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Soccer Injuries

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Abstract

Objective: This chapter reviews the existing epidemiological studies on pediatric soccer injuries and discusses possibilities for future research. **Data Sources:** A comprehensive, web-based search of existing soccer injury literature was performed with an emphasis on the pediatric population. The search encompassed all available studies, including European journals and texts, and initial investigations from the 1970s which serve as a basis of comparison to more recent work. **Main Results:** Youth soccer is a relatively safe sport with an injury incidence ranging from 2.3 per 1,000 practice hours to 14.8 per 1,000 game hours. Similar to adults, youth soccer injuries occur mostly in the lower extremities, specifically the knee and ankle. Contusions are the most common injury, and minor/moderate injuries predominate. Extrinsic risk factors for youth soccer include: dangerous play, play on small fields, and inclusion of youth players on adult teams. The most important intrinsic risk factor is the relation of knee injury and female gender. **Conclusions:** Adolescent females suffer a disproportionate number of knee and anterior cruciate ligament injuries compared to adolescent males, but recent injury prevention studies yielded encouraging results. Head injuries in youth soccer are low, and rarely, if ever, occur from head to ball contact. Adherence to the rules of the game, proper coaching, and adequate refereeing are important factors in youth soccer injury prevention.

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Introduction

Soccer is the world's most popular organized sport with over 200 million males and 21 million females registered with the Fédération Internationale de Football Association (FIFA). There has been a considerable increase in soccer participation by American youth over the past two decades. In 1999, the Soccer Industry Council of America estimated that 18.2 million Americans played organized soccer, with 13.8 million players less than 18 years of age. Among

players aged 12–17, participation in soccer rose 20% between 1987 and 1999, and high school participation increased 65% [1–3]. In a comparison of sport participation data from 1983 to 1998, a 159% increase in soccer injuries was evident, indicating a large increase in participation for both boys and girls [4].

Investigations in adult male soccer players identified an incidence of 10–35 injuries per 1,000 game hours [5, 6], and adult female studies revealed an incidence of 2–24 injuries per 1,000 player hours [7–10]. Effectively every player incurs one performance limiting injury per year. However, in a review of 20 epidemiological studies on adult soccer injuries, Dvorak and Junge [5] agreed with Inklaar's [11] conclusion that epidemiological information regarding soccer injuries is inconsistent and far from complete.

FIFA estimates that the average world-wide medical cost of a soccer injury is USD 150, leading to an estimated annual cost of USD 30 billion [5]. In professional English soccer, the average cost due to injury is approximately USD 70 million per season [12]. The rise in youth soccer participation, and the subsequent cost associated with injuries, place an enormous economic pressure on the health care system. The new-found popularity of youth soccer challenges sports medicine professionals to not only identify the injury patterns, but also develop effective treatment and prevention programs. The purpose of this chapter is to review the existing studies on pediatric soccer injuries and discuss possibilities for future research.

A comprehensive, web-based search of the existing soccer injury literature was performed with an emphasis on the pediatric population. The search encompassed all available studies, including some initial investigations from the 1970s which serve as a basis of comparison to more recent work. Some studies which included both adult and pediatric subjects were included due to the paucity of pediatric soccer literature and to provide comparison of the two populations. Case series and case reports were included only if the available literature was sparse, and were not used to discuss injury incidence or risk of injury. Soccer is an international sport, and, although all available English (or English translated) papers were reviewed, the chapter may be limited by the exclusion of foreign studies that were not available on English-based search engines. The method of investigation, and even the definition of an injury, varied widely in the literature, therefore decreasing the validity of direct comparison of some studies.

Incidence of Injury

Soccer has a wide variety of participation levels world-wide, from recreational leagues to international competitions. Even among specific age

groups, the skill level and goal of participation is quite diverse. For example, a high school player in the United States may play on a relatively low skilled team while the same 'youth club' player in England could be part of a development program for a well-funded, internationally prominent soccer club. Moreover, within each club there can be different teams such as first team and reserve team.

Participation Level, Age, and Gender

Participation level is an important variable in many studies, but the reader should recognize the limitation of varied terminology between different countries and leagues. The studies from which overall injury rates were determined are summarized in table 1 and grouped into: recreational [13, 14], club [10, 15–23], and mixed (pediatric and adult) [24–27] participation. As seen in table 1, most studies reported the incidence as percentage of total injuries or injuries per number of player hours. Age range is an important factor because many clubs use age to separate teams (10–12-year-old, 14–16-year-old, etc.). In a follow-up study over one season, Schmidt-Olsen found that injury incidence increased with age and older youth players approached the incidence rate in adults (12–13 year olds = 3.4/1,000 h, 14–15 year olds = 3.8/1,000 h, 16–17 year olds = 4.0/1,000 h) [18]. Inklaar et al. [26] also found that, among highly skilled players, the injury rate in 17–18 year olds was higher than in other youth groups. In 2001, Soderman found that 15–17-year-old girls had a higher injury rate than other age groups [10], supporting Maehlum and Daljord's [24] findings in 1984 that most injuries occurred in the female 15–19-year-old age group.

Inklaar et al. [26] also showed that injury rates increase with age and are higher in the adult population compared to youth players. Nilsson and Roaas's [15] findings show a much higher rate for both girls and boys; however, when minor abrasions and blisters were excluded, the injury incidence was similar to other studies (boys = 14.0/1,000 h and girls = 32.0/1,000 h). Both Neilsen and Inklaar found that injury incidence, pattern of injury, and traumatology varied between players at different levels of competition, and that injury rates were higher in more competitive players [25, 26]. In contrast, Peterson et al. [27] colleagues performed a prospective, cohort study that compared soccer injuries at different ages and skill levels. They found that low-level youth players had twice as many injuries as high-level youth players in relation to exposure time.

Although soccer epidemiology studies in the 1970s and early 1980s [15, 19] showed that females had a higher injury rate, age and skill level may have more of an influence on injury incidence than gender alone. In a 5-day invitational tournament in 1985 with over 6,000 players, females aged 17–19 showed a much higher injury rate (47.1/1,000 h) compared to males in the same age group (20.6/1,000 h) [17]. In 1984, Maehlum and Daljord [24] studied injuries at the Norway Cup, one of the world's largest youth club tournaments, and found the

Table 1. A comparison of injury rates in youth soccer

Study, year	Age range (in years)	Design P/R	Data collection I/Q	Duration	Number of injuries	Sample number (number of players unless indicated)	Overall injury rate per 1,000 hours	Game injury rate per 1,000 hours	Practice injury rate per 1,000 hours	Injury rate, other
<i>Recreational</i>										4.38%
McCarroll [13], 1984	8–18	P	Q	1 season	176	4,018				
Backous, 1988	6–17	P	I	5 week camp	216	1,139	8.95			
<i>Club</i>										
Nilsson [15], 1978	11–18	P	I	5 day tournament × 2 years (10 days)	1,534	25,000	Boys = 23.0; Girls = 44.0			
Sullivan [16], 1980	7–18	P	Q	1 season	34	1,272	Boys = 0.51; Girls = 1.1			2.6 per 100 players
Schmidt-Olsen [17], 1985	9–19	P	I	5 day tournament	346	6,600	All = 19.1; Boys = 16.1; Girls = 29.9			
Schmidt-Olsen [18], 1991	12–18	P	Q	1 season	312	496	3.7			
Maehlum [19], 1986	11–18	P	I	6 day tournament	411	1,348 teams	All = 11.7; Boys = 9.9; Girls = 17.6			
Maehlum [20], 1999	9–19	P	I	6 day tournament × 2 years (12 days)	278 (in 1993), 296 (in 1997)		7.7 (in 1993), 7.3 (in 1997)			Boys = 7.6 (in 1993), 6.9 (in 1997); Girls = 8.1 (in 1993), 8.3 (in 1997)
Kibler [21], 1993	12–19	P	I	3 day tournament × 4 years (12 days)	179	480 games	2.38			

