Scand J Med Sci Sports 2010: 20: 403–410
doi: 10.1111/j.1600-0838.2009.00971.x



SCANDINAVIAN JOURNAL OF
MEDICINE & SCIENCE
IN SPORTS

# Intrinsic risk factors for acute ankle injuries among male soccer players: a prospective cohort study

A. H. Engebretsen[1], G. Myklebust[1], I. Holme[1], L. Engebretsen[1,2], R. Bahr[1]

[1]Oslo Sports Trauma Research Center, Norwegian School of Sports Sciences, N-0806 Oslo, Norway, [2]Department of Orthopaedic Surgery, Ulleval University Hospital and Medical School, University of Oslo, N-0407 Oslo, Norway
Corresponding author: A. H. Engebretsen, MD, Oslo Sports Trauma Research Center, Norwegian School of Sports Science, PO Box 4014, Ullevål Stadion, N-0806 Oslo, Norway. Tel: +47 23 26 23 57, Fax: 23 26 23 07, E-mail: anders.engebretsen@nih.no

Accepted for publication 12 April 2009

**This prospective cohort study was conducted to identify risk factors for acute ankle injuries among male soccer players. A total of 508 players representing 31 amateur teams were tested during the 2004 pre-season through a questionnaire on previous injury and function score (foot and ankle outcome score; FAOS), functional tests (balance tests on the floor and a balance mat) and a clinical examination of the ankle. Generalized estimating equations were used in univariate analyses to identify candidate risk factors, and factors with a *P*-value $<0.10$ were then examined in a multivariate model. During the season, 56 acute ankle injuries, affecting 46 legs (43 players), were registered. Univariate analyses identified a history of previous acute ankle injuries [odds ratio (OR) per previous injury: 1.25, 95% confidence interval (CI) 1.09–1.43] and the FAOS subscore "Pain" (OR for a 10-point difference in score: 0.81, 95% CI 0.62–1.04) as candidate risk factors. In a multivariate analysis, only the number of previous acute ankle injuries proved to be a significant (adjusted OR per previous injury: 1.23; 95% CI 1.06–1.41, *P* = 0.005) predictor of new injuries. Function scores, functional tests and clinical examination could not independently identify players at an increased risk in this study.**

The ankle joint is one of the most common injury locations in sports in general and soccer in particular. The injury incidence ranges from 1.7 to 4.5 injuries per 1000 playing hours, accounting for 11–25% of all acute injuries (Ekstrand & Tropp, 1990; Árnason et al., 1996; Juma, 1998; Hawkins & Fuller, 1999; Andersen et al., 2004; Junge et al., 2004). An ankle sprain may leave an athlete out of play for several weeks, and in many cases full recovery takes much longer. Injuries to the ankle are therefore a concern.

To possibly prevent new injuries, the specific intrinsic and extrinsic risk factors for the injury type in question must be known (Meeuwisse, 1994). Regarding intrinsic risk factors, it has been suggested that previous injury, especially when rehabilitation is inadequate, places an athlete at an increased risk of suffering an injury to the ankle (Ekstrand & Gillquist, 1983; Tropp et al., 1985; Árnason et al., 2004; Kofotolis et al., 2007). Several other potential risk factors have been tested and suggested as possible predictors of increased risk, however, with limited data on male soccer players. These include a slow reaction time (Taimela et al., 1990; Árnason et al., 2004), personality factors (Taerk, 1977; Lysens et al., 1989; Taimela et al., 1990; Junge et al., 2000; Árnason et al., 2004), age (Backous et al., 1988; Lindenfeld et al., 1994; Ostenberg & Roos, 2000), general joint laxity (Baumhauer et al., 1995; Ostenberg & Roos, 2000; Beynnon et al., 2001), ankle joint laxity (Beynnon et al., 2001) and balance tests (Trojian & McKeag, 2006). Regarding body size measures such as height, weight and body mass index (BMI), the literature is also inconclusive (Backous et al., 1988; Baumhauer et al., 1995; Beynnon et al., 2001; Tyler et al., 2006). Some risk factors have been tested further in intervention studies, and balance training (Tropp et al., 1985) and orthoses (Tropp et al., 1985; Surve et al., 1994) have resulted in significantly fewer ankle sprains, indicating that reduced neuromuscular control is an important risk factor for ankle injuries.

To examine the contribution of the various risk factors of injuries and etiology and to explore their interrelationship, it is necessary to include all in a multivariate analysis (Meeuwisse, 1994). Even though a large number of risk factor studies have been carried out, only a few of them have included multivariate analyses. We therefore planned the present prospective cohort study on soccer players to screen for several potential risk factors for ankle injuries, some of which have not been studied in depth earlier.

Elite players constitute only a small portion of all soccer players, and advanced resources for screening tests are not available for the majority of players. Therefore, one goal of this study was to investigate whether simple screening tests, which are easy to perform and do not require advanced equipment, can be used to identify individuals at risk. In this way, if the questionnaire and balance tests in this study prove useful, teams and players with no medical staff can test themselves in the pre-season to find out whether they have an increased risk of injuries.

We hypothesized that previous ankle injuries, reduced function scores and abnormalities on a clinical examination or balance tests indicating reduced neuromuscular control could predict an increased risk of new ankle injuries. In addition, we included clinical examination and player information such as age, height, weight, BMI and player position to investigate whether there were any correlations between these variables and injury risk.

