**Linköping University Medical Dissertations**

**No. 989**

# Epidemiology and prevention of football injuries

**Martin Hägglund**

Linköping University
FACULTY OF HEALTH SCIENCES

Division of Social Medicine and Public Health Science
Department of Health and Society
Linköpings Universitet
SE-581 85 Linköping, Sweden

**Linköping 2007**

Cover page photo Bildbyrån Hässleholm



Printed by LiU-Tryck, Linköping, Sweden, 2007.

ISBN: 978-91-85715-51-0

ISSN: 0345-0082

The rules of soccer are very simple, basically it is this:
if it moves, kick it. If it doesn't move, kick it until it does.
~Phil Woosnam

# TABLE OF CONTENTS

# ABSTRACT

The aims of this thesis were to study the incidence, severity and pattern of injury in male and female elite football players; to study time trends in injury risk; to identify risk factors for injury; and to test the effectiveness of an intervention programme aimed at preventing re-injury.

All studies followed a prospective design using standardised definitions and data collection forms. Individual training and match exposure was registered for all players participating. Time loss injuries were documented by each team's medical staff.

The amount of training increased by 68% between the 1982 and 2001 Swedish top male division seasons, reflecting the shift from semi-professionalism to full professionalism. No difference in injury incidence or injury severity was found between seasons. The injury incidence was 4.6 vs. 5.2/1000 training hours and 20.6 vs. 25.9/1000 match hours. The incidence of severe injury (absence >4 weeks) was 0.8/1000 hours in both seasons.

The Swedish and Danish top male divisions were followed during the spring season of 2001. A higher risk for training injury (11.8 vs. 6.0/1000 hours, $p<0.01$) and severe injury (1.8 vs. 0.7/1000 hours, $p=0.002$) was observed among the Danish players. Re-injury accounted for 30% and 24% of injuries in Denmark and Sweden respectively.

The Swedish top male division was studied over two consecutive seasons, 2001 and 2002, and comparison of training and match injury incidences between seasons showed similar results. Players who were injured in the 2001 season were at greater risk for injury in the following season compared to non-injured players (relative risk 2.7; 95% CI 1.7-4.3). Players with a previous hamstring injury, groin injury and knee joint trauma were two to three times more likely to suffer an identical injury to the same limb in the following season, but no such relationship was found for ankle sprain. Age was not associated with an increased injury risk.

The effectiveness of a coach-controlled rehabilitation programme on the rate of re-injury was studied in a randomised controlled trial at amateur male level. In the control group, 23 of 79 injured players suffered a recurrence during the season compared to 10 of 90 injured players in the intervention group. There was a 75% lower re-injury risk in the intervention group for lower limb injuries (relative risk 0.25; 95% CI 0.11-0.57). The preventive effect was greatest during the first weeks after return to play.

Both the male and female Swedish top divisions were followed during the 2005 season. Male elite players had a higher risk for training injury (4.7 vs. 3.8/1000 hours, $p<0.05$) and match injury (28.1 vs. 16.1/1000 hours, $p<0.001$) than women. However, no difference was observed in the rate of severe injury (0.7/1000 hours in both groups). The thigh was the most common site of injury in both men and women, while injury to the hip/groin was more frequent in men and to the knee in women. Knee sprain accounted for 31% and 37% of the time lost from training and match play in men and women respectively.

# LIST OF PAPERS

This thesis is based on the following papers which are referred to in the text by their Roman numerals. Some unpublished results will also be presented and are referred to as such.

I. Hägglund M, Waldén M, Ekstrand J. Exposure and injury risk in Swedish elite football: a comparison between seasons 1982 and 2001. *Scand J Med Sci Sports* 2003; 13: 364-370.

II. Hägglund M, Waldén M, Ekstrand J. Injury incidence and distribution in elite football - a prospective study of the Danish and the Swedish top divisions. *Scand J Med Sci Sports* 2005; 15: 21-28.

III. Hägglund M, Waldén 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.

IV. Hägglund M, Waldén M, Ekstrand J. Lower re-injury rate with a coach-controlled rehabilitation program in amateur male soccer – a randomized controlled trial. *Am J Sports Med* 2007; in press.

V. Hägglund M, Waldén M, Ekstrand J. Injuries among male and female elite football players. Manuscript.

# ABBREVIATIONS

| | |
|---|---|
| ACL | Anterior cruciate ligament |
| ANOVA | Analysis of variance |
| BMI | Body mass index |
| CI | Confidence interval |
| CNS | Central nervous system |
| FIFA | Federation of International Football Associations |
| HR | Hazard ratio |
| MRI | Magnetic resonance imaging |
| NS | Not significant |
| OA | Osteoarthritis |
| OR | Odds ratio |
| PNS | Peripheral nervous system |
| RCT | Randomised controlled trial |
| ROM | Range of motion |
| RR | Relative risk |
| SD | Standard deviation |
| UCL | UEFA Champions League |
| UEFA | Union of European Football Associations |
| $VO_2$ max | Maximum oxygen uptake |

# INTRODUCTION

Football is the world's biggest team sport and attracts new players every year. In January 2007, there were 207 associations affiliated to FIFA (Federation of International Football Associations) (www.fifa.com) with 53 member associations in UEFA (Union of European Football Associations) (www.uefa.com). There were approximately 186.500 male and 56.000 female licensed football players (age ≥15 years) in Sweden 2005, an increase of 16% for male and 50% for female players compared to 2000 (www.svenskfotboll.se).

Playing football is associated with a certain risk for injury and the governing football associations have therefore initiated research projects with the aim of increasing player safety. According to the van Mechelen model prevention of sports injuries can be seen as a four step sequence.[139] In the first step the extent of the injury problem is evaluated through injury surveillance. This usually includes describing the incidence, severity, type and location of injury. In step two, the risk factors and mechanisms involved in the occurrence of injury are identified. The third step is to introduce preventive measures likely to reduce the future risk and/or severity of injuries. In the final step the effects of these measures are evaluated either by repeating step one, or in a randomised controlled trial.

## What is the extent of the injury problem?

***Definition of injury***

The operational definition of a football injury varies, and this sometimes makes it difficult to compare results between studies as the definition used will influence the number and types of injuries recorded in a study. Some authors have recorded only injuries where an insurance claim has been submitted,[17,115,121] or have limited their definition to include only injuries for which the player was treated at a hospital or traumatology department.[60,70,86] When using any of these injury definitions one must acknowledge that many less severe and many overuse injuries will not be recorded.[49,71] Furthermore, the population at risk is not known, and exposure data can only be estimated making it difficult to evaluate injury risk.[25,49] Some studies define football injury based on *time loss* from football participation, recording only injuries that result in the player missing a training session or match,[7,8,30,35,39,43,75,80,107,112,113,146] or the day(s) following the injury.[2,12,46,63,92,152] When using a time loss definition, injuries that are likely to affect the player's health and performance are included.[85] A possible limitation, however, is that it depends on the frequency of training sessions and matches and this may introduce bias when comparing different levels of play. Furthermore, it is sports specific, e.g. a broken finger would prevent a player from participating in team handball, but may not prevent participation in a football match. Other factors such as access to medical personnel, the importance of a game, or the pain threshold or motivation of the player may also influence whether an injury results in absence or not. Some studies use a finer filter and include all injuries that occur as a result of playing football regardless of subsequent absence from participation, i.e. an *anatomical tissue injury* definition.[79,83,111] This is potentially the most objective diagnosis, and also enables comparison between different sports. Nonetheless, it is dependant on how active the observer is in seeking out injured players, and requires that a qualified medical practitioner evaluates all injuries. Moreover, it may be difficult to apply a relevant filter so that not all minor complaints (e.g. blisters, wounds, bruises) are included, as these may not affect the player's performance and health. Finally, some studies include only injuries where the player requires *medical attention* or treatment from a physician, physiotherapist or trainer.[59,82,96,104] This diagnosis is also less sport-specific, but is dependent on access to medical personnel. Furthermore, personal and other factors may influence whether a player seeks assistance for an injury or not. Some have used a combination of these injury definitions.[16,41,73,94,141]

***Injury incidence***

The injury risk in football is high; between 65-91% of male elite players[43,92,96,146] and 48-70% of female elite players[46,75] will sustain at least one injury during a season. Drawer & Fuller evaluated the risk for injury in male professional football players in England and showed that the overall injury risk was approximately 1000 higher than high risk industrial occupations.[27]

The incidence of sports injury is usually expressed as the number of injuries per 1000 hours of player exposure.[28,71,139] Table 1 summarises the injury incidences from studies of adult male and female football players at club level. The injury incidence for adult male players ranges between 1.8-7.6 injuries per 1000 training hours and 10.2-35.3 injuries/1000 match hours, and for female adult players between 1.2-7/1000 training hours and 8.7-24/1000 match hours. The variations in injury incidences are to some extent due to differences in study design, injury definition, levels of play etc.

From studies using a time loss injury definition, training injury incidences at the elite level are reported to lie between 1.9-5.9 injuries/1000 training hours and 13-34.8 injuries/1000 match hours for male players[2,7,8,12,35,43,63,112,145,146] and 2.7-7 injuries/1000 training hours and 13.9-24 injuries/1000 match hours for female players.[44,46,75]

Over the years the game of football has developed and become faster, more intense and more aggressive.[138] It is a common impression that the risk for injury has increased as a result of this. However, no obvious trend in injury incidence can be seen over the last two decades (Table 1), but owing to differences in study definitions, study periods and populations it is difficult to evaluate this. Árnason reported no differences in injury incidence in the Icelandic top male divisions between the 1991, 1999 and 2000 competitive seasons.[10]

Studies at the national team level show similar or slightly higher time loss injury incidences compared to the elite club level, with 2.1-6.5 injuries/1000 training hours[39,148] and 29-51 injuries/1000 match hours for male players.[1,39,82-84,148,155] Injury incidences reported for female national team players are similar or lower than that reported for males, with 2.5 injuries/1000 training hours[148] and 24.2-36.0 injuries/1000 match hours.[83,84,148]

**Table 1.** Injury incidence in adult football players (only prospective studies that account for risk exposure included).

| Authors | Sex | Level | Country Year(s) | No. of players | Study period | Injury definition | Injury incidence Total | Training | Match play |
|---|---|---|---|---|---|---|---|---|---|
| Ekstrand et al.[31] | M | Amateur | Sweden 1980 | 180 | 1 year | Time loss[a] | | 7.6 | 16.9 |
| Nielsen & Yde[107] | M | Division (high-level) | Denmark 1986 | 34 | Season | Time loss[a] | | 2.3 | 18.5 |
| | | Series (low-lewel) | | 59 | | | | 5.6 | 11.9 |
| Poulsen et al.[112] | M | Elite | Denmark 1986 | 19 | 1 year | Time loss[a] | | 4.1 | 19.8 |
| | | Amateur | | 36 | | | | 5.7 | 20.7 |
| Ekstrand & Tropp[35] | M | Div I (elite) | Sweden | 135 | 1 year | Time loss[a] | 8.6 | 4.6 | 21.8 |
| | | Div II (elite) | | 180 | | | 8.5 | 5.1 | 18.7 |
| | | Div IV (amateur) | | 180 | | | 10.5 | 7.6 | 16.9 |
| | | Div VI (amateur) | | 144 | | | 9.4 | 7.5 | 14.6 |
| Engström et al.[43] | M | Elite | Sweden | 64 | 1 year | Time loss[a] | 5 | 3 | 13 |
| Inklaar et al.[73] | M | Amateur high-level | Netherlands 1987 | 144 | 2nd half of season | All injuries | | | 21.7 |
| | | Amateur low-level | | 101 | | | | | 11.7 |
| Árnason et al.[7] | M | Elite | Iceland 1991 | 84 | Competitive season | Time loss[a] | 12.4 | 5.9 | 34.8 |
| Lüthje et al.[96] | M | Elite | Finland 1993 | 263 | Season | Medical attention | | 1.8 | 11.3 |
| Hawkins & Fuller[63] | M | Professional | England 1994-97 | 108 | 3 seasons | Time loss[b] | | 3.4 | 25.9 |
| Peterson et al.[111] | M | Top-level | Czech Republic | 21 | 1 year | Tissue | 5.6 | | 18.6 |
| | | Third league | | 30 | | | 4.6 | | 10.2 |
| | | Amateur | | 17 | | | 8.9 | | 21.6 |
| | | Local team | | 16 | | | 20.2 | | 29.7 |
| Morgan & Oberlander[104] | M | Professional | USA 1996 | 237 | Season | Medical attention | 6.2 | 2.9 | 35.3 |

Injury defined as player being unable to participate in at least [a] one training session or match, [b] the day after the injury.

**Table 1.** (continued)

| Authors | Sex | Level | Country Year(s) | No. of players | Study period | Injury definition | Injury incidence Total | Training | Match play |
|---|---|---|---|---|---|---|---|---|---|
| Árnason et al.[8] | M | Elite | Iceland 1999 | 306 | Competitive season | Time loss[a] | 6.1 | 2.1 | 24.6 |
| Árnason et al.[12] | M | Elite | Iceland 2000 | 144 (control) | Competitive season | Time loss[a] | 6.6 | 1.9 | 26.0 |
| Andersen et al.[2] | M | Professional | Norway 2000 | 330 | Competitive season | Time loss[b] (acute) | | | 21.5 |
| Waldén et al.[145] | M | Elite | Sweden 2001 | 310 | Season | Time loss[a] | 7.8 | 5.2 | 25.9 |
| Waldén et al.[146] | M | Professional | Europe 2001/02 | 266 | Season | Time loss[a] | 9.4 | 5.8 | 30.5 |
| Engström et al.[44] | F | Elite | Sweden | 41 | 1 year | Time loss[a] | 12 | 7 | 24 |
| Östenberg & Roos[156] | F | Elite + amateur | Sweden 1996 | 123 | Season | Time loss[a] | | 3.7 | 14.3 |
| Söderman et al.[131] | F | Elite + amateur | Sweden 1998 | 78 (control) | Competitive season | Time loss[a] (acute leg) | 3.8 | 1.5 | 8.7 |
| Söderman et al.[132] | F | Elite + amateur | Sweden 1998 | 146 | Competitive season | Time loss[a] (leg) | 5.5 | 1.3 | 10.0 |
| Jacobson & Tegner[75] | F | Elite | Sweden 2000 | 269 | Season | Time loss[a] | 4.6 | 2.7 | 13.9 |
| Giza et al.[59] | F | Professional | USA 2001-2003 | 202 | 2 seasons | Medical attention | 1.9 | 1.2 | 12.6 |
| Faude et al.[46] | F | Elite | Germany 2003/04 | 165 | Season | Time loss[b] | | 2.8 | 23.3 |

Injury defined as player being unable to participate in at least [a] one training session or match, [b] the day after the injury.

***Injury type and location***

The type and location of injuries to football players have been described in many studies. In Table 2 the location and type of injuries have been re-arranged and classified according to the consensus proposal recently published for studies on football injuries[56] to facilitate comparison between studies. The majority of injuries affect the lower extremities,[151] comprising 70-93% of injuries in male players and 60-82% in female players. The type and location of injury seems to vary between men and women. The knee[46,59,156] and ankle[44,131,132] have typically been the most common injury sites in women, whereas in most recent studies on male players, thigh injuries have dominated.[63,64,96,146] Furthermore, injuries to the hip/groin are typically more common in male players.

For male players, between 65-94% of injuries are acute (traumatic) with sudden onset, and 6-35% are overuse without a specific event causing the injury.[7,8,33,146] Similar results have been found among female players, with 69-85% acute injuries and 15-31% due to overuse.[44,46,75] Common traumatic injuries include contusions, muscle strains (commonly affecting the hamstrings, quadriceps or adductor muscles) and ligament sprains (typically to the ankle and knee joints).[50,137] In men's football, ankle sprains have typically been the most frequent injury, followed by knee sprains, whereas muscle strains to the hamstring and groin used to be less frequent.[31,35,43,107,112] However, in modern elite football, there seems to be a shift towards an increased representation of muscle strain injury, typically to the hamstrings and groin, and these are now as common as or more frequent than joint sprains.[8,63,64,146] Some authors have reported injury incidences for specific acute injuries in male elite players, with the most frequent being contusions (1.5/1000 hours), hamstring strains (0.9-1.5/1000 hours), groin strains (0.4-0.6/1000 hours), ankle sprains (0.6-1.7/1000 hours), and knee sprains (0.4-0.6/1000 hours).[8,10,35] Typical sites of overuse injury observed among football players are the lower back, Achilles tendon, groin, patellar tendon, and lower leg.[31,145,146]

**Table 2.** Summary of injury locations and injury types in prospective studies on adult football players (re-arranged and classified according to Fuller et al.[56]).

| Authors | Ekstrand & Gillquist[31] | Poulsen et al.[112] | Inklaar et al.[73] | Engström et al.[43] | McGregor & Rae[98] | Árnason et al.[7] | Lüthje et al.[96] | Hawkins & Fuller[63] | McGregor et al.[99] | Volpi et al.[143] |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1980 | 1986 | 1987 | - | 1990-93 | 1991 | 1993 | 1994-97 | 1995-98 | 1995-2000 |
| Study period | 1 year | 1 year | 2nd half of season | 1 year | 3 seasons | Competitive season | Season | 3 seasons | 3 seasons | 5 seasons |
| Sex | Male | Male | Male | Male | Male | Male | Male | Male | Male | Male |
| Level | Amateur | Elite/amateur | Amateur | Elite | Professional | Elite | Elite | Professional | Professional | Professional |
| No. of players | 180 | 55 | 245 | 64 | 28 | 84 | 263 | 108 | 1 team | 1 team |
| Injuries studied | Time loss[a] | Time loss[a] | All injuries | Time loss[a] | - | Time loss[a] | Medical attention | Time loss[b] | - | Time loss[d] |
| No. of injuries (% of totals) | 256 (100) | 57 (100) | 40 (100) | 85 (100) | 94 | 85 (100) | 317 (100) | 578 (100) | 77 | 335 (100) |
| **Injury location** | | | | | 94 (100) | | | | 77 (100) | |
| *Head & neck* | - | - | - | - | *4 (4.3)* | - | *27 (8.5)* | *14 (2.4)* | *1 (1.3)* | - |
| *Upper limbs* | - | - | - | - | *3 (3.2)* | - | *20 (6.3)* | *16 (2.8)* | *3 (3.9)* | - |
| *Trunk* | *12 (4.7)* | - | - | *2 (2.4)* | *6 (6.4)* | - | *30 (9.5)* | *44 (7.6)* | *6 (7.8)* | - |
| *Lower limbs* | *223 (87.1)* | *53 (93)* | *28 (70)* | *79 (92.9)* | *81 (86.2)* | *70 (82.4)* | *240 (75.7)* | *504 (87.2)* | *67 (87)* | - |
| - Hip/groin | 32 (12.5) | 6 (19.5) | - | 10 (11.8) | - | - | 6 (1.9) | 77 (13.3) | - | - |
| - Thigh | 35 (13.7) | 10 (17.5) | 7 (17.5) | 7 (8.2) | 42 (44.7) | - | 68 (21.5) | 132 (22.8) | 27 (35.1) | - |
| - Knee | 51 (19.9) | 13 (22.8) | 7 (17.5) | 28 (32.9) | 22 (23.4) | - | 61 (19.2) | 86 (14.9) | 20 (26) | - |
| - Lower leg/Achilles | 30 (11.7) | 1 (1.8) | 3 (7.5) | 9 (10.6) | 4 (4.3) | - | 26 (8.2) | 80 (13.8) | 4 (5.2) | - |
| - Ankle | 44 (17.2) | 11 (19.3) | 11 (27.5) | 19 (22.4) | 12 (12.8) | - | 53 (16.7) | 97 (16.8) | 6 (7.8) | - |
| - Foot/toe | 31 (12.1) | 12 (21.1) | - | 6 (7.1) | 1 (1.1) | - | 26 (8.2) | 32 (5.5) | 10 (13) | - |
| *Other/not specified* | *21 (8.2)* | *4 (7)* | *12 (30)* | *4 (4.7)* | - | - | - | - | - | - |
| **Type of injury** | | | | | 85 (100)[e] | | | | 60 (100)[e] | |
| *Fractures & bone stress* | *10 (3.9)* | *4 (7)* | *3 (7.5)* | *3 (3.5)* | *5 (5.9)* | - | *22 (6.9)* | *22 (3.8)* | *5 (8.3)* | *6 (1.7)* |
| *Joint (non-bone) & ligament* | *78 (30.5)* | *24 (42.1)* | *13 (32.5)* | *31 (36.5)* | *18 (21.2)* | *19 (22.4)* | * | *116 (20)* | *16 (26.7)* | *58 (17.3)* |
| - Dislocation/subluxation | 5 (2) | 0 | 1 (2.5) | 2 (2.4) | - | - | 5 (1.6) | - | - | - |
| - Sprain/ligament | 73 (28.5) | 24 (42.1) | 12 (30) | 29 (34.1) | 13 (15.3) | 19 (22.4) | * | 116 (20) | 16 (26.7) | 58 (17.3) |
| - Meniscus & cartilage | - | - | - | - | 5 (5.9) | - | 11 (3.5) | - | 0 | - |
| *Muscle & tendon* | *105 (41)* | *17 (29.8)* | *13 (32.5)* | *38 (44.7)* | *35 (41.2)* | *25 (29.4)* | * | *245 (42.4)* | *28 (46.7)* | *136 (40.6)* |
| - Muscle rupture/tear/strain | 46 (18) | 17 (29.8) | 7 (17.5) | 10 (11.8) | 35 (41.2) | 25 (29.4) | * | 245 (42.4) | 23 (38.3) | 103 (30.7) |
| - Tendon injury/rupture | 59 (23) | - | 6 (15) | 28 (32.9) | - | - | - | - | 5 (8.3) | 33 (9.8) |
| *Contusion/bruise* | *50 (19.5)* | *7 (12.3)* | *10 (25)* | *11 (12.9)* | *7 (8.2)* | *17 (20)* | *102 (32.2)* | *104 (18)* | *0* | *97 (28.9)* |
| *Laceration & skin lesion* | - | *2 (3.5)* | - | - | *1 (1.2)* | - | - | *10 (1.7)* | *0* | *11 (3.2)* |
| *CNS/PNS* | - | - | - | - | - | - | *1 (0.3)* | - | - | - |
| - Concussion | - | - | - | - | - | - | 1 (0.3) | - | - | - |
| - Nerve injury | - | - | - | - | - | - | - | - | - | - |
| *Other* | *13 (5.1)* | *3 (5.3)* | - | *2 (2.4)* | *19 (22.4)* | *24 (28.2)* | *18 (5.7)* | *81 (14)* | *11 (18.3)* | *27 (8.1)* |
| - Other injuries | - | - | - | - | 15 (17.6) | - | - | 52 (9) | 10 (16.7) | - |
| - Overuse unspecified | - | - | - | 2 (2.4) | 4 (4.7) | - | 18 (5.7) | 29 (5) | 1 (1.7) | 27 (8.1) |

Injury defined as player being unable to participate in at least [a] one training session or match, [b] the day after the injury, [c] 2 days after the injury, [d] 3 days after the injury
* Not possible to separate between strains and sprains.
[e] Number of injuries lower than totals due to missing information.

