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Severe Injuries in Football Players

Influencing Factors

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ABSTRACT

The aims of this prospective study were to analyze factors related to the occurrence of severe football injuries in players of different ages (14 to 42 years) and different skill levels (local teams to first league teams). In the Czech Republic, 398 players were followed up for 1 year, during which time they sustained 686 injuries. Of these, 113 (16.5%) were severe injuries. Ninety-seven severe injuries (86%) were able to be documented in detail. Trauma was the cause of 81.5% of the injuries and overuse was the cause of 18.5%. Joint sprains predominated (30%), followed by fractures (16%), muscle strains (15%), ligament ruptures (12%), meniscal tears and contusions (8%), and other injuries. Injuries to the knee were most prevalent (29%), followed by injuries to the ankle (19%) and spine (9%). More injuries occurred during games (59%) than in practice. Twenty-four percent of the injured players had suffered a previous injury of the same body part. Forty-six percent of injuries were caused by contact and 54% involved no body contact. Thirty-one percent of severe injuries were caused by foul play. From these results and the analysis of injuries in specific body parts, the following factors were determined to influence the occurrence of severe injuries: 1) personal factors (intrinsic): age of player, previous injuries, joint instability, abnormality of the spine, poor physical condition, poor football skills, or inadequate treatment and rehabilitation of injuries; 2) environmental factors (extrinsic): subjective exercise overload during practices and games, amount and quality of training, playing field conditions, equipment (wearing of shin guards and taping) and violations of existing rules (foul play).

Many retrospective and prospective studies have examined the incidence of football injuries and the risk factors related to football injuries.^{9,23,24} These studies have had varying findings, primarily because of the differing methods used. The criteria used to describe the severity of an injury are rarely consistent across studies.²⁷ Details of severe injuries have been discussed either in terms of case reports of fatal incidents^{46,53} or have concerned only commonly injured specific body parts, such as the knee, ankle, hip, and cervical spine.^{1,17,32,37,47,57} Few studies about the incidence of injuries in football players of differing ages and skill levels have been published.^{38,45,52} The aims of the present study were to analyze severe traumatic and overuse injuries incurred by football players of different ages and skill levels (from youth local teams to adult professional teams) and to describe the intrinsic and extrinsic factors influencing the occurrence of these injuries using standardized methodology.

MATERIALS AND METHODS

After a baseline examination (for details see references 28, 29, and 48), all teams were visited weekly by a physician, who documented all injuries and complaints. During a 1-year follow-up period, all players who sustained a severe injury were asked to visit or to meet the orthopaedic surgeon (JC), who then conducted a standard orthopaedic clinical examination and an analysis of the medical history. All players answered a specific questionnaire concerning the circumstances of the injury (for example, training, game, contact) and their judgment of the situation (for example, foul play). Treatment of the injury was not performed by the doctors involved in the study.

Definition of Severe Injury

Definitions of the severity of injury vary widely.²⁷ In the present study, a classification based on the length of incapacity was used, similar to that employed by Ekstrand and Gillquist,¹² Lühje et al.,³³ Arnason et al.,² Engström et al.,¹⁷ Nielsen and Yde,³⁸ and Peterson et al.⁴⁰ According

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to this classification, major or severe injuries are defined as those caused by football, regardless of the consequences with respect to participation in training or games. Such injuries are further defined as being accompanied by complaints lasting more than 4 weeks, absence from the sport for 4 or more weeks, association with serious damage to the musculoskeletal system—such as fractures or dislocations of the joints, or serious damage to the visceral system.

Sample

A population of 398 players from the Czech Republic participated in the baseline examination (see references 28, 29, and 48) and was followed over a 1-year period (see reference 40). Complete weekly follow-ups were accomplished in 264 players; however, in the players who were excluded for various reasons (see reference 40), information about severe injuries was still available.

The ages of the players varied between 14 and 41 years, with an average age of 19.5 years (SD, 4.6). Because some of the junior groups also included some older players, the size of the groups according to age was as follows: youths under 16, $N = 66$, 16.6%; youths between 16 and 18, $N = 150$, 37.7%; and adults, $N = 182$, 45.7%. (See Table 1 in "Medical History and Physical Findings in Football Players of Different Age and Skill Levels" for the skill levels of the players included in the sample population.)

Statistical Analysis

The data were analyzed on an Apple Macintosh computer (Cupertino, California) using Microsoft Office (Microsoft Corp., Redmond, Washington), StatView (version 4.5; SAS Institute, Cary, North Carolina), and SPSS (version 6.1; SPSS Inc., Chicago, Illinois) software. Methods applied were frequencies, cross-tabulations, descriptives, and means. Differences between groups were examined by t -tests or the chi-square test.

RESULTS

Description of All Severe Injuries

Number. Of 686 injuries incurred by all investigated players, 113 injuries (16.5%) were considered severe. Of

these 113 severe injuries, 97 injuries (85.8%) in 87 players were documented in detail.

Anatomic Site. Injuries were sustained in the lower extremities (74.2%) and the upper extremities (14.4%). The injuries were most prevalent in the knee ($N = 29$, 30%) and the ankle ($N = 19$, 19%), followed by the spine, groin, hand, thigh, shoulder, shin, foot, and head (Table 1).

Type of Injury. There were 29 joint sprains (30%), 16 fractures (16%), 15 muscle strains (15%), 12 ligament ruptures (12%), 8 meniscal tears, 8 contusions, 4 joint dislocations, and 5 specific injuries of the spine. (These are discussed in detail later under "Analysis of Anatomic Location of Injury.")