Table 1 (continued)

Study, year	Age range (in years)	Design P/R	Data collection I/Q	Duration	Number of injuries	Sample number (number of players unless indicated)	Overall injury rate per 1,000 hours	Game injury rate per 1,000 hours	Practice injury rate per 1,000 hours	Injury rate, other
Junge [22], 2000*	14–18	P	I	1 year	France = 58; Czech = 130	France = 131; Czech = 180		France = 12.7; Czech = 14.8	France = 2.3; Czech = 2.6	
Elias [23], 2001**	9–19	P	I	6 day tournament × 10 years (60 days)	3,840	89,500				Boys = 7.60 (min)–20.04 (max); Girls = 10.23 (min)–20.11 (max)
Soderman, 2001 <i>Multiple Age Group</i>	14–19	P	I and Q	1 season	79 (Girls only)	175	6.8	9.1	1.5	
Maehlum [24], 1984	5–60	R	I	1 year	1,329			Male = 3.3 (all ages); Female = 4.9 (all ages)		
Nielsen [25], 1989	16–adult	P	I	1 season	All ages = 109; Youth = 27	Adult = 93; Youth = 30		High level adult = 18.5; Youth = 14.4	High level adult = 2.3; Youth = 3.6	
Inklaar [26], 1996	13–60	P	Q	1 season	83	Adult = 245; Youth = 232	13–14 years = 12.8; 15–16 years = 16.1; 17–18 years = 28.3			17–18 years and high skill = 34.6; 17–18 years and low skill = 15.7
Peterson [27], 2000	14–adult	P	I	1 year	558	264	16–18 years and high skill = 6.6; 16–18 years and low skill = 13.7			Adult professional = 5.6; Adult amateur = 4.6; Adult club = 20.2
*Study compared youth injuries in France to the Czech Republic (Czech); see text for details.										
**Injury rates varied over the 10 years of the tournament maximum (max) and minimum (min) values are show for each gender.										

injury rate to be twice as high in girls as boys. In 1999, Maehlum et al. [20] again compared values from the 1984 tournament to the 1993 and 1997 tournaments, and found a 35% total decrease in total injuries with a 50% reduction in female injuries [20]. Elias also found a decline in injury rates for both girls and boys during a large American tournament over a 10-year period [23]. While some studies have shown that youth soccer injury rates are higher in high-skilled players [26], others have shown that low-skilled players are more at risk for injury [27]. High-skilled players train more often and presumably compete more intensely, but poor conditioning and fitness in low-skilled players may lead to more injuries. Comparison of the data in table 1 has shown a narrowing of the injury rate between girls and boys over time, and, if it is presumed that the early injury rates in females are secondary to low skill levels, then the increase in soccer skills and training in girls from the 1980s to 1990s may indicate a relationship between decreased injury and improved soccer skills. Indeed, a study by the FIFA Medical Assessment and Research Centre (FIFA-MARC) in 2002 showed that improved training in low-skilled soccer players can lead to a reduction in injury rates [28].

Player Position

A comparison of injury rates and player position is shown in table 2 [16, 29–31]. Only one study has directly compared injury rates and player position [30]. Accounting for the fact that there are only one or two goalkeepers per team, Junge et al. [30] found that goalkeepers have similar physical and psychological profiles to field players, but a 25% lower injury incidence. There is a specific relationship between injury and player position (table 2), except for Boden's [31] retrospective review of tibia/fibula fractures, who found that forwards suffered nearly 40% of these severe injuries.

Injury Characteristics

Injury Onset

The majority of injuries in youth soccer occur acutely. In a study of adolescent female soccer players, 34% of injuries were chronic [10]. The FIFA-MARC studies of youth soccer injuries revealed that overuse injuries accounted for approximately 18% of injuries and that the number of chronic injuries decreased with a preseason conditioning program [22, 28].

Injury Location

A comparison of anatomical injury location in youth soccer studies is shown in table 3. [10, 13, 15–19, 21–23, 25, 26, 32]. Table 3 shows that the

Table 2. A comparison of injury rates and player position in youth soccer

Study	Age range (in years)	Design P/R	Data collection I/Q	Number of injuries	Sample number (number of players unless indicated)	Goalkeeper (n = number of players unless indicated)	Defender	Midfield	Forward	Unknown position at time of injury
Sullivan [16], 1980	7–18	P	Q	34	1,272	6, 17.6%	11, 32.4%	6, 17.6%	11, 32.4%	
Powell [29], 1999 (Only head injuries)		P	I	Boys = 69; Girls = 76	246 teams	Boys = 11.9%; Girls = 18.8%		Boys (forwards and midfield) = 66.1%	Girls (forwards and midfield) = 70.3%	
Boden [31], 1998 (Only tibia/fibula fractures)	19	R	Q	31	31	2, 6%	6, 19%	5, 19%	13, 42%	5, 16%
Junge [30], 2001	14–18 years, and adults	P	I and Q	GK = 47; F = 511	GK (all) = 28; Field (all) = 236; GK (<18 yrs) = 20; Field (<18 yrs) = 179	All = 6.09; 16–18 and high level = 4.68; 16–18 and low level = 7.46; 14–16 and high level = 3.08; 14–16 and low level = 8.83	Field (all) = 7.42			

Table 3. A comparison of anatomical injury location in youth soccer. All studies are prospective and players are youth club unless indicated. N = player sample, percentage, unless indicated

	Author	Nilsson [15]	Sullivan [16]	Schmidt- Olsen [17]	Machlum [19]	Hoff* [32]	Backous [13]	Nielsen [25]	Schmidt- Olsen [18]	Kibler [21]	Inklaar [26]	Junge** [22]	Elias*** [23]	Soderman 2001
	Year	1978	1980	1985	1986	1986	1988	1989	1991	1993	1996	2000	2001	2001
Injury site	Sample number	25,000	1,272	6,600	1,348 teams	821	1,139	30	496		232	311	89,500	175
Head		54, 10%	5	17, 4.9%	71, 17.3%	O = 10, 22%; I = 6, 8%	7		1.2%	8%			M = 288, 1.56; F = 187, 1.76	
Face							8		1.9%					
Trunk		37, 7%	1	7, 2.0%	31, 7.5%	O = 4, 8%; I = 11, 15%								
Back				6, 1.8%			6		13.8%					1, 1.9%
Abdomen										10.9%				
Upper extremity		80, 15%	6		58, 14.1%	O = 3, 6%; I = 14, 20%							M = 278, 1.51; F = 154, 1.45	2, 3.9%
Shoulder				6, 1.8%					2.6%					
Arm				8, 2.3%					7.7%					
Wrist							4							
Hand				22, 6.3%			6							
Lower extremity					251, 61.0%	O = 26, 63%; I = 43, 58%							M = 1435, 7.79; F = 860, 8.09	