**Table 2.** (continued)

| Authors | Hawkins et al.[64] | Árnason et al.[8] | Árnason et al.[12] | Waldén et al.[146] | Junge et al.[83] | Junge et al.[83] | Yoon et al.[155] | Junge et al.[82] | Junge et al.[84] |
|---|---|---|---|---|---|---|---|---|---|
| Year | 1997-99 | 1999 | 2000 | 2001/02 | 1998 | 2000 | 2000 | 2002 | 2004 |
| Study period | 2 seasons | Competitive season | Competitive season | Season | World Cup | Olympic Games | Asian Cup | World Cup | Olympic Games |
| Sex | Male | Male | Male | Male | Male | Male | Male | Male | Male |
| Level | Professional | Elite | Elite | Professional | National team | National team | National team | National team | National team |
| No. of players | 2376 | 306 | 144 (control) | 266 | - | - | - | - | - |
| Injuries studied | Time loss[c] | Time loss[a] | Time loss[b] (acute) | Time loss[b] | Tissue (match) | Tissue (match) | Tissue (match) | Tissue (match) | Tissue (match) |
| No. of injuries | 6030 (100) | 244 (100) | 96 (100) | 658 (100) | 149 | 116 (100) | 133 (100) | 171 (100) | 77 (100) |
| **Injury location** | | | | | 105 (100)[e] | | | | |
| *Head & neck* | *438 (7.3)* | *8 (3.3)* | *7 (7.3)* | *22 (3.3)* | *16 (15.2)* | *24 (20.7)* | *10 (7.5)* | *25 (14.6)* | *11 (14.3)* |
| *Upper limbs* | *153 (2.5)* | *15 (6.1)* | *4 (4.2)* | *-* | *9 (8.6)* | *3 (2.6)* | *5 (3.8)* | *8 (4.7)* | *5 (5.5)* |
| *Trunk* | *157 (2.6)* | *16 (6.6)* | *2 (2.1)* | *41 (6.2)* | *9 (8.6)* | *11 (9.5)* | *19 (14.3)* | *6 (3.5)* | *6 (7.8)* |
| *Lower limbs* | *5262 (87.3)* | *193 (79.1)* | *73 (76)* | *559 (85)* | *64 (61)* | *69 (59.5)* | *99 (74.4)* | *131 (76.6)* | *55 (71.4)* |
| - Hip/groin | 731 (12.1) | 32 (13.1) | 2 (2.1) | 79 (12) | - | - | 2 (1.5) | 11 (6.4) | 4 (5.2) |
| - Thigh | 1388 (23) | 59 (24.2) | 30 (31.3) | 152 (23) | 21 (20) | 16 (13.8) | 15 (11.3) | 30 (17.5) | 13 (16.9) |
| - Knee | 1014 (16.8) | 38 (15.6) | 12 (12.5) | 131 (19.9) | 24 (22.9) | 12 (10.3) | 25 (18.8) | 22 (12.9) | 12 (15.6) |
| - Lower leg/Achilles | 753 (12.5) | 31 (12.7) | 11 (11.5) | 73 (11.1) | 6 (5.7) | 27 (23.3) | 22 (16.5) | 29 (17) | 14 (18.2) |
| - Ankle | 1011 (16.8) | 21 (8.6) | 16 (16.7) | 89 (13.5) | 13 (12.4) | 14 (12.1) | 27 (20.3) | 25 (14.6) | 9 (11.7) |
| - Foot/toe | 365 (6.1) | 12 (4.9) | 2 (2.1) | 35 (5.3) | - | - | 8 (6) | 14 (8.2) | 3 (3.9) |
| *Other/not specified* | *20 (0.3)* | *12 (4.9)* | *-* | *36 (5.5)* | *7 (6.7)* | *9 (7.8)* | *-* | *1 (0.6)* | *-* |
| **Type of injury** | | | | | 83 (100)[e] | | | | |
| *Fractures & bone stress* | *253 (4.2)* | *-* | *-* | *16 (2.4)* | *3 (3.6)* | *1 (0.9)* | *0* | *3 (1.8)* | *1 (1.3)* |
| *Joint (non-bone) & ligament* | *1505 (25)* | *45 (18.4)* | *-* | *158 (24)* | *10 (12)* | *15 (12.9)* | *22 (16.5)* | *26 (15.2)* | *7 (9.1)* |
| - Dislocation/subluxation | 81 (1.3) | - | - | 6 (0.9) | 0 | 2 (1.7) | 1 (0.8) | - | 0 |
| - Sprain/ligament | 1207 (20) | 45 (18.4) | - | 141 (21.4) | 10 (12) | 13 (11.2) | 21 (15.8) | 25 (14.6) | 7 (9.1) |
| - Meniscus & cartilage | 217 (3.6) | - | - | 11 (1.7) | - | - | - | 1 (0.6) | - |
| *Muscle & tendon* | *2537 (42.1)* | *75 (30.7)* | *-* | *169 (25.7)* | *21 (25.3)* | *4 (3.4)* | *13 (9.8)* | *40 (23.4)* | *6 (7.8)* |
| - Muscle rupture/tear/strain | 2225 (36.9) | 75 (30.7) | - | 169 (25.7) | 19 (22.9) | 4 (3.4) | 13 (9.8) | 35 (20.5) | 5 (6.5) |
| - Tendon injury/rupture | 312 (5.2) | - | - | - | 2 (2.4) | 0 | - | 5 (2.9) | 1 (1.3) |
| *Contusion/bruise* | *767 (12.7)* | *50 (20.5)* | *-* | *105 (16)* | *34 (41)* | *75 (64.7)* | *83 (62.4)* | *84 (49.1)* | *55 (71.4)* |
| *Laceration & skin lesion* | *82 (1.4)* | *-* | *-* | *-* | *6 (7.2)* | *14 (12.1)* | *6 (4.5)* | *13 (7.6)* | *3 (3.9)* |
| *CNS/PNS* | *-* | *-* | *-* | *-* | *1 (1.2)* | *1 (0.9)* | *-* | *4 (2.3)* | *0* |
| - Concussion | - | - | - | - | 1 (1.2) | 1 (0.9) | 1 (0.8) | 4 (2.3) | 0 |
| - Nerve injury | - | - | - | - | - | - | - | - | - |
| *Other* | *886 (14.7)* | *74 (30.3)* | *-* | *210 (31.9)* | *8 (9.6)* | *6 (5.2)* | *8 (6)* | *1 (0.6)* | *5 (6.5)* |
| - Other injuries | 511 (8.5) | 36 (14.8) | - | 31 (4.7) | - | - | - | - | - |
| - Overuse unspecified | 375 (6.2) | 38 (15.6) | - | 179 (27.2) | - | - | - | - | - |

Injury defined as player being unable to participate in at least [a] one training session or match, [b] the day after the injury, [c] 2 days after the injury, [d] 3 days after the injury
[e] Number of injuries lower than totals due to missing information.

**Table 2.** (continued)

| Authors | Engström et al.[44] | Östenberg & Roos[156] | Söderman et al.[131] | Söderman et al.[132] | Jacobson & Tegner[75] | Faude et al.[46] | Giza et al.[59] | Junge et al.[83] | Junge et al.[83] | Junge et al.[84] |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | - | 1996 | 1998 | 1998 | 2000 | 2003/04 | 2001-03 | 1999 | 2000 | 2004 |
| Study period | 1 year | Season | Competitive season | Competitive season | Season | Season | 2 seasons | World Cup | Olympic Games | Olympic Games |
| Sex | Female | Female | Female | Female | Female | Female | Female | Female | Female | Female |
| Level | Elite | Elite/amateur | Elite/amateur | Elite/amateur | Elite | Elite | Professional | National team | National team | National team |
| No. of players | 41 | 123 | 78 (control) | 146 | 269 | 165 | 202 | - | - | - |
| Injuries studied | Time loss[a] | Time loss[a] | Time loss[a] (acute leg) | Time loss[a] (leg) | Time loss[a] | Time loss[b] | Medical attention | Tissue (match) | Tissue (match) | Tissue (match) |
| No. of injuries | 78 (100) | 65 (100) | 31 (100) | 80 (100) | 237 (100) | 241 (100) | 173 (100) | 30 | 32 (100) | 45 (100) |
| **Injury location** | | | | | | | | 24 (100)[e] | | |
| *Head & neck* | - | - | - | - | *14 (5.9)* | *16 (6.6)* | *18 (10.4)* | *8 (33.3)* | *8 (25)* | *7 (15.6)* |
| *Upper limbs* | - | - | - | - | *4 (1.7)* | *13 (5.4)* | - | *1 (4.2)* | *3 (9.4)* | *3 (6.7)* |
| *Trunk* | *3 (3.8)* | *7 (10.8)* | - | - | *25 (10.5)* | *18 (7.5)* | - | *1 (4.2)* | *1 (3.1)* | *4 (8.9)* |
| *Lower limbs* | *62 (79.5)* | *52 (80)* | *31 (100)* | *80 (100)* | *194 (81.9)* | *194 (80.5)* | *(60)* | *14 (58.3)* | *17 (53.1)* | *31 (68.9)* |
| - Hip/groin | 5 (6.4) | 5 (7.7) | 0 | 2 (2.5) | 17 (7.2) | 14 (5.8) | - | - | - | 1 (2.2) |
| - Thigh | 12 (15.4) | 11 (16.9) | 9 (29) | 10 (12.5) | 46 (19.4) | 44 (18.3) | - | 2 (8.3) | 7 (21.9) | 7 (15.6) |
| - Knee | 18 (23.1) | 17 (26.2) | 6 (19.4) | 15 (18.9) | 59 (24.9) | 45 (18.7) | 55 (31.8) | 2 (8.3) | 0 | 5 (11.1) |
| - Lower leg/Achilles | 7 (9) | 4 (6.2) | 1 (3.2) | 3 (3.8) | 25 (10.5) | 20 (8.3) | - | 6 (25) | 3 (9.4) | 6 (13.3) |
| - Ankle | 20 (25.6) | 7 (10.8) | 14 (45.2) | 28 (35) | 31 (13.1) | 43 (17.8) | 16 (9.3) | 4 (16.7) | 7 (21.9) | 9 (20) |
| - Foot/toe | 7 (9) | 8 (12.3) | 1 (3.2) | 3 (3.8) | 16 (6.8) | 27 (11.2) | 16 (9.3) | - | - | 3 (6.7) |
| *Other/not specified* | *6 (7.7)* | *6 (9.2)* | - | - | - | - | *68** | *0* | *3 (9.4)* | - |
| **Type of injury** | | | | | | | | 26 (100)[e] | | |
| *Fractures & bone stress* | *1 (1.3)* | *2 (3.1)* | - | - | *3 (1.3)* | *13 (5.4)* | *20 (11.6)* | *2 (7.7)* | *0* | *1 (2.2)* |
| *Joint (non-bone) & ligament* | *28 (35.9)* | *14 (21.5)* | *16 (51.6)* | *37 (46.3)* | *60 (25.3)* | *85 (35.3)* | - | *5 (19.2)* | *4 (12.5)* | *15 (33.3)* |
| - Dislocation/subluxation | 2 (2.6) | 2 (3.1) | - | - | 2 (0.8) | - | - | 1 (3.8) | 0 | 2 (4.4) |
| - Sprain/ligament | 26 (33.3) | 12 (18.5) | 16 (51.6) | 37 (46.3) | 58 (24.5) | 80 (33.2) | 33 (19.1) | 4 (15.4) | 4 (12.5) | 13 (28.9) |
| - Meniscus & cartilage | - | - | - | - | - | 5 (2.1) | - | - | - | - |
| *Muscle & tendon* | *27 (34.6)* | *30 (46.2)* | *8 (25.8)* | *20 (25)* | *68 (28.7)* | *58 (24.1)* | - | *3 (11.5)* | *8 (25)* | *4 (8.9)* |
| - Muscle rupture/tear/strain | 8 (10.3) | 21 (32.3) | 7 (22.6) | 10 (12.5) | 68 (28.7) | 58 (24.1 | 53 (30.7) | 3 (11.5) | 8 (25) | 4 (8.9) |
| - Tendon injury/rupture | 19 (24.4) | 9 (13.8) | 1 (3.2) | 10 (12.5) | - | - | - | 0 | 0 | 0 |
| *Contusion/bruise* | *12 (15.4)* | *11 (16.9)* | *7 (22.6)* | *11 (13.8)* | *20* | *57 (23.7)* | *28 (16.2)* | *9 (37.5)* | *14 (43.8)* | *16 (35.6)* |
| *Laceration & skin lesion* | - | - | - | - | *3 (1.3)* | - | - | *3 (12.5)* | *4 (12.5)* | *0* |
| *CNS/PNS* | - | - | - | - | *9 (3.8)* | - | - | *0* | *2 (6.3)* | *2 (4.4)* |
| - Concussion | - | - | - | - | 9 (3.8) | - | 5 (2.9) | 0 | 2 (6.3) | 2 (4.4) |
| - Nerve injury | - | - | - | - | - | - | - | - | - | - |
| *Other* | *10 (12.8)* | *8 (12.3)* | - | *12 (15)* | *74 (31.2)* | *63 (26.1)* | *34** | *4 (15.4)* | *0* | *7 (15.6)* |
| - Other injuries | 7 (9) | - | - | - | - | - | - | - | - | - |
| - Overuse unspecified | 3 (3.8) | - | - | 12 (15) | 74 (31.2) | - | - | - | - | - |

Injury defined as player being unable to participate in at least [a] one training session or match, [b] the day after the injury, [c] 2 days after the injury, [d] 3 days after the injury
* Not possible to identify location or type of injury for all injuries and they were grouped into category other.
[e] Number of injuries lower than totals due to missing information.

***Injury severity***
According to van Mechelen et al.[139] injury severity can be described according to six criteria: nature of sports injury, duration and nature of treatment, sporting time lost, working time lost, permanent damage, and cost. Most studies of football injuries describe the severity of injury based on sporting time lost. Commonly, injuries are categorised into slight injuries (absence 1-3 days), minor injuries (absence up to one week), moderate injuries (absence 1-4 weeks) and major injuries (>4 weeks).[27,31,43,63,75,83,96,104,107,113,146] Others have used a slightly different approach, categorising injuries as minor (1-7 days lost), moderate (8-21 days) and severe (>21 days).[1,2,8,12]

The majority of football injuries are minor, where the player is able to resume training and matches within a week. In male players, between 27-59% of injuries are minor, while 12.4-34% are severe.[8,12,27,43,96,104,107,111,146] The injury severity pattern is similar for female players, with minor injuries representing 39-51% and severe injuries 13-22% of all injuries sustained.[44,46,75] Severe injuries commonly constitute joint sprains, typically to the knee, and muscle strains, commonly affecting the hamstrings.[8,22,46,146] Fractures and dislocations are other injury types often leading to substantial absence, but they are more uncommon in football players.

***Consequences of injury and football participation***
Severe injuries, such as ACL tears, may end a football career.[18,43,117] It has been reported that about 2% of English professional football players retire each year because of an acute injury, and that nearly half of former professional players report that they retired from football because of injury.[26] It has also been suggested that a significant proportion of players may leave due to chronic injury resulting from repeated minor injury.[26,51] Social reasons were the most common for male amateur football players giving up football in a Swedish survey, but 22% of players reported quitting football because of injury.[36]

Injuries may also have long-term consequences, such as an increased risk for early osteoarthritis (OA).[26,118] Increased risk for OA has been documented among football players with previous severe knee injury, such as ACL injury or meniscus injury, or ankle injury.[90,95,106,118,144] There is also some evidence that participating in high-level pivoting sports, such as football, increases the risk for OA regardless of suffering an injury or not.[93,116,122,127] The risk for developing OA is, however, significantly increased if the player has suffered previous injury, such as a major knee trauma, and this emphasises the importance of initial prevention.

## What are the causes of injury?
Knowledge regarding risk factors and injury mechanisms is necessary in order to develop effective preventive measures against football injuries. Usually, one differentiates between intrinsic (internal) and extrinsic (external) injury risk factors, where intrinsic risk factors refers to player-specific factors, and extrinsic to factors in the environment.[28,72,105,139] The factors involved in injury causation are multi-factorial and, therefore, to evaluate risk factors for athletic injury a multivariate approach is necessary.[72,101,102] To date there are but a few prospective studies that have used multivariate approaches to evaluate risk factors for football injury.[8,87,89,132,156] Instead, risk factors are often evaluated one at a time, and even if multiple risk factors are at hand a univariate approach assessing causation has usually been applied. Examining each risk factor separately without controlling other risk factors will not give a complete picture of how each contributes to the development of injury.[101] Meeuwisse[101] proposed a multifactorial model for examining the aetiology of sports injuries (Figure 1).

According to this model, an athlete may have several predisposing intrinsic risk factors for injury (e.g. age, body composition, history of injury, etc.) but they are rarely enough to alone cause injury. Once the athlete is predisposed, extrinsic risk factors (e.g. environment, equipment, etc.) may facilitate the occurrence of injury. The presence of both intrinsic and extrinsic risk factors may leave the athlete susceptible to injury but it usually takes an inciting event (e.g. being tackled) to cause the actual injury.

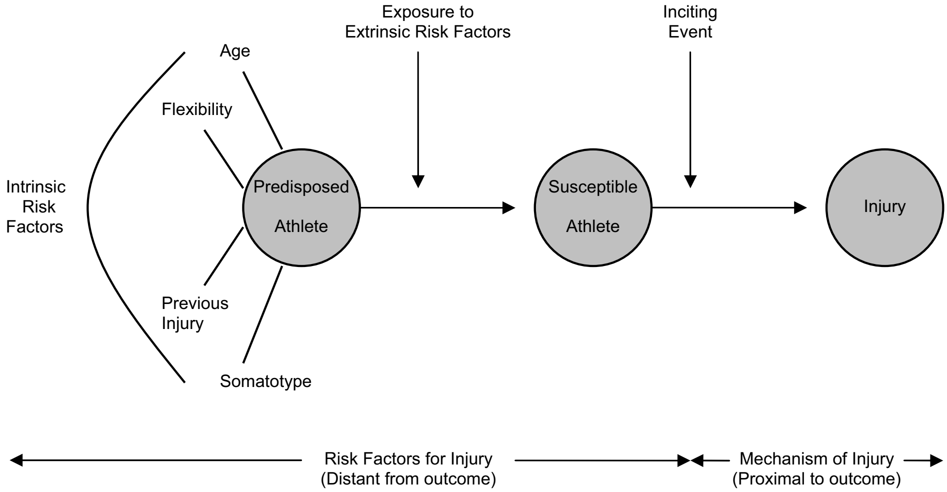


**Figure 1**. Multifactorial model of athletic injury aetiology (Reprinted with permission from Clinical Journal of Sports Medicine, Lippincott Williams & Wilkins, Meeuwisse[101]).

## Intrinsic risk factors

A summary of intrinsic risk factors for injury in adult football players is shown in Table 3. Studies show inconsistent results, probably, in part, due to small sample sizes and unreliable or invalid measures of various risk factors.[14,105]

### *Age*

For youth or adolescent players, risk for injury seems to increase with age.[28,81] Findings regarding the relationship between age and injury risk in adult football players, however, have been contradictory. Three studies found an association between increasing age and injury in general[8,94,156] while four others reported no association between age and injury.[47,75,104,132] Árnason et al. found that increasing age was associated with injury in general in male elite players using multivariate logistic regression, and when data were categorised, players in the older age group (>28 yrs) had a high injury risk.[8] Similarly, Östenberg & Roos reported a multivariate logistic regression analysis showing that older female players (≥25 yrs) had a higher injury risk than younger players (<25 yrs).[156] In contrast, other studies have shown no association between age and injury in female[47,75,132] or male players.[104] The different outcomes of these studies may in part be due to different statistical methods and different cut-off points for age groups between studies, and the effect of age on injury risk among adult players is still equivocal.

***Gender***

At the national team level, lower match injury rates were found during the women's 1999 World Cup and 2000 Olympics compared to the men's 1998 World Cup and 2000 Olympics,[83] while at the 2004 Olympics[84] and the 2004 men's and 2005 women's European championships,[148] no difference was observed between men and women. Two studies evaluated the incidence of injury during indoor tournaments and found no difference in overall injury rates between men and women.[94,113] There are several studies indicating that female players have a higher risk for ACL injury[6,18,117] and female players also sustain their ACL injuries at a lower age than males.[18,117] Male players seem to sustain more concussions than do female players.[16,20] To date, no study has compared male and female elite players at club level using the same study design and over the same study period.

***Previous injury and inadequate rehabilitation***

Previous injury and inadequate rehabilitation are commonly suggested to be risk factors for football injury.[28,50,72] Dvorak et al. found that injured players more often had sustained previous injury, and reported more joint pain at baseline, than uninjured players.[29] Two studies from youth football also indicate that previously injured players are more prone to injury in general.[41,89] In contrast, Söderman et al. found no association between recent previous injury (within 3 months) and injury in a study on female football players.[132] Studying specific injury types, previous injury has been identified as a risk factor for ankle sprain,[8,33,87] knee sprain,[8,89] as well as hamstring and groin strain.[8] However, two studies from male[135] and female football[47] found no association between previous ankle sprain and new sprain. Similarly, Faude et al. reported that female elite players with a previous knee sprain did not have an increased risk for new knee sprain, but players with a previous ACL injury had an increased risk for new ACL tear.[47] Studies are often limited by the fact that medical history is collected retrospectively, and recall bias could therefore contribute to the inconsistencies observed between studies.

The rate of recurrent injury reported in the literature is high, indicating that inadequate rehabilitation is a probable risk factor for injury. In some studies, recurrent injury is defined as having sustained an injury of the same type and location at any time previously in the career, and in these studies between 22-42% of all injuries were recurrences.[7,63,107] Other studies have used a more stringent approach and defined re-injury as an injury of the same type and location within two months of the final rehabilitation day of the index injury, and these report recurrence rates of 15-33%.[34,146] Hawkins et al. reported a remarkably low re-injury rate (7%), but the definition of re-injury was not clear in this study.[64] Between 29-46% of all muscle strains are recurrent, with 12-43% of hamstring strains and 31-50% of groin strains reported as re-injuries.[7,24,63,154] Similarly, 32-58% of ligament sprains are reported to be recurrences, with 9-69% of ankle sprains and 30-40% of knee sprains.[7,63,153] Another study reported that 35% of overuse injuries were recurrences.[146] Studies from female football show similarly high re-injury rates of 19-39%,[46,75,132] with 40-42% of overuse injuries, 38% traumatic injuries, and 28% of muscle strains being recurrence of previous injuries.[75,132]

***Anthropometrics***

Most studies report no association between anthropometrics and injury. In two studies using multivariate approaches no association was found between height, weight, body composition (% fat) or BMI and injury in general in male elite players[8] or female players.[156] Dvorak et al. found that injured players had lower body fat percentage than those who did not sustain an injury, but found no difference for other anthropometrics.[29] Faude et al. found that the tallest female players, and those with a high body weight, had an increased injury risk.[47]

### *Physical fitness*

Physical fitness can be associated with the occurrence of injury in that fatigue appears more quickly in players with low fitness. However, only few studies support this hypothesis. Eriksson et al. found that players with lower estimated $VO_{2max}$ had more distorsion injuries (sprains) whereas players with a higher estimated $VO_{2max}$ had more overuse injuries.[45] Árnason et al. found that three teams with a longer pre-season preparation period had fewer injuries than two teams with a short pre-season, possibly indicating that players with better physical fitness sustain fewer injuries.[7] However, other studies evaluating the relationship between estimated $VO_{2max}$ and injury[41,156] and peak $O_2$ uptake and injury[8] show no association.