Hence, the aim of this study was to examine potential intrinsic risk factors for injuries to the ankle in a prospective cohort study among subelite male soccer players.

## Methods

### Design and participants

This study is based on data from a randomized trial on male amateur soccer players examining the effect of a training program designed to prevent injuries. The design, the intervention program and the results of the study have been described in detail previously in a separate paper (Engebretsen et al., 2008). Because no differences were seen in the injury rates between the intervention and the control groups (Engebretsen et al., 2008), the entire cohort could be used to assess the effect of a number of risk factors assessed at baseline.

A total of 35 teams ($n = 769$ players) from the Norwegian first, second or third division of soccer for men, geographically located in the proximity of Oslo, were invited to participate in the study. The third division teams either won their league or finished as first runners up the previous season, resulting in a relatively homogenous group of teams, even if they competed in three different divisions. Three of the teams ($n = 60$ players) declined the invitation to participate, 177 players did not report for testing, three players did not speak Norwegian and therefore could not complete the questionnaire and four players were excluded for other reasons (Fig. 1). Hence, 244 of the players invited could not be included. In addition, one team ($n = 17$ players) was later excluded because the physiotherapist did not record injuries, resulting in a final sample of 508 players representing 31 teams from three divisions (first division, $n = 7$, 122 players; second division, $n = 16$, 260 players; and third division, $n = 8$, 126 players).

### Risk factor screening

The teams were tested for potential risk factors for ankle injuries during the 2004 pre-season, January through March, at the Norwegian School of Sport Sciences. Every player

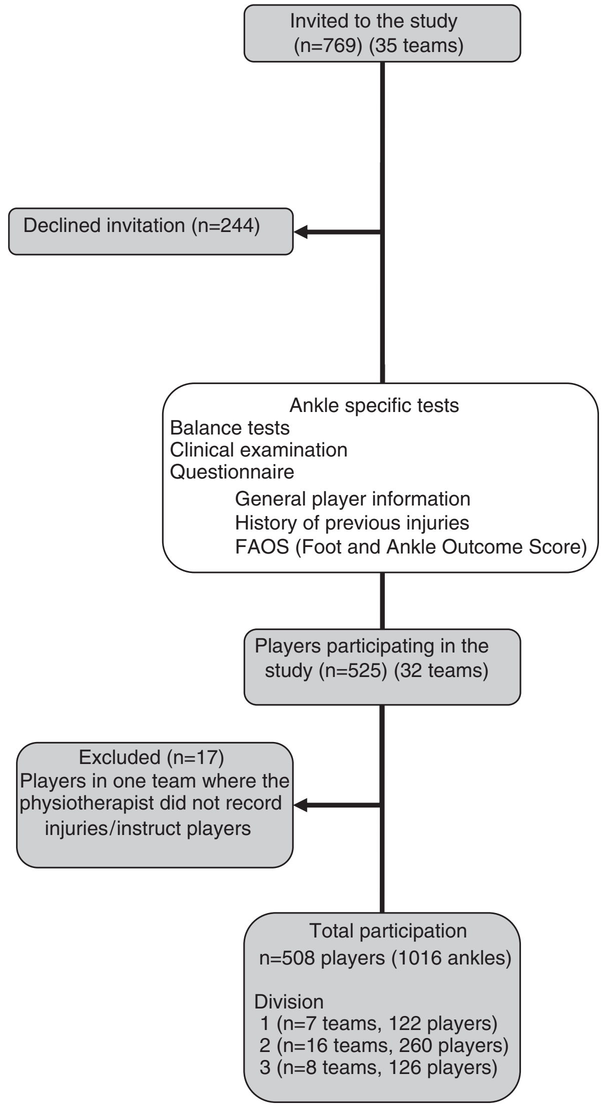


*Fig. 1.* Flow chart showing movement of numbers of players participating.

capable (not injured at the time) completed single leg balance tests for both legs, both on a balance mat and on the floor, a clinical examination and a questionnaire.

For the balance tests players were asked to stand barefoot on one straight leg, keeping his arms crossed across the chest and his other leg bent 90° at the knee, and only using the ankle joint to correct his balance. Both balance tests (Fig. 2(a) and (b)) were scored in the same manner (quantitatively and qualitatively), in five categories:

- 5 points (maximum score): The player can maintain his balance for 60 s with eyes open and for an additional 15 s with eyes closed, always using an ankle strategy only to maintain his balance.
- 4 points: The player can maintain his balance for 60 s with eyes open, using an ankle strategy only for at least 45 s of this period.
- 3 points: The player is able to maintain his balance for 60 s with eyes open, but needs to use body parts other than the ankle joint (knee, hip, torso, and arms) to correct his balance for more than 15 s of this period.


*Fig. 2.* Front (a) and side (b) view of balance test on the floor and a balance mat, respectively. Players were asked to stand barefoot on one straight leg, keeping his arms crossed across the chest and his other leg bent 90° at the knee, and only using the ankle joint to correct his balance.

- 2 points: The player can balance for 60 s but needs to use the upper body and touch the floor with his other foot at times to correct imbalance.
- 1 point: The player cannot manage to balance on one leg for more than short periods of time.