Table 3 (continued)

	Author	Nilsson [15]	Sullivan [16]	Schmidt- Olsen [17]	Maehlum [19]	Hoff* [32]	Backous [13]	Nielsen [25]	Schmidt- Olsen [18]	Kibler [21]	Inklaar [26]	Junge** [22]	Elias*** [23]	Soderman
	Year	1978	1980	1985	1986	1986	1988	1989	1991	1993	1996	2000	2001	2001
Pelvis/ Groin				7, 2.0%			6	4, 14.8%	7.1%			F = 3, 5.3%; Cz = 10, 7.7%		1, 1.9%
Hip Thigh		16, 12%		51, 14.8%			18		1.8%	21%	11	F = 8, 14.0%; Cz = 22, 16.9%	M = 323, 1.65; F = 106, 1.00	14, 26.9%
Knee		72, 14%	4	35, 10.1%			27	6, 22.2%	26%	15.8%	11	F = 14, 24.6%; Cz = 27, 20.8%	M = 348, 1.89; F = 271, 2.55	8, 15.4%
Leg		67, 13%		35, 10.1%			34		10.9%		7	F = 4, 7.0%; Cz = 7, 5.4%	M = 216, 1.56; F = 104, 0.98	3, 5.8%
Ankle		84, 16%	14	55, 15.9%			41	10, 37.0%	23.1%	13%	8	F = 17, 29.8%; Cz = 27, 20.8%	M = 402, 2.18; F = 308, 2.90	18, 34.6%
Foot		67, 13%		97, 28%			22	2, 7.4%	0.3%	12.8%			M = 196, 1.06; F = 86, 0.81	5, 9.6%
Other							37	5, 18.5%	2.2%		6	F = 11, 19.3%; Cz = 36, 7.7%		

*Comparison of outdoor (O) and indoor (I) soccer.

**Comparison of youth soccer injuries in France (F) and Czech Republic (Cz).

***Comparison of male (M) and female (F) injuries. N = injuries, injuries/1,000 player hours.

lower extremity is involved in approximately 60% of injuries, and is the most common injury location in youth soccer. The knee and ankle are the most common sites of injury, in agreement with the adult literature [6, 11, 33, 34]. Upper extremity injuries account for up to 20% of youth injuries, slightly higher than reported for adults [11, 34].

Concussion/Head Injury

Boden et al. [35] determined the incidence of concussion in female collegiate soccer players to be 0.44 per 1,000 athlete exposures; approximately one concussion every 13.5 weeks or one concussion per team per year. The same group also found that 76% of concussions resulted from player-to-player or player-to-object collision (goal post, elbow, sideline advertisement), and only 24% resulted from head-to-ball contact from a ball kicked at full force at a close range [35].

Knee Injuries

The knee can account for up to 25% of all injuries (table 3), similar to adult soccer populations [6, 7, 9, 26, 33, 36–38]. The high incidence of anterior cruciate ligament (ACL) injuries in young female soccer players is alarming. In adults, ACL injury incidence is 0.10 per 1,000 hours, and other investigators found 0.31 adult ACL injuries per 1,000 hours [9, 39].

More adolescent female than male soccer players required ACL reconstruction over a 6-year period at a pediatric sports specialty center [40]. A 1995 study by Arendt and Dick [41] found that female collegiate soccer and basketball players had a significantly higher ACL injury rate than men (0.31 female vs. 0.16 male per 1,000 athlete exposures) [41]. The 1999–2000 National Collegiate Athletic Association injury surveillance data shows the same pattern in young adults and demonstrates that the injury rate is higher in games than practice [42, 43].

Eye Injuries

In a retrospective review of 15 eye injuries which required ophthalmologic consultation, Orlando [44] found hyphema (bleeding within the anterior eye chamber) to be the most common affliction. Six of the fifteen injuries occurred from an underinflated ball which deformed upon striking the head and entered the orbital area.

Wrist Injuries

Upper extremity injuries occur at a much lower frequency than lower extremity injuries (table 3). However, Junge et al. [30] have shown that goalkeepers suffer more upper extremity injuries than field players, but less injuries

overall (table 3). In 2001, Boyd et al. [45] prospectively collected data on 1,920 new fractures seen at a pediatric orthopedic center over one year, 29 of which were wrist fractures in youth goalkeepers. They found that a significant number of wrist fractures in children older than 11 years occurred as a result of impact from adult-sized (size five) balls, and suggested that young players should use appropriately sized balls.

Situational Factors

Geographical Region

Injury epidemiology can also vary according to country. In 2000, Junge et al. [22] showed that injury incidence did not vary between youth soccer programs in France and the Czech Republic, but that the number of injuries committed secondary to fouls was higher in the Czech Republic. It is therefore important for the team physician, trainer, or coach to recognize that injury patterns can change in different soccer regions or with different styles of play.

Practice versus Game

A FIFA-MARC study reported that half of youth players consider 'fair fouls' a regular part of the game, and that acceptance of intentional rule violations increases with age and experience [46]. As seen in table 1, youth soccer game injury rates are higher than practice rates [10, 25, 42, 43, 47]. The injury rates reported in tournament-related studies are similar to those for game rates, as tournaments consist primarily of games [15, 17, 19, 23]. Game injury rates are much higher in adults, probably because players will compete more intensely during a match [6, 11, 33, 36].

Indoor versus Outdoor

A comparison of studies with injury data on indoor and outdoor soccer is shown in table 4 [32, 48]. The incidence of indoor soccer injuries in adults has been reported as 4.4 per 100 player hours [49], which is similar to outdoor rates for adults [11, 50]. Indoor soccer has a higher incidence than outdoor soccer due to the smaller playing area, use of walls, and artificial surface [32, 48, 49]. However, only one questionnaire-type study directly compared indoor and outdoor soccer in children [32]. In that study, the incidence of injuries is 4.5 times higher for indoor soccer compared to outdoor soccer, injuries increased with increasing age, and children less than 10 years had relatively few injuries for both indoor and outdoor soccer [32]. Lindenfeld et al. [48] prospectively followed a population of children and adults during one indoor soccer season, and found injury rates similar to outdoor soccer (table 4).

Table 4. A comparison of indoor and outdoor injury rates in youth soccer

Study	Year	Age range (in years)	Design P/R	Data collection I/Q	Duration	Number of injuries	Sample number (number of players unless indicated)	Indoor injury rate per 100 hours	Outdoor injury rate per 100 hours	Practice injuries (number of injuries, percent)	Game injuries (number of injuries, percent)	Injury rate, other
Hoff [32]	1986	8–15	P	Q	1 season	Outdoor = 46; Indoor = 74	Outdoor = 455; Indoor = 366	10.11	5.08	Outdoor = 13, 30.2%; Indoor = 4, 5.5%	Outdoor = 33, (69.8%); Indoor = 70, (94.5%)	
Lindenfeld [48]*	1994	7–50	P	I	7 weeks (adults), 3 weeks (kids)	136 (all)	300 games	All ages = 5.0; <12 yrs: M = 2.8, F = 5.6; 12–15 yrs: M = 4.4, F = 6.3; 16–18 yrs: M = 4.9, F = 4.6				

*Comparison of male (M) and female (F) injuries.

