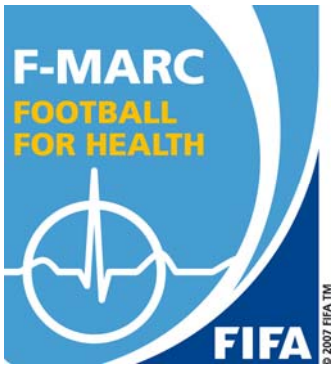

Mario Bizzini

Injuries and musculoskeletal complaints in football referees

DISSERTATION FROM THE NORWEGIAN SCHOOL OF SPORT SCIENCES – 2010

Oslo Sports Trauma
RESEARCH CENTER

Summary

Football (soccer) is the the most popular sport worldwide, with a constantly increasing number of male and – moreover – female players. There would be no official football match without the referee and the two assistant referees. The three officials are responsible for ensuring that the players follow the Laws of the Game. Over the last ten years, several studies have examined various aspects of the referee's performance and training. However, contrary to players, there is a lack of research on injuries in football referees. Therefore, the main aim of this thesis was to investigate the injuries and musculoskeletal complaints of male and female football referees at different levels of performance.

Paper I. During the spring of 2006, all seventy-one referees (including 5 females) of the two top divisions of the Swiss Football League (season 2005-06) participated in a survey. They answered a questionnaire on their personal characteristics, referee qualifications, time spent in training and matches, career history of injuries and musculoskeletal complaints caused by training or refereeing, and were subsequently interviewed about the location, type, circumstances and consequences of reported injuries. Forty-four percent of the referees reported at least one injury during their career. Injuries incurred more frequently in training than during matches, and all injuries reported resulted in at least two weeks of absence from sport. About a quarter of the referees reported an injury and almost 90% of the referees reported musculoskeletal complaints caused by refereeing during the preceding 12 months. In male referees, hamstring strains and ankle sprains were the most common injuries, whilst the hamstrings, knee, Achilles tendon and calf were the most prevalent locations of musculoskeletal complaints.

Paper II. During the preparation camps for the 2006 FIFA World Cup™ in Germany, all 123 referees pre-selected for the tournament completed a questionnaire on injuries and musculoskeletal complaints. During the tournament, the characteristics and consequences of all injuries and complaints incurred by the 63 officiating referees were documented. More than 40% of the referees reported having incurred an injury and more than 60% having had musculoskeletal complaints during their career. During the World Cup, fourteen referees (22%) incurred an injury and more than 30% had musculoskeletal complaints. This prospectively collected data showed an incidence of 20.8 injuries per 1000 match hours (95% CI: 4.17 to 37.4). The most common acute

injuries were hamstring strains, calf strains, and ankle sprains, while the most frequent locations of complaints were the low back, hamstring and knee.

Paper III. During the preparation camps a few months prior to the FIFA Women's World Cup 2007, all pre-selected 81 female referees completed a questionnaire on injuries and musculoskeletal complaints. During the final 32 matches of the tournament in China, all injuries, musculoskeletal complaints and related treatment of the 36 officiating referees were documented. Almost 50% of the referees reported having incurred at least one injury during their career that had led to time loss from the game, and almost 80% reported musculoskeletal complaints related to refereeing. Fourteen referees (39%) incurred an injury during the World Cup, and 17 (33%) were treated for musculoskeletal complaints. The most common location of injuries and complaints were hamstrings, quadriceps, calf, and ankle. The prospectively collected data showed an incidence of 34.7 match injuries per 1000 match hours (95% CI: 4.2 to 65.1).

Paper IV. A representative sample of 489 Swiss referees (of all levels of performance) were interviewed regarding their socio-demographic characteristics, refereeing qualifications, time spent in training and in matches, history of injuries and musculoskeletal complaints caused by training or refereeing, and other medical problems. A total of 110 referees (22.5%) reported having suffered at least one injury related to officiating, and 126 referees (25.8%), at least one refereeing-related musculoskeletal complaint. Thigh strains and ankle sprains were the most frequent injuries, with the most frequent locations of complaints being the knee and lower back. The injury rates were similar for referees officiating at adult level, but lower at junior level. In comparison with elite football referees, the incidence of training injuries and the prevalence of musculoskeletal complaints were lower in amateur referees.

The results of these studies show that the football referee and assistant referee are exposed to a low risk of acute time-loss injuries, but to a high risk of developing musculoskeletal problems related to officiating. Based on this, considering the physiological demands and the length of a referee's career, specific injury prevention programs should be developed and implemented in the training routine of referees at all levels of performance.

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List of papers

This dissertation is based on the following original research papers, which are referred to in the text by their Roman numerals:

I. Bizzini M, Junge A, Bahr R, Dvorak J. Injuries ans musculoskeletal complaints in referees – A complete survey in the top divisions of the Swiss football league. Clin J Sports Med 2009: 19(2):95-100

II. Bizzini M, Junge A, Bahr R, Helsen W, Dvorak J. Injuries and musculoskeletal complaints in referees and assistant referees selected for the 2006 FIFA World Cup: retrospective and prospective survey. Br J Sports Med. 2009 Jul; 43(7):490-7. Epub 2008 Jul 4.

III. Bizzini M, Junge A, Bahr R, Dvorak J. Female soccer referees selected for the FIFA Women's World Cup 2007 – A survey of injuries and musculoskeletal complaints. Br J Sports Med. 2008 Oct 16 (Epub ahead of print)

IV. Bizzini M, Junge A, Bahr R, Dvorak J. Injuries of football referees: a representative survey of Swiss referees officiating at all levels of play. Scand J Med Sci Sports. 2009 Oct 22 (Epub ahead of print)

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Introduction

History of football refereeing

Football (or soccer) is one of the most popular sports worldwide. It would be difficult to imagine today's football without the presence of the football referee. Supported by his two assistant referees, his role is to observe that the players follow the Laws of the Game.