### *Limb dominance*

Some studies comparing limb dominance with injury risk indicate that the dominant leg is injured more often. Ekstrand & Gillquist found that ankle injuries occurred more frequently in the dominant leg, but no difference was observed for muscle strains.[31] Chomiak et al. found no difference in risk for severe ankle or knee injuries between the dominant and non-dominant leg, but for contact knee injuries the dominant leg was injured more often.[22] Hawkins & Fuller reported more injuries in the dominant limb overall, without specifying the type of injury.[63] Faude et al. found more overuse injuries and contact injuries to the dominant leg in female players.[47]

### *Muscle strength/muscle imbalance*

Muscle conditioning, and particularly resistance training, constitutes a significant part of football training, especially during the pre-season preparation period. Strengthening the muscle and connective tissues is believed to result in fewer muscle injuries.[129] Reduced muscle strength or muscle imbalance are commonly proposed risk factors for injury[134] though few studies support this hypothesis. Some authors have studied the association between isokinetic muscle strength tests and injury, and generally fail to show such an association[33,156] or show contradicting results.[132] One reason could be that these tests probably have little correlation with the muscle functions required in football. Using a different approach, Árnason et al. studied maximal average power (tested in the extension phase of a knee squat in a Smith machine) but found no association with injury in a study on male elite football players.[8] Thus, no study has really been able to identify players at risk for injury based on tests of muscle strength or imbalance. However, the benefit of strength training has been shown in a population of male elite football players who sustained fewer hamstring injuries after performing specific hamstring strengthening exercises.[13]

### *Flexibility*

Many authors have studied the potential relationship between flexibility and injury risk, but the results are ambiguous. In male players, decreased range of motion (ROM) in hip abduction was found to predispose to adductor strains in two studies[8,33] but not in others.[7,150] Similarly, poor flexibility has been found to be a risk factor for hamstring and quadriceps strains in one study[150] whereas other studies show no association between hamstring[7,8,33] or quadriceps flexibility[7,33] and subsequent strain. Dadebo et al. reported that clubs that regularly employed stretching had lower hamstring injury rates, which could indirectly indicate that poor flexibility is a risk factor.[24] Finally, ankle ROM does not seem to predispose to calf muscle injury.[33,150] In female players, decreased ROM was not found to be a risk factor for muscle strain[74] or traumatic leg injury[132] even though side to side differences in ankle dorsiflexion and hamstring flexibility were found to be risk factors for overuse injury to the legs.[132]

***Joint laxity/instability***
Generalised joint laxity in female players seems to be a risk factor for injury to the lower extremity.[132,156] In male players, one study reported more ankle sprains in ankles showing clinical instability,[33] whereas two other studies found no increased risk for ankle sprain among players with ankle instability.[7,8] Similarly, one study found an increased risk for knee injury for players with a medial instability in the knee,[7] whereas another study found no association between knee instability and knee sprain.[8]

***Malalignment***
No association was found between foot or knee alignment, or Q-angle and injury in a study on female players.[132]

***Functional skills/balance***
Increased postural sway (stabilometry) may predispose to ankle sprain among male players,[135] whereas, in contrast, good balance was associated with an increased risk for leg injury in female players.[132] Similarly, Árnason et al. found no association between performance in various jump tests and injury in male elite players.[8] Surprisingly, female players with a greater number of square-hops sustained more injuries.[156]

***Skill level/level of play***
For male players, there seems to be a tendency towards higher match injury rates among elite players,[35,73,107] whereas amateurs possibly sustain more injuries during training.[35,107] However, this relationship has not been confirmed in other studies. Poulsen et al.[112] found no difference in injury incidence between different levels of play, and Peterson et al.[111] reported generally higher injury rates among players at lower levels compared to players at higher levels. The results from two retrospective surveys suggest that the risk for suffering an ACL injury is higher for elite players than for non-elite players.[18,117] Studying individual skill factors, Dvorak et al. reported that injured players had a lower score on self rated technique than uninjured players, suggesting that more highly skilled players may be less prone to injury.[29]

***Psychological factors***
In a review on the influence of psychological factors on sports injuries, Junge concluded that athletes who are more prepared to take risks are more likely to get injured.[77] This seems to be supported by the finding that players with a previous injury are more prone to any injury, and further, that players with several previous injuries are more likely to sustain injury.[29,89] Dvorak et al. also found that injured players were more of a “fighter” when approaching an opponent.[29] They did not find any difference in various psychological variables (competitive anxiety, athletic coping skills, anger-trait, and expression of anger) between injured and injury-free players, but injured players reported more life-event stress than injury-free players. Junge et al. found that players with a lower than average number of previous injuries had less worries about their performance, less competitive anxiety, less peaking under pressure, a lower anger trait, and less outward anger expression.[78] This suggests that the mentality and behaviour of players is a contributing factor in football injury and should be the target of intervention.[76]

**Table 3**. Intrinsic risk factors for football injury from prospective cohort studies in adult male and female players.

| Authors | Sex | Level | n | Analysis | Study Period | Risk factors | Increasing age | Gender (female sex) | Previous injury | Anthropometrics | Low fitness | Dominant leg | Low strength/ muscle imbalance | Decreased flexibility | Joint laxity/ instability | Malalignment | Increased postural sway | Poor performance functional tests | Psychological factors |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ekstrand & Gillquist[31] | M | Amateur | 180 | Uni | 1 year | | | | | | | 0 + | | | | | | | |
| Ekstrand & Gillquist[33] | M | Amateur | 180 | Uni | 1 year | | | | + | | | | 0 | 0+ | | | | | |
| Tropp et al.[135] | M | Amateur | 127 | Uni | 1 year | | | | 0 | | | | | | | | + | | |
| Eriksson et al.[45] | M | Amateur | 40 | Uni | 1 year | | | | | | + - | | | | | | | | |
| Árnason et al.[7] | M | Elite | 84 | Uni | Season | | | | | | | | | 0 | 0 + | | | | |
| Hawkins & Fuller[63] | M | Prof. | 108 | Uni | 3 years | | | | | | | + | | | | | | | |
| Chomiak et al.[22] | M | Mixed | 398 | Uni | 1 year | | | | | | | 0 + | | | | | | | |
| Dvorak et al.[29] | M | Mixed | 398 | Uni | 1 year | | | | + | 0 + | | | | | | | | | 0 + |
| Morgan & Oberlander[104] | M | Prof. | 237 | Uni | Season | | 0 | | | | | | | | | | | | |
| Witvrouw et al.[150] | M | Prof. | 146 | Uni | Season | | | | | | | | | 0 + | | | | | |
| Árnason et al.[8] | M | Elite | 306 | Multi | Season | | + | | + | 0 | 0 | | 0 | 0 + | 0 | | | 0 | |
| Kofotolis et al.[87] | M | Amateur | 312 | Multi | 2 years | | 0 | | + | 0 | | | | | | | | | |
| Lindenfeld et al.[94] | M,F | Mixed | - | Uni | 7 weeks | | + | 0 | | | | | | | | | | | |
| Putukian et al.[113] | M,F | Mixed | 824 | Uni | 3 days | | | 0 | | | | | | | | | | | |
| Junge et al.[83] | M,F | Nat team | - | Uni | Tourn. | | | - | | | | | | | | | | | |
| Junge et al.[84] | M,F | Nat team | - | Uni | Tourn. | | | 0 | | | | | | | | | | | |
| Östenberg & Roos[156] | F | Mixed | 123 | Multi | Season | | + | | | 0 | 0 | | 0 | | + | | | | |
| Söderman et al.[132] | F | Mixed | 146 | Multi | Season | | 0 | | 0 | | | | + - | 0 | 0 + | 0 | - | - | |
| Faude et al.[47] | F | Elite | 165 | Uni | Season | | 0 | | 0 + | + | | + | | | | | | | |
| Jacobson & Tegner[75] | F | Elite | 269 | Uni | Season | | 0 | | | | | | | | | | | | |
| Jacobson[74] | F | Mixed | 522 | Uni | Season | | | | | | | | | 0 | | | | | |

Effects of risk factor displayed as: + increased risk from risk factor; 0 no association between risk factor and injury; - decreased risk from risk factor (in cases where a risk factor produced different results for various injury types, multiple entries have been made, e.g. if poor flexibility was associated with increased risk for hamstring strain but not adductor strain this is marked with 0 +)

Abbreviations: Uni: univariate; Multi: multivariate; Prof: professional; Nat team: national team; Tourn: tournament.

## Extrinsic risk factors

### *Risk exposure and training/match ratio*

Studies evaluating exposure as a possible risk factor for injury generate conflicting results, with studies reporting high overall exposure,[132] low training exposure,[29,47] high or low training exposure,[8] high match exposure,[8] or low match exposure[47] as risk factors for injury. One study observed a trend towards a negative correlation between training/match ratio and the incidence of injury[32] whereas another study found no association with injury.[8] For many reasons it is difficult to study an association between risk exposure and injury. For instance, the association between high exposure and injury is reasonable since too great demand on players may lead to physical and mental overload and subsequently to injury.[38] On the other hand, correlating low exposure with injury is equally logical since a player with injury will be absent from training and matches, thus leading to lower exposure.

### *Time of season*

In Sweden, studies on male[31,43,145] and female football[44,75] show that overuse injuries are more common during the pre-season, while traumatic injuries are common at the beginning of the spring competitive season and at the start of the autumn season after the summer break. Hawkins et al. showed a peak in match injuries in English professional players in the beginning of the competitive season, possibly indicating that players have not yet reached appropriate levels of fitness and are therefore not in optimal physical and physiological states to be able to withstand the stresses associated with competitive football.[64] Woods et al. showed that players were at greater risk for overuse injuries, tendon-related injuries, lower leg injuries and quadriceps strains during the pre-season compared to the competitive season.[152]

The risk for injury appears to be increased during training camps compared to the regular season[32,39] and this is probably due to a sudden increase in amount and intensity of training.

### *Time of training or match*

Studies from male elite/professional football have reported that more match injuries occur towards the end of the first and second halves,[43,63,64,82] and more training injuries towards the end of training sessions.[43] These results suggest that fatigue could be a contributing factor to injury. Not all studies concur with these results however. Two studies reported no difference in injury incidence between the first and second halves[8,22] whereas another observed more injuries during the first half of matches.[31]

### *Warm-up*

It is commonly believed that cold and stiff muscles are more susceptible to injury, and warm-up could thus act to prevent muscle injury by increasing range of motion, increasing muscle temperature and thereby muscle viscosity, and by muscle relaxation.[120] Dvorak et al. observed that severely injured players had less adequate muscular and cardiovascular warm-up compared to uninjured players.[29] In another study, it was reported that all quadriceps injuries occurred in teams that were shooting at the goal before warm-up, thus providing a plausible link between warm-up and muscle injury.[32]

### *Surface*

A few studies have evaluated the risk for injury when playing football on artificial turf compared to natural grass. In studies from the 1970's and 1980's, the tendency observed was that football played on 1st generation of artificial surfaces was associated with an increased risk for injury compared to natural grass.[42,68,114] This was especially true for overuse injuries and friction injuries. Similar results were observed in the beginning of the 1990's in Icelandic elite football where the injury risk when playing football on 2nd generation artificial pitches was higher than that on natural grass or gravel.[7] However, in a recent study it was found that the risk for injury was similar when playing elite football on 3rd generation artificial surfaces compared to natural grass,[40] indicating that modern artificial surfaces are more adapted to the game.

A relatively high incidence of injury in indoor football (futsal) compared to outdoor tournaments was observed in FIFA tournaments and Olympic Games between 1998-2001.[83] Lüthje et al. found in male elite players that the incidence of training injury was higher indoors than outdoors, but for matches the relationship was reversed with higher injury risk outdoors than indoors.[96]

***Playing position***

Many authors have studied the risk for injury according to playing position, and most of these have shown no association between playing position and injury.[22,32,43,62,104] Other studies have shown conflicting results, with some studies reporting that strikers/forward players were more susceptible to injury[2,75] or ACL injury[117] than other players. Another study reported higher injury rates among strikers and defenders compared to midfielders and goalkeepers,[47] while two studies found that midfielders had the highest risk for injury.[11,59] There are many possible reasons for these inconsistent results. Players are usually categorised according to their typical playing position at the start of the season even though the player might change position during the season, or even during a match. In modern football, most outfield players are to some extent involved in both attack and defence and the playing position is therefore not static. Teams may also change formation during a match, and this will cause alternate playing positions for players. The only consistent finding thus appears to be that goalkeepers sustain fewer injuries than other players.[11,47,75] Goalkeepers, on the other hand sustain more injuries to the head/face, neck and upper extremity.[28]

***Equipment***

The equipment used may also contribute to injury but this has been poorly evaluated. Failure to wear shin guards may increase the incidence of lower leg injuries[28,31] and using bad-quality footwear may also predispose to injury.[33,114] Wearing an ankle orthosis has been found to reduce the risk for ankle sprain in previously sprained ankles.[130,136] Finally, specific headgear may be of benefit in head-to-head impacts, but are rarely used.[149]

***Foul play***

From studies defining foul play according to the decision of the referee, between 18-31% of match injuries in male players were due to foul play, with the majority being due to opponent foul (76-100%).[3,11,30,43,63,82,96] Studies from women's football show similar foul play rates (19-23%).[46,75] Other studies report foul play rates based on the player's opinion, or lack definition, and these show between 25-31% foul play injuries.[22,107,111] Foul play is thus a considerable risk factor for injury, and the attitudes of players should be a focus of attention. Junge et al. showed that nearly all players were ready to commit a "professional foul" if necessary and a majority stated that concealed fouls were a part of the game.[78]

## Injury mechanisms

Injury mechanisms are usually described in terms of whether the injury is due to player contact or not. Studies from male players show a diversity of results, with contact injuries comprising 38-74% of injuries.[7,31,63,64,96] Many recent studies on male elite players, however, tend to show a dominance of non-contact injuries,[7,63,64] which probably reflects the high proportion of muscle strain injuries in modern elite footballers. Between 52-55% contact injuries have been reported from studies on female players.[46,156] From studies at the national team level, between 73-91% of match injuries in men, and 79-84% in women, have been due to player contact.[82,83] These relatively high contact injury frequencies at national football level can be explained by the fact that only match injuries were studied, and that an anatomical tissue injury diagnosis was used, which usually means that more minor contusions and bruises are included in the data.

Tackling (24-27%) and collisions (6-27%) are the most common contact injury mechanisms in male football, whereas non-contact injuries usually result from such actions as sprinting (18-19%), shooting/kicking (4-14%) or cutting/turning (6-8%).[7,31,61,63,64,96,151] Similar mechanisms have been reported for women's football.[46,151] Tackling is a common cause of ankle sprain[58,153] and ACL injury.[18] In contrast, Faunø & Jakobsen found that only 18% of ACL injuries resulted from player-to-player contact, and identified landing after heading as a common injury mechanism.[48]

Most studies have collected information on injury mechanisms from player interviews or reports from medical staff. It has been proposed that identification of injury mechanisms from regular injury surveillance is less useful.[140] Observations are limited by recall bias, and it is difficult for the player (or medical staff) to determine the cause of injury as they often occur suddenly and may involve several players.[88] For this reason, some study groups have used video-based methods to study the mechanisms of football injury.[1-5,11,52-55,62] Using this approach, the inciting event can be described in more detail regarding the playing situation, player and opponent behaviour, body biomechanics, etc.[15] An interesting finding with many contact injuries is that injured players often are unaware of the opposing player challenging them for ball possession.[2,11] Identification of high-risk situations from video analysis may also lead to development of preventive programmes.[12]

It should be remembered, however, that not all injury types are identified in video analyses. Approximately half of all match injuries are identified on video, including most head injuries, two-thirds of knee and ankle injuries, but less than one-third of thigh injuries.[2,11] Thus, information about the mechanisms of many common football injuries, such as hamstring strain, groin strain, and other non-contact injuries, are not provided. Furthermore, video analysis has so far been limited to studies on match injuries.

## Injury prevention

Preventing injury is important not only from the medical or health perspective, but also from the sports perspective since teams with fewer injuries have a better chance of success.[9] Despite the fact that several authors have suggested preventive measures against football injury, there are still relatively few controlled trials involving football players. Fourteen studies evaluating preventive measures for football players were found in the literature (Table 4).

By implementing multi-modal intervention programmes, the injury risk has been reduced in male adult[34] and youth players.[80] Both these programmes included modalities such as specific warm-up routines, flexibility exercises, taping of previously injured or instable ankles and controlled rehabilitation, and were aimed at preventing overall injury rates. In their study on male amateurs, Ekstrand et al. reported 75% fewer injuries in the intervention compared to the control group (0.6 vs. 2.6 injuries/team/month), including fewer ankle and knee sprains, and muscle strains.[34] Junge et al. reported 21% fewer injuries overall in the intervention group

(6.71 vs. 8.48 injuries/1000 hours) in their study on male youth players.[80] The preventive effect was only seen at low-skill team level while no preventive effects were seen among high-skill teams.

Other studies have evaluated the preventive effects of various training programmes on overall injury rates or specific injuries. Heidt et al. evaluated a pre-season neuromuscular training programme consisting of sport-specific cardiovascular conditioning, plyometric work, sport cord drills, strength training, and flexibility exercises, on female youth players.[65] The authors found fewer injured players in the intervention compared to the control group during the season. Strength training has been found to reduce the number of injuries in two studies. Lehnhard et al. reported a reduction in overall injuries over a two-year period when a year-round strength training programme was introduced in a college football team compared to the previous two years when players weren't involved in any specific strength training.[91] The authors did, however, notice an increase in muscle strains. Askling et al. implemented a specific pre-season hamstring strengthening programme in two elite male football teams and reported fewer players with hamstring strain in the intervention compared to the control group.[13]

Three studies have focused on ankle sprains specifically. These show that balance board training and use of ankle orthoses are effective in reducing the number of ankle sprains in previously sprained ankles in male[130,136] and female players.[126] However, no preventive effect was seen in previously uninjured ankles.[130,136]

Another three studies showed positive effects of specific balance or neuromuscular training programmes on the rate of severe knee injuries. Caraffa et al. showed a reduction in ACL injuries in male amateur and semi-professional players following a balance training programme, including balance board exercises.[21] A reduction in ACL injuries was also shown in female youth players that participated in a specific training programme including warm-up, stretching, strengthening exercises, plyometrics and agility exercises, compared to controls that performed their normal warm-up routines.[97] Similarly, female high-school football players who followed a 6-week neuromuscular training programme including plyometrics as well as jumping and landing techniques had fewer severe knee injuries than did controls.[66] In contrast to these findings, Söderman et al. found no preventive effect of a balance board training programme on the incidence of acute lower limb injuries in female adult players.[131] The intervention group had a similar acute injury rate to the control group (4.75 vs. 3.83 injuries/1000 hours) and four of five ACL injuries occurred in the intervention group.

A cognitive-behavioural intervention lowered the incidence of injury in male and female football players at high competitive level.[76] Thirty-two players who were identified as having high injury risk profiles were selected for the study and randomised to an intervention and control group. Players in the intervention group (who received somatic and cognitive relaxation, stress management, goal setting skills, attribution and self-confidence training, and identification and discussion around critical incidents) sustained fewer injuries than did the control group (0.22 vs. 131 injuries per player).

Finally, Árnason et al. found no effect of a video-awareness programme on the rate of acute injuries in male elite players.[12] The intervention consisted of information about risk factors for injury which included viewing 12 video sequences of common injury incidents showing the entire play situation leading up to the incident. The authors found no difference in injury incidence between the two groups (6.6 acute injuries/1000 hours in both groups).

To summarise, there is evidence that multi-modal intervention programmes can reduce the number of injuries in football. There is also support for the preventive effect of ankle bracing and ankle disc training on the rate of ankle sprains in previously injured ankles. Neuromuscular and proprioceptive training has been found to reduce the rate of severe knee injuries, including ACL injuries, in most studies, even though one study showed no benefits from balance board training. Some studies have shown benefits of strength training, and cognitive-behavioural interventions, but these results must be verified in future studies. Intervention based solely on education was not found to lower injury rates. Many studies are limited by small number of players or injuries,[13,66,76,91,126] lack player exposure,[13,21,33,65,66,76,91,97,126] or lack randomisation.[80,91,97,126] Hence, there is still a need for well-sized, randomised controlled trials that account for risk exposure.[81,110]

**Table 4.** Studies evaluating preventive measures in football players.

| Author | Sex<br>Age | n | Injuries studied | Design<br>Period | Intervention | Effects of intervention |
|---|---|---|---|---|---|---|
| Ekstrand et al.[34] | Male<br>17-37 | 180 | All injuries | RCT<br>6 months | Multi-modal programme | 75% fewer injuries in the intervention group. |
| Junge et al.[80] | Male<br>14-19 | 194 | All injuries | CT<br>1 year | Multi-modal programme | 21% lower injury incidence in the intervention group. |
| Heidt et al.[65] | Female<br>14-18 | 300 | All injuries | RCT<br>1 year | Pre-season neuromuscular training programme | 61% fewer injured players in the intervention group. |
| Johnson et al.[76] | Male<br>22.9<br>Female<br>20.1 | 29 | All injuries | RCT<br>6 months | Cognitive-behavioural intervention for players with high-risk profiles | 83% fewer injuries in the intervention group. |
| Lehnhard et al.[91] | Male<br>college | 1 team | All injuries | Pros<br>4 years | Strength training | 47% fewer injuries in two years of strength training than two years without training. |
| Árnason et al.[12] | Male<br>adult | 271 | Acute injuries | RCT<br>1 season | Educational video-based awareness programme | No effect of intervention |
| Söderman et al.[131] | Female<br>20.5 | 221 | Traumatic leg injuries | RCT<br>1 season | Balance board training | No effect of intervention |
| Tropp et al.[136] | Male<br>adult | 450 | Ankle sprains | RCT<br>6 months | Either ankle orthosis or balance board training | Fewer injured players among those with previous problems with both interventions (2% and 5%) than control (25%). No effect for players without injury history. |
| Surve et al.[130] | Male<br>adult | 504 | Ankle sprains | RCT<br>1 season | Semirigid ankle orthosis | 60% lower incidence of ankle sprains in intervention group. No effect for players without injury history. |
| Sharpe et al.[126] | Female<br>19.1 | 38 | Ankle sprains | Retro<br>1 season | Tape, brace, combination tape + brace or no intervention in previously sprained ankles | Fewer ankle sprains in ankles using bracing (0) than those with no intervention (35%). No effect from tape (25%) or with combination (25%). |
| Caraffa et al.[21] | Male<br>adult | 600 | ACL injuries | RCT<br>3 years | Balance training, including balance board | 87% fewer ACL injuries in the intervention group. |
| Mandelbaum et al.[97] | Female<br>14-18 | 2946<br>2757 | ACL injuries | CT<br>2 years | Neuromuscular and proprioceptive training | 74-88% fewer ACL injuries in the intervention groups. |
| Hewett et al.[66] | Female<br>high-school | 290 | Serious knee injuries | RCT<br>1 season | Neuromuscular training programme | Fewer knee injuries in the intervention group (non-significant). |
| Askling et al.[13] | Male<br>24 | 30 | Hamstring strains | RCT<br>1 season | Pre-season hamstring strengthening programme | 70% fewer players in the intervention group suffered a hamstring strain. |

RCT: randomised controlled trial; CT: (non-randomised) controlled trial; Pros: prospective cohort study; Retro: retrospective cohort study.