Table 5. A comparison of injury rates and injury mechanism in youth soccer. All studies are prospective unless indicated

Study	Number of injuries	Number of injuries with player contact (N, %, unless indicated)	Number of injuries without player contact (N, %, unless indicated)
Heidt [53]*	Trained = 7; Control = 91	All players = 36, 37%; Trained = 3, 42.9%; Control = 33, 36.3%	All players = 62, 63%; Trained = 7, 57.1%; Control = 55, 63.7%
Junge [22]**	France = 58; Czech = 130	France = 28; Czech = 58	France = 20; Czech = 70
Junge [28]*	Trained = 77; Control = 111	Trained = 0.43 per player per year; Control = 0.74 per player per year [‡]	Trained = 0.34 per player per year; Control = 0.45 per player per year
Kibler [21]	179	56.3%	

*Study involved comparison of group with preseason injury prevention program (Trained) and control group (Control).

**Not all injuries had exact injury mechanism.

[‡]Statistically significant value ($p < 0.05$) between two groups.

Action or Activity

The outcome of certain injuries is related to the injury mechanism. For example, severe adult ankle injuries are more likely to occur from a contact situation where the foot is planted on the ground [51], while Delfico and Garrett [52] showed that 72% of ACL injuries in soccer occurred from noncontact situations [52]. A comparison of injury mechanisms in youth soccer is shown in table 5 [21, 22, 28, 53]. In the pediatric population, player-to-player contact accounted for approximately half of the injuries [22], and contact occurred in one third of the injuries [53]. Two studies have compared controls to a group of youth players who underwent preseason conditioning [28, 53]. In one study, the control group suffered more injuries due to player-to-player contact, and this could indicate that fitter players are less likely to be hurt during contact situations, such as tackling or heading [28]. In the other investigation, there was no difference in the number of injuries in controls and conditioned players, although this finding may be incidental due to the number of participants [53]. Youth players are most frequently injured during tackles, while professionals are most frequently injured while running. This could indicate that adults or better conditioned adolescents fare better in contact situations [25].

Chronometry

Injury Time During Game/Practice

Drawer and Fuller [12] showed that in professional and World Cup soccer more injuries occur during the second half of a game [6, 33, 37]. In college athletes, a similar game pattern was found, but no relationship to practice time was found [42, 43].

Time of Year

There is a correlation between heat illness and summer soccer tournaments: heat illnesses accounted for 4.5% of injuries in a summer tournament [21]. Elias [23] studied a large summer tournament in Minnesota for over 10 years, and found that the number of heat related illness cases were related to the ambient temperature. Physicians, coaches and trainers should be aware of potential dehydration, and encourage frequent water breaks during summer camps and tournaments [54, 55].

Injury Severity

Injury Type

A summary of studies reporting injury type data is shown in table 6. [10, 13–16, 18, 19, 21, 23, 32, 35, 44, 53, 56, 57] As with adult soccer injury studies [34, 37, 50], contusions represent the most common injury in youth soccer (25–47%). Sprains (20–35%) and muscular strains (8–25%) are also common, and fortunately fractures/dislocations are uncommon and represent approximately 3–12% of injuries reported.

Avulsion Fractures

Rossi and Dragoni [57] reviewed 238 radiographs taken for acute pelvic pain during sports, and found that the prevalence of avulsion fractures in the pelvis in youth soccer is 17.7% (74 of 418 radiographs). The ischial tuberosity was the most common avulsion site (table 6).

Catastrophic Injuries

Fortunately, catastrophic injuries in soccer are rare. A summary of catastrophic injuries in youth soccer is shown in table 7 [58–60]. Death in youth soccer is usually related to falling goalposts. Goalposts rarely fall during the course of normal play, and most accidents related to goalposts are due to climbing or hanging from the goalposts [58, 59]. Goalposts should be properly secured, and the playing field should be cleared of all debris to create a safe environment [60, 61]. In 2003, Filipe et al. [62] outlined the severity and long-term sequelae of 168 eye injuries in soccer. Forty-eight of the 168 injuries occurred among

Table 6. Injury types in youth soccer. All studies prospective unless indicated

Study	Total number of injuries	Abrasion	Contusion	Concussion	Laceration	Fracture/ Dislocation	Pain (site)	Sprain	Strain	Tendonitis/ Inflammation	Other
Nilsson [15]	1,534	336, 39%	306, 36%			29, 3.5%		174, 20% (strains and sprains)			13, 1.5%
Sullivan [16]	34		13, 38.2%			3, 8.8%		12, 35.3%	3, 8.8%		3, 8.8%
McCarroll [14]	176		44, 25.0%	5, 2.8%		22, 12.5%		47, 26.7%	17, 9.7%		41, 23.3%
Hoff [32]*	O = 46; I = 74		O = 8; I = 14			O = 1; I = 7		O = 16; I = 30	O = 11; I = 17		O = 10; I = 6
Maehlum [19]	411		193, 47.0%		74, 18.0%	27, 6.6%		89, 21.7%			28, 6.8%
Backous [13]	216	4	69					35	61	10	37
Schmidt-Olsen [18]	312			1.2%		4%	14% (back)				
Kibler [21]	179		32%	1.5%		9%		21.8%	24.5%		4.5%
Jones [56]**	23					Blow-out fracture = 7					
Inklaar [26]	83		12			2		14	7		8
Heidt [53]	98		15			7		25	23	9	
Elias [23]****	3,840			71, 0.24 per 1,000 h		164, 0.56 per 1,000 h		577, 1.99 per 1,000 h (ankle sprain only)			
Soderman Injury specific studies	79		8			4	19	25	15	3	5

Orlando [44]**	15	Hyphema = 9	Secondary glaucoma = 3	Retinal edema = 5	Corneal laceration = 1	Blow-out fracture = 1	Lid laceration = 1	Angle recession = 5	Chorioretinal rupture = 2
Boden [35]***	29								
Rossi [57]*****	All sports = 203; Soccer = 74	Ischial tuberosity = 34	Anterior inferior iliac spine = 18	Anterior superior iliac spine = 15	Superior corner of pubic symphysis = 6	Iliac crest = 1			

*Comparison of outdoor (O) and indoor (I) soccer.

**Retrospective study including only eye injuries in soccer.

***Investigation of concussions during 2 soccer seasons.

****Not all injury types reported in study.

*****Retrospective study of pediatric pelvic avulsion fractures. All injuries reported represent avulsion fractures.

Table 7. Catastrophic injuries in youth soccer

Study	Total number of injuries	Mechanism	Fatal injuries	Contusion	Concussion	Laceration	Fracture	Cardiac injury	Other	Comment
Blond [58]	117	Falling goalpost	2	40	6	25	37		9	Fatal and severe injury were due to hanging on the goalposts
DeMarco [59]	27	Falling goalpost	18							Goalposts should be secured properly
Stephenson [60]	1	Cranium impaled on fence	1							Fences and debris should be positioned away from playing field

children: Thirty-five were severe (causing permanent visual deficit), and 13 were nonsevere.