However, it wasn't always like this. The history of football refereeing has been described in detail by Lanfranchi et al. (2004) and in a FIFA publication (FIFA 1986). The origins are linked to the development of "modern football" in England in the nineteenth-century. Football, which was already a popular game among the so-called „common people", became an official sport in the most important English public schools (Eton and Harrow were among the first around 1840). The new school system introduced three half-days for compulsory sport, and football and rugby were the favorites. Clubs and teams were formed and tournaments were played. The team captains were in charge of the settings (e.g. duration of the game, field measurements), and of the control of the game ("genteleman's rules"). As an example, misconduct (ungentlemanly behavior) was punished by an expulsion by one's own captain. But, with the growing of the game in terms of tournaments and trophies, winning soon became important. Consequently, persons with neutral judgment in cases of disputes and conflicts between players were sought. The school laws of Eton and Winchester introduced the character of the „umpire" (from the Old French „nomper", in English „single man"), who was already well-known in cricket. Each team had to line up an umpire, whose place was near the goal. His duty was to count the goals (he raised the flag when one goal was scored) and to make decisions in difficult cases occurring in his own half of the field. In the school of Harrow, the umpires were even allowed to disallow a goal (if scored by unfair means) and to expel players (if they intentionally violated the rules). The school of Cheltenham introduced the „referee". For important matches, both captains had to appoint an umpire. The two umpires then agreed on a neutral referee (positioned on the touch-line), who was responsible for any decisions that the umpires could not or did not want to take. In these years the Football Association (FA) was founded in London (1863), and published the first rules (Laws of the Game) of „modern football".

In 1871, the first „Cup“ (the FA Challenge Cup) was also the first competition where the two umpires and the referee could not be a member of the participating teams. The idea of a neutral match official(s) was born. But it took several years to define the referee's position and decisions. In 1888 the first championship of the 12 professional clubs of the FA was held; professional football was growing, as well as the importance of the game's results. The need for neutral referees controlling the rules was also growing.

The International Football Association Board (IFAB), founded in 1886 by the four British Associations (England, Scotland, Wales, Ireland) had (and still has today!) in its statutes the control over the Laws of the Game. In 1891, the IFAB decided on important revisions of the rules, in particular for refereeing. The referee appeared now as sole match supervisor on the field and the umpires moved as linesmen on/of the touch-lines. They kept their flags but their duty consisted now in indicating if the ball was out of play. The referee (with his whistle) was given from the beginning many powers and became the ruler on the field. The positions of the referee and his two linesmen (as well their relationship) evolved then over the years (parallel with the changes of the rules).

In 1893, in order to promote football refereeing, Wall and Pickford founded the Referee's Association in London. They wanted to train the referees in their own centers, to prepare them for their duties, and also to improve their status (including a financial help for travelling and officiating matches). Pickford published the first „Referee's Chart“ in 1896: this important guide then became a yearly publication, including regulations for referees, IFAB announcements, instructions for the clubs and for the football players (there were about 1000 English professionals in 1891) (FIFA 1986; Lanfranchi et al., 2004).

FIFA and refereeing: the beginning

The Fédération Internationale de Football Association (FIFA) was founded in 1904 in Paris by nine European national associations (i.e. France, Belgium, Netherlands, Switzerland, Spain, Denmark, Sweden, Netherlands, Germany). FIFA adopted the Laws of the Game of IFAB, where later two FIFA representatives were admitted (1913). FIFA alone had the authority to organize an international tournament (this was the origin of the World Cup, whose first edition was held in Uruguay in 1930).

From its first years, refereeing was an important issue in FIFA, and in 1923 a „Referee's Committee" was established, also in order that the Laws of the Game were followed by all member associations. In 1939, the Referee's Committee introduced the so-called „FIFA badge", to be awarded to the best international referees. In the years after the end of Second World war, under the lead of Sir Stanley Rous (former English international referee, IFAB member, and later FIFA President 1961-1974) FIFA promoted worldwide training courses for referees (including theoretical and practical technique exercises, physical fitness training) (FIFA 1986; Lanfranchi et al., 2004).

FIFA and refereeing: today

Football is played worldwide by more than 265 millions players, and 208 national associations are affiliated with FIFA today. As the game, refereeing has also evolved in terms of outlook and preparation, both physically and mentally. In some countries (e.g. England, Brazil, Italy) referees have even become full-time paid professionals.

An official survey („Big Count 2006") by FIFA (2007) revealed that in 2006 there were, worldwide, and across all levels of football, more than 840 000 registered referees and asssistant referees (about 90% male, 10% female). With the growth of women's football in recent years, the number of female referees has also increased substancially. In 2006, there were about 85 000 female referees registered in FIFA. Compared with the FIFA Big Count 2000, this represents an increase in almost 50% in the number of women's referees (compared with just 11% for male referees).

The role of the referee (and assistant referees)

According to the Laws of the Game FIFA 2008/09 (FIFA 2008a), "a match is played by two teams, each consisting of not more than eleven players, one of whom is the goalkeeper", and "each match is controlled by a *referee* who has full authority to enforce the Laws of the Game in connection with the match to which he has been appointed". The referee is supported in his tasks by *two assistant referees*, who oversee both touchlines of the football pitch (one in each of the two halves). Additionally, "a fourth official may be appointed under the competition rules and officiates if any of the three match officials is unable to continue, unless a reserve assistant referee is appointed (= the fifth official).