Mechanism. There were 79 traumatic injuries (81.4%) and 18 overuse injuries (18.6%). Fifty-seven injuries (59%) occurred during games, 39 (40%) during training, and 1 (1%) during warm-up. Injuries during training mostly occurred in situations similar to games (56%, $N = 22$). Five "injuries" (5%) were associated with an existing health condition: lateral discoid meniscus ($N = 1$), Scheuermann's disease ($N = 2$), scoliosis ($N = 1$), and spondylolysis ($N = 1$). The overuse injuries are analyzed in more detail under "Analysis of Anatomic Location of Injury."

The circumstances of injury involved contact in 45 cases (46.4%) and noncontact in 52 (53.6%). Two-thirds of the contact injuries were caused by opposing foul play ($N = 30$, 31% of all injuries) and one-third by body contact without foul play ($N = 15$, 15.5% of all injuries). Injuries associated with fouls prevailed in games, although three injuries caused by foul play were recorded during training.

Description of Severely Injured Players

Age. The proportions of severely injured players were similar in the three age groups (<16 years, 22.7%, 15 of 66; 16 to 18 years, 25.3%, 38 of 150; >18 years, 18.7%, 34 of 182).

In examining the association between age and type of injury (Fig. 1), it was observed that in the 14- to 16-year-old group the most frequently incurred injuries were generally less severe in nature, namely spinal problems (24%), joint sprains (23%), and contusions (23%). Fractures represented 12% of all their injuries (a similar figure

TABLE 1
Mechanism of Injury According to Body Part Injured

Body part injured	Overuse		Noncontact		Contact without foul		Contact and foul	
	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%
Knee ($N = 29$)	2	7	16	55	6	21	5	17
Ankle ($N = 19$)			6	32	5	26	8	42
Spine ($N = 9$)	6	67	2	22			1	11
Hand ($N = 8$)			2	25	3	38	3	38
Groin ($N = 8$)	4	50	3	38	1	13		
Thigh ($N = 7$)	1	14	3	43			3	43
Shoulder ($N = 6$)			2	33			4	67
Lower leg ($N = 5$)	3	60					2	40
Foot ($N = 4$)	2	50					2	50
Head ($N = 2$)							2	100
Total ($N = 97$)	18	19	34	35	15	15	30	31

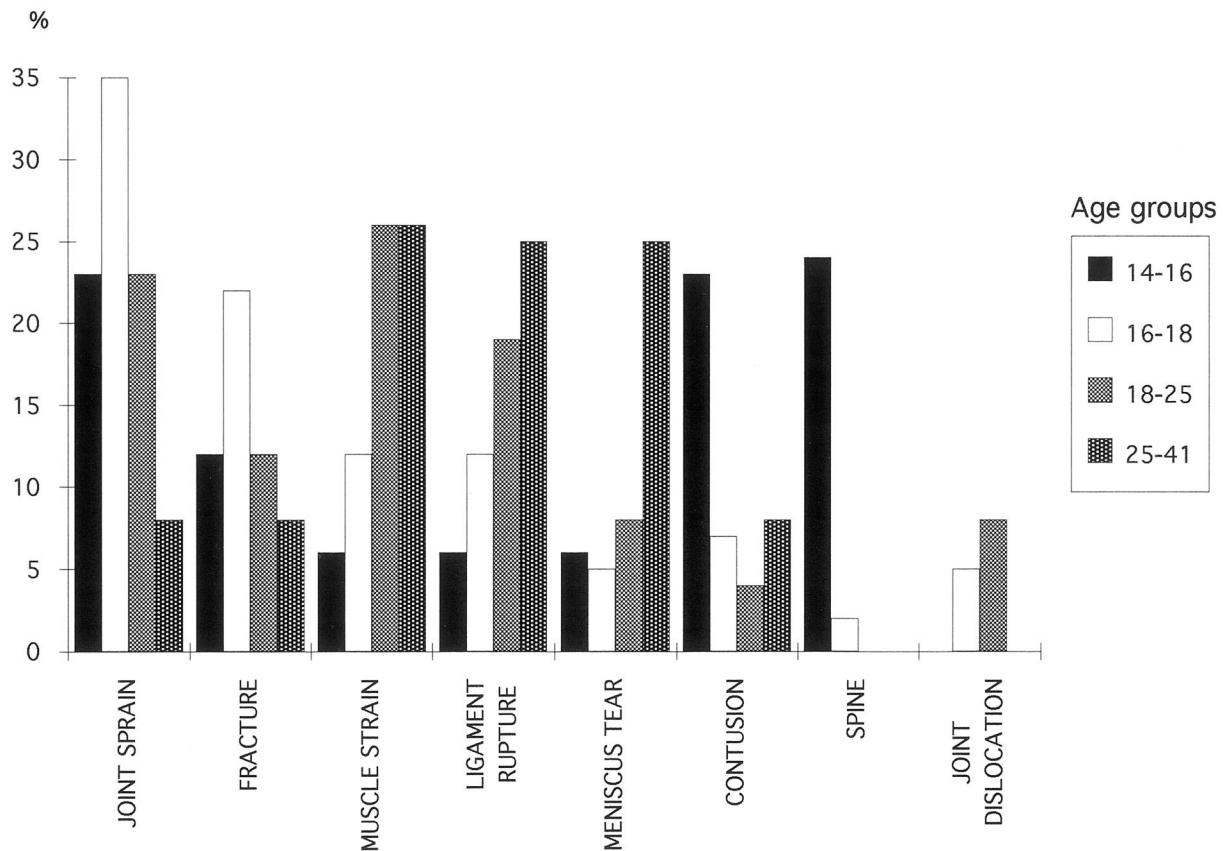


Figure 1. Type of injury in different age groups (percentages based on the number for each group).

to that for the young adult players), and muscle strains, ligament ruptures, and meniscal tears were rare (each 6%). In the 16- to 18-year-old players, joint sprains were the most common injury (35%), followed by fractures (22%); both of these types of injury were relatively more common injuries for this age group than they were for any other group. In the 18- to 25-year-old players, muscle strains and joint sprains were the most frequent injuries (26% and 23%, respectively), followed by ligament ruptures (19%). In the group of older players, between 25 and 41 years old, the most severe type of knee injuries, namely ligament ruptures and meniscal tears, as well as muscle strains, were recorded with approximately equal frequency (25%, 25%, and 26%, respectively). There were no spinal problems or joint dislocations in this age group, and the number of joint sprains, fractures, and contusions made up a low proportion of all injuries (8% each). Looking across the age groups, there was a general tendency for an increase in the relative proportions of muscle strains, ligament ruptures, and meniscal tears, and a decrease of joint sprains, contusions, and spinal injuries with increasing age.