The clinical testing of the players was performed by a group of 10 sports physical therapists and sports physicians who were blinded to any injury history. Both legs were examined for foot type (normal, pes planus, pes cavus, splayed forefoot), standing rearfoot alignment (normal, valgus), hallux position (normal, valgus), anterior drawer (normal, pathologic) and range of motion for supination, pronation (measured in degrees with the ankle at 10° of plantar flexion) and dorsiflexion.

The players also completed a questionnaire in two parts, where the first part covered general player information (age, height, body mass index, position on the field, number of junior or senior national team matches played, level of play this season and level of play the previous season), and a history of previous injuries (number, severity, nature and number of months since the most recent ankle injury, use of protective gear such as tape or brace and whether the most recent injury had caused the player to miss matches). The second part was a function score for the ankle (foot and ankle outcome score; FAOS) (Roos et al., 2001) translated into Norwegian. This form consists of five major parts (symptoms, pain, activities of daily living, function in sports and recreation, quality of life) and is scored by calculating the mean value of the five parts in percent of the total possible score, where 100% is the maximal and 0% the lowest score.

In addition, a similar screening was carried out for risk factors for hamstring, knee and groin injuries. The data from these tests will be reported in separate papers.

## Injury reporting

Each team was supplied with a physiotherapist who was responsible for reporting injuries for all the players on the team throughout the pre-season and the season. An injury was defined as any physical complaint sustained by a player that resulted from a soccer match or soccer training, forcing the player to miss or unable to take full part in future soccer training or match play ("time-loss" injury). Acute injuries were defined as injuries with a sudden onset associated with a known trauma, whereas overuse injuries were those with a gradual onset without any known trauma. Two of the authors were blinded to all other information regarding risk factors and categorized all injuries based on the injury reports from the physiotherapist. For the purpose of the present paper, an injury was classified as an ankle sprain if it was recorded as an acute injury of the ankle ligaments. Injuries were classified into three severity categories according to the time it took until the player was fully fit to take part in all types of organized soccer play: minor (1–7 days), moderate (8–28 days) and major ($>28$ days). The head coach for every team registered each player's participation in training and the number of minutes played in matches.

Most of the teams from the first and second division already had a physical therapist working with the team. In cases where there was no physical therapist attached to the team, we provided them with one. However, the physiotherapist was not required to be present at every training session and match; the degree of follow-up therefore varied from team to team participating in the study.

## Reliability testing

Interobserver reliability tests were carried out by different test personnel for both the clinical examination and the single leg balance test by having the same player repeat the same test with different personnel after he had completed the first test. Each examiner was blinded to the other's results. The same scoring system/clinical forms were used at both stations. The interobserver reliability for the categorical variables in the interpretation of the balance tests and the clinical examination was computed using $\kappa$ statistics.

### Statistical methods

Exposure to matches and training was calculated by adding the individual duration of all training and match play during the season.

For the continuous dependent variable risk factor analyses, where each leg was the unit of analysis, generalized estimating equations (STATA, version 8; STATA, Texas, USA) were used, accounting for total individual exposure during the soccer season and for the fact that the left and right foot belonged to the same player. Logistic regression analyses were used to analyze the relationships between per subject first occurrence of calculated dichotomous injury variables and their risk factors.

All risk factor variables were examined in univariate analyses, and those with a *P*-value $<0.10$ were investigated further in a multivariate model.

## Results

The total incidence of injuries during the season was 4.7 injuries per 1000 playing hours [95% confidence interval (CI) 4.3–5.1], 12.1 (95% CI 10.5–13.7) for match injuries and 2.7 (95% CI 2.4–3.1) for training injuries. The total exposure to match play and training was 108 111 player hours. A total of 56 acute ankle injuries were reported, affecting 46 legs on 43 (8.5%) of the 508 players in the study. The total incidence of acute ankle injuries was 0.5 injuries per 1000 playing hours (95% CI 0.4–0.7), 0.3 injuries per 1000 training hours (95% CI 0.2–0.4) and 1.5 injuries per 1000 match hours (95% CI 0.9–2.0). A total of 34 players sustained one ankle injury, while six and two players sustained two and three injuries, respectively. One player sustained four ankle injuries throughout the season. Of the 56 injuries, 34 occurred on the right side, while 22 were on the left. There were 26 minor injuries (time loss 1–7 days), 22 moderate injuries (8–28 days) and five severe injuries ($>28$ days). In three cases, information on the duration of time loss was missing.

Interobserver reliabilities for the categorical variables, computed using κ statistics, were 0.40 and 0.19 for balance tests on the floor and mat, respectively. For the clinical examination, κ values were 0.45 (anterior drawer), 0.84 (foot type), 0.91 (standing rearfoot alignment), 1.00 (hallux position) and 1.00 (toe deformity).

Univariate analyses revealed the number of previous acute ankle injuries and the FAOS sub score "Pain" as potential leg-dependent risk factors for acute ankle injuries (Table 1). None of the balance tests, floor or balance mat, or clinical tests were candidates for predicting an increased risk of ankle injury. Additionally, none of the player-dependent factors (age, height, body mass index, position on the field, having played at the junior national team or at the senior national team level, level of play this season or level of play the previous season) were significantly associated with the risk of ankle injury (Table 2).