He assists the referee at all times". During the match, the referee moves inside the field of play with no restrictions, as he has to follow the playing actions in order to achieve a good positioning for his decisions. The players act by kicking or heading the ball within the pitch, trying to score in the opposite goal. This implies having alternately an attacking and a defending team. There are rules (FIFA 2008a) restricting the movement (e.g. the offside rule) and behavior (e.g. fouls and misconduct) of the players on the pitch; the referee plays a crucial role in officiating a match, and no regular game would be possible without him.

Characteristics of referees

Maybe also because historically the referees were seen more as the „necessary evil" (FIFA 1986), this population have often been negleted in the world of football. Similar as among the general public, football players have received more attention than referees in the field of research. A considerable number of research studies have focused on elite (national/international) and professional male football players, whereas little scientific literature is available on football refereeing (Castagna et al., 2007). Very few studies include female football players, and none have been dedicated to the female referee (Kirkendall 2007). Castagna et al. (2007) in their review on male football referees, located approximately 150 studies of differing quality, of which 22 were peer-reviewed papers published between 1995 and 2007.

Physical and fitness characteristics

Rontoyannis et al. (1998) were the first to report anthropometric data on referees, after examining 188 referees from the four divisions of the Greek Football Association. The mean height was 177.4 ± 5.7 (SD) cm and the mean weight was 81.6 ± 7.8 (SD) kg, with a corresponding BMI of 25.9 ± 2.1 (SD) $kg \cdot m^{-2}$. Only few studies focusing on referees at the national level have reported height and weight data (Castagna & D'Ottavio 2001; Krustrup & Bangsbo 2001; Castagna et al., 2002; Castagna & Abt 2003), and these show a mean height of 182.9 ± 4.5 (SD) cm, and a mean weight of 77.6 ± 7 (SD) kg (Castagna & Abt 2003). Helsen and Bultynck (2004) reported similar figures for the 17 referees involved in the UEFA Euro 2000 Championship, with a corresponding BMI of 24.2 ± 2.6 (SD) $kg \cdot m^{-2}$. In the classification system for underweight, overweight and obesity of

the World Health Organization, BMI values ranging from 18.5 to 24.9 $kg \cdot m^{-2}$ are given for persons of normal weight (Wilmore & Costill 2004).

Many studies have reported the average age of referees (Johnston & McNaughton 1994; Rontoyannis et al., 1998; Castagna & D'Ottavio 2001; Castagna et al., 2002; Castagna & Abt 2003; Da Silva & Fernandez 2003; Weston et al., 2004). The age of referees officiating nationally ranged from 36.3 ± 4.5 (SD) yrs (Rontoyannis et al., 1998) to 41.8 ± 4.2 (SD) yrs (Weston et al., 2006). Studies dealing with international competitions (Castagna et al., 2004; Helsen & Bultynck 2004) showed that referees officiating such tournaments tend to have a higher mean age (40.2 ± 3.9 (SD) years) than those officiating nationally. It is noteworthy that 45 years is the age limit set by FIFA for international referee's license, and this is usually the same for the elite referees at national level (e.g. in Switzerland).

In the only publication dealing with elite female referees, Mallo et al. (2008a) reported the anthropometric characteristics of 10 *female* referees, participating at the FIFA Under -20 World Cup 2006 in Russia. Their mean age was 35.3 ± 4.3 (SD) years, their mean height was 168.4 ± 3.9 (SD) cm, and their weight was 62.5 ± 6.4 (SD) kg. This corresponds to a BMI of 22.2 ± 2.4 (SD) $kg \cdot m^{-2}$.

Measurements of maximal oxygen uptake (VO_2 max) in a laboratory setting have been performed in male referees (Castagna & D'Ottavio 2001; Krustrup & Bangsbo 2001; Bangsbo et al., 2004; Weston et al., 2004). Krustrup and Bangsbo (2001) found average VO_2 max values of 46.3 $mL \cdot kg^{-1} \cdot min^{-1}$ (range: 40.9 – 55.7) in elite Danish referees. Castagna and D'Ottavio (2001) reported VO_2 max values of 49.3 ± 8 (SD) $mL \cdot kg^{-1} \cdot min^{-1}$ in elite Italian referees. Bangsbo et al. (2004) showed decreasing VO_2 max values in three increasing age categories of Danish referees: 47.7 ± 1.5 (SD) $mL \cdot kg^{-1} \cdot min^{-1}$ (age 29-34 yrs), 45.9 ± 1.1 (SD) $mL \cdot kg^{-1} \cdot min^{-1}$ (age 35-39 yrs), and 44.7 ± 0.8 (SD) $mL \cdot kg^{-1} \cdot min^{-1}$ (age 40-46 yrs). The highest VO_2 max values, averaging 50.9 ± 5.7 (SD) $mL \cdot kg^{-1} \cdot min^{-1}$ were measured by Weston et al. (2004) in English Premier League referees. There are no reported VO_2 max values for elite female referees in the literature.

The average VO_2 max values in male football referee are slightly higher than those reported in nonathletes (age ranges 30-39 and 40-49 yrs), and similar to those reported in untrained or nonathletic males (age range 20-30 yrs) and in normally active college students (age ranges 18-22 yrs) (Wilmore & Costill 2004). Elite male distance runners

over 40 years of age have an average VO_2 max above 60 $mL \cdot kg^{-1} \cdot min^{-1}$ (Wilmore & Costill 2004).