# AIMS OF THE STUDY

The aims of this thesis were to study:

The incidence, severity and pattern of injury among male and female elite football players (Papers I – III and V).

Whether the injury risk in Swedish elite male football has changed with time (Paper I).

Whether the incidence, severity and pattern of injury differed between male elite players in Sweden and Denmark (Paper II).

Whether the incidence, severity and pattern of injury differed between two consecutive seasons in Swedish male elite football (Paper III).

Whether previous injury, age and anthropometrics could be identified as risk factors for injury in male elite football players (Paper III).

Whether recurrent injuries could be prevented in male amateur football players using a coach-controlled intervention programme (Paper IV).

Whether the incidence, severity and pattern of injury differed between male and female elite football players (Paper V).

# MATERIAL AND METHODS

## Study populations and data collection

Four of the papers in this thesis (Papers I – III and V) are based on prospective data collected from male and female elite football players. The Swedish top male division was followed over four different seasons (1982, 2001, 2002 and 2005), the Danish top male division was followed during the second half of the 2000/01 season, and the Swedish top female division was studied during the 2005 season. Paper IV, was a randomised controlled trial including two male division 4 series (amateur) in Östergötland, Sweden, during the 2003 season. A summary of the study populations included in each paper is presented in Table 5.

All studies had the same basic design and data collection methods. However, in the study on the Swedish top division in 1982, the methodology differed slightly from the other studies and this is specified in the following sections. Furthermore, in the randomised trial the documentation of injuries differed from the studies at elite level since the amateur teams had no medical staff to assess injuries.

**Table 5.** Description of the populations included in the five papers (inclusion marked with ×).

| Population | Swedish Top Division | Swedish Top Division | Danish Top Division | Swedish Top Division | Swedish Division 4 Intervention | Swedish Division 4 Control | Swedish Top Division | Swedish Top Division |
|---|---|---|---|---|---|---|---|---|
| Sex | Male | Male | Male | Male | Male | Male | Male | Female |
| Level | Elite | Elite | Elite | Elite | Amateur | Amateur | Elite | Elite |
| Year | 1982 | 2001 | 2001 | 2002 | 2003 | 2003 | 2005 | 2005 |
| Study period | Full season Jan-Oct | Full season Jan-Oct | Spring season Jan-Jun | Full season Jan-Nov | Full season Jan-Oct | Full season Jan-Oct | Full season Jan-Oct | Full season Jan-Oct |
| Teams (n) | 8 | 14 | 8 | 12 | 10 | 10 | 11 | 12 |
| Players (n) | 118 | 310 | 188 | 262 | 241 | 241 | 239 | 228 |
| Age (years)[a] | 25 ± 3 (19–35) | 25 ± 5 (17–38) | 26 ± 4 (17–37) | 25 ± 5 (17–39) | 24 ± 6 (15–42) | 24 ± 5 (15–46) | 25 ± 5 (16–37) | 23 ± 4 (15–41) |
| Height (cm)[a] | No data | 182 ± 6 (168–198) | 183 ± 5 (167–195) | 183 ± 6 (167–199) | 180 ± 6 (160–197) | 180 ± 6 (168–196) | 183 ± 6 (167–200) | 169 ± 5 (157–180) |
| Weight (kg)[a] | No data | 79 ± 6 (62–98) | 79 ± 6 (61–95) | 79 ± 6 (65–98) | 77 ± 9 (54–114) | 77 ± 8 (62–110) | 79 ± 6 (64–105) | 63 ± 6 (49–80) |
| Paper I | × | × | | | | | | |
| Paper II | | × | × | | | | | |
| Paper III | | × | | × | | | | |
| Paper IV | | | | | × | × | | |
| Paper V | | | | | | | × | × |

[a] Values are mean ± SD (range)

### *Inclusion and exclusion of players*

All clubs participating in the series studied, and all players contracted to the first teams of these clubs during the first month of each season (January), were invited to participate. Players who were injured at the start of the study were included, but the existing injury was not included in the study data. Players joining the squad after January were not included. Players who left their club during the study period (e.g. due to transfer, quit playing football, etc.) were included in the analyses for their time of participation in the study. The inclusion criteria were slightly different in the study on the Swedish top division in 1982 (Paper I) where each team coach selected the best 15 players (first team) to participate in the study.

***Study period***
In general, the whole season, including pre-season and competitive season, was studied (Papers I, III – V). However, only the second half of the season was studied in the Danish top division (Paper II). The Swedish league season is from spring to autumn, with pre-season usually from January to March, and competitive season from April to October/November. The Danish league follows the traditional West European season from autumn to spring. The competitive season starts in late July and ends in June, with a pre-season at the beginning of July and a mid-season break from late December to February.

***Club representatives***
Each team had one or two representatives that were responsible for the collection of data and communication with the study group. They received verbal and written information about the study procedures and definitions, as well as examples of completed forms and how to document exposure and injuries. Regular contact was maintained with the clubs to increase compliance and ensure complete data delivery.

Data were collected using the same three standardised forms in all papers (except in the study on the Swedish top division in 1982 where only one standardised attendance record was used for registering player participation and injuries).

***Baseline form***
Player anthropometrics (age, weight, height), dominant leg (preferred kicking leg) and information about previous severe injuries (absence from football >4 weeks) and surgery was collected prior to study start (Appendix 1). Each player signed this form, thereby giving consent to participate in the study.

***Exposure form***
The team representative registered individual playing exposure (minutes of participation) for all training sessions and matches for the players included. This included training and match play with the first team, reserve team, as well as national teams. Absence due to injury or other reasons was also documented on the exposure form (Appendix 2). A criterion for filling in the form was that this person (usually a member of the medical staff or the coaching staff) should be present at all training sessions and matches. The exposure form was sent to the study group each month. In the Swedish top division in 1982, individual attendance at all training sessions and matches was registered in a similar fashion on a standardised form, but exact training and match exposure was not recorded and each training session and match was estimated as 90 minutes exposure. Definitions of training and match exposure are shown in Table 6.

***Injury form***
Each team's medical staff recorded injuries that occurred during the season on a standardised form (Appendix 3). All male clubs had medical staff working with the team that filled in the injury forms. Some of the clubs in the female top division did not have medical staff present at all training sessions, but had access to a doctor or physiotherapist for injury assessment. The forms were sent in on a monthly basis, but clubs were encouraged to fill in the injury form immediately after the event. Information collected for each injury included the time of occurrence (training or match), type and location of injury, diagnosis, whether the injury was

a recurrence and whether the injury was due to foul play (match injuries). In the Swedish top division in 1982, each team's medical staff recorded absence due to injury on the exposure form, using the same injury definition, but no standardised injury form was used and information about the nature of injuries was not collected.

**Table 6**. Summary of definitions used in the thesis.

| | Used in papers | Definition |
|---|---|---|
| Injury | All | A physical complaint sustained during training or match play resulting in the player missing at least one training session or match. |
| Duration of injury | All | A player was considered injured until the team medical staff (Papers I – III & V) or the team coach (Paper IV) allowed full participation in team training and availability for first team match selection. |
| Injury severity | All | Based on the number of calendar days absence from training and match play: |
| Slight / Minimal | | Absence 1-3 days. |
| Minor / Mild | | Absence 4-7 days. |
| Moderate | | Absence 8-28 days. |
| Major / Severe | | Absence >28 days. |
| Re-injury / Recurrence | II & III | An identical injury (same type and same site) sustained within 2 months after return to play from the index injury. |
| | IV & V | An injury of the same type and same site as an index injury occurring after a player's return to full participation from the index injury; a re-injury that occurred within two months of a player's return to full participation was defined as an early recurrence, and one that occurred after two months as a late recurrence. |
| Contact injury | V | An injury resulting from contact with another player. |
| Foul play injury | II & V | A match injury caused by violation of the laws according to the referee. This could be either an opponent foul (injured player was rewarded with a free kick/penalty) or own foul (player who violated the laws was injured). |
| Overuse injury | All | A pain syndrome of the musculoskeletal system with insidious onset and without any known trauma or disease that might have given previous symptoms (modified from Orava[108]). |
| Traumatic injury | All | An acute injury with sudden onset; subdivided into: |
| Contusion | | Tissue bruise without concomitant injuries classified elsewhere |
| Sprain | | Acute distraction injury of ligaments or joint capsules |
| Strain | | Acute distraction injury of the muscle-tendon unit |
| Fracture | | Traumatic break of bone |
| Dislocation | | Partial or complete displacement of the bony parts of a joint |
| Other | | Injuries not classified elsewhere |
| Training exposure | All | Any coach-directed physical activity carried out with the team (including training with first, reserve and national teams). |
| Match exposure | All | Match play between teams from different clubs (including matches with first, reserve and national teams). |

A time loss injury definition was used in all papers: a physical complaint sustained during training or match play resulting in the player missing at least one training session or match.[30] If a player participated in a modified training programme because of a physical complaint sustained during football, this was also recorded as an injury. A player was defined injured until the team's medical staff (Papers I – III & V) or team coach (Paper IV) allowed full participation in team training and availability for first team match selection. Injuries were categorised into four severity categories based on the number of days absence (Table 6). Absence was calculated from the exposure forms, and represented the number of calendar days lost. A player who sustained a season-ending injury was generally followed to the final rehabilitation day even if this occurred after the end of the study period.

## Papers I – III and V

### *Swedish top male division 1982*

All 12 teams in the Swedish top division during the 1982 season were invited to participate in the study, with a total of 180 players at study start. Four teams (n=60) that did not deliver complete data, and two players who joined their squads after the first study month (January 1982), were excluded from the analysis. Thus, 118 players were included in the analysis and three of these (3%) dropped out during the study. Data from the whole season (January – October) were collected. The competitive season ranged from April 26$^{th}$ – September 25$^{th}$, with all teams playing 22 league matches. The top eight teams in the table then went on to the final play-offs where the teams had double elimination matches in quarter-finals, semi-finals, and finals. This gave an extra possible 2 to 6 games for these 8 teams in October. The bottom four teams played two degradation play-off matches each. All play-off games were included in the analyses.

### *Swedish top male division 2001*

All 14 teams in the Swedish top division during the 2001 season participated and delivered complete prospective data throughout the season (January – October). Of the 312 players in the 14 teams, 310 accepted participation, and 31 (10%) of these dropped out during the study. The competitive season started on April 8$^{th}$ and the last league game was played on October 27$^{th}$, with each team playing 26 league matches.

In Paper I, each team coach was asked at the end of the season to select the 15 best players in their squad for additional analysis with the 1982 season. The coaches were asked to select the 15 players that they had considered to be the first team prior to the start of the season, regardless of the players' actual performance or injuries during the season.

In Paper II, data from the spring season (including pre-season January – March and first half of the competitive season April – June) and the autumn season (July – October, including the second half of the competitive season) were analysed separately for comparison with the Danish cohort. Sixteen players (5%) dropped out during the spring season. The teams had 11-12 league games during the spring season (April 8$^{th}$ – June 27$^{th}$) and 14-15 league games during the autumn season (July 1$^{st}$ – October 27$^{th}$).

In Paper III, the 12 teams that participated in the Swedish top division during both the 2001 and 2002 seasons were included. In 2001, 263 players participated in the 12 teams (mean ± SD age 25 ± 5, range 17-38 yrs) and 28 of these (11%) dropped out during the season.

### *Swedish top male division 2002*

For inter-season comparison, we chose to include all players in the 12 teams to increase power. In 2002, 262 players participated and 33 of these (13%) dropped out before the end of the season. The competitive season comprised 26 league games for each team, starting April 6$^{th}$ with the last game on November 2$^{nd}$.

Only the 197 players that participated during both the 2001 and 2002 seasons were included in the risk factor analysis (mean ± SD age 25 ± 4, range 17-38 yrs). Eighteen of these (9%)

dropped out during the 2002 season. The potential risk factors studied were player age, weight, height and BMI (weight [kg] / height$^2$ [m]) and previous injury.

***Swedish top male division 2005***
All 14 clubs were invited and initially accepted to participate in the study. Eleven clubs (n=239) delivered complete data and were included, whereas three clubs withdrew after 2, 3 and 4 months respectively. Twenty-six players (11%) dropped out during the season. All teams played 26 league games during the competitive season (April 9$^{th}$ – October 23$^{rd}$).

***Danish top male division 2001***
All 12 teams in the Danish top division were invited to participate during the spring season (January – June) of 2001. Three teams did not agree to participate, and one team had to be excluded due to incomplete data. Eight teams (n=188) delivered complete data for the study period, and 11 players (6%) dropped out during the study. The study period included a mid-season break (January – February) and the second half of the competitive season 2000/01 (March – June), which comprised 15 league games, starting at March 11$^{th}$ and the last game on June 13$^{th}$.

***Swedish top female division 2005***
All 12 teams (n=228) in the top female division were invited to participate in the study and delivered complete data during the 2005 season (January – October). Sixteen players (7%) dropped out during the season. The teams played 22 league games during the competitive season (April 16$^{th}$ – October 22$^{nd}$).

## Paper IV
***Participants***
Prior to starting the 2003 season, all 24 male division 4 teams (sixth highest division) in the region of Östergötland, Sweden, were invited to participate in a randomised controlled trial. Teams were randomised to an intervention (12 teams, 282 players) and control group (12 teams, 300 players). Two teams in the intervention group (n=41) and two in the control group (n=59) withdrew their participation prior to study start, or within the first two months of the study, leaving 10 teams with 241 players for analysis in each group. Twenty-five players in the intervention group (10%) and 20 in the control group (8%) dropped out during the season. The competitive season ranged from April 18$^{th}$ – October 5$^{th}$, with all teams playing 22 league games.

***Data collection***
The same three forms that were used in the studies on elite level players were also used in the RCT. The team coach registered individual player exposure on the exposure form and sent them in on a monthly basis. However, since the amateur teams only have limited access to medical personnel the injury form was filled in by the study group based on either a clinical investigation or a structured telephone interview with the player and team coach. If an injured player had visited a hospital or other clinic for injury assessment these medical journals were reviewed whenever possible to verify assessment of the injury. The study group was not involved in the rehabilitation of players or return-to-play decisions.

***Intervention programme***
Team coaches in the intervention group received instructions about the intervention programme at a meeting prior to the start of the study. Intervention was aimed at preventing re-injury and consisted of information about risk factors for re-injury, rehabilitation

principles, and a 10-step progressive rehabilitation programme including return-to-play criteria (Figure 2). The programme was intended to serve as a guide for the coaches, with structured assessment during the functional rehabilitation of players, and to assist in return-to-play decisions. It was primarily designed for lower extremity injuries but coaches were instructed to use the programme for all injuries. The control group teams did not receive any information about prevention of re-injury, and were told to go on with training and management of injuries as usual. All intervention team coaches signed a contract not to reveal the content of the prevention programme to the other clubs.

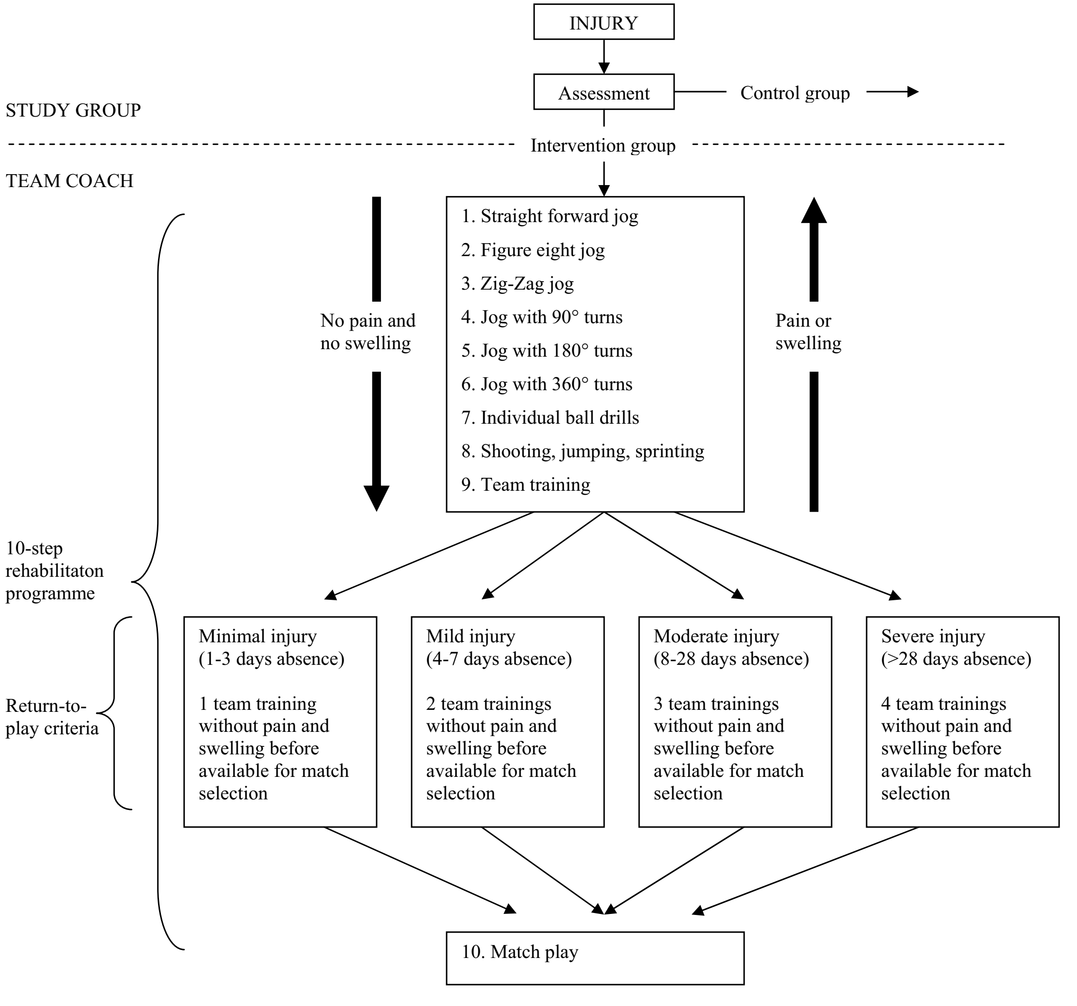


**Figure 2.** 10-step rehabilitation programme including return-to-play criteria for injured players. Progress to the next level was allowed when the player could complete the exercise without pain and swelling at the injured site. If the player experienced pain or swelling he returned to the previous symptom-free level and resumed progress at a later session.

## Statistical methods

Data were statistically analysed using StatView® version 5.0.1 (SAS Institute Inc., Cary, NC, USA). The significance level was set at $p<0.05$.

Descriptive data are generally presented for quantitative variables (e.g. anthropometrics, risk exposure and injury rates) as mean values with standard deviations (SD) or 95% confidence intervals (95% CI). Groups were compared using *Student's t-test* or *ANOVA*, or the *Mann-Whitney U-test* in case of heterogeneity of variance between groups (F-ratio test), or a non-normal distribution (Kolmogorov-Smirnov test).

Groups were compared for qualitative variables with the $\chi^2$ *test*, or *Fisher's exact test* for small numbers. This included comparisons of categorical variables such as injury severity (Papers I and II), type of injury (Papers II, III and V), location of injury (Papers II, III and V), re-injury rate (Papers II, IV and V), frequency of match injury due to foul play (Papers II and V), frequency of contact vs. non-contact injury (Paper V) and distribution of age and professional status between groups (Paper V).

Injury incidences are presented as the number of injuries/1000 player hours (i.e. sum of injuries / sum of player hours ×1000) and are given for all injuries, as well as for training and match injuries separately. Injury incidences are presented with 95% CI ("incidence / $e^{(1.96\times\sqrt{(1/\text{injuries.})}}$" to "incidence × $e^{(1.96\times\sqrt{(1/\text{injuries})}}$"). In Papers I and II, the mean injury incidences for the teams in each cohort were calculated and groups compared using the *Mann-Whitney U-test* (due to non-normal distributions). In Papers III – V, injury incidences were calculated using aggregated data for each cohort and groups compared using *z-statistics*.[94]

In Paper III, a *Cox proportional hazards model* was used to determine the relationship between the potential risk factors (previous injury, age, height, weight and BMI) and subsequent injury. In this model, the time (hours of exposure) from the start of follow up period until the event (first injury) or the end of follow-up (end of season) is the main variable. The model also takes censorship into account, i.e. abbreviated length of absence for reasons other than injury. Analyses were carried out with the risk factors treated as continuous or categorical variables. For the categorical analyses, the players were divided in three groups for each variable. Hazard ratios with 95% confidence intervals were calculated for the groups of players with the lowest (>1SD below mean) and the highest (>1SD above mean) values for each variable with the intermediate group (mean ± 1SD) used as the reference group. Analyses were carried out using both the player as well as the limb as unit of analysis. The latter was performed since the effects of a previous injury may be associated with characteristics of the limb rather than with the player.[14] All variables were assessed in a univariate analysis and variables that were $p<0.20$ were entered into a multivariate model for further analysis. In the multivariate model, variables that were $p<0.05$ were considered significant.

In Paper IV, a *univariate Cox proportional hazards model* was used to compare the risk of re-injury (for all injuries and lower limb injuries separately) between the intervention and control groups. Recurrence from an injury sustained during the study period was the uncensored event and a player was included in the model when he sustained his first injury. Player age and diagnostic method (whether the injury was assessed clinically or via a structured telephone interview) were checked for confounding. *Univariate logistic regression* was performed to evaluate the risk for suffering a re-injury within various time periods after return to play (≤1 week, ≤4 weeks, ≤2 months and within the season).

In Paper V, the effect of player age on the incidence and pattern of injury was evaluated by dividing players into three age groups: younger players (>1SD below mean age), intermediate group (mean ± 1SD) and older players (>1SD above mean). Multiple comparisons between age groups were performed for risk exposure (*ANOVA*), injury incidence (*z-statistics*) and injury pattern ($\chi^2$ *test or Fisher's exact test*) and a *Bonferroni correction* was made. The significance level was adjusted to p<0.0167 according to the formula $P^1 = P/n$, i.e. the accepted significance level is 0.05 / number of comparisons (n=3).[19]

## Ethics

All studies were approved by the ethics committee of Linköping University, Sweden. All participating players were informed about the study and gave written informed consent. In order to maintain players' confidentiality, all players were given an individual code when data were analysed.