Previous Injuries. Almost one-quarter of injured players ($N = 23$, 24%) had previously injured the same body part, seven of them within a preceding period of between 0 (same game) and 3 months. In 3 of the 10 players who sustained 2 severe injuries during follow-up, the second

injury occurred at the same anatomic location (thigh, knee, clavicle). Nearly one-third of traumatic noncontact injuries (11 of 34) and 20% of contact injuries (9 of 45) occurred in players who had previously been injured at the same body part.

Skill Level. Skill level had no influence on the total proportions of severe injuries: 59 injuries (22.7%) were incurred by players in the high-level groups and 38 (27.5%) by players in the low-level groups. However, because exposure to football was lower in the low-level groups,⁴⁰ the incidence of severe injuries (injuries per 1000 hours of exposure) was twice as high in the low-skill as in the high-skill groups. There was no significant difference between high- and low-level players in the frequency of contact and noncontact injuries.

Circumstances of Injury

Football Seasons. The number of traumatic injuries registered was highest during the autumn competitive season ($N = 39$, 49%), followed by the winter preseason ($N = 18$, 23%), spring competitive season ($N = 17$, 22%), and summer preseason ($N = 5$, 6%). The distribution was similar for overuse injuries: eight injuries were registered during the autumn season, five during the winter preseason, three during the summer preseason, and two during the spring season.

Outdoor and Indoor Games. Ninety-four injuries were sustained during outdoor football; only three injuries occurred during indoor games. Of the six severe injuries that occurred on artificial turf, three were serious ankle sprains, one was a knee sprain, one a scaphoid fracture, and one a partial rupture of the adductor longus muscle. No severe overuse injuries occurred in association with play on artificial turf.

Pitch Quality. Only 42 severely injured players (45.2%) described the pitch quality in the area where the injury had happened as being "good." However, 18 players (21%) attributed the cause of injury to bad pitch quality (for example, uneven or slippery surface).

Position of the Player. There were no statistical differences concerning the incidence of severe injuries in different playing positions: of 72 forwards, 16 (21%) were severely injured; of 111 defenders, 29 (26%) were injured; of 134 midfield players, 26 (19%) were injured; of 30 all-round players, 6 (20%) were injured; and of 41 goalkeepers, 8 (20%) were severely injured.

Characteristics of the Game. Two-thirds of severe injuries were incurred during away games. Of all severe game injuries, 59% occurred during competition and 28% occurred during friendly games (that is, competitive matches but not regular national or international competition). The majority of players did not attach any personal importance to the game in which the injury occurred.

Part of the Game and Field. The distribution of injuries occurring in the first and second halves of the game was almost equal. Most injuries ($N = 26$, 46%) occurred in the opponent's half of the pitch, 19 (33%) were sustained while the player was in his own half, and 12 (21%) occurred close to the midline.

Contact Injury. Two-thirds of all game injuries ($N = 36$, 63.2%) were caused by contact and one-third ($N = 20$, 35.1%) occurred without contact. In the majority of the contact injuries ($N = 27$, 75%), players stated that they had been fouled by an opponent. One-quarter of contact injuries were caused by body contact without foul play ($N = 9$, 25%). No player reported being severely injured by a foul that he had committed. The players classified 16 fouls as open fouls and 11 as hidden ones. Nine players (33%) judged the foul as a "professional foul," nine players did not see any reason why the foul had been committed, and seven players assumed that the reason for the foul was to generate a break in the flow of the game. Two players depicted the foul as resulting from the personal aggression of the opponent. Six severe injuries (6%), representing 22% of all severe injuries caused by foul play, were caused while the player was being tackled.

Consequences of Injury

Referee. The referees did not punish the fouls in nine cases (33%). Only nine times (33%) was the perpetrator of the foul that caused the severe injury punished with a yellow card, and in no case was the red card shown. However, 43 injured players judged the control of the game by the referee as good, 9 players rated it as partial, and only 4 players considered it to be insufficient.

Play After Injury. Twenty-four players stopped playing after their injury, 13 played for a short time after injury, and 17 players continued to play until the end of the game.

Treatment. In 54% of the injuries, players received no immediate treatment on the pitch or in the dressing room. In 39% of injuries, players were treated with a cold pack, and in only 7% of injuries (4 of 57) were players immediately treated by immobilization and fixation of the injured extremity. In nearly all injuries ($N = 94$) players were subsequently treated by a physician; 11 players were treated surgically. The treatment involved immobilization of the injured body part in 51 injuries and physical therapy procedures in 49 injuries (in some cases both treatments were applied).

Duration of Absence. The duration of absence from regular training and competition was on average 9.2 weeks (SD, 8.13), although 75% of injured players (65 of 87) returned to normal football activity after 8 weeks. Nine players (9% of injuries) did not participate in practice or games for more than 6 months as a result of the following injuries: knee injuries ($N = 3$), spinal problems ($N = 2$), adductor tendinosis ($N = 1$), Achilles tendinitis ($N = 1$), quadriceps muscle strain ($N = 1$), foot-joint sprain ($N = 1$). Of all severe injuries, those involving the knee resulted in the longest absences from practice and game.