Match performance

Several studies have focused on match analyses and time motion analyses in male football referees (Asami et al., 1988; Catterall et al., 1993; Johnston & McNaughton 1994; D'Ottavio & Castagna 2001; Krustrup & Bangsbo 2001; Harley et al., 2002; Castagna et al., 2004). The distances covered by the officials were reported to range from 7 496 m (Harley et al., 2002) to 11 469 m (Dottavio & Castagna 2001), varying in part on account of the different methods of measurement used (Castagna et al., 2007). D´Ottavio and Castagna (2001) reported the highest range of distances covered (7.82-14.12 km) in a group of 33 elite referees officiating in the Italian first division championship ("Serie A"), which is considered one of the best football competitions worldwide (Castagna et al., 2004). Krustrup et al. (2002) and Mallo et al. (2008b) reported a total distance covered by elite *assistant* referees of 7.3 and 6.1 km, respectively. High-intensity running (including sideways running) accounted for 16% and 20% of the total match distance, respectively.

When comparing the total distance covered in the two halves of a match, conflicting results have been reported in the literature (Catterall et al., 1993; Johnston & McNaughton 1994; Dottavio & Castagna 2001; Krustrup & Bangsbo 2001; Castagna et al., 2004). D'Ottavio and Castagna (2001) and Catterall et al. (1993) showed a significant reduction (-5.5% and -4.1%, respectively) in the distance covered in the second 45 minutes. In lower leagues, an even greater decrement in the second half (-13.4%) was documented (Harley et al., 2002). However, other authors found no difference between halves in national referees (Johnston & McNaughton 1994; Krustrup & Bangsbo 2001) and international referees (Castagna et al., 2004). One possible explanation is that referees may adopt pacing strategies, a so-called "sparing behavior", in order to conserve energy during the match (Castagna et al., 2007).

Mallo et al (2008a) reported a total distance covered of 10 032 ± 300 (SD) m in top *female* referees during the FIFA Women's Under-20 World Cup 2006 in Russia. During the same tournament, female *assistant* referees covered a distance of 5 594 ± 473 (SD) m during the match.

The total match distance covered by football referees is characterized by activities at different intensities (low, medium, high), and by different types of running (sprinting, running backwards and sidewards) (Castagna et al., 2007). In relation to the aforementioned studies (Asami et al., 1988; Catterall et al., 1993; Johnston & McNaughton 1994; Dottavio & Castagna 2001; Krustrup & Bangsbo 2001; Harley et al., 2002; Krustrup et al., 2002; Castagna et al., 2004), over 50% (average 53%) of the distance is performed at low intensity, i.e. walking, jogging and running at low speed (6-13 km/h). Standing still may account for 11-22% of the match duration (Castagna et al., 2007); 26.9% and 12.9% of the total distance, respectively, comprises medium intensity and very high intensity activities (speeds > 15-18 km/). Backwards running, a typical action of the referee, is reported to represent an average 10.7 % of the total distance (Castagna et al., 2007). Interestingly, in the studies reporting "sparing behavior" (see above), it was documented that elite referees were able to perform at a similarly high intensity in both halves and even in the later stages of the match (Castagna & Abt 2003; Castagna et al., 2007).

In the study of Mallo et al (2008a), it was concluded that the movement patterns of elite female referees were similar to those described during male standard refereeing, with 13% high intensity activities.

Changes in motor behavior during a football match are typical not only for players, but also for referees. Krustrup et al. (2002) reported that, in elite referees, the total number of match activities was 1268 (965-1577), corresponding to a change in activity every 4.3 s. In elite *assistant* referees, the total number of match activities was 1053 (832-1459), corresponding to a change every 5 s (Krustrup et al., 2002).

During the course of a match, referees also have to make a good number of decisions. In reviewing the videotapes of the matches of the UEFA Euro Championship 2000, Helsen and Bultynck (2004) reported an average number of 137 observable decisions per match (range 104-162). These data clearly show that, in addition to the physical demands, the referee has to cope with a considerable perceptual-cognitive load during the match.

Match physiological responses

In attempting to quantify the aerobic demands of football refereeing, heart rate (HR) monitoring and measurements (indirect/direct) of VO_2 max have been made (Catterall et

al., 1993; Johnston & McNaughton 1994; Dottavio & Castagna 2001; Krustrup & Bangsbo 2001; Weston & Brewer 2002). These studies show that an elite referee may reach between 85% (Johnston & McNaughton 1994) and 95% (Catterall et al., 1993) of his maximal HR during the game. Helsen and Bultynck (2004) reported an average match HR of 85% of maximal HR (values were obtained using various testing methods, such as laboratory testing, training HR monitoring, and match HR monitoring).

The estimated match VO_2 uptake, calculated from the HR-VO_2 curve, has been found to be approximately 80-81% of the VO_2 max (assessed in the laboratory setting) (Weston & Brewer 2002). Weston and Brewer (2002), looking at the differences between the two halves, found lower HR and lower estimated percentages of VO_2 max in the second 45 min of the match; however, these figures were not confirmed in other studies (Dottavio & Castagna 2001; Krustrup & Bangsbo 2001). Using portable gas analyzers, D'Ottavio and Castagna (2002) studied the aerobic match demands in Italian referees during friendly matches, and found that the oxygen uptake was 68% of the individual VO_2 max (D'Ottavio & Castagna 2002). The authors found than a significantly higher oxygen uptake (74 % of VO_2) max than with the HR-VO_2 estimation method. Although the accuracy of "directly measured" values of oxygen consumption is also the subject of some debate (due to the potential of portable gas analysis systems to hinder movement and hence influence motor behaviour), specialists nonetheless advise caution when interpreting the results obtained by estimation from HR-VO_2 data collected in the laboratory setting. Either way, it is probably safe to conclude that the average oxygen uptake during the match is in the region of 70% VO_2 max.