# RESULTS AND DISCUSSION

## Injury incidence and severity in elite players

The risk for injury observed among the elite football players was high. Between 76-79% of male elite players (Papers I, III & V) and 65% of female elite players (Paper V) sustained at least one performance-limiting injury during a full season. These results are in line with previous studies on elite football, reporting that 65-91% of male players[43,92,96,146] and 48-70% of female players suffer at least one injury during a season.[46,75]

***No increase in risk for injury in Swedish male elite football over the last two decades***

In Paper I, risk exposure and injury risk was compared between seasons 1982 and 2001 of the Swedish top male division. The mean number of team training sessions over one season had increased by 68% between 1982 and 2001 (142 ± 11 vs. 238 ± 19, p<0.001) reflecting the transition from semi-professionalism to full professionalism. However, no difference in injury incidence or injury severity was observed between seasons. Exact player exposure was not registered during the 1982 season, making calculation of injury incidences less optimal. However, by using official match statistics for the league games played in the 1982 season[128] we were able to calculate match injury incidences for the 1982 and 2001 seasons including exposure and injuries from league games only, and this analysis showed similar results. The league match injury incidence in 1982 was 23.5/1000 hours (95% CI 18.4-29.9) compared to 27.0/1000 hours (95% CI 23.0-31.6) in 2001 (z-value 0.94, NS, unpublished data). If anything, we believe the injury incidence in the 1982 season is slightly underestimated due to lower medical access in the clubs, less frequent training sessions, etc. This would indicate that the risk for injury has not increased over the last two decades. Similar injury rates were also observed in the 2002 (Paper III) and 2005 seasons (Paper V) (Table 7).

**Table 7.** Injury incidences (95% CI) in the Swedish top male division over four seasons.

| | 1982[a] | 2001[a] | 2002[b] | 2005[c] |
|---|---|---|---|---|
| Training | 4.6 (2.7-6.6) | 5.2 (3.4-7.1) | 5.3 (4.7-5.8) | 4.7 (4.2-5.3) |
| Match play | 20.6 (14.0-27.1) | 25.9 (16.7-35.2) | 22.7 (20.0-25.8) | 28.1 (24.8-31.8) |
| Total | 8.3 (5.1-11.5) | 7.8 (5.2-10.4) | 7.6 (7.0-8.3) | 7.7 (7.1-8.3) |
| Minimal (1-3 days) | 3.4 (0.8-6.0) | 2.5 (1.2-3.8) | 2.8 (2.4-3.2) | 2.8 (2.4-3.2) |
| Mild (4-7 days) | 2.2 (1.2-3.1) | 2.2 (1.3-3.0) | 2.1 (1.8-2.5) | 2.2 (1.9-2.6) |
| Moderate (8-28 days) | 2.0 (1.3-2.7) | 2.4 (1.7-3.0) | 1.9 (1.6-2.2) | 2.0 (1.7-2.3) |
| Severe (>28 days) | 0.8 (0.5-1.1) | 0.8 (0.5-1.0) | 0.8 (0.7-1.1) | 0.7 (0.5-0.9) |

Data from [a] Paper I, [b] Paper III, [c] Paper V

Due to methodological differences between studies it is difficult to evaluate trends in injury incidence from the literature, but our findings are in accordance with the results from Icelandic male elite football where no difference in injury incidence was observed between the 1991, 1999 and 2000 seasons.[10]

***Injury risk in Swedish versus Danish football***

Surprisingly, a higher rate of training injury (11.8/1000 h) and severe injury (1.8/1000 h) was observed among the Danish male elite players compared to their Swedish counterparts (Paper II). There could be several explanations for this. One is that the different season time span meant that the Danish players were followed during the second part of the season and completion of the league table. Players may also have carried an increased risk for injury because of injuries sustained during the first part of the season. A higher re-injury rate was observed amongst Danish players (30% vs. 24%, p=0.032) and this could indicate such a causal relationship. We tried to control for this by further analyses including the autumn season in Sweden and this showed similar results. A second is that Swedish players had a more favourable training/match ratio, and a previous study reported a negative correlation between high training/match ratio and injury.[32] Finally, the mean age for Danish players was slightly higher than for Swedish players, and an increase in injury incidence with increasing age has been reported.[8] However, we stratified injury rates for different age groups in the Danish cohort and found that young players (<21 yrs) had the highest training injury incidence (19.7; 95% CI 14.9-26.1) of all age groups; 21-25 yrs 9.3 (7.4-11.7), 26-30 yrs 11.1 (9.2-13.4) and >30 yrs 13.5 (10.0-18.4) (unpublished data). We thus identified young players as a high-risk group regarding training injury in Danish elite football. Many other variables may influence comparison between countries, such as the type of training, medical service, weather and pitch conditions, quality of data collection, etc., none of which were controlled for in our study. Nevertheless, the training injury incidence observed among the Danish players was also higher than those reported from male elite players in other European countries (1.9-5.9 injuries/1000 h)[7,8,12,63,146] suggesting that the training content should be reviewed in order to reduce the number of injuries.

### *Injuries among male compared to female elite players*

During the 2005 season, a higher injury incidence for male players compared to women was observed during both training (4.7 vs. 3.8 injuries/1000 h, p<0.05) and match play (28.1 vs. 16.1/1000 h, p<0.001) (Paper V). However, when injuries were stratified by severity, a higher rate of minimal to mild injury (absence up to 1 week) was seen for male players, whereas the incidence of moderate to severe injury (>1 week) was similar between sexes (Table 8).

**Table 8.** Injury incidence in male and female players in the Swedish top division during the 2005 season.

| | Men | | | | Women | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Injuries | N | % | Inc | (95% CI) | N | % | Inc | (95% CI) | P-value |
| Training | 294 | *54* | 4.7 | (4.2-5.3) | 175 | *59* | 3.8 | (3.2-4.4) | <0.05 |
| Match play | 254 | *46* | 28.1 | (24.8-31.8) | 124 | *41* | 16.1 | (13.5-19.2) | <0.001 |
| Total | 548 | *100* | 7.7 | (7.1-8.3) | 299 | *100* | 5.5 | (4.9-6.2) | <0.001 |
| Minimal | 200 | *36* | 2.8 | (2.4-3.2) | 76 | *25* | 1.4 | (1.1-1.8) | <0.001 |
| Mild | 158 | *29* | 2.2 | (1.9-2.6) | 84 | *28* | 1.6 | (1.3-1.9) | <0.01 |
| Moderate | 142 | *26* | 2.0 | (1.7-2.3) | 102 | *34* | 1.9 | (1.6-2.3) | NS |
| Severe | 48 | *9* | 0.7 | (0.5-0.9) | 37 | *12* | 0.7 | (0.5-0.9) | NS |

One concern regarding females playing football at the elite level is that whereas they train almost as much as male elite players (4.7 ± 0.6 vs. 5.9 ± 0.5 training sessions/week) they often have a regular job besides football. In a previous investigation, it was stated that 9 of 10 clubs in the Swedish female top division had some form of economic benefit for their players.[74] In paper V, we documented monthly salaries and found that only 5% of female players were full-time professionals, while 67% had no salary at all. In comparison, 86% of male players were full time professionals. This puts a great strain on female players with a tight schedule since they have less chance to prepare for training and matches, to have sufficient time for recovery, to have proper nutrition, etc. It is plausible that this could lead to an increased risk for injury, as well as a delayed recovery from injury.

Three studies have compared the risk for injury in male and female players at the elite level. These studies showed lower match injury rates during the women's 1999 World Cup and

2000 Olympic Games compared to the men's World Cup 1998 and 2000 Olympics,[83] while at the 2004 Olympics[84] and the 2004 men's and 2005 women's European championships[148] no difference was observed between men and women. The injury rates observed for the Swedish female elite players in our study are comparable to those previously reported from elite club football, with time loss injury incidences between 2.7-7 injuries/1000 training hours and 13.9-24/1000 match hours.[44,46,75] These also show a tendency towards lower injury incidences, at least in matches, compared to those reported for male elite players. Our data shows the importance of accounting for injury severity when comparing injury rates between men and women.

## Type and location of injury

The types of injury are shown in Table 9, where injuries have been re-classified according to the consensus proposal.[56] Muscle strain was the most common type of injury in both men and women, comprising approximately one-third of all injuries. Ligament sprains and contusions were common acute injury types. Overuse injuries to tendons and joints were also frequent. Serious injuries such as fractures and dislocations were uncommon. The majority of injuries were to the lower extremity (87-89%), the most common sites of injury among male elite players being the thigh (22-23%), knee (15-21%), hip/groin (15-19%) and ankle (9-13%). Injuries to the head/neck (1-3%), upper extremity (2-4%) and trunk/spine (7-9%) were less frequent among the male players.

**Table 9.** Injury types in male and female elite football players.

| | Swedish top male division | | | | | | Danish top male division | | Swedish top female division | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2001 | | 2002 | | 2005 | | | | | |
| | N | *%* | N | *%* | N | *%* | N | *%* | N | *%* |
| Fracture | 23 | *3* | 19 | *3* | 14 | *3* | 6 | *2* | 10 | *3* |
| Dislocation | 6 | *<1* | 5 | *<1* | 0 | *0* | 10 | *3* | 3 | *1* |
| Sprain/ligament injury | 99 | *14* | 77 | *13* | 96 | *18* | 75 | *19* | 66 | *22* |
| Meniscus/cartilage | 23 | *3* | 31 | *5* | 8 | *1* | 4 | *1* | 13 | *4* |
| Muscle injury/strain | 247 | *35* | 201 | *34* | 182 | *33* | 136 | *34* | 84 | *28* |
| Tendon injury | 69 | *10* | 53 | *9* | 61 | *11* | 49 | *12* | 10 | *3* |
| Haematoma/contusion | 117 | *16* | 89 | *15* | 101 | *18* | 58 | *15* | 33 | *11* |
| Abrasion | 2 | *<1* | 2 | *<1* | 2 | *<1* | 0 | *0* | 0 | *0* |
| Laceration | 4 | *<1* | 2 | *<1* | 1 | *<1* | 0 | *0* | 1 | *<1* |
| Concussion | 5 | *<1* | 8 | *1* | 7 | *1* | 2 | *<1* | 6 | *2* |
| Nerve injury | 1 | *<1* | 2 | *<1* | 1 | *<1* | 0 | *0* | 1 | *<1* |
| Synovitis/effusion | 25 | *3* | 12 | *2* | 9 | *2* | 14 | *4* | 13 | *4* |
| Overuse complaints | 81 | *11* | 81 | *14* | 59 | *11* | 32 | *8* | 53 | *18* |
| Other type | 13 | *2* | 6 | *1* | 7 | *1* | 9 | *2* | 6 | *2* |
| Total | 715 | *100* | 588 | *100* | 548 | *100* | 395 | *100* | 299 | *100* |

The category "other" according to the consensus proposal was split into three categories: "synovitis/effusion", "overuse complaints" and "other type".

When comparing male and female elite players (Paper V), joint injuries in general (including dislocation, sprain, meniscus and cartilage injuries) were more common among women than men. Women had a higher proportion of unspecified overuse complaints (e.g. low back pain, medial tibial stress syndrome) than men, whereas problems located to tendons seemed more frequent among male players. Male players also had a higher proportion of contusions than women. Men had more injuries to the hip/groin, while women had a higher frequency of knee injuries. These findings are consistent with most studies on male[8,64,146] and female elite players.[44,46,75]

Previous studies have indicated that women have a higher risk for knee sprain[94] including ACL injury.[6,18,117] We could not confirm these findings in our studies. In Paper V, no difference in the rate of knee sprain or ACL tear/1000 hours of total exposure was observed between men (knee 0.5; ACL 0.11) and women (knee 0.6; ACL 0.15). The rate of ACL injury (per 1000 hours) in our study is comparable to two previous studies from male[8] (0.15) and female elite players[59] (0.09) but somewhat lower than that found in two other studies on female players[46,156] (0.31), all using a similar prospective cohort design. Thus, the relative risk for ACL injury between female and male players based on prospective studies accounting for risk exposure seems almost equal or at least lower than that reported from a retrospective study on Swedish football (OR female vs. male elite 6.9).[117] However, most prospective studies are, for obvious reasons, limited by the small number of ACL injuries and must be interpreted with caution.

Hamstring strain, groin strain, ankle sprain and knee sprain were the most common injuries among the Swedish elite players in our study, the rate of injury per 1000 hours of total exposure (Table 10) being comparable to previous studies.[8,10,35] Unfortunately, insufficient information regarding the nature of injuries occurring during the 1982 Swedish top division season was collected. We were therefore unable to directly compare the type and location of injuries between 1982 and the later seasons studied. However, most studies from the 1980's report that ankle sprain was the most common injury, followed by knee sprain, whereas strain of the hamstring and groin muscles were less frequent.[31,35,43,107,112] In modern elite football, there seems to be a shift towards an increased representation of muscle strain injury, typically to the hamstrings and groin, and these are now more common than joint sprains.[8,63,64,146] Our findings from elite level football in Sweden and Denmark concur with this trend, and a plausible explanation is the increased speed and intensity observed in modern day elite football.

**Table 10.** Total injury incidences (95% CI) for common injury types in Swedish elite football (unpublished data)

| | Top male division | | | | | | Top female division 2005 | |
|---|---|---|---|---|---|---|---|---|
| | 2001 | | 2002 | | 2005 | | | |
| Hamstring strain | 0.8 | (0.6-1.0) | 1.0 | (0.8-1.2) | 1.0 | (0.8-1.2) | 0.8 | (0.6-1.1) |
| Groin strain | 0.8 | (0.7-1.0) | 0.9 | (0.7-1.1) | 1.0 | (0.8-1.3) | 0.2 | (0.1-0.4) |
| Ankle sprain | 0.6 | (0.4-0.7) | 0.5 | (0.4-0.7) | 0.8 | (0.6-1.0) | 0.8 | (0.6-1.1) |
| Knee sprain | 0.4 | (0.3-0.6) | 0.4 | (0.3-0.6) | 0.5 | (0.4-0.7) | 0.6 | (0.4-0.9) |

## Consequences of injury

When reviewing the severity of injuries based on the days lost from football, between 60-68% of injuries among male elite teams (Papers I, II, III and V) were minimal to mild where the player resumed football participation within a week. Between 21-31% were moderate, and 9-12% of injuries were severe, requiring more than four weeks of rehabilitation. Among the female elite teams the relative percentage of severe injuries (12%) was similar to the male teams, but the distribution of minimal and mild injuries was slightly lower (54%) (Paper V). For amateur teams, 22-26% of injuries were severe, 41% moderate, and 33-37% minimal to mild (Paper IV). These variations in distribution of injury severity are probably related not only to anatomical tissue damage, but also to the frequency of training sessions and matches.

Severe injuries among elite players comprised mainly ligament sprains (31% of severe injuries in men; 35% women), strains (29% men; 22% women) and fractures (17% men; 19% women), and were located to the knee (40% men; 38% women), hip/groin (21% men; 8% women) and thigh (13% men; 16% women) (Paper V).

In Paper V, the consequences of injury were also evaluated with respect to the total days lost for all injuries in men's and women's elite football (Table 11). When studying risk, not only the probability of injury, but also the consequences of injury should be addressed.[27] This analysis showed that knee injuries accounted for 52% of the total days lost among female players. Knee sprain comprised 6% of all injuries in male and female players, but accounted for 31% and 37% of the risk. The most common injury in both male and female players was hamstring strain, representing 12% of injuries and 10% of the risk in male players, and 15% of injuries, with 7% of the risk in female players. Fractures were relatively uncommon, but accounted for 8% and 16% of the risk for male and female players respectively. Conversely, contusions and ankle sprains represented a high proportion of injuries, but comprised a lower risk due to shorter absence. This information has implications for developing preventive strategies, as these should focus on injuries with a high risk, taking into account both the frequency and consequences of injury.

**Table 11.** Frequency and consequences of selected injury types in male and female elite football (Paper V).

| | Men | | | | Women | | | |
|---|---|---|---|---|---|---|---|---|
| Injury type | N | % | Days lost | % | N | % | Days lost | % |
| Contusions | 101 | *18* | 491 | *6* | 33 | *11* | 176 | *3* |
| Hamstring strain | 68 | *12* | 749 | *10* | 44 | *15* | 498 | *7* |
| Groin strain | 68 | *12* | 858 | *11* | 12 | *4* | 123 | *2* |
| Ankle sprain | 57 | *10* | 440 | *6* | 44 | *15* | 401 | *6* |
| Lower limb tendinopathies | 55 | *10* | 503 | *7* | 10 | *3* | 85 | *1* |
| Knee sprain | 31 | *6* | 2399 | *31* | 19 | *6* | 2573 | *37* |
| Quadriceps strain | 26 | *5* | 195 | *3* | 13 | *4* | 228 | *3* |
| Low back pain | 22 | *4* | 98 | *1* | 16 | *5* | 137 | *2* |
| Calf strain | 14 | *3* | 211 | *3* | 10 | *3* | 143 | *2* |
| Fractures | 14 | *3* | 621 | *8* | 10 | *3* | 1088 | *16* |
| Knee cartilage or meniscus lesion | 7 | *1* | 275 | *4* | 13 | *4* | 427 | *6* |
| Other types | 85 | *16* | 811 | *11* | 75 | *25* | 996 | *14* |
| Total | 548 | *100* | 7651 | *100* | 299 | *100* | 6875 | *100* |

## Risk factors for injury

A number of potential risk factors for injury were investigated using both multivariate (Paper III) and univariate analyses (Papers III, V):

***Previous injury and re-injury***

We examined the association between having suffered an injury in the 2001 season and subsequent injury in the 2002 season. A multivariate Cox proportional hazards regression model analysis (including player age) showed that players sustaining an injury during the preceding season had an almost threefold higher risk of injury compared to previously uninjured players (HR 2.7, 95% CI 1.7-4.3, p<0.0001). It was also found that the more injuries a player had sustained the previous season, the greater the risk for injury. Players with one or two injuries had double the risk for injury (HR 2.2, 95% CI 1.4-3.6, p=0.0014), those with three to four injuries had a tripled risk (HR 3.0, 95% CI 1.8-5.3, p<0.0001) and players with five or more injuries had five times the risk for injury compared to previously uninjured players (HR 5.2, 95% CI 2.9-9.0, p<0.0001). Our observation is in agreement with previous studies from various skill and age groups.[29,41,89]

There are several possible explanations as to why an increased injury risk is observed for players with many injuries in the preceding season. One is that re-injury is a strong risk factor for injury,[8] and players with multiple previous injuries may be expected to have an increased risk for re-injury. A second is that remaining physiological deficits or altered movement patterns following a previous injury may predispose to injury. A previous ACL injury, for instance, has been found to increase the risk for other knee injuries, especially overuse injury.[147] A third is that the category of players who are repeatedly injured may comprise individuals with a more risk-taking behaviour[77] or an aggressive playing style.[29]

We also studied previous injury as a risk factor for the four most common injury types identified in the 2001 season. For this analysis, each limb was used as unit of analysis as in some previous studies.[8,14,47,147] Table 12 shows the risk factors with a p-value <0.20 from the univariate Cox proportional hazards regression model. The risk for sustaining a hamstring injury was three times higher in limbs with a previous hamstring injury, based on a multivariate analysis. Previous injury was the only significant risk factor for groin injury, and the univariate analysis showed that previous injury doubled the risk for injury in the same limb. Both these findings are in accordance with the results from a previous study on male elite players in Iceland.[8] Previous knee joint trauma tripled the risk for new knee injury and this finding also concurs with previous reports.[8,89] However, previous injury was not identified as a risk factor for new ankle sprain in a multivariate analysis. Studies investigating the association between previous ankle sprain and new sprain have produced conflicting results; four studies showed an association[8,33,87,89] and two did not.[47,135]

**Table 12.** Risk factors for injury in male elite players based on Cox proportional hazards regression analyses using each limb as unit of analysis (Paper III).

| | Univariate analysis | | | Multivariate analysis | | |
|---|---|---|---|---|---|---|
| | Hazard ratio | 95% CI | P-value | Hazard ratio | 95% CI | P-value |
| Hamstring injury | | | | | | |
| Previous hamstring injury | 3.2 | 1.8 to 6.0 | <0.001 | 3.5 | 1.9 to 6.5 | <0.0001 |
| Increasing age (one year) | 1.1 | 1.0 to 1.2 | 0.021 | 1.1 | 1.0 to 1.2 | 0.011 |
| Groin injury | | | | | | |
| Previous groin injury | 2.4 | 1.2 to 4.6 | <0.01 | | | |
| Knee joint trauma | | | | | | |
| Previous knee joint trauma | 3.1 | 1.3 to 7.6 | 0.011 | 3.1 | 1.3 to 7.6 | 0.011 |
| Increasing height (one cm) | 1.05 | 1.0 to 1.1 | 0.13 | 1.05 | 1.0 to 1.1 | 0.13 |
| Ankle sprain | | | | | | |
| Previous ankle sprain | 2.8 | 0.8 to 9.6 | 0.099 | 3.0 | 0.9 to 10.4 | 0.079 |
| Increasing age (one year) | 0.9 | 0.8 to 1.0 | 0.12 | 0.9 | 0.8 to 1.0 | 0.061 |
| Increasing height (one cm) | 1.1 | 1.0 to 1.2 | 0.16 | 1.0 | 0.9 to 1.1 | 0.89 |
| Increasing weight (one kg) | 1.1 | 1.0 to 1.2 | 0.091 | 1.1 | 1.0 to 1.2 | 0.19 |

The early recurrence rates (within 2 months) observed among Swedish and Danish male elite players ranged between 15-30% and did not differ from that of the female elite players (18%). Our data is also within the range of the re-injury rates reported in most previous studies on male and female elite football.[7,46,63,75,146] When reviewing the type of injuries that resulted in early recurrence, muscle strains accounted for around 40% of all recurrences (table 13). In male elite players, between 19-24% of all muscle strains were early recurrences, being 29-37% of groin strains and 12-21% of hamstring strains. This suggests that players return to full-load team training and competition too soon, before sufficient healing of damaged muscles has been achieved. The rate of recurrent muscle strains previously reported for male players is consistent with our findings, being 29-46% of muscle strains, 12-43% hamstring strains, and 31-50% groin strains.[7,24,63,154] It has also been suggested that persistent muscle strength abnormalities following injury may give rise to recurrent hamstring injury and discomfort.[23] An individualised rehabilitation programme focusing on eccentric training based on specific deficits may therefore contribute to a decrease in recurrences on return to play. A large proportion of tendon injuries, especially Achilles tendinopathies, were recurrent complaints. This could be due to the fact that players with a painful Achilles tendon are able to play matches but may have several resting periods to offload the injury. The percentage of recurrent ankle and knee sprains, however, was low compared to many previous studies on male football; ligament sprains (32-58%), ankle sprains (9-69%) and knee sprains (30-40%).[7,64,153] One reason for this discrepancy could be that all, not only early recurrences, were reported in these studies.