Time Loss

A comparison of injury severity in youth soccer is shown in table 8 [10, 16, 21, 22, 28]. The definition of injury and the grading of injury severity varies in the available studies on pediatric soccer injuries. The most widely accepted definition is from Engström et al. [63]. However, the FIFA-MARC has recently modified the definition to include chronic injuries [5, 30] as follows:

- (1) Minor Acute: Absence from participation more than one day, but less than one week.
- (2) Moderate Acute: Absence from participation of more than 1 week, but less than 4 weeks.
- (3) Severe Acute: Absence from participation of more than 4 weeks.
- (4) Minor Chronic: Complaint of pain for more than 2 weeks, but less than 4 weeks that does not prevent participation.
- (5) Moderate Chronic: Complaint of pain for more than 4 weeks that does not prevent participation.
- (6) Severe Chronic (e.g. stress fractures).

Review of the data in table 8 shows that approximately 70–80% of the injuries in youth soccer are minor or moderate, and do not result in a significant loss of time from play. Of 113 severe injuries (both pediatric and adult) that resulted in greater than 4 weeks absence from play, 22.7% occurred in players less than 16 years old, and 25.3% occurred in players aged 16–18 years. Also, the incidence of severe injuries was twice as high in low skilled players compared to highly skilled players [64].

Injury Outcome

An awareness of the propensity for knee injuries in female soccer players is particularly important for the sports medicine professional, as 12 years postinjury, 34% of previous female soccer players in Sweden who suffered an ACL injury have radiographic changes consistent with osteoarthritis [65]. Although there have been no longitudinal studies on the long-term outcome of pediatric soccer injuries, the incidence of hip and knee arthritis for former adult soccer players is much higher when compared to age-matched controls [66, 67].

The relationship of chronic traumatic brain injury and soccer remains a controversial topic, as soccer players exhibit deficiencies in memory and planning compared to controls [68, 69]. In contrast, a recent study used similar neuropsychological tests to those used by Matser et al. [69], and showed that soccer-related concussions were not associated with impaired neurocognitive function [70]. A laboratory study in which a size four ball was lobbed from

Table 8. A comparison of injury severity in youth soccer. All studies are prospective unless indicated

Study	Year	Sample number (number of players unless indicated)	Minor injury	Moderate injury	Severe or major injury
Sullivan	1980	1,272		7	1
Kibler*	1993	74,900 player hours	1st degree = 38%; 1st degree + = 24.5%	2nd degree = 21.8%; 2nd degree + = 7%	3rd degree = 8%; 3rd degree + = 0.6%
Junge**	2000	France = 131; Czech = 180	France = 40.4%; Czech = 40.0%	France = 31.6%; Czech = 35.45%	France = 28.1%; Czech = 24.6%
Soderman**	2001	175	26	41	11
Junge**	2002	Trained = 101; Control = 93	Trained = 0.46; Control = 0.80 [‡]	Trained = 0.17; Control = 0.24	Trained = 0.14; Control = 0.16

*Moderate = >7 days missed, Severe = season out.

**No clarification of 1st – 3rd degree rating system provided by author.

***Mild ≥ 1 week loss of participation, Moderate = 2–3 weeks loss of participation, Severe = > 4 weeks loss of participation; N = percentage of injuries.

****Minor = 0–7 days absent, Moderate = 7–30 days absent, Major = >30 days absent; N = number of injuries.

[‡]Statistically significant value (p < 0.05).

three meters found that the greatest peak accelerometer readings had a head injury criteria of only 61, where 1,000 is threshold for brain injury [71]. Naunheim et al. [72] measured head impacts by a triaxial accelerometer placed in a helmet and showed that significantly higher values were reached in soccer than in hockey or football. However, all soccer values were much lower than the impact values needed to cause acute brain injury.

Janda et al. [73] tested the use of padded goalposts in 471 games: no injuries resulted from 7 player/padded post collisions during a 3-year study [73]. They also tested the padded goal posts in the laboratory and showed that the modified posts, even after 2 years of outside exposure, significantly decreased object to post impact force.

Injury Risk Factors

Dangerous Play

Injuries resulting from fouls are potentially preventable injuries. The punishments of a free kick and a yellow or red card for foul tackles are risk control measures that are intended to modify players' behaviors to minimize the number of unsafe acts that expose players to high risk situations. In a study of 4 FIFA tournaments, 63% of tackles that resulted in foot and ankle injuries were deemed to be the result of foul play [51]. Moreover, FIFA [74] specifically declared before the 1998 World Cup competition in France that referees should treat tackles from behind as a foul. Despite this ruling, the proportion of injuries caused by tackles from behind was still high (24%) in the four competitions assessed by Giza et al. [51]. Therefore, youth soccer matches should have adequate refereeing and adhere to the FIFA 'Fair Play' principles [74].

Most concussions are related to collision with another player or the post. Concussions are more likely to occur with rough play, on small fields, and in the penalty area [75].

Age

Soderman [76] found that 59% of females below the age of 16 years playing on senior teams (teams with an average age over 20 years) sustained ACL injuries during contact situations. The authors suggested that female soccer players under the age of 16 years should not be allowed to participate in games at a senior level [76].

Gender

The three to four times higher rate of ACL tear in females compared to males has been attributed to many factors, including joint laxity, core stability,

hormonal influence, femoral notch size, and hamstring weakness [9, 77–79]. A recent study in a sheep model by Strickland et al. [80] demonstrated that estrogen did not have an effect on failure of the ACL. However, others have shown an increase in ACL injuries during the ovulatory phase of menstruation [79]. The gender discrepancy in ACL tears appears to be a combination of dynamic factors [78], and there is a low correlation between isokinetic strength measurements and functional tests in adult female soccer players [81].

Level of Play

Elite and professional players achieve a higher level of fitness than recreational players [82], and this fitness level may be protective. Junge et al. [47] have shown a lower injury rate in elite players compared to less skilled players, and a prospective cohort study from the FIFA-MARC showed that the incidence of soccer injuries can be reduced by preventative interventions, especially in low-skill level youth teams [28]. A review of injuries in the elite Women's United Soccer Association by Giza et al. [7] found a relatively low ACL injury rate of 0.09 per 1,000 hours which could represent a 'pre-selection' phenomenon in which players who are at risk for an ACL injury may have had an injury earlier in their career and not reached the Women's United Soccer Association or have had a reconstruction prior to their participation in the Women's United Soccer Association.

Physical Maturity

In 1988, Backous et al. [13] found that boys with the highest incidence of injury were tall (greater than 165 cm) and had a weak grip (less than 25 kg), suggesting that skeletally mature but muscularly weak boys may be more susceptible to injury while playing soccer with peers of the same chronological age.

Suggestions for Injury Prevention

The studies that have addressed injury prevention are summarized in table 9 [28, 53, 71–73, 81, 83, 84]. Review of this table suggests the following preventive measures which are discussed below: shin guards, preseason conditioning, and recognition of physical capabilities.