Analysis of Anatomic Location of Injury

Knee Injuries. Of the 29 knee injuries, 7 were total or partial ruptures of the ACL, 6 were meniscal tears, and 16 were less serious injuries. The majority of knee injuries (18 of 29, or 62%) were noncontact (Table 1). Of the 18 noncontact injuries, 7 involved previous knee injury and in 7, patients had knee instability (anterior drawer sign in neutral rotation and Lachman sign or pathologic varus or valgus stress) that had been evident at the baseline medical examination. In contrast, of the 11 contact injuries, no previous knee abnormalities had been documented and only one player had suffered a previous injury. In cases of noncontact injury, dominant and nondominant legs were affected with approximately equal frequency. In contact injuries, the dominant leg was involved significantly more often.

The most serious knee injuries were two total ruptures of the ACL and five partial ruptures of the ACL in combination with injury of other structures of the knee, including one case of an "unhappy triad" injury (tear of the medial collateral ligament, medial meniscus, and ACL). Four injuries were caused without contact and three were the result of body contact, two of which involved foul play (tackles from the side after the ball had gone and vicious kicking). Five injuries occurred during a game; nearly all of these players ($N = 4$) had had at least one previous knee injury. One of them had experienced a knee sprain during the same game. The mean age of these players (23.3 years) was greater than that of players with other severe knee injuries (18.5 years). After sustaining their injuries, two players (ages 31 and 35 years) decided to give up their football careers.

All six meniscal tear injuries (isolated or in combination with tears of the collateral ligaments) were noncontact injuries and most of them occurred during training. The majority of these players ($N = 4$) had previously injured the same knee. The mean age of these players was 21.2 years.

The less serious knee injuries, namely partial ruptures of the collateral ligaments ($N = 6$), knee sprains ($N = 7$), and contusions of the knee ($N = 3$) were mostly noncontact injuries (with the exception of the contusions). The mean age of the players who sustained these injuries (17.6 years) was lower than that of any other knee injury group.

Ankle Injuries. Of the 19 ankle injuries, 3 were fracture-dislocations, and 16 were serious ligament injuries. The fracture-dislocations consisted of one nondislocated fracture of the distal tibia combined with a lateral ankle ligament injury; one fracture-dislocation of the lateral malleolus, type A (according to the classification of Weber⁶⁰); and one fracture-dislocation of the lateral malleolus, type B (according to the classification of Weber). In the two later malleolus injuries there was no displacement or syndesmotic tear. Sixteen serious ligament injuries of the ankle were the result of inversion and plantar flexion. Of these, two were grade III sprains⁸ and consisted of marked ruptures of the lateral ankle ligaments (anterior talofibular ligaments), as evaluated by the anterior drawer test. Fourteen ankle sprains were moderate (grade II), consisting of a partial tear of the ligaments and moderate ankle instability.

The majority of ankle injuries were caused by foul play, in three cases in association with the player being tackled (Table 1). Of the six players injured without body contact, four had sustained previous injuries of the same ankle. In contrast, of the 13 players injured because of body contact, only 4 had previously injured the same ankle. Instability, identified at the baseline examination by means of the anterior drawer test or talar tilt, was evident in 50% of noncontact injured players (3 of 6) and in just 15% of players injured due to contact (2 of 13). The age of injured players and the dominance of the leg seemed to have no influence on the injury rate.

Lumbar and Thoracic Spine Injuries. A total of nine severe spine injuries were registered. The most serious complaints, in which there was a gradual onset of symptoms ($N = 4$) were the result of overuse in association with an existing problem, namely spondylolysis ($N = 1$), lumbar scoliosis ($N = 1$), and Scheuermann's disease ($N = 2$). An L5-S1 disk protrusion was registered once. Three injured players had symptoms of sprains (acute pain after injury in combination with some stiffness and tenderness in the paraspinal muscles). No serious or fatal traumatic injury of the spine (fracture, dislocation) was recorded in relation to football activity. All except one were noncontact injuries (Table 1).

The majority of players ($N = 6$, 66%) declared that overuse (mostly in training) was the cause of their spine problems. Bad pitch quality (hard surface) was considered to be responsible in only one case. Six players had declared at the baseline examination that they had had previous problems with their spine. All injured players were in the

youth age group, between 14 and 17 years old, within the adolescent growth spurt.

Hand Injuries (Including the Wrist and Distal Forearm). Nearly all of the hand injuries (seven of eight) were fractures without displacement involving the metacarpal bones (I, III, V) ($N = 3$), the scaphoid ($N = 2$), the distal radius ($N = 1$), and the proximal phalanx of the third finger ($N = 1$). A severe contusion of the wrist joint was recorded in one player. The majority of the hand injuries (six of eight) were caused by contact with another player (Table 1). In the scaphoid, distal radius, and wrist joint injuries, the mechanism of injury was a fall on the hyperdorsiflexed hand. The fractures of the metacarpal bones and proximal phalanx were the result of direct trauma to the hand. Three of the injured players were goalkeepers, two of whom were injured by body contact. The majority of players ($N = 6$) were less than 18 years of age.

Groin Injuries. Of the eight groin injuries, three were classified as partial ruptures of the proximal origin of the adductor muscles, one as a partial rupture of the proximal tendon of the rectus femoris muscle, and four as strains of the proximal origin of the adductor muscles. One player was operated on for a chronic bilateral adductor muscle strain.

Seven of the eight groin injuries were caused without body contact (Table 1). Half of the injuries were due to overuse. Two players ascribed their injury to a poor warm-up. Two players had suffered from groin problems before. The mean age of the injured players was 19 years. Three players were older than 20 years and only one player was less than 16 years old.

Thigh Injuries. Of the seven thigh injuries, four were severe contusions: two located in the quadriceps femoris muscle, one in the muscle belly of the adductor muscles, and one in the hamstring muscles. Two injuries were classified as partial ruptures of the quadriceps tendon or of the quadriceps muscle. One player suffered from tendinopathy of the vastus medialis muscle. No severe strains of the hamstring muscles were observed.