As for female players, we observed a similar low rate of recurrent sprains, a high proportion of recurrent tendon injuries, and a seemingly lower rate of recurrent muscle strains compared to male players. From a previous study on the top female division in Sweden in the year 2000, 28% muscle strains, 26% ligament sprains and 40% of overuse injuries were found to be early recurrences.[75] The definition of re-injury in that study differed from ours and could explain this inconsistency.

**Table 13.** Pattern of early recurrent injuries for selected injury types in Swedish male and female elite football players. Values within brackets show percentage of re-injuries of total within each category.

| | Top male division | | | | | | Top female division 2005 | |
|---|---|---|---|---|---|---|---|---|
| | 2001 | | 2002 | | 2005 | | | |
| Early recurrent injury | No | Yes | No | Yes | No | Yes | No | Yes |
| Sprain/ligament injury | 90 | 9 (9) | 72 | 5 (6) | 80 | 16 (17) | 58 | 8 (12) |
| Ankle sprain | 47 | 6 (11) | 38 | 4 (10) | 44 | 13 (23) | 37 | 7 (16) |
| Knee sprain | 33 | 3 (8) | 30 | 1 (3) | 30 | 1 (3) | 18 | 1 (5) |
| Muscle injury/strain | 187 | 60 (24) | 157 | 44 (22) | 148 | 34 (19) | 74 | 10 (12) |
| Groin strain | 49 | 29 (37) | 48 | 20 (29) | 48 | 20 (29) | 12 | 0 |
| Hamstring strain | 59 | 16 (21) | 62 | 13 (17) | 60 | 8 (12) | 38 | 6 (14) |
| Quadriceps strain | 24 | 9 (27) | 23 | 6 (21) | 21 | 5 (19) | 11 | 2 (15) |
| Tendon injury | 45 | 24 (35) | 38 | 15 (28) | 48 | 13 (21) | 6 | 4 (40) |
| Achilles tendon | 26 | 13 (33) | 11 | 5 (31) | 11 | 10 (48) | 2 | 1 (33) |
| Patellar tendon | 6 | 0 | 7 | 1 (13) | 10 | 2 (17) | 1 | 1 (50) |
| Total injuries | 557 | 158 (22) | 481 | 107 (18) | 465 | 83 (15) | 246 | 53 (18) |

### *Age*

In Paper III, age was not found to be a significant risk factor for injury in general. We used a similar approach as a previous investigation on male elite players, treating age as a continuous as well as category variable (based on a cut-off point of mean ± 1 SD age of the cohort) but could not repeat the findings from that study.[8] In Paper V, older male players (>30 yrs) were found to have a higher injury incidence during training than the intermediate (20-30 yrs) and young player groups (<20 yrs). The same tendency (though not significant) was observed among female players. One reason why the results differed between the studies is that no adjustment was made for previous injury in Paper V, and previous injury is a known confounder when analysing age as a risk factor for injury.[8] Another reason can be found in the statistical methods used. In the Cox proportional hazards regression model, only one event (injury) is registered for each player, whereas when comparing injury rates over the whole season several injuries in one player is possible. Different study populations and study periods and different analytical methods could thus be a reason for the contradicting results found in the literature concerning the association between age and injury risk.[8,47,94,132,156]

A higher risk for hamstring injury with increasing age was observed among the male elite players in season 2002 (Paper III), and this is in accordance with two previous studies from male elite football.[8,154] A high proportion of muscle and tendon injuries was also found among older players in the season of 2005 (Paper V). Decreasing muscle strength with increasing age could be a mechanism behind the increased risk for muscle strain among older athletes.[109] It can also be speculated that altered muscle/tendon properties with increasing age, i.e. decreased elasticity, is another contributing factor.

A high risk for severe knee injury among young female players has been an area of concern[18,117] and it has been suggested that young women (<18 yrs) should only be allowed to participate in training and not games at senior level.[133] In Paper V, younger female players (<19 yrs) had the lowest injury rate overall, and also the lowest rate of severe injury. This suggests that their clubs had successful strategies to reduce the risk for injury of young players being transferred to the senior team. Younger players, for example, had less match exposure than the other groups.

Tendon injuries and other overuse complaints were common among young male players, and one can speculate that the load is too great for these young players. Young male players were also less exposed to match play than older players, so it could rather be an increase in the amount and intensity of training at senior level, compared to that with the youth team which is a concern for young male players playing at the senior elite level.

***Anthropometrics***
None of the variables height, weight or BMI were significantly associated with injury in the risk factor analysis of male elite players (Paper III), and this is consistent with most studies.[8,156] Only Faude et al. could report an association between body weight, height and injury.[47]

***Level of play***
The injury incidence observed in male amateur teams was lower than that found among the male elite players. In the control group (Paper IV), there were 2.7 injuries/1000 training hours and 12.3/1000 match hours. However, a lower number of minimal injuries (absence 1-3 days) can be expected among amateur teams with the current injury definition used, due to fewer training sessions and matches. Stratifying by severity, the injury incidence at amateur level (control group) was 0.7 (95% CI 0.4-1.1) minimal injuries/1000 hours, 1.2 (0.9-1.7) mild injuries, 2.1 (1.6-2.8) moderate injuries, and 1.1 (0.8-1.6) severe injuries. Thus, the amateur teams show similar rates of moderate to severe injury as male and female elite players based

on total exposure. Even though a low access to medical supervision could cause longer rehabilitation from injury, this is still a worrying finding and emphasises the need of implementing preventive measures also at the amateur and grassroot level of football.

Overall, 75-79% of players in a male elite team, 65% in a female elite team, and 33% in a male amateur team, will sustain at least one injury that limits participation in team training or match play during a season. Assuming a squad of 20 players, a male elite football team can expect about 45 injuries during a season, of which 4-5 severe with absence of more than four weeks. The equivalent for a female elite team is 25 injuries (3 severe injuries), and for a male amateur team 11 injuries (2-3 severe injuries).

***Playing position***

To evaluate injury risk related to playing position we stratified injury incidences observed in the top male and female divisions during the 2005 season according to the player's typical playing position at the beginning of the season (Table 14) (unpublished data). This analysis showed that among male players, goalkeepers had a significantly lower injury incidence compared to other players both in training (2.9 vs. 5.0 injuries/1000 training hours, $p<0.01$) and match play (12.8 vs. 30.0/1000 match hours, $p<0.01$). The other playing positions showed higher injury rates that were similar. No significant differences were observed in injury incidences between playing positions for women, but a trend with lower injury incidence for goalkeepers was seen, and forwards tended to have a higher injury incidence than other players. The finding that goalkeepers have a lower risk for injury than other players is consistent with previous reports from male and female football[11,47,75] and seems reasonable considering the lower exposure to many high-risk incidents such as being challenged for the ball, tackling, etc. Otherwise, contradicting results have been reported regarding playing position and risk for injury, in part due to the fact that playing position at the start of the season may not be held throughout the season, or even during a match.

**Table 14.** Injury incidences for different playing positions in the top male and female divisions in Sweden during the 2005 season. Goalkeeper (GK), defender (DF), midfielder (MF) and forward (FW).

| | | Training | | | Match play | | |
|---|---|---|---|---|---|---|---|
| Position | Players (%) | Injuries | Exposure | Incidence | Injuries | Exposure | Incidence |
| Men | | | | | | | |
| - GK | 25 (10) | 21 | 7333 | 2.9 (1.9-4.4) | 13 | 1018 | 12.8 (7.4-22.0) |
| - DF | 81 (34) | 111 | 21262 | 5.2 (4.3-6.3) | 91 | 3306 | 27.5 (22.4-33.8) |
| - MF | 82 (34) | 106 | 20886 | 5.1 (4.2-6.1) | 90 | 2887 | 31.2 (25.4-42.1) |
| - FW | 51 (21) | 56 | 12834 | 4.4 (3.4-5.7) | 60 | 1835 | 32.7 (25.4-42.1) |
| - Total | 239 (100) | 294 | 62315 | 4.7 (4.2-5.3) | 254 | 9046 | 28.1 (24.8-31.8) |
| Women | | | | | | | |
| - GK | 25 (11) | 14 | 5021 | 2.8 (1.7-4.7) | 8 | 716 | 11.2 (5.6-22.3) |
| - DF | 75 (33) | 53 | 15808 | 3.4 (2.6-4.4) | 43 | 2773 | 15.5 (11.5-20.9) |
| - MF | 79 (35) | 58 | 15826 | 3.7 (2.8-4.7) | 38 | 2558 | 14.9 (10.8-20.4) |
| - FW | 49 (21) | 50 | 9814 | 5.1 (3.9-6.7) | 35 | 1640 | 21.3 (15.3-29.7) |
| - Total | 228 (100) | 175 | 46469 | 3.8 (3.2-4.4) | 124 | 7687 | 16.1 (13.5-19.2) |

***Foul play***

Almost one of four match injuries to Swedish male elite players during the three seasons resulted from violation of the rules (overall 23%, range 20-25%), the majority being due to opponent foul (95-97%). The rate of foul play injury in male elite players was higher than at male amateur level (12%, p<0.01) and there was also a tendency towards higher rates compared to the female elite players (16%, p=0.08) (Table 15). The rate of foul play injury observed in our studies is in line with those reported previously in male[3,11,43,63,82,96,146] (18-31%) and female elite football[46,75] (19-23%). It is not known whether the low foul play rate observed in the amateur series in our study was due to a higher sense of fair play among players, or due to a lower standard of refereeing. A previous study on amateur male football reported 30% foul play injuries[33] indicating, perhaps, that our figures are uncharacteristically low.

**Table 15.** Injuries due to foul play for selected injury types in the Swedish top male division (2001, 2002 and 2005 seasons), Swedish top female division (2005) and male amateur series (intervention + control groups).

| Injury type | Top male division | | Top female division | | Male amateur series | |
|---|---|---|---|---|---|---|
| | Foul | No foul | Foul | No foul | Foul | No foul |
| Fracture | 15 | 19 | 1 | 3 | 2 | 2 |
| Dislocation | 1 | 4 | 1 | 0 | 2 | 0 |
| Sprain/ligament injury | 51 | 84 | 8 | 29 | 4 | 33 |
| Haematoma/contusion | 94 | 89 | 8 | 14 | 7 | 16 |
| Concussion | 7 | 8 | 0 | 5 | 2 | 1 |
| Total injuries | 181 (23%) | 603 | 20 (16%) | 104 | 19 (12%) | 135 |

Among the male elite players, 44% of fractures and 38% of ligament sprains sustained during match play were due to foul play. Both injury types have the potential of causing substantial absence from training and matches and also have possible long-term consequences. From a study using video analysis it was shown that almost half of the incidents that occurred where the referee awarded no foul resulted in injury, raising the question as to whether the rule interpretation of referees and/or rules should be changed to protect players from injury.[11] This view was supported in another study where it was suggested that the current football rules provide limited guidance and sanction for referees to deal with tackles that could lead to injury.[54] Two studies have evaluated the correlation between the judgement of the match referee and that of an independent expert panel of referees in high-risk incident situations in football. One study found good agreement between the decisions made by the match referee and the decisions made by an expert panel in Norwegian professional football indicating that there is a need for an improvement of the rules of the game.[3] On the other hand, another study from FIFA tournaments reported poor agreement between match referees and an expert panel, suggesting that injuries were more likely to be caused by a player's failure to comply with the rules, and that match referees often fail to punish players for the incidents that led to injury.[52] Changing the attitudes of players is most important if the number of injuries due to foul play are to be reduced.

## Circumstance of injury

In Paper V the circumstance of injury according to player-to-player contact was registered, and this showed that non-contact injuries dominated among both male (65%) and female players (74%). Our finding concurs with those of recent studies on male elite players where non-contact injuries have dominated (56-59%),[7,63,64] whereas previous studies have documented more contact injuries in female football.[46,156] In male football 61 of 96 (64%) ligament sprains (40/57 ankle sprains, 17/31 knee sprains), four of seven concussions and 12 of 14 fractures were due to player-to-player contact. Similarly for women, 34 of 66 (52%) ligament sprains (23/44 ankle sprains, 11/19 knee sprains), five of 6 concussions and 6 of 10 fractures occurred in contact situations. Overall, male players had a greater proportion of contact injuries during match play compared to women (52 vs. 40%, p=0.05) whereas in training there was no difference between the sexes. (21 vs. 16%, NS) This finding is similar to that reported from the FIFA World Cup and the Olympic Games, where men had a slightly higher proportion of contact match injuries (86-91%) than women (79-84%),[83,84] probably reflecting the higher intensity in male competitive football, but a lower sense of fair play in men may also contribute.

## Effects of the intervention programme

In Paper IV, we tested the effects of an intervention programme aimed at preventing re-injury in male amateur players. Overall 11% (14 of 132) of injuries in the intervention group and 30% (40 of 134) in the control group were recurrences of an injury sustained during the season ($p<0.001$, $\chi^2$ test). The 10-step rehabilitation programme was primarily designed for lower limb injuries, and when these were analysed separately 8% (9 of 115) of lower limb injuries in the intervention group were recurrent compared to 33% (39 of 117) in the control group. Due to the limited number of injuries, it was not possible to test the effect of the prevention programme for different specific injury types, but for most injury types re-injury rates were lower in the intervention group.

When the risk for recurrence was analysed, 90 players in the intervention group and 79 players in the control group who were injured during the study were included for further analysis. Ten of the players in the intervention group (11%) and 23 (29%) in the control group suffered a recurrence. Univariate Cox regression analysis showed a 66% lower risk for re-injury overall (HR 0.34, 95% CI 0.16-0.72, p=0.0047) and 75% lower re-injury risk for lower limb injury (HR 0.25, 95% CI 0.11-0.57, p<0.001) in the intervention group. In a previous intervention study on male amateur players in Sweden, Ekstrand et al. reported 33% re-injuries in the control group in their intervention study, which is similar to the control group in our study.[34] The same authors reported no re-injury at all in the intervention group that followed a multi-modal prevention programme including structured rehabilitation, but their intervention also included the rule that return-to-play decisions were made by medical personnel. Our results show that it is possible to reduce the number of re-injuries in amateur football using a low cost and simple programme helping coaches during assessment of functional rehabilitation and in return-to-play decisions without the close monitoring of medical personnel.

When the time period between return to play and re-injury was analysed, it was seen that 44% of all re-injuries occurred within the first week of return to play. Another 34% occurred between weeks one to four, and thus, 80% of re-injuries occurred within four weeks of return to play. Using univariate logistic regression, we found that the greatest preventive effect of intervention was seen within the first week of return to play (Table 16). The intervention group had an 89% reduction in re-injury risk in the first week of return to play; only three recurrent injuries (two players) occurred during the first week in the intervention group and all of these resulted from not following the intervention programme. In the control group 21 recurrences in 14 players occurred within the first week of return to play. This indicates that avoiding early recurrence due to premature return to play was an important component of the intervention programme.

**Table 16.** Risk for re-injury for injured players in the intervention (n=90) versus control group (n=79). Table shows number (n) and percentage (%) of players within each group that suffered a re-injury, and odds ratios (OR) with 95% confidence intervals and p-values from the univariate logistic regression analysis.

| | Intervention | | Control | | | | |
|---|---|---|---|---|---|---|---|
| | n | % | n | % | OR | (95% CI) | P-value |
| Re-injury within 1 week | 2 | *2* | 14 | *18* | 0.11 | (0.02-0.48) | 0.0036 |
| Re-injury within 4 weeks | 7 | *8* | 20 | *25* | 0.25 | (0.01-0.63) | 0.0031 |
| Re-injury within 2 months | 9 | *10* | 22 | *28* | 0.29 | (0.12-0.67) | 0.0039 |
| Re-injury within season | 10 | *11* | 23 | *29* | 0.30 | (0.13-0.69) | 0.0043 |

Regarding the external validity of our intervention programme, we recommend its use at grassroot and lower levels of football. The programme could also be used in other levels of play as assistance for trainers where medical availability is low, for instance in many women's clubs. Various physical and functional performance test batteries that could be valuable in monitoring progress during rehabilitation after football injury have been suggested[67,119] and a standardised rehabilitation protocol was recently evaluated at the professional level with promising results.[57] The principle of not allowing match play before completion of full team training without symptoms of pain and swelling used in our programme seems valid also in high-level football. Our finding shows that, even at the elite level, many recurrences occur shortly after return to competition, indicating premature return. Finally, we suggest that our programme may also be used in the rehabilitation of lower limb injuries in other high-pivoting sports with a few modifications.

# GENERAL DISCUSSION

## Reliability and validity of recordings

As stressed by many authors, a problem associated with epidemiological studies on sports injuries is the inconsistent manner in which injury is defined, and data collected and recorded.[28,37,49,71,85,139] Furthermore, the quality of data reported from a study is dependant on the accuracy and reproducibility of data collection. To date, there are only few studies that describe the validity and/or reliability of injury surveillance systems used in sports research.[100,103] The present thesis follows the data collection procedures and definitions developed within UEFA (Union of European Football Associations) for studies on injuries to professional football players.[69] The development and validation of the injury surveillance system was carried out in three stages. In step one, the UEFA Medical Committee held consensus discussions about design, methodology and study definitions. Already existing injury surveillance systems were used as the basis for these discussions. As with other surveillance systems, it was decided that three forms of data collection were needed: baseline form, exposure form, and injury form. In step two, these methods were introduced in a prospective cohort study on top male divisions in Sweden and Denmark in January 2001 (Paper II). The study procedures and data collection forms were evaluated after the spring season of 2001. In the third step, the proposed methodology and definitions, and experiences from implementation of the injury surveillance system in Swedish and Danish top division football, were discussed with team doctors from various European professional football clubs that were enrolled in a separate study (UCL injury study[146]). After minor revision, the procedures were approved. One innovation was the obligatory entry of diagnosis on the injury form. This was not the case for injuries reported during the spring of 2001 and the exact diagnosis of some injuries during this period is therefore not known (there was, for instance, an accurate history of hamstring injury in 383 of 394 limbs (97%) and these were used for the risk factor analysis of the Swedish top male division during 2001 and 2002 (Paper III)).

Since different observers (team medical staff) were used for data collection, the question of reliability is inevitable. As for the exposure form, the reliability of recording after training sessions cannot be evaluated. As regards match exposure, this was regularly verified against official match reports found in newspapers, websites etc. and is believed to be accurate. As for the recording of injuries, the reliability is of more concern. Even though the data collected in our studies at the elite level (by experienced doctors and physiotherapists working with the teams) probably have a high level of accuracy compared to similar studies at amateur or recreation level, evaluation of typical injuries may vary between observers.

In Paper II we found that the overall rate of training and match injury was similar between two consecutive seasons, and the overall location and type of injuries were also similar. This indicates consistency in observations between the two seasons. However, the rate of specific injury types varied between seasons and it is not known whether this is due to an actual fluctuation in injury rates between seasons or whether it is due to inconsistencies in injury reporting. For example, the rate of hamstring injury in training and match play varied between seasons. Hamstring strains were often diagnosed clinically, and an magnetic resonance imaging (MRI) confirming actual muscle fibre rupture was not obligatory. Thus, in some cases, referred pain from the spine could be diagnosed as a hamstring injury. Studies from professional Australian Rules football indicate that the agreement between clinical findings of hamstring strain and MRI findings are only moderate; with 18-31% of clinically diagnosed strains showing no abnormalities on MRI.[124,142] MRI-detected hamstring muscle strains caused longer absence from competition than strains with a normal MRI.[142] It is thus apparent that the comparison of groups with respect to type of injury, and injury severity, may be affected by the ability to diagnose the injury. Future studies should therefore strive even further to standardise diagnostic procedures in order to increase inter-observer reliability.

Throughout all studies, a number of measures were taken to assure as complete and accurate data collection as possible. First, all participating teams were provided with a study manual describing study procedures, definitions, etc. and that also contained practical examples of how to fill in the study forms, and typical scenarios where there may be uncertainty as to how to fill in the forms. Second, all monthly reports were immediately reviewed by the study group and any inaccuracies or incomplete registrations were corrected together with the contact person in the clubs. In this way all analyses were based on complete reports from the clubs that participated throughout the study period.

## Consensus about study design and definitions

After informal discussions during the 1st World Congress on Sports Injury Prevention in Oslo in June 2005, an Injury Consensus Group was gathered with the purpose of establishing definitions and methodology, implementation and reporting standards that should be adopted in studies in injury in football.[56] The methodology and definitions used in the present thesis largely comply with this consensus proposal, but in some issues they varied slightly.

### *Injury definitions*

According to the consensus proposal, an injury is defined as:

Any physical complaint sustained by a player that results from a football match or football training, irrespective of the need for medical attention or time loss from football activities. An injury that results in the player receiving medical attention is referred to as a "medical attention" injury, and an injury that results in a player being unable to taka a full part in future football training or match play as a "time loss" injury. A player being unable to take a full part in future football training or match play is independent of whether a training session actually takes place on the day after the injury or whether a player is selected to play in the next match. The term future refers to any time after the onset of the injury, including the day of injury.

The time loss definition applied in the present thesis differed slightly from this in that only injuries where a player missed a training session or match were recorded. If the injury only caused absence one day after the onset and the team had no training or match that day, the injury would not have been registered. At the elite level, the male teams more or less had daily sessions so in this respect our time loss definition did not differ from the consensus proposal. The female elite teams had approximately 5-6 activities per week, meaning that a few minimal injuries could have been missed. At amateur level, teams had just over 3 activities per week and this means that the chance of missing a minimal injury is greater. This must be borne in mind when the incidence, severity and pattern of injury are compared between men and women, and between elite and amateur levels. However, one must also consider that it can be difficult to judge whether or not a player will be able to participate the day after injury, and that the suitability of such judgement may be lacking at amateur level without medical support.

Another important issue to consider when using a time loss injury definition is to establish what constitutes exposure and what should be considered part of an injury. Players may participate in only a part of a training session or perform alternative training because of a physical complaint sustained from football, or because they are undergoing rehabilitation after an injury. In the present thesis, all forms of restricted training due to a physical complaint resulting from football training or match play was defined as an injury, according to the UEFA model.[69] Accordingly, even if a player participated in team training but with a modified programme, or if the team had a recovery session that day and the injured player was able to participate but had not been given clearance for full participation in all team training sessions and match play by the medical staff, this was considered absence due to injury and not training exposure. A player was defined injured until he/she was allowed by the medical staff to participate fully in all parts of team collective training and be available for first team match selection.

The definition of a recurrent injury used in Papers I – III included a time limit of two months and this would only be comparable to “early recurrences” in future studies, as defined in the consensus proposal. The reason why we initially chose to have a time limit in our definition of a re-injury was to avoid recall bias. Recall bias is a concern when using retrospective data collection, even when assessing injuries occurring during the preceding season.[79] In Papers IV and V, we defined re-injury as an identical injury of the same type and to the same site during the same season, which also would enable comparison with future studies reporting “late recurrences” according to the consensus proposal.