Krustrup et al. (2002) found that elite *assistant* referees exhibited an average match HR of 73% of maximal HR, equivalent to 65 % of VO_2 max as assessed in the laboratory setting.

Krustrup and Bangsbo (2001) and Castagna et al. (2002) analyzed in detail the blood lactate profile of referees during the match. Blood lactate concentrations of, on average, 5 mmol/l were found at the end of each half, although Krustrup and Bangsbo (2001) showed high inter-individual variations with values ranging between 2.0-9.8 mmol/l (first half) and 2.3-14.0 mmol/l (second half).

Injuries in referees?

In reviewing the literature, there are only two peer-reviewed publications on injuries in referees: one in Australian Rules Football (ARF) and one in football (Brukner et al., 1991; Fauno et al., 1993). Brukner et al. (1991) describes a comparison of injuries in ARF players and referees (called „umpires"). While the match demands for football players differ from ARF players, they are similar for referees. All time-loss injuries were recorded during the 22 matches of the 1989 season. A total of 13 injuries were recorded in 50 umpires. The study of Fauno et al (1993) investigated the effects of shock absorbing heel inserts on soreness in the lower extremity and back in 91 international referees in a 5-day tournament in Denmark. In the control group between 16 and 93% of the referees reported soreness while the prevalence was lower in intervention group. Additionally six acute injuries were reported, resulting in an incidence of 4.6 injuries per 1000 referee hours. So, it appears thinkable that the referee may experience some injuries or physical problems during his/her career, but there is clearly a lack of scientific data.

Referee characteristics in comparison to players

A comparison between the fitness characteristics and work requirements of *football players* and referees may provide a rationale for the *expected injury profile* in the referee and assistant referee. In their review on the physiology of soccer, Stolen et al. (2005) identified almost 10,000 publications dealing with various physiological aspects of football, and finally made reference to 181 relevant papers.

Physical and fitness characteristics of football players

Various studies have reported on the anthropometric and laboratory-based physiological characteristics of football players. In adult male players, height has been reported to range from 169 ± 2.3 (SD) cm (Adhikari & Kumar Das 1993) to 190 ± 6.0 cm (Bangsbo 1994), and weight from 64.0 ± 3.0 (SD) kg (Adhikari & Kumar Das 1993) to 87.8 ± 8.0 (SD) kg (Bangsbo 1994). Junge and Dvorak (2004), in reviewing 14 studies on football players, found ages within a range of 16-38 yrs old. Arnason et al. (2004a) reported a mean age of 24.0 ± 4.2 (SD) yrs in 297 players from the 20 teams included in the Icelandic elite and first division during the 1999 season. This figure may be

representative for national championships, but it is well known that some professional clubs (for example, those playing in the UEFA Champions League) may have a squad with an average age of over 30 years, due to the presence of many experienced players.

VO_2 max in *male* field players reportedly ranges from 52.1 ± 10.7 (SD) $mL \cdot kg^{-1} \cdot min^{-1}$ (Matkovic et al., 1993) to 73.9 ± 10.8 (SD) $mL \cdot kg^{-1} \cdot min^{-1}$ (Apor 1988). Bangsbo (1994) reported values of 51.0 ± 2.0 (SD) $mL \cdot kg^{-1} \cdot min^{-1}$ among elite Danish goalkeepers. The anaerobic threshold is reported to lie between 76.6% (Casajus 2001) and 90.3% (Vanfraechen & Tomas 1993) of VO_2 max. All these values have been measured using valid and reliable laboratory tests.

In *female* players, height is reported to range from 164.0 ± 6.1 (SD) cm (Tumilty & Darby 1992) to 169.7 ± 7.1 (SD) cm (Helgerud et al., 2002), and weight from 58.5 ± 5.7 (SD) kg (Tumilty & Darby 1992) to 65.2 kg (Polman et al., 2004). Söderman et al. (2001) reported a mean age of 20.6 ± 4.7 (SD) (range 20-25) yrs in 199 players in the Swedish league during the 1998 season.

The VO_2 max in *female* field players is reported to range from 47.1 ± 6.4 (SD) $mL \cdot kg^{-1} \cdot min^{-1}$ (Rhodes & Mosher 1992) to 57.6 $mL \cdot kg^{-1} \cdot min^{-1}$ (Jensen & Larsson 1993). Lower values of VO_2 max (under 40 $mL \cdot kg^{-1} \cdot min^{-1}$) have also been reported, but these were estimates and not direct measurements (Polman et al., 2004). The anaerobic threshold has not been reported in any studies on females (Stolen et al., 2005).

Early studies showed that the challenge to the aerobic and anaerobic systems was similar in men's and women's football (Helgerud et al., 2002), even though women typically covered a lesser total distance on the pitch than men (Davis & Brewer 1992). However, women's football has evolved so much in recent years (as seen during the FIFA Women's World Cup™ 2007 and recently at the UEFA Women's Euro 2009), that the distance covered is possibly closer to that of male players now (Krustrup et al., 2005).