Risk factors with a *P*-value of $<0.10$ were then considered as candidates to predict which players are more prone to sustain an acute injury to the ankle. Because these factors may be inter-correlated, a multivariate analysis was performed, and only previous acute ankle injury was found to be a significant risk factor for new acute ankle (Table 3). The importance of this risk factor increases with the number of previous injuries (test of trend, $P=0.001$), and seems to decrease with time since the last injury (test of trend, $P=0.06$).

## Discussion

The main finding of this cohort study investigating the potential risk factors for ankle injuries in soccer was that previous ankle injury was the only significant predictor we could identify for new acute ankle injuries. The risk increases with the number of previous injuries and is the highest during the first 6 months after injury. Other candidates for identification of players with an increased risk of acute ankle injuries, such as function scores, balance tests, other player characteristics or a clinical examination, were not significantly associated with injury risk.

Several authors have found previous ankle injuries to be a significant risk factor for new injuries, both in male soccer (Ekstrand & Gillquist, 1983; Tropp et al., 1985; Árnason et al., 2004; Kofotolis et al., 2007) and in male athletes in other sports (Bahr & Bahr, 1997; McKay et al., 2001; McGuine & Keene, 2006; McHugh et al., 2006; Tyler et al., 2006). Árnason et al. (2004) found previous ankle injury to be the only significant risk factor for a new injury to the same ankle in a large cohort study investigating risk factors for soccer injuries. In the same study, lateral instability and a positive anterior drawer test were also correlated with previous injury. In contrast to these findings, Trojian and McKeag (2006) and Hägglund et al. (2006) did not find a history of previous ankle injury to be associated with future ankle sprains. However, a limited number of acute ankle injuries were included in these studies (Árnason et al., 2004; Hägglund et al., 2006; Trojian & McKeag, 2006).

Ankle injuries have been prevented effectively through neuromuscular training, either on a balance board or on a balance mat, in soccer (Tropp et al., 1985; Árnason et al., 1996) and in other sports (Bahr et al., 1997; Olsen et al., 2005; McHugh et al., 2007). It therefore seemed reasonable to suggest that a similar exercise could be used as a screening test to identify players at risk. The literature is limited on the topic, and only two publications have looked at

Table 1. Risk factor analyses where each leg was the unit of analysis, including both continuous (mean ± SEM) and categorical (yes/no) dependent variables