***Categorising injuries***

To be able to compare injury patterns between studies it is also important to use the same categories when describing the type and location of injury. In Papers IV and V, the categories were adapted to the consensus proposal to facilitate comparison with future studies. Many injuries were categorized into the group “other type” according to the consensus, and this category was further split into “synovitis/effusion”, “overuse complaints” and “other type” to give a more detailed picture of the type of injury. This still enables comparison with future reports.

***Study methodology***

All studies included in this thesis were prospective. Apart from the study on the Danish top male division, all studies lasted for at least one complete season, including pre-season and competitive season. The comparison between the Danish and Swedish cohorts (Paper II) is thus limited by the fact that only the second half of the season was included for the Danish players. To compensate for this, additional analyses were carried out comparing the Danish data with data from the second part of the Swedish season, revealing similar results. Our comparison of injury incidence and injury pattern between two consecutive seasons (Paper III) indicated that a study period of one full season can provide a reasonable overview of the injury problem among elite football players in a specific environment. However, a longer study period should be considered for studies of specific injury types owing to possible variations in injury rates between seasons.

The registration of player exposure was performed on an individual basis in all studies. This is the most stringent method when registering exposure, and allows individual risk to be estimated. However, in the study on the Swedish top male division in season 1982 (Paper I) an estimation of 90 minutes exposure per training session or match was used. If anything, we believe that this is an overestimation of the time of risk exposure, thus underestimating the true injury incidence. According to the consensus proposal, training and match exposure can be collected on an individual player basis or for a group of players (i.e. team basis), depending on the aim of the study. However, even if exposure is collected on a group basis, the duration and number of participants in training sessions and matches should be collected.

## Sample size

Inadequate sample size is a common reason why many studies fail to report significant association between potential risk factors and injury.[14,105] This is also a limitation in some of the analyses made in the present studies. It could explain, for instance, why we failed to find an association between previous ankle sprain and new ankle sprain (Paper III) as found in some previous studies. To calculate the total sample size (N) required to detect a significant association between a dichotomous risk factor (e.g. previous injury yes/no) and injury in the univariate Cox proportional hazards regression model, the following formula has been suggested (significance level of $\alpha=0.05$ and power $1-\beta=0.90$)[14,123,125]:

$$N = (1.96 + 1.28)^2 / [(\log RR)^2 p(1-p) q]$$

In the formula, RR is the expected relative risk between the previously injured and uninjured players, p is the proportion of players with the risk factor (previous injury) at baseline, and q is the probability of an uncensored observation, i.e. an injury. Table 17 shows data from Paper III where we investigated the association between injury during the previous season and risk for injury in the Swedish top male division. Our analysis, with a previous injury as a risk factor for any injury is well sized. However, because only few players had a previous ankle sprain at baseline (22 players, 24 limbs), and few players suffered an ankle sprain during the 2002 season (19 players, 20 limbs), the possibility to detect a significant association diminished, as shown by the required sample sizes. Bahr & Holme proposed that to be able to detect moderate to strong associations (RR 1.65 to 2.18) 20-50 cases are needed, whereas small to moderate associations (RR 1.28 to 1.65) would require about 200 injured subjects.[14] This recommendation was based on a censorship probability of $1-q = 0.10$, that is 90 % of the players would suffer an injury during the observation period. For an analysis of any previous injury as a risk factor, this assumption of q is valid since between 65-91 % of male elite players will suffer an injury during a season. However, when studying specific injury types, the proportion of previously injured players (p), and certainly the proportion of players injured during a season (q), will drop considerably and consequently the required number of cases will increase (Table 17). Thus, for specific injury types, the required number of cases in a risk factor study should be even higher than that recommended by Bahr & Holme[14] and this should be considered in studies trying to find an association between potential risk factors and less prevalent injuries.

**Table 17.** Association between previous injury in the 2001 season and subsequent injury in the 2002 season in the male Swedish top division (Paper III) using a univariate Cox proportional hazards regression model, and required sample sizes required to detect a significant association. A significance level of $\alpha=0.05$ and power $1-\beta=0.90$ was assumed.

| Risk factor | Number of players/ limbs | Players/limbs injured at baseline | Proportion injured at baseline (p) | Observed RR | Proportion injured players (q) | Required sample size (N)[a] |
|---|---|---|---|---|---|---|
| Any previous injury | 197 | 151 | 0.77 | 2.73 | 0.78 | 76 (58) |
| Previous ankle sprain (unit player) | 197 | 22 | 0.11 | 1.54 | 0.10 | 5752 (633) |
| Previous ankle sprain (unit limb) | 394 | 24 | 0.06 | 2.81 | 0.05 | 3488 (210) |

[a] Values show the total sample size required, and projected number of injured subjects within brackets ($N \times p$).

For the randomised controlled trial (Paper IV) the same formula was used to calculate the necessary sample size for our study. It was estimated that in all, 20% of players would suffer a recurrence during the study period (q=0.2), that 50% of players would be randomised to the intervention group (p=0.5), and we reckoned with a 50% reduction in re-injury risk (RR=0.5). Approximately 220 players were needed in each group and this requirement was met for the final analyses (n=241 in both groups).

## Risk factors studied

While injury risk factors are usually divided into intrinsic and extrinsic, another approach is to differentiate between modifiable and non-modifiable risk factors.[14] Many of the risk factors studied in this thesis, e.g. previous injury, age, height, gender are non-modifiable as such. However, the study of these risk factors still provide important information as a basis for injury prevention. For example, it is not possible to modify a player's age, but by identifying older players as a high risk group for hamstring injury as in our and previous studies, we can modify other factors thought to contribute to hamstring injury in this group of players, i.e. apply a specific hamstring strengthening programme.

In our analysis of previous injury as a risk factor for injury (Paper III) only prospectively recorded injuries from the preceding season were used as independent variable. Even though we avoided recall bias by this procedure, we acknowledge that residual deficit from previous injuries further back in time than one season might be a confounding factor in our analysis. Furthermore, injuries sustained outside football training or match play were not included, meaning that a player could have been placed in the "no previous injury" group even though he might have sustained an injury in his leisure time. Therefore, the relative risks observed for previous injury are probably minimal values.

## Intervention programme

In Paper IV, our intervention programme aimed at decreasing the re-injury rate among football players was implemented by team coaches. We chose this method since at amateur level medical support is little or non-existent. Even though many players receive treatment and rehabilitation for their injuries from medical personnel, surveillance during sports-specific functional rehabilitation is rarely provided, and the return-to-play decisions are left to the player and team coach. We therefore set out to test the efficacy of a low cost, simple rehabilitation programme that could be employed without the close attention of medical personnel. We believe that this also increases the likelihood of teams continuing to use the programme after conclusion of the study.

Randomisation was performed at team level. This means that team-related factors, such as access to medical assistance, experience of the coach, club organisation, type of training etc. could interfere with our analyses as no adjustment was made at team level. This is a possible weakness of the study design. It was decided to implement the intervention programme through the coach as it was thought that this would increase the likelihood of players sticking to the rehabilitation programme. Furthermore, rules on return to play were a part of the intervention programme and we were thus dependent on the team coaches since they decide the starting line-up for matches. Finally, it was not thought to be feasible to randomise at individual level within a club as the coaches would then have to keep some players out of team training and match play longer than others.

Compliance to the intervention programme could only be partially evaluated, which is another limitation of the study. Based on the individual exposure forms, we found that players followed the recommended number of training sessions before return to matches for 68% of all injuries. All analyses were performed according to the intention-to-treat principle, meaning that the preventive effect observed with intervention was not an overestimation. It is noteworthy that all three recurrences within the first week of return to play in the intervention group came from not following the intervention programme.

A few issues relating to the assessment of injured players should also be addressed. Firstly, the accuracy of injury assessment might have been compromised in that all injured players were not assessed clinically, but had to be interviewed by telephone. To assure high telephone interview reliability a standard procedure was followed. Both the injured player and team coach were interviewed to double-check the information obtained, and if the player had visited a hospital or other clinic the medical notes were reviewed whenever possible. The distribution of players assessed via clinical examination and telephone interview did not differ between groups, and the risk for re-injury in the Cox proportional hazards regression model did not differ when diagnostic procedure was entered into the model. One of the authors responsible for assessing injured players was not blinded to team allocation, which is a weakness. The study workers did not give any advice on rehabilitation or return-to-play decisions so it is believed that the effect of non-blinding on the recurrence rate was minimal.

# CONCLUSIONS

- ✓ An increased amount of training was seen between the 1982 and 2001 seasons of the Swedish top male division reflecting the transition from semi-professionalism to full professionalism – we did not observe an increased injury risk during the same period.

- ✓ Danish male elite players had a higher incidence of training injury and severe injury than their Swedish counterparts, indicating that the training content should be reviewed.

- ✓ Assuming a squad of 20 players, the expected number of injuries during a season is about 45 (4-5 severe injuries) in a male elite football team, 25 (3 severe) in a female elite team, and 11 (2-3 severe) in a male amateur team.

- ✓ Hamstring injury, groin injury, ankle sprain and knee sprain were common injuries observed among male and female elite players, and should be the target for prevention. Knee sprain accounted for 31% and 37% of the total days lost from play in men and women respectively and warrant specific attention.

- ✓ Previous injury from a preceding season was identified as a strong risk factor for injury in elite football players. Previous injury and increasing age were risk factors for hamstring injury, and having a previous groin injury or knee joint trauma increased the risk for a new similar injury in the same limb. No association was found between previous ankle sprain and new sprain.

- ✓ Female elite players had a lower risk for training and match injury than male elite players in general, but the risk for incurring a moderate to severe injury was similar between the sexes. No difference in the rate of knee sprain was observed between men and women.

- ✓ A high proportion of injuries were early recurrence from an injury within the previous two months, suggesting inadequate rehabilitation and premature return to play.

- ✓ The rate of re-injury in the lower limbs was reduced by 75% in amateur male football players following a controlled rehabilitation programme implemented by coaches.

# ACKNOWLEDGEMENTS

During the course of this project I have had the pleasure of meeting and working with some outstanding people. I would especially like to express my sincere gratitude to

Jan Ekstrand, MD, PhD, professor at the Department of Health and Society, Division of Social Medicine and Public Health Science, Linköping University, Sweden, vice chairman of the UEFA Medical Committee, and my tutor, for introducing me to the field of sports medicine, both clinical and research, and for your guidance in the jungle of science. Your experience and knowledge of football medicine is truly impressive.

Markus Waldén, MD, fellow PhD student at the Department of Health and Society, Division of Social Medicine and Public Health Science, Linköping University, Sweden, and co-worker in my studies, for your invaluable help in the production of this thesis, as well as for your good friendship. Our interesting and stimulating discussions about football, research and life in general has made work on this thesis even more enjoyable.

Toomas Timpka, MD, PhD, professor at the Department of Health and Society, Division of Social Medicine and Public Health Science, Linköping University, for valuable comments on this research project.

Kajsa Rothman, Division administrator at the Department of Health and Society, Division of Social Medicine and Public Health Science, Linköping University, for keeping track of the practical things for a sometimes absent-minded PhD student.

Statisticians Nadine Karlsson and Karin Borg, PhD, at the Department of Health and Society, Division of Social Medicine and Public Health Science, Linköping University for statistical advice.

All the participating clubs, contact persons, medical staff, coaches and players involved in the studies. Without your cooperation this project would not have been possible.

Östergötland's Football Association for the help with arranging the meetings with the team coaches in the regional division IV series.

My colleagues at the Sports Clinic and at Hertig Karl, Linköping, Margaretha, Anki and Linda, for your help during various parts of this project and for interesting conversations over coffee.

Peter Cox, MB BS, BSc, for valuable help with language revision.

Petra, my wife, for your constant support, and for your patience on the numerous occasions when I have been stuck in front of the computer, and Emilia, my daughter, for constantly bringing a smile to your father's face, and for putting life and research into it's right perspective.

Finally, a big thank-you to the rest of my family, Doris, Hans, Freddie, Gunilla, Kalle, Erik and Anders for being constantly present and supportive throughout my life and during the creation of this thesis.

The main financial support for these studies came from the Swedish National Centre for Research in Sports (Centrum för idrottsforskning), UEFA (Union of European Football Associations) and Praktikertjänst AB.

Linköping, January, 2007
Martin Hägglund

# REFERENCES


1. Andersen TE, Larsen Ø, Tenga A, Engebretsen L, Bahr R. Football incident analysis: a new video based method to describe injury mechanisms in professional football. *Br J Sports Med* 2003; 37: 226-232.
2. Andersen TE, Tenga A, Engebretsen L, Bahr R. Video analysis of injuries and incidents in Norwegian professional football. *Br J Sports Med* 2004; 38: 626-631.
3. Andersen TE, Engebretsen L, Bahr R. Rule violations as a cause of injuries in male Norwegian professional football – are the referees doing their job? *Am J Sports Med* 2004; 32: 62S-68S.
4. Andersen TE, Floerenes TW, Árnason Á, Bahr R. Video analysis of the mechanisms for ankle injuries in football. *Am J Sports Med* 2004; 32: 69S-79S.
5. Andersen TE, Árnason Á, Engebretsen L, Bahr R. Mechanisms of head injuries in elite football. *Br J Sports Med* 2004; 38: 690-696.
6. Arendt E, Randall D. Knee injury patterns among men and women in collegiate basketball and soccer. NCAA data and review of the literature. *Am J Sports Med* 1995; 23: 694-701.
7. Árnason Á, Gudmundsson A, Dahl HA, Jóhannsson E. Soccer injuries in Iceland. *Scand J Med Sci Sports* 1996; 6: 40-45.
8. Árnason Á, Sigurdsson SB, Gudmundsson A, Holme I, Engebretsen L, Bahr R. Risk factors for injuries in football. *Am J Sports Med* 2004; 32: S5-S16.
9. Árnason Á, Sigurdsson SB, Gudmundsson Á, Holme I, Engebretsen L, Bahr R. Physical fitness, injuries, and team performance in soccer. *Med Sci Sports Exerc* 2004; 36: 278-285.
10. Árnason Á. Injuries in football: risk factors, injury mechanisms, team performance and prevention (Thesis). Oslo, the Norwegian University of Sport and Physical Education, 2004.
11. Árnason Á, Tenga A, Engebretsen L, Bahr R. A prospective video-based analysis of injury situations in elite male football – Football incident analysis. *Am J Sports Med* 2004; 32: 1459-1465.
12. Árnason Á, Engebretsen L, Bahr R. No effect of a video-based awareness program on the rate of soccer injuries. *Am J Sports Med* 2005; 33: 77-84.
13. Askling C, Karlsson J, Thorstensson A. Hamstring injury occurrence in elite soccer players after preseason strength training with eccentric overload. *Scand J Med Sci Sports* 2003; 13: 244-250.
14. Bahr R, Holme I. Risk factors for sports injuries - a methodological approach. *Br J Sports Med* 2003; 37: 384-392.
15. Bahr R, Krosshaug T. Understanding injury mechanisms: a key component of preventing injuries in sports. *Br J Sports Med* 2005; 39: 324-329.
16. Barnes BC, Cooper L, Kirkendall DT, McDermott PT, Jordan BD, Garrett Jr WE. Concussion history in elite male and female soccer players. *Am J Sports Med* 1998; 26: 433-438.
17. Berger-Vachon C, Gabard G, Moyen B. Soccer accidents in the French Rhône-Alpes soccer association. *Sports Med* 1986; 3: 69-77.
18. Bjordal JM, Arnøy F, Hannestad B, Strand T. Epidemiology of anterior cruciate ligament injuries in soccer. *Am J Sports Med* 1997; 25: 341-345.
19. Bland MJ, Altman DG. Statistics notes. Multiple significance tests: the Bonferroni method. *BMJ* 1995; 310: 170.
20. Boden BP, Kirkendall DT, Garrett Jr WE. Concussion incidence in elite college soccer players. *Am J Sports Med* 1998; 26: 238-241.

21. Caraffa A, Cerulli G, Projetti M, Aisa G, Rizzo A. Prevention of anterior cruciate ligament injuries in soccer. A prospective controlled study of proprioceptive training. *Knee Surg Sports Traumatol Arthrosc* 1996; 4: 19-21.
22. Chomiak J, Junge A, Peterson L, Dvorak J. Severe injuries in football players. Influencing factors. *Am J Sports Med* 2000: 28: S58-S68.
23. Croisier J-L, Forthomme B, Namurois M-H, Vanderthommen M, Crielaard J-M. Hamstring muscle strain recurrence and strength performance disorders. *Am J Sports Med* 2002; 30: 199-203.
24. Dadebo B, White J, George KP. A survey of flexibility training protocols and hamstring strains in professional football clubs in England. *Br J Sports Med* 2004; 38: 388-394.
25. de Loës M. Exposure data. Why are they needed? *Sports Med* 1997; 24: 172-175.
26. Drawer S, Fuller CW. Propensity for osteoarthritis and lower limb joint pain in retired professional soccer players. *Br J Sports Med* 2001; 35: 402-408.
27. Drawer S, Fuller CW. Evaluating the level of injury in English professional football using a risk based assessment process. *Br J Sports Med* 2002; 36: 446-451.
28. Dvorak J, Junge A. Football injuries and physical symptoms: A review of the literature. *Am J Sports Med* 2000: 28: S3-S9.
29. Dvorak J, Junge A, Chomiak J, Graf-Baumann T, Peterson L, Rösch D, Hodgson R. Risk factor analysis for injuries in football players. Possibilities for a prevention program. *Am J Sports Med* 2000; 28: S69-S74.
30. Ekstrand J. Soccer injuries and their prevention (Thesis). Department of Surgery, Linköping University, Linköping, Sweden, 1982.
31. Ekstrand J, Gillquist J. Soccer injuries and their mechanisms. A prospective study. *Med Sci Sports Exerc* 1983: 15: 267-270.
32. Ekstrand J, Gillquist J, Möller M, Öberg B, Liljedahl S-O. Incidence of soccer injuries and their relation to training and team success. *Am J Sports Med* 1983; 11: 63-67.
33. Ekstrand J, Gillquist J. The avoidability of soccer injuries. *Int J Sports Med* 1983; 4: 124-128.
34. Ekstrand J, Gillquist J, Liljedahl S-O. Prevention of soccer injuries. Supervision by doctor and physiotherapist. *Am J Sports Med* 1983; 11: 116-120.
35. Ekstrand J, Tropp H. The incidence of ankle sprains in soccer. *Foot Ankle* 1990; 11: 41-44.
36. Ekstrand J, Roos H, Tropp H. Normal course of events amongst Swedish soccer players: an 8-year follow-up study. *Br J Sports Med* 1990; 24: 117-119.
37. Ekstrand J, Karlsson J. The risk for injury in football. There is a need for a consensus about definition of the injury and the design of studies. *Scand J Med Sci Sports* 2003: 13: 147-149.
38. Ekstrand J, Waldén M, Hägglund M. A congested football calendar and the wellbeing of players: correlation between match exposure of European footballers before the World Cup 2002 and their injuries and performances during that World Cup. *Br J Sports Med* 2004; 38: 493-497.
39. Ekstrand J, Waldén M, Hägglund M. Risk for injury when playing in a national football team. *Scand J Med Sci Sports* 2004; 14: 34-38.
40. Ekstrand J, Timpka T, Hägglund M. Risk of injury in elite football played on artificial turf versus natural grass: a prospective two-cohort study. *Br J Sports Med* 2006; 40: 975-980.
41. Emery CA, Meeuwisse WH, Hartmann SE. Evaluation of risk factors for injury in adolescent soccer: implementation and validation of an injury surveillance system. *Am J Sports Med* 2005; 33: 1882-1891.

42. Engebretsen L, Kase T. [Soccer injuries and artificial turf]. *Tidsskr Nor Laegeforen* 1987; 107: 2215-2217.
43. Engström B, Forssblad M, Johansson C, Törnkvist H. Does a major knee injury definitely sideline an elite soccer player? *Am J Sports Med* 1990; 18: 101-105.
44. Engström B, Johansson C, Törnkvist H. Soccer injuries among elite female players. *Am J Sports Med* 1991; 19: 372-375.
45. Eriksson LI, Jorfeldt L, Ekstrand J. Overuse and distorsion injuries related to the player's estimated maximal aerobic work capacity. *Int J Sports Med* 1986; 7: 214-216.
46. Faude O, Junge A, Kindermann W, Dvorak J. Injuries in female soccer players: a prospective study in the German national league. *Am J Sports Med* 2005; 33: 1694-1700.
47. Faude O, Junge A, Kindermann W, Dvorak J. Risk factors for injuries in elite female soccer players. *Br J Sports Med* 2006; 40: 785-790.
48. Faunø P, Wulff Jakobsen B. Mechanism of anterior cruciate ligament injuries in soccer. *Int J Sports Med* 2006; 27: 75-79.
49. Finch C. An overview of some definitional issues for sports injury surveillance. *Sports Med* 1997; 24: 157-163.
50. Fried T, Lloyd GJ. An overview of common soccer injuries – management and prevention. *Sports Medicine* 1992; 14: 269-275.
51. Fuller CW, Hawkins RD. Developing a health surveillance strategy for professional footballers in compliance with UK health and safety legislation. *Br J Sports Med* 1997; 31: 48-49.
52. Fuller CW, Junge A, Dvorak J. An assessment of football referees' decisions in incidents leading to player injuries. *Am J Sports Med* 2004; 32: S17-S22.
53. Fuller CW, Smith GL, Junge A, Dvorak J. An assessment of player error as an injury causation factor in international football. *Am J Sports Med* 2004; 32: S28-S35.
54. Fuller CW, Smith GL, Junge A, Dvorak. The influence of tackle parameters on the propensity for injury in international football. *Am J Sports Med* 2004; 32: S43-S53.
55. Fuller CW, Junge A, Dvorak J. A six year prospective study of the incidence and causes of head and neck injuries in international football. *Br J Sports Med* 2005; 39: i3-i9.
56. Fuller CW, Ekstrand J, Junge A, Andersen TE, Bahr R, Dvorak J, Hägglund M, McCrory P, Meeuwisse WH. Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries. *Br J Sports Med* 2006; 40: 193-201; *Clin J Sports Med* 2006; 16: 97-106; *Scand J Med Sci Sports* 2006; 16: 83-92.
57. Fuller CW, Walker J. Quantifying the rehabilitation of injured football players. *Br J Sports Med* 2006; 40: 151-157.
58. Giza E, Fuller CW, Junge A, Dvorak J. Mechanisms of foot and ankle injuries in soccer. *Am J Sports Med* 2003; 31: 550-554.
59. Giza E, Mithöfer K, Farrell L, Zarins B, Gill T. Injuries in women's professional soccer. *Br J Sports Med* 2005; 39: 212-216.
60. Goga IE, Gongal P. Severe soccer injuries in amateurs. *Br J Sports Med* 2003; 37: 498-501.
61. Hawkins RD, Fuller CW. Risk assessment in professional football: an examination of accidents and incidents in the 1994 World Cup finals. *Br J Sports Med* 1996; 30: 165-170.
62. Hawkins RD, Fuller CW. An examination of the frequency and severity of injuries and incidents at three levels of professional football. *Br J Sports Med* 1998; 32: 326-332.
63. Hawkins RD, Fuller CW. A prospective epidemiological study of injuries in four English professional football clubs. *Br J Sports Med* 1999; 33: 196-203.