Shin Guards

While other sports include the use of protective equipment, the main source of protection in soccer is shin guards. Shin guards most likely reduce the incidence of soft tissue injuries, but clinical evidence is lacking. Boden et al. [85] investigated thirty-one fractures of the tibia and fibula in soccer, and found that

Table 9. Suggestions for injury prevention and improved fitness in youth soccer

Study	Year	Design	Purpose	Findings	Conclusions
Junge [28]	2002	Prospective, cohort	Evaluate the effects of a prevention program on the incidence of soccer injuries in male youth amateur players	The prevention group had significantly less players injured (Prevention = 53, Control = 67, $p < 0.001$) For low skilled players, the prevention group had significantly less injuries per 1,000 player hours (Prevention = 6.95, Control = 11.1, $p < 0.05$)	The incidence of soccer injuries can be reduced by preventative interventions, especially in low-skill level youth teams
Heidt [53]	2000	Prospective, cohort	Evaluate the role that preseason conditioning had on the occurrence and severity of injury in female soccer players	Less injuries in the preseason training group (Training = 14%, 6 injuries in 42 players; Control = 33.7%, 87 injuries in 258 players)	Preseason conditioning resulted in an overall reduction of injuries to adolescent women playing competitive soccer
Hewett [83]	1999	Prospective, multiple sports	To test the effect of neuromuscular training on the incidence of knee injury in female athletes	97 trained females, 193 untrained females, and 209 male control soccer players were compared 6 severe knee injuries occurred in 5 untrained females and 1 male control No injuries occurred in the trained female group	Decreased incidence of knee injury in female soccer players compared to untrained females utilizing a group of male controls. Subset reported of soccer, but study included basketball and volleyball also

Table 9 (continued)

Study	Year	Design	Purpose	Findings	Conclusions
Janda [73]	1995	Part I: Prospective Part II: Laboratory testing of goalposts	Present laboratory and clinical experience with padded goal posts for preventing head injury in soccer	Padded goal posts significantly decrease object to post impact force in laboratory testing. No injuries resulted from 7 player/padded post collisions during a 3-year study	Subjective questioning of players and coaches revealed did not feel that padded posts negatively effected game play or outcome
Naunheim [72]	2000	Prospective measurements of force in hockey and football, laboratory testing of heading in soccer	To compare acceleration forces to the head in high school-level football, hockey and soccer players	Hockey and football scores from impact during game, but soccer from ball from 30 yards traveling 39 mph Peak g's: Football = 29, Hockey = 35, Soccer = 55	Impacts measured by a triaxial accelerometer placed in a helmet were significantly higher in soccer than in hockey or football; however, all soccer values were much lower than the impact of 200 g needed to cause acute brain injury
Reed [71]	2002	Part I : Eye exam regular play Part II: Field testing of soccer ball to head impact with accelerometer	Define forces of youth soccer heading and determine if it is linked to retinal hemorrhage	After 2 weeks of regular play with an average of 79 headers, eye exams in 21 soccer players were no different than 30 controls With ball lobbed from 3 meters, the mean peak cranial acceleration was 3.7 ± 1.3 Even for greatest impact observed, head injury criteria = 61, where 1,000 is threshold for brain injury	Routine headers not associated with globe impact are unlikely to cause retinal hemorrhage

Diallo [84]	2001	Laboratory testing on group of soccer players and controls	To determine the effects of short-term plyometric training and detraining on motor performance in pubescent soccer players	10 weeks of specific plyometric training revealed a significant increase in jump, running, and sprint-cycling performances vs. controls Results remained after 8 weeks of detraining
Ostenberg [81]	1998	Laboratory testing on different age groups of female soccer players	Compare isokinetic knee muscle strength, functional performance, aerobic capacity, and general joint laxity between female soccer players >20 years old and <20 years old	Younger players had significantly lower values of isokinetic knee flexor strength, older players had a significantly higher BMI No significant differences for functional performance tests, aerobic capacity, or general joint laxity

90% of players were wearing shin guards at the time of injury, and commented that shin guards are not likely to be helpful after a certain critical force is exceeded. Boden also reviewed the biomechanical studies that have been performed on shin guards and summarized that shin guards decrease the magnitude of forces on the tibia by prolonging the contact time. Depending on the type of shin guard, the load forces were reduced by 41.2–77.1% [31].

Preseason Conditioning

Some authors have shown that preseason neuromuscular training and plyometrics can decrease knee injury rates in females [53, 83, 86]. Heidt et al. [53] evaluated the role that preseason conditioning had on the occurrence and severity of injury in 300 female high school soccer players. The conditioning group of 42 players suffered 6 injuries (one ACL tear), while the control group of 258 players suffered 87 injuries (8 ACL tears) [53]. Hewett et al. [83] performed a prospective cohort study in high school soccer, basketball, and volley ball players in which knee injuries were compared between a preseason conditioned group, a nonconditioned group, and male controls. They found that six severe knee injuries occurred in 5 untrained females and one male control, and that no injuries occurred in the trained female group. Both studies show the positive trends of preventative training, but studies with a large, national injury registry will be needed to statistically prove their effect. In a 3-year prospective study using proprioceptive training for semi-professional soccer players, Caraffa et al. [87] found a significantly lower rate of ACL injury in the trained team compared to the untrained controls [88].

The advent of competitive soccer in the United States has resulted in the opportunity for youngsters to play soccer year round. While increased play can lead to improved skill levels, balance of training is important. Diallo et al. [84] compared a group of 12-year-old boys who underwent a strengthening and fitness program to a control group who only played soccer. They showed that 10 weeks of specific plyometric training resulted in a significant increase in jump, running, and sprint-cycling performances versus controls. They also found that the results remained even after 8 weeks of detraining [84].

Physical Capabilities

The maturation process can also effect the level of play that a soccer athlete achieves. Malina et al. [89] performed a laboratory study on groups of 12-year-old soccer players where height, body mass index, chronological and skeletal age were compared to physical capabilities. They found that elite soccer systematically excludes late maturing boys and favors average and early maturing boys. Reilly et al. [82] have shown that there are anthropometric and physiological predispositions for elite soccer. They state that players may not

need to have an extraordinary capacity within any areas of physical performance criteria, but must possess a reasonably high level within all areas, such as muscle strength, aerobic capacity, speed, and coordination. Player position is also related to his or her physiological capacity. Thus, mid-field players and defenders have the highest maximal oxygen intakes and perform best on intermittent exercise tests.

Suggestions for Future Research

Kirkendall and associates at the United States Soccer Federation have commented that, to further our understanding of the relationship between heading, head injury and cognitive deficits, we need to: learn more about the actual impact of a ball on the head, verify the exposure to heading at all ages and competitive levels, determine stable estimates of concussive injury rates across the soccer spectrum, conduct prospective longitudinal studies on soccer players focusing on exposure, injury and cognition, and determine the minimum safe age to begin instruction on the skill of heading [75]. Until the above suggestions can be accomplished, it is important for coaches to teach young soccer players correct heading techniques, such as centering the ball on the forehead, correct timing, and strengthening of the neck muscles. It is also important that parents and coaches are aware of the type of ball used. The balls should be made of a light-weight material that does not readily absorb water during rainy or wet conditions. All young children should use size three balls, and older children should use size four balls. The use of standard size five balls should be reserved for adults and adult-sized teenagers.