| | Current injury, | | | | SD | OR | 95% CI | *P*-value |
|---|---|---|---|---|---|---|---|---|
| | *n* | Uninjured ($n = 970$) | Injured ($n = 46$) | | | | | |
| | | *n*/mean ± SEM | *n*/mean ± SEM | % injured | | | | |
| Previous ankle injury | | | | | | | | |
| Yes | 616 | 582 | 34 | 5.5% | | 1.95 | [0.99–3.84] | 0.05 |
| No | 399 | 387 | 12 | 3.0% | | 1.00 | | |
| Missing | 1 | | | | | | | |
| Number of previous injuries* | | | | | | | | |
| Average number | | 1.6 ± 0.1 | 2.5 ± 0.3 | | | 1.25 | [1.09–1.43] | 0.001 |
| No previous injury | | | | | | 1.00 | | |
| 1 injury | 219 | 210 | 9 | 4.1% | | 0.92 | [0.44–1.95] | 0.84 |
| 2 injuries | 145 | 140 | 5 | 3.4% | | 0.74 | [0.29–1.91] | 0.54 |
| 3 injuries | 87 | 83 | 4 | 4.6% | | 1.02 | [0.34–2.97] | 0.97 |
| 4 injuries | 45 | 41 | 4 | 8.9% | | 2.34 | [0.78–7.01] | 0.13 |
| 5 injuries | 25 | 22 | 3 | 12.0% | | 2.58 | [0.69–9.59] | 0.16 |
| > 5 injuries | 95 | 86 | 9 | 9.5% | | 2.55 | [1.17–5.56] | 0.02 |
| Time since previous injury ($n = 1016$)† | | | | | | | | 0.06 |
| Never | 399 | 387 | 12 | 3.0% | | 1.00 | | |
| 0–6 months | 137 | 124 | 13 | 9.5% | | 2.81 | [1.42–5.54] | 0.003 |
| 6–12 months | 114 | 109 | 5 | 4.4% | | 0.96 | [0.37–2.50] | 0.93 |
| 1–2 years | 141 | 134 | 7 | 5.0% | | 1.10 | [0.47–2.56] | 0.83 |
| > 2 years | 218 | 209 | 9 | 4.1% | | 0.89 | [0.42–1.90] | 0.77 |
| Missing | 7 | | | | | | | |
| FAOS‡ function score | | | | | | | | |
| Total score | 902 | 93 ± 0.3 | 91 ± 1.7 | | 9.7 | 0.83 | [0.65–1.06] | 0.14 |
| Symptoms | 931 | 88 ± 0.4 | 86 ± 2.2 | | 12.9 | 0.87 | [0.71–1.07] | 0.19 |
| Pain | 956 | 96 ± 0.3 | 93 ± 1.5 | | 9.2 | 0.81 | [0.62–1.04] | 0.10 |
| Activities of daily life | 957 | 98 ± 0.2 | 97 ± 1.3 | | 6.4 | 0.89 | [0.60–1.32] | 0.58 |
| Sport | 961 | 94 ± 0.4 | 92 ± 2.3 | | 13.2 | 0.92 | [0.75–1.11] | 0.38 |
| Quality of life | 960 | 90 ± 0.5 | 87 ± 3.0 | | 15.3 | 0.88 | [0.75–1.04] | 0.13 |
| Testing§ | | | | | | | | |
| Balance test, floor | 999 | 4.6 ± 0.02 | 4.7 ± 0.1 | | 0.55 | 1.08 | [0.79–1.48] | 0.64 |
| Balance test, mat | 999 | 3.0 ± 0.02 | 3.2 ± 0.1 | | 0.90 | 1.14 | [0.84–1.54] | 0.41 |
| Clinical examination | | | | | | | | |
| Any pathological findings ($n = 817$) | | | | | | | | |
| Yes | 427 | 407 | 20 | 4.7% | | 1.03 | [0.75–1.42] | 0.85 |
| No | 390 | 374 | 16 | 4.1% | | 1.00 | | |
| Foot type ($n = 886$) | | | | | | | | 0.78 |
| Normal | 568 | 543 | 25 | 4.4% | | 1.00 | | |
| Pes planus | 228 | 221 | 7 | 3.1% | | 0.69 | [0.29–1.61] | 0.39 |
| Pes cavus | 73 | 68 | 5 | 6.8% | | 1.60 | [0.59–4.31] | 0.36 |
| Splayed forefoot | 17 | 16 | 1 | 5.9% | | 1.36 | [0.17–10.6] | 0.77 |
| Standing rearfoot alignment (valgus) ($n = 864$) | | | | | | | | |
| Yes | 134 | 131 | 3 | 2.2% | | 1.00 | | |
| No | 730 | 697 | 33 | 4.5% | | 1.86 | [0.56–6.24] | 0.31 |
| Hallux position (valgus) ($n = 873$) | | | | | | | | |
| Yes | 76 | 72 | 4 | 5.3% | | 1.46 | [0.49–4.34] | 0.50 |
| No | 797 | 763 | 34 | 4.3% | | 1.00 | | |
| Anterior drawer (pathologic) ($n = 876$) | | | | | | | | |
| Yes | 138 | 129 | 9 | 6.5% | | 1.83 | [0.85–3.98] | 0.13 |
| No | 738 | 698 | 29 | 3.9% | | 1.00 | | |
| Supination (degrees)§ | 886 | 28.8° ± 0.6 (848) | 35.0° ± 4.5 (38) | | 19.2 | 1.21 | [0.93–1.57] | 0.15 |
| Pronation (degrees)§ | 884 | 9.2° ± 0.2 (846) | 9.5° ± 0.6 (38) | | 9.2 | 0.98 | [0.48–2.00] | 0.95 |
| Dorsal extension (degrees)§ | 865 | 10.4° ± 7.3 (827) | 10.1° ± 5.3 (38) | | 10.3 | 0.94 | [0.60–1.48] | 0.79 |

The number of legs in the uninjured and injured groups reflect the number of legs that completed each of the tests.

*Results (OR and 95% CI) are presented per previous injury.

†Results (OR and 95% CI) are presented per category increase.

‡FAOS (foot and ankle outcome score). Roos et al. (2001) All results (OR and 95% CI) are presented for a change of 10 in FAOS score.

§Results (OR and 95% CI) are presented per increase of 1 SD.

Range (mean, minimum – maximum) of continuous variables: FAOS (total score: 93.3, 37.2–100.0), (symptoms: 88.4, 28.6–100.0), (pain: 95.6, 38.9–100.0), (activities of daily life: 98.2, 45.6–100.0), (sport: 94.1, 25.0–100.0), (quality of life: 90.1, 6.3–100.0), balance test on floor (4.6, 1.0–5.0), balance test on mat (3.1, 1.0–5.0), supination (29.1, 0–150), pronation (9.2, 0–30) and dorsal extension (10.3, 0–90).

Comparisons of risk factors between ankles that sustained at least one injury during the following season (''Injured'') and ankles that did not (''Uninjured''). *P*-values are the results from univariate analyses in STATA using generalized estimating equations taking into account the individual exposure and the fact that the left and the right leg belong to the same player.

OR, odds ratio; CI, confidence interval; SD, standard deviation.

Table 2. Risk factor analyses where each player was the unit of analysis, including both continuous (mean ± SEM) and categorical (yes/no) dependent variables