Three of the injuries, namely two contusions and one partial rupture, were caused by foul play. The muscle strains and tendinosis were noncontact injuries. Three players had a history of thigh injury. Players injured because of contact were younger (mean age, 18.7 years) than those injured without contact (mean age, 22.0 years).

Shoulder Injuries. The six shoulder injuries included three separations of the acromioclavicular joint (grade I or II, after Tossy⁵⁵), one fracture and one refracture of the clavicle, and one dislocation of the glenohumeral joint.

The majority of the injuries ($N = 4$) were caused by foul play (one by tackling from behind after the ball had gone), two were noncontact injuries (Table 1). No goalkeepers suffered a severe injury of the shoulder girdle.

Lower Leg Injuries. The five lower leg injuries included two injuries of the triceps surae muscle and three injuries of the Achilles tendon. The two cases of noninsertional tendinitis of the Achilles tendon and the strain of the triceps surae muscle were due to overuse. A partial rupture of the gastrocnemius muscle and a contusion of the Achilles tendon were caused by foul play involving a

tackle from behind after the ball had gone and by being kicked viciously (Table 1).

The two players with tendinitis of the Achilles tendon attributed their noncontact injury to overuse in training, combined with bad surface, the use of inappropriate shoes, and inadequate warm-up. Both players were relatively old (41 years and 30 years old). The strain of the triceps surae muscle was attributed to bad technique and inadequate warm-up.

Foot Injuries (Excluding Ankle). Two of four severe injuries of the foot were noncontact injuries and involved stress fractures of the fifth metatarsal bone at the junction of the shaft and the base of the bone. Both injuries were acutely symptomatic, with radiographic findings showing preexisting bony changes, and were caused by overuse.

The two injuries that were caused by foul play both involved a combination of a sprain and contusion of the subtalar (Chopart) joint and tarsal bones. All injured players were between 17 and 18 years old.

Head Injuries. There were two serious head injuries, one a fracture of the zygomatic and nasal bones and one a double fracture of the mandible. Both players were injured during games, in association with foul play: one player was injured in a head-to-head collision and the other by being hit by an elbow. Both were adult players (20.6 and 28.0 years). No serious brain injuries and no serious injuries caused by heading the ball were recorded.

DISCUSSION

There are only a few prospective studies in which researchers have examined the incidence of injury in football in relation to differing levels of skill,^{16,38,45,52} and these have all grouped severe injuries together with other less serious injuries. In the present study, the severe injuries were analyzed separately.

The proportion of severe injuries in the present study is similar to the proportion found by Sadat-Ali and Sankaran-Kutty⁴⁹ (16%), but lower than that found by Engström et al.¹⁷ (34%) and Nielsen and Yde³⁸ (35%), and higher than that of Høy et al.²² (9%) and Ekstrand and Gillquist¹¹ (11%). These differences, however, are probably the result of using different data collection procedures, different definitions of severe injury, and the different age and skill levels of the investigated players. The majority of these studies involved elite senior players. Only Nielsen and Yde³⁸ investigated players of varying skill levels and ages.

Concerning the location of injuries, in the present study the lower extremity was involved in 74.2% of all cases, which is in accordance with the 60% to 88% incidence of other reports.^{30,34,38,50} The upper extremity was involved in 14.4% cases, which is also in line with the 8% and 17% figures reported in the literature.³⁰ In the present study, 9% of the injuries were located in the spine. According to van Akkerveeken,⁵⁸ back problems occur in football with a frequency of approximately 10%. Schmidt-Olsen et al.⁵² reported a 14% incidence of back-related injuries.

With the exception of fractures, the distribution of the types of severe injuries associated with football is not well reported in the literature. The incidence of fractures in the

present study was comparable with that reported by Høy et al.²² and by Maehlum et al.³⁴ (18% and 19%, respectively). As in previous studies, severe joint sprains and muscle strains were the most common injuries encountered.

It is difficult to compare our data on the relative proportion of traumatic and overuse injuries with that of previous studies because the latter have examined either the total number of injuries regardless of severity or have examined the injuries only in relation to specific anatomic locations; for example, Nielsen and Yde³⁸ reported 34% overuse injuries involving the lower extremity.

A significantly higher proportion of injuries were sustained during games than during practices. These figures concur with those of Kujala et al.³¹ (55% versus 45%), Sullivan et al.⁵⁴ (62% versus 38%), and Arnason et al.² (66% versus 34%). Ekstrand and Gillquist¹² found that injuries in senior players were approximately equally distributed between practices and games, but 84% of overuse injuries occurred during practice. In contrast, Høy et al.²² reported that only 5% of all injuries occurred during practice.

The proportion of severely injured players was similar in the three age groups. However, of note in our study was the finding that the incidence of injuries in general was highest in the 16- to 18-year-old group. Nielsen and Yde³⁸ and Schmidt-Olsen et al.⁵² found that the incidence of injuries in youth players (16 to 18 years) was comparable with that of the highest senior level. The possible explanations for these findings are manifold and probably also multifactorial: the intensity of training and games in 16- to 18-year olds is most likely similar to that of adults; the aggressiveness of play begins to increase at this age; and the pubertal maturity and growth spurt leads to higher speeds and higher joint-reaction forces and impact forces on collision,³⁰ but body condition, muscle coordination, and strength are not adequately developed.³

The types of severe injuries incurred changed with age, with the frequency of the most severe injuries, such as ligament ruptures and meniscal tears, increasing with increasing age. This is in agreement with one previous report in the literature.³⁰ In the present study, spinal problems, joint sprains, and contusions prevailed in the youngest players (14- to 16-year-olds). In players between 16 and 18 years old, joint sprains were the most common injury, but the proportion of fractures was higher than in the younger age group. In the young adult players (18 to 25 years old), serious ligament injuries and meniscal tears represented a higher proportion of injuries sustained by the group. In the older players (25 to 41 years old), severe ligament injuries, meniscal tears, and muscle strains predominated. As in other studies,^{34,54} injuries in the upper extremities were more prevalent in younger players. The reason for the difference in the predominant location of injuries in youth players and senior players is not yet clear.²³

Concerning previous injuries at the same anatomic location, the results of the present study are in agreement with those of Ekstrand and Gillquist¹¹ and Nielsen and Yde,³⁸ who found that in specific body parts (ankle, knee,

groin), previous injuries were a significant factor influencing the occurrence of future severe injuries. Our data also agree with those of Ekstrand and Gillquist,^{11,13} who found that in one-third of cases minor and moderate injuries were followed by major ones.