Other variables such as strength, power, and jumping ability have been measured in male and female football players (Stolen et al., 2005). However, due to the many different test methods used (i.e. isokinetic devices, free barbells, force plates, contact mats), and the lack of specific test protocols, it is almost impossible to draw any meaningful conclusions on these aspects of performance.

Match performance

In elite football, male field players run on average more than 10 km during a match. The values reported in different studies vary depending on the specific method of measurement used (hand notation, trigonometry, TV camera, tape recorder, cine film, video) (Carling et al., 2008). Four studies (Withers et al., 1982; Bangsbo et al., 1991; Rienzi et al., 2000; Mohr et al., 2003) utilizing the video technique, reported a detailed description of the distance covered according to playing position. The range of the "action radius" was 8.7 to 11.0 km for defenders, 10.0 to 12.2 km for midfielders, and 7.8 to 11.8 km for attackers.

In actual fact, football players do not simply "run", because the number and variety of explosive activities performed is very high (Drust et al., 2007). Players kick the ball, jump to head the ball, tackle, accelerate/decelerate, and change direction (turning, cutting). It has been documented that a bout of sprinting occurs approximately every 90 s, each time lasting on average 2-4 s, such that about 10-20 bouts per match are performed. Other match activities that have been documented include high-intensity running (approximately every 70 s), and approximately 15 tackles, 10 headers, and 30 passes (Stolen et al., 2005). These figures may vary depending on the playing position: in general, fullbacks and attackers sprint more than midfielders and central defenders (Withers et al., 1982; Mohr et al., 2003).

In two studies using video technique, *female* players were reported to cover on average 8.5 km (Brewer & Davis 1994) and 9.5 km (Bangsbo 1994). Recently Krustrup et al. (2005) reported that elite female players averaged 10.3 (range 9.7 – 11.3) km per match. The same authors showed that the elite female player ran at high intensity for 1.31 km (0.7-1.7); on average, this type of activity was performed 125 times (72-159) for 2.3 s (2.0-2.4).

In a recent review paper on muscle fatigue during football match-play (Mohr et al., 2005), it was reported that studies had shown that the distance covered in the second half of the game was lower than that in the first half, in both male and female players (at any level) (Reilly et al., 2008). Rampinini et al. (2007a) showed a decline in technical and physical performance between the first and second halves in professional football players during matches of the Italian "Serie A". In another study, the same authors reported that the total distance and the bouts of very high intensity running undertaken by players were influenced by the activity profile of their opponent teams (Rampinini et al., 2007b).

The "fight" for possession of the ball is one of the main characteristics of the game of football, and in this context players may go beyond the limits set by the Laws of the Game (FIFA 2008a). A number of research studies have focused on tackle mechanisms and tackle parameters in football, in which a tackle was defined as any incident during normal play in which there was obvious contact between at least two players (Fuller et al., 2004a; Tscholl et al., 2007). In a study on injuries in international male football (123 matches of three FIFA tournaments), Fuller et al. (2004) documented that there were 70 player-to-player contacts per match, of which 40% were fouls. Tackle assessment was primarily based on the referee's decision on the legitimacy of the tackle (foul/non foul). In a similar study in *women's elite football* tournaments (24 representative matches of six FIFA tournaments), Tscholl et al. (2007) reported 147 tackles per match, of which 17% were fouls. In other words, there seems to be as many tackles but half as many fouls in female compared to male elite football.

Match physiological responses

Playing football at a high level means dealing with a combination of aerobic and anaerobic energy demands during the match. The average work intensity (measured as a percentage of maximal heart rate) is close to the anaerobic threshold; however, during a 90-minute match, periods of high-intensity activity (with an increase in blood lactate) are typically followed by periods of low-intensity activity (necessary to remove lactate from the musculature). Studies in *male* football players indicate that the percent of maximal HR ranges between 80% (Seliger 1968) and 93% (Agnevik 1970).

Concerning *female* players, Brewer and Davis (1994) reported a range of 89-91% of maximal HR in elite Swedish footballers. In Danish elite female players, Krustrup et al. (2005) found that the average and peak HRs during a match were 167 beats per minute (152-186) and 186 (171-205) beats per minute, respectively, corresponding to 87% (81-93) and 97% (96-100) of maximal HR.

Attempts have been made to obtain measures of oxygen uptake during play**,** either indirectly or directly. Indirect measures involve the use of the so-called HR-VO_2 curve (Bangsbo 1994), determined during a laboratory treadmill test, to estimate the VO_2 uptake from the average HR recorded during the game. An average performance intensity of 85% of HR max corresponds to approximately 75% of VO_2 max (Astrand et

al., 2003). This equates to an average VO_2 of 45.0, 48.8 and 52.5 $mL \cdot kg^{-1} \cdot min^{-1}$ for players with a VO_2 max of 60, 65 and 70 $mL \cdot kg^{-1} \cdot min^{-1}$, respectively. Direct measures of oxygen uptake during a match require the use of portable gas analysers. However, it is difficult to get accurate data, because the equipment used (special bags or masks) represents a hindrance to normal performance, as evidenced by players failing to cover their usual distances during the match (Stolen et al., 2005).

Studies have also been carried out to examine the blood lactate profile during and at the end of a football match (Stolen et al., 2005). The data vary among studies, not least because the measured lactate concentration depends to a large extent on the type of activity of the player in the five minutes prior to the blood sampling. Values at the end of the first 45 minutes of a match range between 2.6 (2.0-3.6) mmol/L (Bangsbo 1994) and 9.5 (6.9-14.3) mmol/L (Ekblom 1986), and, after 90 minutes, between 2.7 (1.6-4.6) mmol/L (Bangsbo 1994) and 10.0 (10.0-15.5) mmol/L (Agnevik 1970). Corresponding values in elite Swedish female players were reported to be 5.1 ± 2.1 mmol/L (end of the first half) and 4.6 ± 2.1 mmol/L (end of the second half) (Brewer & Davis 1994). Measurements made during the actual match itself indicate that the lactate concentration is lower during the first half than during the second half in elite male players (Bangsbo et al., 1991; Mohr et al., 2003).