| | *n* | Current injury | | | SD | OR | 95% CI | *P*-value |
|---|---|---|---|---|---|---|---|---|
| | | Uninjured (*n* = 465) | Injured (*n* = 43) | | | | | |
| | | *n*/mean ± SEM | *n*/mean ± SEM | % injured | | | | |
| Factor | | | | | | | | |
| Age* (years) | 500 | 24.0 ± 0.2 (458) | 24.0 ± 0.6 (42) | | 4.2 | 1.00 | [0.85–1.18] | 0.99 |
| Height* (cm) | 497 | 181.4 ± 0.3 (455) | 181.0 ± 1.0 (42) | | 6.3 | 0.93 | [0.68–1.27] | 0.66 |
| Weight* (kg) | 493 | 78.0 ± 1.1 (450) | 77.9 ± 0.4 (43) | | 8.0 | 1.01 | [0.74–1.38] | 0.94 |
| BMI* (kg/m) | 486 | 23.7 ± 0.1 (444) | 23.8 ± 0.2 (42) | | 2.1 | 1.13 | [0.76–1.68] | 0.56 |
| Player position | 485 | | | | | | | 0.51 |
| Forward | 84 | 78 | 6 | 7.1 | | 1.00 | | |
| Winger | 70 | 65 | 5 | 7.1 | | 1.00 | [0.29–3.43] | 1.00 |
| Attacking midfielder | 62 | 54 | 8 | 12.9 | | 1.93 | [0.63–5.87] | 0.25 |
| Central midfielder | 66 | 61 | 5 | 7.6 | | 1.07 | [0.31–3.66] | 0.92 |
| Wingback | 87 | 77 | 10 | 11.5 | | 1.69 | [0.59–4.87] | 0.33 |
| Center back | 71 | 65 | 6 | 8.5 | | 1.20 | [0.37–3.90] | 0.76 |
| Goalkeeper | 45 | 44 | 1 | 2.2 | | 0.30 | [0.03–2.53] | 0.27 |
| Level of play | 508 | | | | | | | 0.89 |
| 1st division | 119 | 109 | 10 | 8.4 | | 1.00 | | |
| Second division | 256 | 233 | 23 | 9.0 | | 1.08 | [0.50–2.34] | 0.85 |
| Third division | 133 | 123 | 10 | 7.5 | | 0.89 | [0.36–2.21] | 0.80 |
| Level of play last season | 485 | | | | | | | 0.71 |
| Elite division | 4 | 3 | 1 | 25.0 | | 1.00 | | |
| First division | 126 | 115 | 11 | 8.7 | | 0.29 | [0.03–3.00] | 0.30 |
| Second division | 154 | 141 | 13 | 8.4 | | 0.28 | [0.03–2.85] | 0.28 |
| Third division or lower | 201 | 184 | 17 | 8.5 | | 0.28 | [0.03–2.81] | 0.28 |
| Junior or senior national team matches | 508 | | | | | | | |
| Yes | 92 | 86 | 6 | 6.5 | | 0.72 | [0.29–1.75] | 0.46 |
| No | 416 | 379 | 37 | 8.9 | | 1.00 | | |

Comparison between the players who sustained at least one ankle injury during the following season ("Injured") and the players who did not ("Uninjured").

The number of players in the uninjured and injured groups reflect the number of players who completed each of the tests.

*Results (OR and 95% CI) are presented per increase of 1 SD.

Range (mean, minimum – maximum) of continuous variables: age (24.0, 16.2–37.7), height (181.4, 153–198), weight (77.9, 56.0–105.0), BMI (23.7, 19.4–29.8).

BMI, body mass index; OR, odds ratio; CI, confidence interval; SD, standard deviation.

Table 3. Multivariate analyses of the potential risk factors with $P<0.10$ in univariate analyses

| Risk factors | Adjusted OR | 95% CI | *P*-value |
|---|---|---|---|
| Previous ankle injury | | | |
| Per previous ankle injury | 1.23 | [1.06–1.41] | 0.005 |
| FAOS* sub-score "Pain" | 0.89 | [0.67–1.18] | 0.41 |

*FAOS (foot and ankle outcome score) (Roos et al., 2001) (OR and 95% CI) are presented for a change of 10 in FAOS score.

Adjusted odds ratio (OR) and 95% confidence interval (CI) of number of previous ankle injuries as continuous variable and per difference of 10 in FAOS (foot and ankle outcome score) (Roos et al., 2001) sub-score "Pain."

whether single leg balance tests can predict the risk of new ankle injuries in male soccer (McHugh et al., 2006; Trojian & McKeag, 2006). Trojian and McKeag (2006) found a predictive value of balance tests, while McHugh et al. (2006) did not. However, several publications looking at balance, measured in different ways, as a predictor of an increased risk of injury among male athletes do exist from other sports (Tropp et al., 1984; McGuine et al., 2000; Willems et al., 2005; Wang et al., 2006; Hrysomallis et al., 2007). In the present study, none of the balance tests, on the floor or on a balance mat, turned out to be significant predictors. There are several potential explanations for this apparent discrepancy. First, even though this study is one of the largest cohort studies on risk factors for injuries to date, with as many as 56 acute ankle injuries, the statistical power is limited for multivariate tests. Nevertheless, the strength of the candidate risk factors studied does not indicate that any of these would be helpful as screening tools. As pointed out by Bahr and Holme (2003) in their review, to detect moderate to strong associations, 20–50 injury cases are needed, whereas small to moderate associations would need about 200 injured subjects. However, for a risk factor to be clinically relevant with sufficient sensitivity and specificity, strong associations are needed. Second, the results indicate that the intertester reliability for the balance tests used is low, with κ values of 0.40 and 0.19. This shows that the same player will not necessarily be scored the same way from two different tests of the same ankle, a factor that clearly influences the ability to identify players with reduced ankle control. Third, the floor test has a ceiling effect in this player population, with 97.4% of the subjects obtaining a normal or a supranormal test score. Because we suspected that this test could be too easy, we also included the balance mat test. For this, the test distribution was better (34.6%, 34.5% and 25.8% in categories 2, 3 and 4, respectively), and the main problem may be that the balance mat test is inconsistent, as indicated by the low κ value. Also, data from Australian football suggest that balance deficits do not necessarily persist among previously injured athletes (Hrysomallis et al., 2005). To identify athletes at risk based on tests measuring balance and ankle control, we clearly need to develop a new methodology with better test properties and reliability. One limitation of the current study is that we had to rely on the coaches for the exposure registration. We had no way to check their figures, but there should be no reason to misreport. If a game or a practice session was missed, it would affect all players on the team, which is unlikely to influence the analysis regarding any specific risk factor. The same should be the case for the physiotherapists registering injuries.