In the lower-skill players there was a higher incidence of severe injuries. These results differ from those of Nielsen and Yde³⁸ and Ekstrand and Tropp,¹⁶ who found a higher injury rate in higher-skill players. Our findings might be explained by the lower value for the ratio of time spent in practice relative to games in the lower-skill than the higher-skill groups, and by the different amount and standard of training in lower-skill groups. Because few substantial differences between the injured and uninjured players were found for the practical tests,¹⁰ physical overload may also be responsible for the increased number of injuries in the lower-skill players.

Examination of the relative frequency of injuries throughout the *football seasons* showed that nearly half of all severe injuries (both traumatic and overuse) were registered during the autumn season. A lower number of injuries occurred during the winter preseason, spring season, and summer preseason. This conflicts with the findings of Nielsen and Yde,³⁸ who reported that the majority of injuries occurred in the spring season, followed by the winter preseason and autumn season. Furthermore, in contrast with the results of Engström et al.¹⁷ and Peterson et al.,⁴⁰ we did not find a greater number of severe injuries at the end of the main seasons. The explanation for these differences is unclear, although it may be related to the dependence of pitch quality on the prevailing weather conditions.

In the present study, few injuries were associated with the playing of *indoor* as opposed to outdoor football. Few injuries occurred while playing on *artificial turf*. It is difficult to compare these findings with those of previous studies because in the present study the exposure to indoor football and to play on artificial turf was not specifically documented (although it was believed to be quite low). From the literature it is known that the incidence of injuries for the indoor game is 4.5 times greater than that for outdoor games²¹ and that significantly more injuries and abrasions occur on artificial turf.^{2,15}

Although half of the injured players declared that the *pitch quality* at the time of their injury was inadequate, only 18.5% specifically cited poor pitch quality as a causative factor. This may be because the majority of youth and lower-skill players normally practice on such inadequate pitches (with hard or slippery surfaces). Ekstrand and Gillquist¹³ reported that 24% of injuries were related to the playing surface and that pitch quality seems to be one of the important extrinsic factors influencing the incidence of injuries.

Only three players cited inadequate *shoe quality* as the cause of their severe injury. This was a subjective assessment, and we did not specifically study shoe quality. Some studies have shown that the frequency and severity of injury—particularly of the knee and ankle—are influenced by the frictional characteristics of the surface-shoe combination.^{15,39} Soccer shoes vary in the construction of

both uppers and soles.^{18,41} The soles should be flexible around the metatarsophalangeal joints and have torsional stability, and friction resistance should be kept to a minimum.¹⁵

As in other studies,^{19,38} no significant difference in the frequency of injury in different *playing positions* was found in the present study. The number of injuries incurred by goalkeepers also did not differ from the number sustained by players in other positions on the field.

Regarding the *area of pitch*, more injuries occurred in the opponent's half of the field. This might be explained by the greater exposure to body-contact injuries when attacking than when defending. No significant differences were found in the distribution of injuries occurring in the first and second halves of the game or in certain parts of a given game half. This finding is similar to that of Ekstrand and Gillquist.¹¹

Examination of the *mechanism of injury* revealed that there were almost equal proportions of contact and non-contact injuries. Foul play caused two-thirds of all contact injuries, which represents 31% of all severe injuries. This proportion was similar to that reported by Nielsen and Yde³⁸ (25%) and Hawkins and Fuller²⁰ (29%), but higher than that recorded in other studies (19%,²² 12%¹¹). The fouls prevailed in games, but three severe injuries were caused by foul play during training. Six severe injuries (6% of all injuries; 20% of all foul-associated injuries) resulted from the player being tackled; this figure is lower than those reported in the literature.^{2,5,38} In the present study no players declared being severely injured as a result of a foul which they themselves had committed. This is not in agreement with previous work,^{2,11} which has suggested that about one-third of injuries occur in this way.

During this study, the *referees* punished only two-thirds of the offending players but in no case with the red card. It can be concluded that violation of the rules of the game, and control of the game by referees, represent important extrinsic factors influencing the frequency of severe injuries. The achievement of a reduction in the incidence of injuries in football will obviously require changes in the perception of "fair play" by players, coaches, and referees.²⁹

With regard to the issue of *playing on after severe injury*, 17.5% of injured players reported remaining on the pitch until the end of the game. In considering all types of injury, Nielsen and Yde³⁸ reported that 40% of players continued to play after injury. We support their conclusion that players who continue playing after they have incurred an injury run the risk of both increasing the severity and prolonging the duration of their injury.