Future research should be directed towards longitudinal outcome studies of pediatric soccer injuries to identify those injuries which preclude continuation of the game into adulthood. To accomplish this difficult epidemiological task, injury data surveillance systems will be needed. Currently, comprehensive databases which track injury diagnosis, treatment and outcomes are in place in the National Collegiate Athletic Association and Major League Soccer. Inclusion of these databases by the United States Soccer Federation youth programs is the best model to follow players throughout an established soccer system.

References

- 1 Metzl JD: Sports-specific concerns in the young athlete: Soccer. *Pediatr Emerg Care* 1999; 15:130–134.
- 2 Metzl JD, Micheli LJ: Youth soccer: An epidemiologic perspective. *Clin Sports Med* 1998; 17:663–673.
- 3 Soccer Industry Council of America: North Palm Beach, FL 33048: Soccer Industry Council of America; 1999.

- 4 Jones SJ, Lyons RA, Sibert J, Evans R, Palmer SR: Changes in sports injuries to children between 1983 and 1998: Comparison of case series. *J Public Health Med* 2001;23:268–271.
- 5 Dvorak J, Junge A: Football Injuries and Physical Symptoms. *Am J Sports Med* 2000;28:S3–S9.
- 6 Hawkins R, Fuller C: A prospective epidemiological study of injuries in four English professional football clubs. *Br J Sports Med* 1999;33:196–203.
- 7 Giza E, Mithoefer K, Farrell L, Zarins B, Gill T: Injuries in Women's Professional Soccer. *Br J Sports Med* 2004. In Print.
- 8 Engstrom B, Johansson C, Tornkvist H: Soccer injuries among elite female players. *Am J Sports Med* 1991;19:372–375.
- 9 Ostenberg A, Roos H: Injury risk factors in female European football. A prospective study of 123 players during one season. *Scand J Med Sci Sports* 2000;10:279–285.
- 10 Soderman K, Adolphson J, Lorentzon R, Alfredson H: Injuries in adolescent female players in European football: A prospective study over one outdoor soccer season. *Scand J Med Sci Sports* 2001;11:299–304.
- 11 Inklaar H: Soccer injuries I: Incidence and severity. *Sports Med* 1994;18:55–73.
- 12 Drawer S, Fuller C: An economic framework for assessing the impact of injuries in professional football. *Safety Science* 2001;39:in press.
- 13 Backous DD, Friedl KE, Smith NJ, Parr TJ, Carpine WD Jr: Soccer injuries and their relation to physical maturity. *Am J Dis Child* 1988;142:839–842.
- 14 McCarroll J, Meaney C, Sieber J: Profile of Youth Soccer Injuries. *Phys Sportsmed* 1984;12:113–117.
- 15 Nilsson S, Roaas A: Soccer injuries in adolescents. *Am J Sports Med* 1978;6:358–361.
- 16 Sullivan J, Gross R, Grana W, Garcia-Moral C: Evaluation of injuries in youth soccer. *Am J Sports Med* 1980;8:325–327.
- 17 Schmidt-Olsen S, Bunemann LK, Lade V, Brassoe JO: Soccer injuries of youth. *Br J Sports Med* 1985;19:161–164.
- 18 Schmidt-Olsen S, Jorgensen U, Kaalund S, Sorensen J: Injuries among young soccer players. *Am J Sports Med* 1991;19:273–275.
- 19 Maehlum S, Dahl E, Daljord O: Frequency of injuries in a youth soccer tournament. *Phys Sportsmed* 1986;14:73–79.
- 20 Maehlum S, Daljord O, Hansen KJ: Frequency of injuries in youth soccer. *Med Sci Sports* 1999;31:S401.
- 21 Kibler W: Injuries in adolescent and preadolescent soccer players. *Med Sci Sports Exerc* 1993;25:1330–1332.
- 22 Junge A, Chomiak J, Dvorak J: Incidence of football injuries in youth players. *Am J Sports Med* 2000;28:S47–S57.
- 23 Elias SR: 10-year trend in USA Cup soccer injuries: 1988–1997. *Med Sci Sports Exerc* 2001;33:359–367.
- 24 Maehlum S, Daljord OA: Football injuries in Oslo: A one-year study. *Br J Sports Med* 1984;18:186–190.
- 25 Nielsen A, Yde J: Epidemiology and traumatology of injuries in soccer. *Am J Sports Med* 1989;17:803–807.
- 26 Inklaar H, Bol E, Schmikli S: Injuries in Male Soccer players: Team risk analysis. *Int J Sports Med* 1996;17:229–234.
- 27 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.
- 28 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.
- 29 Powell JW, Barber-Foss KD: Traumatic brain injury in high school athletes (comment). *JAMA* 1999;282:958–963.
- 30 Junge A, Chomiak J, Peterson L, Graf-Baumann T, Dvorak J: Goalkeepers – Physical performance, psychological characteristics and incidence of injuries. *Personal Communication* 2001.
- 31 Boden B: Leg injuries and shin guards. *Clin Sports Med* 1998;17:769–777.
- 32 Hoff G, Martin T: Outdoor and indoor soccer: Injuries among youth players. *Am J Sports Med* 1986;14:231–233.

- 33 Hawkins R, Hulse M, 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.
- 34 Inklaar H: Soccer injuries II: Aetiology and prevention. *Sports Med* 1994;18:81–93.
- 35 Boden B, Kirkendall D, Garrett W: Concussion incidence in elite college soccer players. *Am J Sports Med* 1998;26:238–241.
- 36 Dvorak J, Peterson L, Junge A: Risk factors and incidence of injury in football players. *Am J Sports Med* 2000;28:1–74.
- 37 Hawkins R, Fuller C: 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.
- 38 Ekstrand J, Gillquist J: Soccer injuries and their mechanisms: A prospective study. *Med Sci Sports* 1983;15:267–270.
- 39 Bjordal JM, Arnly F, Hannestad B, Strand T: Epidemiology of anterior cruciate ligament injuries in soccer. *Am J Sports Med* 1997;25:341–345.
- 40 Micheli LJ, Metzl JD, Di Canzio J, Zurakowski D: Anterior cruciate ligament reconstructive surgery in adolescent soccer and basketball players. *Clin J Sport Med* 1999;9:138–141.
- 41 Arendt E, Dick R: Knee injury patterns among men and women in collegiate basketball and soccer NCAA data and review of literature. *Am J Sports Med* 1995;23:694–701.
- 42 NCAA. Injury Surveillance System, Men's Soccer. Indianapolis: National Collegiate Athletic Association; 2000.
- 43 NCAA. Injury Surveillance System, Women's Soccer. Indianapolis: National Collegiate Athletic Association; 2000.
- 44 Orlando R: Soccer-related eye injuries in children and adolescents. *Phys Sportsmed* 1988;16:103–106.
- 45 Boyd KT, Brownson P, Hunter JB: Distal radial fractures in young goalkeepers: A case for an appropriately sized soccer ball. *Br J Sports Med* 2001;35:409–411.
- 46 Junge A: The influence of psychological factors on sports injuries. *Am J Sports Med* 2000;28:S10–S15.
- 47 Junge A, Dvorak J, Chomiak J, Peterson L, Graf-Baumann T: Medical history and physical findings in football players of different ages and skill levels. *Am J Sports Med* 2000;28:S16–S21.
- 48 Lindenfeld T, Schmitt D, Hendy M, Mangine R, Noyes F: Incidence of injury in indoor soccer. *Am J Sports Med* 1994;22:364–371.
- 49 Putukian M, Knowles W, Swere S, Castle N: Injuries in indoor soccer. *Am J Sports Med* 1996;24:317–322.
- 50 Dvorak J, Junge A, Chomiak J, Graf-Baumann T, Peterson L, Rosch D, Hodgson R: Risk factor analysis for injuries in football players. *Am J Sports Med* 2000;28:S69–S74.
- 51 Giza E, Fuller C, Junge A, Dvorak J: Mechanisms of foot and ankle injuries in soccer. *Am J Sports Med* 2003;31:550–554.
- 52 Delfico A, Garrett W: Mechanisms of injury of the ACL in soccer players. *Clin Sports Med* 1998;17:779–785.
- 53 Heidt RS Jr, Sweeterman LM, Carlonas RL, Traub JA, Tekulve FX: Avoidance of soccer injuries with preseason conditioning. *Am J Sports Med* 2000;28:659–662.
- 54 Casa D, Armstrong L, Hillman S, Montain S, Reiff R, Rich B, Roberts W, Stone J: National Athletic Trainers' Association Position Statement: Fluid replacement for athletes. *J Athl Train* 2002;35:212–224.
- 55 Binkley H, Beckett J, Casa D, Kleiner D, Plummer P: National Athletic Trainers' Association Position Statement: Exertional heat illness. *J Athl Train* 2002;37:329–343.
- 56 Jones N: Orbital blowout fractures in sport. *Br J Sports Med* 1994;28:272–275.
- 57 Rossi F, Dragoni S: Acute avulsion fractures of the pelvis in adolescent competitive athletes: Prevalence, location, and sports distribution of 203 cases collected. *Skeletal Radiol* 2001;30:127–131.
- 58 Blond L, Hansen L: Injuries caused by falling soccer goalposts in Denmark. *Br J Sports Med* 1999;33:110–112.
- 59 DeMarco J, Reeves C: Injuries associated with soccer goalposts – United States, 1979–1993. *MMWR* 1994;43:153–155.