Comparison referees - players

Table 1 sums up the data available on the fitness characteristics and exercise profile of players and referees.

Differences in anthropometric data (height/weight) between players and referees are difficult to interpret, because of the large inter-individual variations. BMI is typically considered to be an indicator of overweightness or obesity, and an important measure of body composition (Wilmore & Costill 2004). A BMI value lower than 25 $kg \cdot m^{-2}$ (classified as "normal") is considered a favorable index for sports performance (Castagna et al., 2007). However, in athletes, BMI should be used cautiously when classifying fatness, because a large muscle mass will also increase BMI the same way as fat (Ode et al., 2007). Reilly and Gregson (2006) presented body composition data for English Premier League players and referees, and found higher BMI in referees, but normal figures for body fat values (age-related) and higher bone mineral density compared with

Table 1. VO_2 max, match performance and match physiological responses in male football players and referees (Stolen et al., 2005, Castagna et al., 2007)

		Players	**Referees**
VO_2 max ($mL \cdot kg^{-1} \cdot min^{-1}$)		52-74	41-56
Distance covered		10-12 km	9-14 km
Distance covered (ProZone*)		10.6 km	11.4 km
Match activities	Activity changes (number)	1000-1400	965-1577
	Activity changes (time between)	4-6 s	4 s
	High intensity activity (sprinting) (% of distance covered)	1-11%	2-12 %
	High intensity running (ProZone*)	1 km	1.1 km
Aerobic demands	Average work intensity	80-90% of HR max	85-95% of HR max
	Match oxygen uptake 1 (indirect measure)	70-75% VO_2 max	apx 80 % VO_2 max
	Match oxygen uptake 2 (direct measure)	43-69% VO_2 max	apx 68% VO_2 max
Blood lactate	End of 1st half	apx 5.4 mmol/L	apx 4.8 mmol/L
	End of 2nd half	apx 5.0 mmol/L	apx 5.1 mmol/L

** ProZone data (Weston 2009, personal communication)*

the norm in both players and referees. The authors concluded that the data demonstrate the limitations in interpretation of the BMI in referees and players (Reilly & Gregson 2006). Among the laboratory assessment techniques, dual-energy X-ray absorptiometry (DXA) provides precise and reliable estimates of total body composition: fat mass and fat-free mass, additionally to bone density and bone mineral content (Wilmore & Costill 2004). The multiple skinfold fat thickness measurement technique also provide a good estimation of body composition, and may be more accessible for athletes than the laboratory techniques (Wilmore & Costill 2004).

The available literature clearly indicates that there is a notable *age difference* between elite football players and referees. Referees are on average 15-20 years older than players, with the world-class officials involved in the top tournaments (FIFA World Cup, UEFA Euro

Championship) exceeding 40 years of age (Bangsbo 1994; Helsen & Bultynck 2004; Castagna et al., 2007). Referee age is, to a certain extent, even dependent on their career: they typically progress from lower leagues to national and later international championships by demonstrating (at each competitive level) the required technical and decision-making skills, acquired through mounting experience (Castagna et al., 2007).

There is some debate as to whether the maximal oxygen uptake is a sensitive measure of performance capacity in football (Stolen et al., 2005). Castagna and D`Ottavio (2001) showed that, in Italian referees, VO_2 max determined both the total distance covered and the exercise intensity during a game. The referees who possessed a higher VO_2 max were shown to be more active during the course of the second half compared with their less well-trained counterparts. Reilly et al. (2000) suggested a minimum threshold for VO_2 max of 60 $mL \cdot kg^{-1} \cdot min^{-1}$ for "achieving performance success" as an elite football player. Across all studies, the VO_2 max values found in football referees were lower than those in players (Stolen et al., 2005; Castagna et al., 2007) (Table 1).

Match performance and match physiological responses both show similarities in players and referees (Table 1). The match distance coverage of the referee is very close to that of a midfield player (Bangsbo et al., 1991; Bangsbo 1994; Castagna et al., 2007). The sequence of alternating attacking situations obliges the referee to constantly move between the attack and defence lines, in order to keep up with the game (Castagna et al., 2007). Different studies report different distances covered by the referee during a match. D´Ottavio and Castagna (2001) reported a range between 7 and 14 km. There are many reasons why this figure might vary between studies (country, level of competition, team/players' behavior, refereeing strategies, aerobic fitness level) (Castagna et al., 2007).

The different methods of measurement (motion analysis systems) also play a role in this context (Carling et al., 2008). Recently, the Premier League adopted a valid/reliable computerised, semi-automatic video match analysis image recognition system (ProZone, Leeds, England) for the monitoring of players and referees performances during official matches (Weston et al., 2008; Di Salvo et al., 2009). This allows a „real" comparison between players and referees. Data from the season 2008-09 (Weston 2009, personal communication) reported in Table 1 indicate that the activity profile of referees is very similar to that of players.