Treatment on the playing pitch was in the majority of cases inadequate; in 54% of injuries players received no immediate treatment. The most common treatment was the application of a cold pack. Only 7% of injured body parts were immobilized immediately after injury. This may have been because of the lack of a team physician, which is typical in amateur and youth teams. The final treatment of the most serious injuries (fractures, dislocations, meniscal tears, ligament ruptures) was adequate, but the treatment required for the less severe injuries (joint sprains, muscle strains, tendinosis) was in the ma-

majority of cases underestimated or inadequate. Three injuries were not treated by the physician and in only 51% of cases was the injured body part immobilized. Also, rehabilitation after injury was inadequate, with only 41% of injuries being treated by a physical therapist. The reason for inadequate treatment and rehabilitation was that most of the amateur and youth teams did not have a team physician and because of the coaches' desire to return the player to competition as soon as possible. With the exception of the most serious injuries, for example, knee ligament injuries, the extent of treatment and rehabilitation required seemed to be underestimated by both players and coaches.

Knee Injuries

The most serious injuries—namely ACL injuries and meniscal tears—represented 45% of the severe knee injuries, a figure that agrees with those of Engström et al.¹⁷ and Ekstrand and Gillquist.¹¹ However, in contrast with the results of previous studies,^{11,38} most knee injuries were traumatic noncontact injuries. According to other studies,^{2,11} a history of injury and pathologic instability of the knee were present in the majority of players with noncontact injured knees.

The age of the player seems to represent an important intrinsic factor influencing the severity of knee injuries. The most serious injuries (ACL ruptures and meniscal tears) prevailed in the older age groups, while the less severe injuries (such as partial ruptures of the collateral ligaments, sprains, and contusions) were more common in the lower age groups. These findings agree with those of previous reports^{2,11,38} and might be explained by the players' greater exposure to knee injury with increasing age, in conjunction with an increased risk posed by existing instability caused by previous injuries.

Previous findings concerning the influence of skill level on the incidence of severe knee injuries are controversial.^{11,17,47} In the present study, the incidence of severe knee injuries in lower- and higher-skill players was similar, with the exception of ACL injuries. The majority of players who had ACL ruptures with or without other injured knee structures were from the lower-skill group and had a higher average age than players with less severe knee injuries or than uninjured players.

The literature suggests that nearly half of all ACL injuries are noncontact injuries.¹ The noncontact ACL injuries seem to be influenced by many intrinsic and extrinsic factors, but the overall picture is not yet clear. In particular, the relationship between joint instability and injury is controversial. Arendt and Dick¹ did not find any relationship between joint instability and injury, whereas Arnason et al.² and Ekstrand and Gillquist¹¹ both described a correlation between previous knee injuries and medial and anterolateral knee instability. Roos et al.⁴⁷ reported that more ACL injuries were registered in elite soccer players than in lower-skill players, whereas other authors have found a higher frequency in lower-skill players.^{11,17}

The majority of the less serious injuries (partial ruptures of the collateral ligaments, knee sprains, and contusions of the knee) were noncontact injuries and were caused mainly by tactical error, by overloading or overuse, or by poor ground surface. The majority of these injured players were less than 18 years old. According to previous reports,^{11,12} reduced muscle strength may predispose players to noncontact injuries of the knee, especially in youth and lower-skill players. These injuries seem to be caused, in particular, by overuse, physical overload, or inadequate training.

Watson⁵⁹ proposed that there was a relationship between previous spinal problems and future severe knee injuries. In the present study, four players with knee injuries had suffered spinal problems in the same season, but such a correlation remains far from clear. The type of soccer shoe has been proposed as a possible risk factor for knee injury^{15,24}; this issue was not, however, investigated in any detail within the confines of the present study.

It can be concluded that previous knee injury and instability of the knee do predispose football players to subsequent major knee injury.^{2,12} The severity of knee injuries increases with age. Body contact and foul play (tackling and kicking) represent additional factors predisposing players to ACL injury.

Ankle Injuries

Severe injuries of the ankle were the second most frequent type of injury recorded. These injuries were mostly the result of body contact, particularly foul play, and mostly involved inversion-plantar flexion of the foot. Previous ankle sprains were a significant factor in reinjury in 67% of the noncontact-injured players. This correlates with the findings of previous studies.^{2,11,38} The players injured during contact did not have a significantly increased incidence of previous injury or of ankle instability. According to a published report, both the treatment and rehabilitation of ankle injuries are mostly inadequate, which often increases a player's predisposition to reinjury.³⁸ Only Tropp et al.⁵⁶ have suggested that a history of previous ankle injury does not lead to functional ankle instability or to a higher risk of reinjury, and that taping does not influence the stabilometric values of the ankle. However, other reports suggest that adequate ankle stabilizers or taping and prophylactic exercises are effective in the prevention of ankle injuries and reinjuries in football.^{14,25}

Spine Injuries

In the present study, spinal problems represented 9.2% of all severe injuries. No fractures or dislocations were observed in this study. Their rarity is also confirmed by examination of the prevailing literature, which reveals that serious spinal injuries are described only as case reports.^{46,53} Most authors reported the incidence of all neck and back problems as being between 2% and 10%, but without any further specific analyses.^{26,38,58} Ekstrand and Gillquist¹¹ reported that 5% of all injuries occurred in the back, while Schmidt-Olsen et al.⁵² found a

somewhat higher proportion (14.1%). In the present study, the main factors influencing the frequency of thoracic and lumbar spine injuries were structural abnormalities of the spine, overuse caused by overload during practices or games, a young age, and previous spinal problems.

Our finding that innate structural abnormalities of the spine (Scheuermann's disease, scoliosis, spondylolysis) predispose players to spinal problems concurs with the findings of Watson.⁵⁹ van Akkerveeken⁵⁸ described the spinal problems that occur in football as being caused by asymmetric impacts to the trunk. This is believed to occur with greater frequency in football players because if the player is off balance and the motion is not so well controlled, torsional injury to the back may occur, leading to sprains. Indirect muscle injuries are also related to the sprained back syndrome, most notably in players with fatigued, weak, and unconditioned or over-stretched muscles, and those who perform inadequate warm-up.