- 60 Stephenson G, Gibson R: Fatal penetrating head injury during a game of soccer. *Injury* 1992;23:197–198.
- 61 Fuller C, Hawkins R: Assessment of football grounds for player safety. *Safety Science* 1997;2: 115–128.
- 62 Filipe JC, Fernandes V, Barros H, Falcao-Reis F, Castro-Correia J: Soccer-related ocular injuries. *Arch Ophthalmol* 2003;121:687–694.
- 63 Engstrom B, Forssblad M, Johansson C, Tornkvist H: Does a major knee injury definitely sideline an elite soccer player? *Am J Sports Med* 1990;18:101–105.
- 64 Chomiak J, Junge A, Peterson L, Dvorak J: Severe injuries in football players. *Am J Sports Med* 2000;28:S58–S68.
- 65 Roos H, Ostenberg A, Lohmander L: High prevalence of knee OA and functional limitations in female soccer players with ACL injury. Conference Proceedings: Presentation on female soccer injuries; Gothenburg, Sweden; October 2001.
- 66 Larsen E, Jensen P, Jensen P: Long term outcome of knee and ankle injuries in elite football. *Scand J Med Sci Sports* 1999;9:285–289.
- 67 Lindberg H, Roos H, Gardsell P: Prevalence of coxarthrosis in former soccer players. *Acta Orthop Scand* 1993;64:165–167.
- 68 Tysvaer AT: Head and neck injuries in soccer. Impact of minor trauma. *Sports Med* 1992;14: 200–213.
- 69 Matser E, Kessels A, Lezak M, Jordan B, Troost J: Neuropsychological impairment in amateur soccer players. *JAMA* 1999;282:971–973.
- 70 Guskiewicz KM, Marshall SW, Broglio SP, Cantu RC, Kirkendall DT: No evidence of impaired neurocognitive performance in collegiate soccer players. *Am J Sports Med* 2002;30: 157–162.
- 71 Reed W, Feldman K, Weiss A, Tencer A: Does soccer ball heading cause retinal bleeding? *Arch Pediatr Adolesc Med* 2002;156:337–340.
- 72 Naunheim R, Standeven J, Richter C, Lewis L: Comparison of impact data in hockey, football, and soccer. *J Trauma* 2000;48:938–941.
- 73 Janda D, Bir C, Wild B, Olson S, Hensinger R: Goal Post injuries in soccer. *Am J Sports Med* 1995;23:340–344.
- 74 FIFA. FIFA Handbook, Laws of the Game. Zurich: FIFA; 1998.
- 75 Kirkendall DT, Jordan SE, Garrett WE: Heading and head injuries in soccer. *Sports Med* 2001; 31:369–386.
- 76 Soderman K, Pietila 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.
- 77 Soderman K, Alfredson H, Pietila T, Werner S: Risk factors for leg injuries in female soccer players: A prospective investigation during one out-door season (comment). *Knee Surg Sports Traumatol Arthrosc* 2001;9:313–321.
- 78 Ireland ML: The female ACL: Why is it more prone to injury? *Orthop Clin North Am* 2002;33: 637–651.
- 79 Wojtys EM, Huston LJ, Boynton MD, Spindler KP, Lindenfeld TN: The effect of the menstrual cycle on anterior cruciate ligament injuries in women as determined by hormone levels. *Am J Sports Med* 2002;30:182–188.
- 80 Strickland S, Belknap T, Turner S, Wright T, Hannafin J: Lack of hormonal influences on mechanical properties of sheep knee ligaments. *Am J Sports Med* 2003;31:210–215.
- 81 Ostenberg A, Roos E, Ekdahl C, Roos H: Isokinetic knee extensor strength and functional performance in healthy female soccer players. *Scand J Med Sci Sports* 1998;8:257–264.
- 82 Reilly T, Bangsbo J, Franks A: Anthropometric and physiological predispositions for elite soccer. *J Sports Sci* 2000;18:669–683.
- 83 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 (comment). *Am J Sports Med* 1999;27:699–706.
- 84 Diallo O, Dore E, Duche P, Praagh EV: Effects of plyometric training followed by a reduced training programme on physical performance in prepubescent soccer players. *J Sports Med Phys Fitness* 2001;41:342–348.

- 85 Boden BP, Lohnes JH, Nunley JA, Garrett WE Jr: Tibia and fibula fractures in soccer players. *Knee Surg Sports Traumatol Arthrosc* 1999;7:262–266.
- 86 Silvers HJ, Mandelbaum BR: Preseason conditioning to prevent soccer injuries in young women. *Clin J Sport Med* 2001;11:206.
- 87 Caraffa A, Cerulli G, Proietti 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.
- 88 Cerulli G, Benoit DL, Caraffa A, Ponteggia F: Proprioceptive training and prevention of anterior cruciate ligament injuries in soccer. *J Orthop Sports Phys Ther* 2001;31:655–660; discussion 61.
- 89 Malina R, Reyes MP, Eisenmann J, Horta L, Rodrigues J, Miller R: Height, mass and skeletal maturity of elite Portuguese soccer players aged 11–16 years. *J Sports Sci* 2000;18:685–693.

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