64. Hawkins RD, Hulse MA, Wilkinson C, Hodson A, Gibson M. The association football medical research programme: an audit of injuries in professional football. *Br J Sports Med* 2001; 35: 43-47.
65. Heidt RS, Sweeterman LM, Carlonas RL, Traub JA, Tekulve FX. Avoidance of soccer injuries with preseason conditioning. *Am J Sports Med* 2000; 28: 659-662.
66. Hewett TE, Lindenfeld TN, Riccobene JV, Noyes FR. The effect of neuromuscular training on the incidence of knee injury in female athletes: a prospective study. *Am J Sports Med* 1999; 27: 699-706.
67. Hodson A. Post-injury functional testing for return to competitive play. In: Ekstrand J, Karlsson J, Hodson A. Football medicine. London: Martin Dunitz (Taylor & Francis Group), 2003: 395-413.
68. Hort W. Behandlung von schäden auf konststoffboden. *BISP Köln* 1977; 9: 176-181.
69. Hägglund M, Waldén M, Bahr R, Ekstrand J. Methods for epidemiological study of injuries to professional football players: developing the UEFA model. *Br J Sports Med* 2005; 39: 340-346.
70. Høy K, Lindblad BE, Terkelsen CJ, Helleland HE, Terkelsen CJ. European soccer injuries – a prospective epidemiologic and socioeconomic study. *Am J Sports Med* 1992; 20: 318-322.
71. Inklaar H. Soccer injuries. I: Incidence and severity. *Sports Med* 1994: 18: 55-73.
72. Inklaar H. Soccer injuries. II: Aetiology and prevention. *Sports Med* 1994: 18: 81-93.
73. Inklaar H, Bol E, Schmikli SL, Mosterd WL. Injuries in male soccer players: team risk analysis. *Int J Sports Med* 1996; 17: 229-234.
74. Jacobson I. Injuries among female football players (Thesis). Luleå: Department of Health Sciences, Luleå University, 2006.
75. Jacobson I, Tegner Y. Injuries among Swedish female elite football players: a prospective population study. *Scand J Med Sci Sports* 2007; 17: 84-91.
76. Johnson U, Ekengren J, Andersen MB. Injury prevention in Sweden. Helping soccer players at risk. *J Sport Exerc Psychol* 2005; 1: 32-38.
77. Junge A. The influence of psychological factors on sports injuries – review of the literature. *Am J Sports Med* 2000; 28: S10-S15.
78. 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: S22-S28.
79. Junge A, Dvorak J. Influence of definition and data collection on the incidence of injuries in football. *Am J Sports Med* 2000; 28: S40-S46.
80. Junge A, Rosch D, Peterson L, Graf-Baumann T, Dvorak J. Prevention of soccer injuries: a prospective intervention study in youth amateur players. *Am J Sports Med* 2002; 30: 652-659.
81. Junge A, Dvorak J. Soccer injuries. A review on incidence and prevention. *Sports Med* 2004; 34: 929-938.
82. Junge A, Dvorak J, Graf-Baumann T. Football injuries during the World Cup 2002. *Am J Sports Med* 2004; 32: S23-S27.
83. 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: S80-S89.
84. Junge A, Langevoort G, Pipe A, Peytavin A, Wong F, Mountjoy M, Beltrami G, Terrell R, Holzgraefe M, Charles R, Dvorak J. Injuries in team sport tournaments during the 2004 Olympic Games. *Am J Sports Med* 2006; 34: 565-576.
85. Keller CS, Noyes FR, Buncher CR. The medical aspects of soccer injury epidemiology. *Am J Sports Med* 1987; 15: 272-274.

86. Klasen HJ. Acute soccer injuries. *Int J Sports Med* 1984; 5: 156-158.
87. 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; DOI: 10.1177/0363546506294857
88. Krosshaug T, Andersen TE, Olsen O-E, Myklebust G, Bahr R. Research approaches to describe the mechanisms of injuries in sport: limitations and possibilities. *Br J Sports Med* 2005; 39: 330-339.
89. Kucera KL, Marshall SW, Kirkendall DT, Marchak PM, Garrett Jr WE. Injury history as a risk factor for incident injury in youth soccer. *Br J Sports Med* 2005; 39: 462-466.
90. Larsen E, Jensen PK, Jensen PR. Long-term outcome of knee and ankle injuries in elite football. *Scand J Med Sci Sports* 1999; 9: 285-289.
91. Lehnhard RA, Lehnhard HR, Young R, Butterfield A. Monitoring injuries on a college soccer team: the effect of strength training. *J Strength Cond Res* 1996; 10: 115-119.
92. Lewin G. The incidence of injury in an English professional soccer club during one competitive season. *Physiother* 1989: 75: 601-605.
93. Lindberg H, Roos H, Gärdsell P. Prevalence of coxarthrosis in former soccer players. 286 players compared with matched controls. *Acta Orthop Scand* 1993; 64: 165-167.
94. Lindenfeld TN, Schmitt DJ, Hendy MP, Mangine RE, Noyes FR. Incidence of injury in indoor soccer. *Am J Sports Med* 1994; 22: 364-371.
95. Lohmander LS, Östenberg A, Englund M, Roos H. High prevalence of knee osteoarthritis, pain, and functional limitations in female soccer players twelve years after anterior cruciate ligament injury. *Arthritis Rheum* 2004; 50: 3145-3152.
96. Lüthje P, Nurmi I, Kataja M, Belt E, Helenius P, Kaukonen JP, Kiviluoto H, Kokko E, Lehtipuu TP, Lehtonen A, Liukkonen T, Myllyniemi J, Rasilainen P, Tolvanen E, Virtanen H, Walldén M. Epidemiology and traumatology of injuries in elite soccer: a prospective study in Finland. *Scand J Med Sci Sports* 1996; 6: 180-185.
97. Mandelbaum BR, Silvers HJ, Watanabe DS, Knarr JF, Thomas SD, Griffin LY, Kirkendall DT, Garrett Jr W. Effectiveness of a neuromuscular and proprioceptive training program in preventing anterior cruciate ligament injuries in female athletes. 2-year follow-up. *Am J Sports Med* 2005; 33: 1003-1010.
98. McGregor JC, Rae A. A review of injuries to professional footballers in a premier football team (1990-93). *Scot Med J* 1995; 40: 16-18.
99. McGregor JC, Rae A, Melvin WD. A three year review of injuries to professional footballers (1995-98) and comparison with previous observations (1990-93). *Scot Med J* 2000; 45: 17-19.
100. McManus A. Validation of an instrument for injury data collection in rugby union. *Br J Sports Med* 2000; 34: 342-347.
101. Meeuwisse WH. Assessing causation in sport injury: a multifactorial model. *Clin J Sports Med* 1994; 4: 166-170.
102. Meeuwisse WH. Athletic injury etiology: distinguishing between interaction and confounding. *Clin J Sports Med* 1994; 4: 171-175.
103. Meeuwisse WH, Love EJ. Development, implementation, and validation of the Canadian Intercollegiate Sport Injury Registry. *Clin J Sport Med* 1998; 8: 164-77.
104. Morgan BE, Oberlander MA. An examination of injuries in major league soccer. The inaugural season. *Am J Sports Med* 2001; 29: 426-30.
105. Murphy DF, Connolly DAJ, Beynnon BD. Risk factors for lower extremity injury: a review of the literature. *Br J Sports Med* 2003; 37: 13-29.
106. Neyret P, Donell S, Dejour D, Dejour H. Partial meniscectomy and anterior cruciate ligament rupture in soccer players. A study with a minimum of 20-year followup. *Am J Sports Med* 1993; 21: 455-460.

107. Nielsen AB, Yde J. Epidemiology and traumatology of injuries in soccer. *Am J Sports Med* 1989; 17: 803-807.
108. Orava S. Excertion injuries due to sports and physical exercise. A clinical and statistical study of nontraumatic overuse injuries of the musculoskeletal system of athletes and keep-fit athletes (Thesis). University of Oulu, Finland, 1980.
109. Orchard JW. Intrinsic and extrinsic risk factors for muscle strains in Australian football. *Am J Sports Med* 2001; 29: 300-303.
110. Parkkari J, Kujala UM, Kannus P. Is it possible to prevent sports injuries? Review of controlled clinical trials and recommendations for future work. *Sports Med* 2001; 31: 985-995.
111. Peterson L, Junge A, Chomiak J, Graf-Baumann T, Dvorak J. Incidence of football injuries and complaints in different age groups and skill-level groups. *Am J Sports Med* 2000; 28: S51-S57.
112. Poulsen TD, Freund KG, Madsen F, Sandvej K. Injuries in high-skilled and low-skilled soccer: a prospective study. *Br J Sports Med* 1991; 25: 151-153.
113. Putukian M, Knowles WK, Swere S, Castle NG. Injuries in indoor soccer – The Lake Placid dawn to dark soccer tournament. *Am J Sports Med* 1996; 24: 317-322.
114. Renström P, Peterson L, Edberg B. Valhalla artificial pitch at Gothenburg 1975-1977, a two-year evaluation. Sweden: Naturvårdsverket, 1977.
115. Roaas A, Nilsson S. Major injuries in Norwegian football. *Br J Sports Med* 1979; 13: 3-5.
116. Roos H, Lindberg H, Gärdsell P, Lohmander LS, Wingstrand H. The prevalence of gonarthrosis in former soccer players and its relation to meniscectomy. *Am J Sports Med* 1994; 22: 219-222.
117. Roos H, Ornell M, Gärdsell P, Lohmander LS, Lindstrand A. Soccer after anterior cruciate ligament injury – an incompatibel combination? *Acta Orthop Scand* 1995; 66: 107-112.
118. Roos H. Are there long-term sequelae from soccer? *Clin Sports Med* 1998; 17: 819-831.
119. Rösch D, Hodgson R, Peterson L, Graf-Baumann T, Junge A, Chomiak J, Dvorak J. Assessment and evaluation of football performance. *Am J Sports Med* 2000; 28: S29-S39.
120. Safran MR, Seaber AV, Garrett Jr WE. Warm-up and muscular injury prevention – an update. *Sports Medicine* 1989; 8: 239-249.
121. Sandelin J, Santavirta S, Kiviluoto O. Acute soccer injuries in Finland in 1980. *Br J Sports Med* 1985; 19: 30-33.
122. Saxon L, Finch C, Bass S. Sports participation, sports injuries and osteoarthritis – implications for prevention. *Sports Med* 1999; 28: 123-135.
123. Schmoor C, Sauerbrei W, Schumacher M. Sample size considerations for the evaluation of prognostic factors in survival analysis. *Statist Med* 2000; 19: 441-452.
124. Schneider-Kolsky ME, Hoving JL, Warren P, Connell DA. A comparison between clinical assessment and magnetic resonance imaging of acute hamstring injuries. *Am J Sports Med* 2006; 34: 1008-1015.
125. Schoenfeld DA. Sample-size formula for the proportional-hazards regression model. *Biometrics* 1983; 39: 499-503.
126. Sharpe SR, Knapik J, Jones B. Ankle braces effectively reduce recurrence of ankle sprains in female soccer players. *J Athl Train* 1997; 32: 21-24.
127. Shephard GJ, Banks AJ, Ryan WG. Ex-professional association footballers have an increased prevalence of osteoarthritis of the hip compared with age matched controls despite not having sustained notable hip injuries. *Br J Sports Med* 2003; 37: 80-81.

128. Sjöman F. Fotboll 1982 [Football 1982]. 26th ed. Stockholm: Brunnhages Förlag AB, 1983.
129. Stone M. Muscle conditioning and muscle injuries. *Med Sci Sports Exerc* 1990; 22: 457-462.
130. 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.
131. Söderman K, Werner S, Pietilä T, Engström B, Alfredson H. Balance board training: prevention of traumatic injuries of the lower extremities in female soccer players? A prospective randomized intervention study. *Knee Surg Sports Traumatol Arthrosc* 2000; 8: 356-363.
132. Söderman K, Alfredson H, Pietilä T, Werner S. Risk factors for leg injuries in female soccer players: a prospective investigation during one out-door season. *Knee Surg Sports Traumatol Arthrosc* 2001; 9: 313-321.
133. Söderman K, Pietilä T, Alfredson H, Werner S. Anterior cruciate ligament injuries in young females playing soccer at senior levels. *Scand J Med Sci Sports* 2002; 12: 65-68.
134. Taimela S, Kujala UM, Osterman K. Intrinsic risk factors and athletic injuries. *Sports Medicine* 1990; 9: 205-215.
135. 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.
136. Tropp H, Askling C, Gillquist J. Prevention of ankle sprains. *Am J Sports Med* 1985; 13: 259-62.
137. Tucker AM. Common soccer injuries – diagnosis, treatment and rehabilitation. *Sports Med* 1997; 23: 21-32.
138. Tumilty D. Physiological characteristics of elite soccer players. *Sports Med* 1993; 16: 80-96.
139. van Mechelen W, Hlobil H, Kemper H. Incidence, severity, aetiology and prevention of sports injuries. *Sports Medicine* 1992; 14: 82-99.
140. van Mechelen W. Sports injury surveillance systems – one size fits all? *Sports Med* 1997; 24: 164-168.
141. van Vulpen AV. Sports for all, sports injuries and their prevention, scientific report. Council of Europe. Oosterbeek: National Institute for Sports Health Care, 1989.
142. Verrall GM, Slavotinek JP, Barnes PG, Fon GT. Diagnostic and prognostic value of clinical findings in 83 athletes with posterior thigh injury. Comparison of clinical findings with magnetic resonance imaging documentation of hamstring muscle strain. *Am J Sports Med* 2003; 31: 969-973.
143. Volpi P, Melegati G, Tornese D, Bandi M. Muscle strains in soccer: a five-year survey of an Italian major league team. *Knee Surg Sports Traumatol Arthrosc* 2004; 12: 482-485.
144. von Porat A, Roos EM, Roos H. High prevalence of osteoarthritis 14 years after an anterior cruciate ligament tear in male soccer players: a study of radiographic and patient relevant outcomes. *Ann Rheum Dis* 2004; 63: 269-273.
145. Waldén M, Hägglund M, Ekstrand J. Injuries in Swedish elite football - a prospective study on injury definitions, risk for injury and injury pattern during 2001. *Scand J Med Sci Sports* 2005; 15: 118-125.
146. Waldén M, Hägglund M, Ekstrand J. UEFA Champions League study: a prospective study of injuries in professional football during the 2001-2002 season. *Br J Sports Med* 2005; 39: 542-546.
147. Waldén M, Hägglund M, Ekstrand J. High risk of new knee injury in elite footballers with previous anterior cruciate ligament injury. *Br J Sports Med* 2006; 40: 158-162.

148. Waldén M, Hägglund M, Ekstrand J. Football injuries during European championships 2004-2005. *Knee Surg Sports Traumatol Arthrosc* 2007; in press.
149. Withnall C, Shewchenko N, Wonnacott M, Dvorak J. Effectiveness of headgear in football. *Br J Sports Med* 2005; 39: S40-S48.
150. Witvrouw E, Danneels L, Asselman P, D'Have T, Cambier D. Muscle flexibility as a risk factor for developing muscle injuries in male professional soccer players: a prospective study. *Am J Sports Med* 2003; 31: 41-46.
151. Wong P, Hong Y. Soccer injuries in the lower extremities. *Br J Sports Med* 2005; 39: 473-482.
152. Woods C, Hawkins R, Hulse M, Hodson A. The Football Association medical research programme: an audit of injuries in professional football – analysis of preseason injuries. *Br J Sports Med* 2002: 36: 436-441.
153. Woods C, Hawkins R, Hulse M, Hodson A. The Football Association Medical Research Programme: an audit of injuries in professional football: an analysis of ankle sprains. *Br J Sports Med* 2003; 37: 233-238.
154. Woods C, Hawkins RD, Maltby S, Hulse M, Thomas A, Hodson A. The Football Association Medical Research Programme: an audit of injuries in professional football-analysis of hamstring injuries. *Br J Sports Med* 2004; 38: 36-41.
155. Yoon YS, Chai M, Shin DW. Football injuries at Asian tournaments. *Am J Sports Med* 2004; 32: S36-S42.
156. Östenberg 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.

# APPENDIX 1

## CLUB

______________________________

______________________________

## BASELINE FORM

I hereby certify that I have been informed about the research project by my team doctor:____________________ and that I am willing to participate

| Name | Code Nr | Age (years) | Height (cm) | Weight (kg) | Dominant leg | Major operations and injuries in the past (absence > 1 month) | Signature of the player |
|---|---|---|---|---|---|---|---|
| | 1 | | | | | | |
| | 2 | | | | | | |
| | 3 | | | | | | |
| | 4 | | | | | | |
| | 5 | | | | | | |
| | 6 | | | | | | |
| | 7 | | | | | | |
| | 8 | | | | | | |
| | 9 | | | | | | |
| | 10 | | | | | | |
| | 11 | | | | | | |
| | 12 | | | | | | |

# APPENDIX 2

## EXPOSURE FORM

**CLUB**……………………………… **MONTH**……………

**Contact person**…………………………………………

**Fax**………………………………**Tel**…………………………

**Mobile**……………………………… **E-mail** …………………………

X = participation in training session (min)
A = participation in first team match (min)
B = participation in reserve- or youth match (min)
N = participation in national team (min)
AT = absence from training because of injury
AM = absence from match because of injury
0 = absence due to other reasons

| **Name** | **Date** | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Exp** | | | | | | | | | | | | | | | | | | | | | |
| | **1** | | | | | | | | | | | | | | | | | | | | | |
| | **2** | | | | | | | | | | | | | | | | | | | | | |
| | **3** | | | | | | | | | | | | | | | | | | | | | |
| | **4** | | | | | | | | | | | | | | | | | | | | | |
| | **5** | | | | | | | | | | | | | | | | | | | | | |
| | **6** | | | | | | | | | | | | | | | | | | | | | |
| | **7** | | | | | | | | | | | | | | | | | | | | | |
| | **8** | | | | | | | | | | | | | | | | | | | | | |
| | **9** | | | | | | | | | | | | | | | | | | | | | |
| | **10** | | | | | | | | | | | | | | | | | | | | | |
| | **11** | | | | | | | | | | | | | | | | | | | | | |
| | **12** | | | | | | | | | | | | | | | | | | | | | |

# APPENDIX 3

# INJURY FORM

**Name:**______________________________ **Team:**______________________

**Date of injury:**__________ ☐ **Training** ☐ **Match** **Code:**______________________

| | | | | |
|---|---|---|---|---|
| **Type of injury:** | ☐ Sprain | | ☐ Overuse injury | ☐ Contusion |
| | ☐ Strain | | ☐ Fracture | ☐ Dislocation |
| | ☐ Other | | | |
| **Location of injury:** | ☐ Foot | | ☐ Ankle | ☐ Lower leg |
| | ☐ Knee | | ☐ Thigh | ☐ Hip/groin |
| | ☐ Back | | ☐ Head/face/neck | ☐ Other |
| **Side:** | ☐ Right | | ☐ Left | ☐ Bilateral |
| **Re-injury:** | ☐ No | | ☐ Yes | |
| **Violation of rules:** | ☐ No | | ☐ Yes, opponent | ☐ Yes, own |
| **Severity:** | ☐ Slight | ☐ Minor | ☐ Moderate | ☐ Major |

**Diagnosis:** ____________________________________________________

____________________________________________________

**Comments:** ____________________________________________________

____________________________________________________

# SVENSK SAMMANFATTNING

Syftet med avhandlingen var att studera skaderisk, svårighetsgrad och skademönster hos manliga och kvinnliga elitfotbollsspelare; att studera utveckling av skaderisk över tid; att identifiera riskfaktorer för skada; samt att testa effekten av ett interventionsprogram mot återfallsskador.

Samtliga studier hade en prospektiv (framåtblickande) design med standardiserade definitioner och datainsamlingsformulär. Individuell tränings- och matchexponering (speltid) registrerades för alla deltagande spelare och samtliga frånvaroskador dokumenterades av respektive lags medicinska team.

Träningsmängden hade ökat med 68% mellan säsongerna 1982 och 2001 i Allsvenskan, vilket visar på utvecklingen från semiprofessionalism till full professionalism. Ingen skillnad i skaderisk eller svårighetsgrad noterades mellan säsonger. Skadefrekvensen var 4,6 vs. 5,2 skador/1000 träningstimmar och 20,6 vs. 25,9/1000 matchtimmar. Risken att drabbas av svår skada (frånvaro >4 veckor) var 0,8/1000 timmar båda säsongerna.

Allsvenskan och danska SAS Ligan följdes under vårsäsongen 2001. En ökad risk för träningsskada (11,8 vs. 6,0/1000 timmar, p<0,01) och svår skada (1,8 vs. 0,7/1000 timmar, p=0,002) observerades hos de danska spelarna. Återfallsskador utgjorde 30% respektive 24% av samtliga skador i Danmark och Sverige.

Skaderisken på träning och match var lika mellan säsongerna 2001 och 2002 i Allsvenskan. Spelare som skadades säsongen 2001 hade en ökad skaderisk nästkommande säsong jämfört med icke skadade spelare (relativ risk 2,7; 95% CI 1,7-4,3). Spelare som drabbades av en hamstringsskada, ljumskskada eller knäledsstukning hade två till tre gånger ökad risk för ny identisk skada i samma ben följande säsong, medan inget sådant samband noterades för fotledsstukning. Inget samband fanns mellan ålder och ökad skaderisk.

Effekten av ett tränarstyrt rehabiliteringsprogram på risken för återfallsskada utvärderades i en randomiserad kontrollerad studie på amatörnivå för herrar. Tjugotre av 79 skadade spelare i kontrollgruppen ådrog sig en återfallsskada under säsongen jämfört med 10 av 90 skadade spelare i interventionsgruppen. Spelare i interventionsgruppen hade 75% lägre risk för återfallsskada i nedre extremiteten jämfört med kontrollgruppen (relativ risk 0,25; 95% CI 0,11-0,57). Den förebyggande effekten var störst under de första veckorna efter återgång till matchspel.

Allsvenskan och Damallsvenskan följdes under säsongen 2005. Män hade en ökad risk för såväl träningsskada (4,7 vs. 3,8/1000 timmar, p<0,05) som matchskada (28,1 vs. 16,1/1000 timmar, p<0,001) jämfört med kvinnor. Däremot var det ingen skillnad i risken att drabbas av en svår skada (0,7/1000 timmar i båda grupperna). Låret var den vanligaste skade-lokalisationen för både kvinnor och män, medan ljumskskador var vanligare hos män och knäskador hos kvinnor. Knäligamentskada orsakade 31% respektive 37% av det totala antalet frånvarodagar på grund av skada i Allsvenskan och Damallsvenskan.