Disk protrusion at L5-S1 may also be explained by a mechanism of overload in compression.⁵⁸ Low back pain symptoms associated with spondylolysis may be explained by an overload of the trunk muscles during football. Exercise programs to increase the strength and endurance of the trunk muscles are recommended.

All the players in the present study who had spine injuries were adolescents between 14 and 17 years old, within the adolescent growth spurt, where muscle strength and coordination may be inadequately developed, such that overload in practice and games becomes an important risk factor.^{3,24} In conclusion, it would appear that more attention should be paid to the training activities of players with spinal abnormalities, and that training should include appropriate stretching, strengthening, and endurance exercises of the trunk muscles,⁵¹ particularly in youth players.

Hand Injuries

Injuries of the hand were caused predominantly by body contact and foul play in the field players and by direct or indirect trauma in the goalkeepers. A previous study has suggested that goalkeepers are at greater risk of hand injury than field players.⁴ In the present study, 38% of hand injuries (3 of 8) were sustained by goalkeepers. The mechanism of hand injuries was very similar to that described for injuries incurred in American football.⁶ The majority of injured players were under 18 years of age; only two players were older than 20 years. This finding correlates with those of some previous literature reports,^{24,30} but the underlying reason is unclear.

Groin Injuries

Chronic groin problems are usually associated with tendinosis or partial rupture of different anatomic structures, such as the adductor longus, iliopsoas, rectus femoris, and rectus abdominis muscles.⁴² In the present study, the cases of tendinosis or partial rupture were located mostly in the origin of the adductor muscles. The main factors leading to groin problems appeared to be overuse and

overloading during the long period of competition and training and inadequate rehabilitation after previous injury. The age of the players seemed to be an important factor: the majority of the players were older than 18 years. According to Ekstrand and Gillquist,¹¹ adductor tenosynovitis and Achilles tendinitis are the most common chronic overuse injuries in male senior amateur players.

Thigh Injuries

Contusions of the thigh represent one of the most common contact injuries in soccer, especially in young players.²⁴ Not only contusions but also partial ruptures of the quadriceps muscle can occur as a result of impact against a contracted muscle, such as can occur when one player's knee hits an opposing player's thigh. Another cause of quadriceps muscle strains or partial rupture is noncontact overload, such as occurs during sudden explosive contractions in a fast start.⁴³ In the present study, severe injuries of the quadriceps muscle were caused mainly by body contact. The muscle strains and tendinosis were caused by tactical error, inadequate rehabilitation after previous injury, and bad pitch quality. Strains of the hamstring muscles were not recorded in our group of severely injured players. In contrast, Ekstrand and Gillquist¹³ found 9% of strains in hamstring muscles.

It is possible to conclude that, as with the prevention of groin problems, adequate warm-up and adequate rehabilitation after previous injury are the crucial factors in preventing strains and ruptures of the thigh muscles in noncontact situations. A reduction in foul play may also be expected to reduce the frequency of thigh injuries.

Shoulder Injuries

In the present study, most of the shoulder injuries were caused by foul play. Indirect noncontact injuries involving a fall on the outstretched upper extremity were associated with tactical faults or lack of body condition and bad pitch surface or weather conditions. The mechanism of shoulder injuries is similar to that described in American football.⁶ In contrast with the hand injuries, the severe shoulder injuries did not affect any goalkeepers.

Lower-Leg Injuries

Serious contact injuries of the shin are usually caused by foul play, and for this reason shin guards are a most important piece of protective equipment.^{3,24} In the present study, all players stated that they wore shin guards during games, although only 11% wore them during practice. Both of the lower-leg contact injuries recorded were in the posterior uncovered part of calf, namely in the Achilles tendon and triceps surae muscle. Both of these were caused by foul play during competition.

With regard to noncontact injuries, repetitive impact loading associated with jumping has been shown to cause Achilles tendinitis in older players.^{7,11} As in these reports, both players in the present study with Achilles tendinitis were older (30 and 41 years). Shoes and surface suppos-

edly play an important role in overuse injuries of the calf,^{11,12} although this finding was not substantiated in the present study. It can be concluded that the risk factors for strains and tendinitis in the lower leg are multifactorial and include overload in practices and games, age of the player, inadequate treatment and rehabilitation, insufficient warm-up, inadequate shoes, and uneven ground.

Foot Injuries

In the present study, two traumatic and two overuse injuries were recorded. Both traumatic injuries were caused by foul play. Both overuse injuries were stress fractures. The stress fractures were not associated with any factors such as skeletal asymmetry, malalignment, leg-length discrepancy, gait variation, or prior injury, as has otherwise been described.^{35,44}

Head Injuries

Both head injuries recorded in the present study were caused by foul play. We did not register any serious brain injuries associated with unconsciousness, or any serious acute or chronic problems caused by heading. The neurologic and neuropsychological changes that occur because of repetitive minor head and neck injuries are known and have been described for active and former top-level players.⁵⁷

CONCLUSION

In conclusion, our results generally concur with those of previous, similarly designed prospective studies, although the latter have not always specifically dealt with severe injuries.^{38,45,52}

Classifying the risk factors into person-related (intrinsic) and environment-related (extrinsic) categories, we found that the influence of the most important factors on the occurrence of severe injuries can be summarized as follows:

- **Intrinsic risk factors:** abnormal findings in the physical assessment, such as joint instability and previous injury at the same location. Age is an intrinsic factor: younger players sustain more joint sprains, contusions, and spinal injuries, while older players are more prone to muscle strains, ligament ruptures, and meniscal tears.
- **Extrinsic risk factors:** continued play after sustaining an injury, inadequate treatment on the pitch as well as later on, short rehabilitation time, exercise overload during training and games as well as poor quality of training, poor playing field conditions, inadequate or nonexistent equipment (shin guards, taping, shoes) and, not least, violation of rules.

These factors should be addressed within the context of prevention programs to reduce the incidence of severe injury in football.

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