]			
Age (years)	25.7 ± 4.5	24.8 ± 4.7	25.0 ± 4.8
Height (cm)	181.7 ± 6.4	182.5 ± 5.7	181.8 ± 6.2
Weight (kg)	78.0 ± 7.0	79.0 ± 6.1	78.1 ± 6.9
Stress fractures	31	10	10
Training	14	8	6
Match play	17	2	4
Exposure (hours)	673.419	231.800	274.305
Training	564.690	202.244	235.421
Match play	108.729	29.556	38.884
Injury incidence[4]	0.046 (0.032-0.066)	0.043 (0.023-0.080)	0.037 (0.020-0.068)
Training[4]	0.025 (0.015-0.042)	0.040 (0.020-0.079)	0.026 (0.011-0.057)
Match play[4]	0.156 (0.097-0.252)	0.068 (0.017-0.271)	0.103 (0.039-0.274)

[1] UEFA Champions League (UCL), Swedish Super-League (SWE), UEFA Artificial Turf (ART)

[2] One team or player participating in one season equals one team and one player season respectively

[3] Values are mean ± standard deviation

[4] Injury incidence expressed as no of stress fractures / 1000 hours of exposure and 95% confidence interval

Table 2. Operational definitions

Training session	Team training that involved physical activity under the supervision of the coaching staff.
Match	Competitive or friendly match against another team.
Injury	Injury resulting from playing football and leading to a player being unable to fully participate in future training or match play (i.e. time-loss injury).
Stress fracture	Partial or complete fractures of bone that result from the repeated application of a stress less than that required to fracture a bone in a single loading situation
Rehabilitation	A player was considered injured until team medical staff allowed full participation in training and availability for match selection.
Re-injury	Injury of the same type and at the same site as an index injury occurring no more than two months after a player's return to full participation from the index injury.
Minimal injury	Injury causing absence of 1–3 days from training and match play.
Mild injury	Injury causing absence of 4–7 days from training and match play.
Moderate injury	Injury causing absence of 8–28 days from training and match play.
Severe injury	Injury causing absence of over 28 days from training and match play.
Traumatic injury	Injury with sudden onset and known cause.
Overuse injury	Injury with insidious onset and no known trauma.
Injury incidence	Number of injuries per 1,000 player hours [(Σ injuries/Σ exposure hours) × 1,000].

Table 3. Diagnosis and days' absence

Diagnosis	**Number**	**Absence (mean no of days ±SD)**	**Range (days)**
Fifth metatarsal fracture	40	95 ± 44	35-240
Tibia stress fracture	6	88 ± 91	13-231
Pelvic stress fracture	3	136 ± 64	71-200
Foot fracture, tarsal bones	1	125	
Fibula stress fracture	1	16	

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