Using multivariate methods where we have controlled for significant risk factors as well as player exposure, this study confirms the consistent finding from previous studies that players with a history of ankle sprains are at an increased risk (Ekstrand & Gillquist, 1983; Tropp et al., 1985; Árnason et al., 2004; Kofotolis et al., 2007). The high-risk period is the first 6 months after a previous injury, as also shown in a study among volleyball players (Bahr & Bahr, 1997). It seems reasonable to recommend that injured players complete a program of balance training on a wobble board for 10 weeks, as first described by Tropp et al. (1985), and that they use tape or a brace during high-risk activities until their rehabilitation is completed (Ekstrand et al., 1983; Tropp et al., 1985). Studies have shown that taping (Ekstrand et al., 1983; Tropp et al., 1985) or using an orthotic device (Surve et al., 1994) prevents reinjury in athletes with a history of ankle sprain, but that neither of these methods appears to have any effect on athletes who have not been injured before. This may be due to the manner in which taping and braces apparently work; that is, they improve the ability of the ankle to react quickly to an inversion stress, but not as a passive mechanical support. Following these guidelines may prevent the athlete from entering a vicious circle with repeated ankle sprains and chronic ankle instability problems.

## Perspectives

A history of previous acute ankle injury proved to be the only significant risk factor for new injuries to the same ankle in this prospective cohort study among male soccer players. Players with multiple and/or recent injuries are at a high risk. For practical use, the sensitivity of previous injury (yes or no) as a predictor for new ankle sprains was 74%, which means 74% of the players who sustained an ankle injury during the season had a history of ankle sprains. However, the positive predictive value was only 6%, which means that only 6% of previously injured players suffered a new ankle sprain during the season. This figure increases gradually with the number of previous injuries to 10%, if the player has had five or more previous acute ankle injuries. The same is the case if there is a history of a recent sprain, i.e. during the last 6 months (9%). Based on these results, it does not seem possible to target preventive measures based on a history of ankle sprains alone. The results from this study also show that additional information such as balance tests, player interviews or clinical examination does not increase our ability to identify players at risk.

**Key words:** ankle injuries, football, risk factors, prospective cohort study, previous injuries.

## References

Andersen TE, Floerenes TW, Arnason A, Bahr R. Video analysis of the mechanisms for ankle injuries in football. Am J Sports Med 2004: 32: 69S–79S.

Árnason A, Gudmundsson A, Dahl HA, Johannsson E. Soccer injuries in Iceland. Scand J Med Sci Sports 1996: 6: 40–45.

Árnason A, Sigurdsson SB, Gudmundsson A, Holme I, Engebretsen L, Bahr R. Risk factors for injuries in football. Am J Sports Med 2004: 32: 5S–16S.

Backous DD, Friedl KE, Smith NJ, Parr TJ, Carpine WD Jr. Soccer injuries and their relation to physical maturity. Am J Dis Child 1988: 142: 839–842.

Bahr R, Bahr IA. Incidence of acute volleyball injuries: a prospective cohort study of injury mechanisms and risk factors. Scand J Med Sci Sports 1997: 7: 166–171.

Bahr R, Holme I. Risk factors for sports injuries – a methodological approach. Br J Sports Med 2003: 37: 384–392.

Bahr R, Lian O, Bahr IA. A twofold reduction in the incidence of acute ankle sprains in volleyball after the introduction of an injury prevention program: a prospective cohort study. Scand J Med Sci Sports 1997: 7: 172–177.

Baumhauer JF, Alosa DM, Renstrom AF, Trevino S, Beynnon B. A prospective study of ankle injury risk factors. Am J Sports Med 1995: 23: 564–570.

Beynnon BD, Renstrom PA, Alosa DM, Baumhauer JF, Vacek PM. Ankle ligament injury risk factors: a prospective study of college athletes. J Orthop Res 2001: 19: 213–220.

Ekstrand J, Gillquist J. Soccer injuries and their mechanisms: a prospective study. Med Sci Sports Exerc 1983: 15: 267–270.

Ekstrand J, Gillquist J, Liljedahl SO. Prevention of soccer injuries. Supervision by doctor and physiotherapist. Am J Sports Med 1983: 11: 116–120.

Ekstrand J, Tropp H. The incidence of ankle sprains in soccer. Foot Ankle 1990: 11: 41–44.

Engebretsen AH, Myklebust G, Holme I, Engebretsen L, Bahr R. Prevention of injuries among male soccer players: a prospective, randomized intervention study targeting players with previous injuries or reduced function. Am J Sports Med 2008: 36: 1052–1060.

Hägglund M, Walden M, Ekstrand J. Previous injury as a risk factor for injury in elite football: a prospective study over two consecutive seasons. Br J Sports Med 2006: 40: 767–772.

Hawkins RD, Fuller CW. A prospective epidemiological study of injuries in four English professional football clubs. Br J Sports Med 1999: 33: 196–203.

Hrysomallis C, McLaughlin P, Goodman C. Does a balance deficit persist in Australian Football players with previous lower limb ligament injury? J Sci Med Sport 2005: 8: 85–91.

Hrysomallis C, McLaughlin P, Goodman C. Balance and injury in elite Australian footballers. Int J Sports Med 2007: 28: 844–847.

Juma AH. Outline of sport injuries in the V World Youth Championship for FIFA Cup in Saudi Arabia. Ind J Med Sci 1998: 52: 433–437.

Junge A, Dvorak J, Graf-Baumann T, Peterson L. Football injuries during FIFA tournaments and the Olympic Games, 1998–2001: development and implementation of an injury-reporting system. Am J Sports Med 2004: 32: 80S–89S.

Junge A, Dvorak J, Rösch D, Graf-Baumann T, Chomiak J, Peterson L. Psychological and sport-specific characteristics of football players. Am J Sports Med 2000: 28: 22–28.

Kofotolis ND, Kellis E, Vlachopoulos SP. Ankle sprain injuries and risk factors in amateur soccer players during a 2-year period. Am J Sports Med 2007: 35: 458–466.

Lindenfeld TN, Schmitt DJ, Hendy MP, Mangine RE, Noyes FR. Incidence of injury in indoor soccer. Am J Sports Med 1994: 22: 364–371.

Lysens RJ, Ostyn MS, Vanden AY, Lefevre J, Vuylsteke M, Renson L. The accident-prone and overuse-prone profiles of the young athlete. Am J Sports Med 1989: 17: 612–619.

McGuine TA, Greene JJ, Best T, Leverson G. Balance as a predictor of ankle injuries in high school basketball players. Clin J Sport Med 2000: 10: 239–244.

McGuine TA, Keene JS. The effect of a balance training program on the risk of ankle sprains in high school athletes. Am J Sports Med 2006: 34: 1103–1111.

McHugh MP, Tyler TF, Mirabella MR, Mullaney MJ, Nicholas SJ. The effectiveness of a balance training intervention in reducing the incidence of noncontact ankle sprains in high school football players. Am J Sports Med 2007: 35: 1289–1294.

McHugh MP, Tyler TF, Tetro DT, Mullaney MJ, Nicholas SJ. Risk factors for noncontact ankle sprains in high school athletes: the role of hip strength and balance ability. Am J Sports Med 2006: 34: 464–470.

McKay GD, Goldie PA, Payne WR, Oakes BW. Ankle injuries in basketball: injury rate and risk factors. Br J Sports Med 2001: 35: 103–108.

Meeuwisse WH. Assessiong cuasation in sport injury: a multifactorial model. Clin J Sport Med 1994: 4: 166–170.

Olsen OE, Myklebust G, Engebretsen L, Holme I, Bahr R. Exercises to prevent lower limb injuries in youth sports: cluster randomised controlled trial. BMJ 2005: 330: 449–455.

Ostenberg A, Roos H. Injury risk factors in female European football. A prospective study of 123 players during one season. Scand J Med Sci Sports 2000: 10: 279–285.

Roos EM, Brandsson S, Karlsson J. Validation of the foot and ankle outcome score for ankle ligament reconstruction. Foot Ankle Int 2001: 22: 788–794.

Surve I, Schwellnus MP, Noakes T, Lombard C. A fivefold reduction in the incidence of recurrent ankle sprains in soccer players using the Sport-Stirrup orthosis. Am J Sports Med 1994: 22: 601–606.

Taerk GS. The injury-prone athlete: a psychosocial approach. J Sports Med Phys Fitness 1977: 17: 186–194.

Taimela S, Kujala UM, Osterman K. Intrinsic risk factors and athletic injuries. Sports Med 1990: 9: 205–215.

Trojian TH, McKeag DB. Single leg balance test to identify risk of ankle sprains. Br J Sports Med 2006: 40: 610–613.

Tropp H, Askling C, Gillquist J. Prevention of ankle sprains. Am J Sports Med 1985: 13: 259–262.

Tropp H, Ekstrand J, Gillquist J. Stabilometry in functional instability of the ankle and its value in predicting injury. Med Sci Sports Exerc 1984: 16: 64–66.

Tyler TF, McHugh MP, Mirabella MR, Mullaney MJ, Nicholas SJ. Risk factors for noncontact ankle sprains in high school football players: the role of previous ankle sprains and body mass index. Am J Sports Med 2006: 34: 471–475.

Wang HK, Chen CH, Shiang TY, Jan MH, Lin KH. Risk-factor analysis of high school basketball-player ankle injuries: a prospective controlled cohort study evaluating postural sway, ankle strength, and flexibility. Arch Phys Med Rehabil 2006: 87: 821–825.

Willems TM, Witvrouw E, Delbaere K, Mahieu N, De BI, De CD. Intrinsic risk factors for inversion ankle sprains in male subjects: a prospective study. Am J Sports Med 2005: 33: 415–423.