Since the games became faster in recent years, the number of activities during a match increased for referees similar to elite football players (Krustrup & Bangsbo 2001). High-

intensity phases (distributed over the 90 minutes of the game) probably differ between players and referees in terms of their duration, speed and power, even if they are almost identical in terms of the corresponding percentage distance covered. Players are characterized by multiple actions with and without the ball, and show repeated sprint activities (Spencer et al., 2005; Impellizzeri et al., 2008). The referees cover more than 50% of the total distance moving at a low intensity, but they also need to perform a considerable amount of medium-intensity and high-intensity activities, in order to keep up with the tempo of the game. For this reason, elite refereeing is considered a highly intermittent exercise mode (Castagna et al., 2007). Another difference between players and referees is the amount of backward running during a game (Stolen et al., 2005). Referees usually run backwards (studies show distances ranging from 7 to 18% of the whole distance) when taking off from a game action while still controlling it (Castagna et al., 2007). Directional modes, as backward and sideways running, are physically demanding and represent an additional energy expenditure for the match officials (Reilly & Bowen 1984). In comparison, players run backward distances ranging from 5 to 15% of the whole distance, with the central defenders showing the highest averages of backward running (Stolen et al., 2005).

Players and referees have been shown to subject themselves to comparable aerobic demands during the game, as documented by the average work intensity, expressed as the percent of HR max**,** and by indirect/direct measures of oxygen uptake given as a percent of VO_2 max (Stolen et al., 2005; Castagna et al., 2007). However, some reports indicate that referees work at a higher percentage of maximum oxygen uptake (about 7-14% higher) than players (Krustrup & Bangsbo 2001; Weston et al., 2004), perhaps as a consequence of the referee's requirement to keep up with the tempo of game, in order to ensure good positioning, close to the action. Players, in contrast, and depending on the game situation, may have more choice in terms of action participation or activity type (and may also benefit from a better fitness level than referees).

In studies that have used the same timing of blood sampling, in games at the same competitive level, the blood lactate concentrations of players and referees appear to be similar (Stolen et al., 2005; Castagna et al., 2007). However this area remains controversial, because there is still a lack of knowledge regarding the details of blood lactate production during the game, in both players and referees (Castagna et al., 2007).

When considering the overall activities on the pitch, the biggest difference between players and the referee is that the referee is not directly involved in the game (with the ball). This means that, in distinct contrast to the players of the two "battling" teams, the referee makes no actions involving intentional physical contact during the match. Tackling is one of the key tasks for players to take possession of the ball from their opponents. As reported by Fuller et al. (2004b), there is a considerable amount of tackling among players during a match, and this behaviour, especially when it constitutes a foul (a violation of the Laws of the Game, (FIFA 2008a)), may subsequently lead to injury (Fuller 2005).

The following considerations might also be of importance in comparing football players and referees. In elite football, referees often have a non-professional status, but they have to officiate games between full professional players. Recently, the English FA Premier League has promoted the introduction of a team with 20 fully professional referees (Weston et al., 2006; Weston et al., 2007); this is unique worldwide. The non-professional status of the referee has huge implications in terms of training possibilities and facilities, coaching, and care at different levels (e.g. medical care). If the referee has another career, which is usually the case, then the amount of time he can dedicate to refereeing (training, game, recovery, other) is naturally limited. The situation differs between countries, ranging from very organized structures (in, for example, Italy) to very disorganized conditions (in, for example, some African countries) (Garcia Aranda 2008, personal communication). The following examples of two "top" European countries illustrate this point. In Italy, during the 2007-2008 season, the referees of the "Serie A-B", met every 2 weeks for specific preparation camps, and were followed in their training throughout the whole season (Castagna 2008). The Italian referees have a full team of specialists (head fitness trainer, technical coaches, medical doctor, psychologist, physiotherapist, massage therapist) at their disposal, and can take advantage of the facilities at the National Football Training Center in Coverciano (Collina 2008, personal communication). In Switzerland, the referees of the first two divisions are invited to 2 training camps (of maximum one week duration) per year. During the season each referee has to organize his own best possible training environment (and other related issues) at his own cost (Meier 2008, personal communication). Even for the highest-level football tournament, the FIFA World Cup, referees have only been enjoying the benefits of a professional support team since the 2002 competition (and for female referees, since 2007) (Garcia Aranda 2008, personal communication).

In conclusion, the elite-level football referee is exposed to similar *physiological* match demands to those placed on a midfield player. While activity changes are almost similar as in players, the referee has to make a large number of decisions during the match; this implies an additional perceptual-cognitive workload for the referee. The referee is not directly involved in the game, and moreover he/she is not involved in any intentional duels for the possession of the ball. Some other unique characteristics are: he/she is older than the players (up to 15-20 years, at the elite level) and he/she is rarely a full-time professional.

Expected injury profile of the referee

From the aforementioned review of fitness characteristics, match performance, and match physiological responses of the football referee, the following aspects are considered likely to have a potential influence on the corresponding injury profile of the elite referee: no physical contact with other players, no kicking or heading of the ball (Table 2), more backwards and sideways running, higher age, and reduced training possibilities.

The key issue is that the referee (by definition of his role) is not directly involved in the game with the ball, and therefore has no intentional physical contact with the players. The majority of injuries in football players are caused by direct player-to-player contact, particularly in relation to tackling (Hawkins & Fuller 1999; Junge & Dvorak 2004). About two thirds of traumatic injuries are considered to be due to player-contact, and between 12% and 28% of all injuries, to foul play (Junge & Dvorak 2004) (Tab. 3). These figures obviously do not transfer to football referees (or assistant referees). The chance of incurring a traumatic injury because of physical contact is expected to be very low. Consequently, referees are not expected to be at risk of incurring contact injuries, and at much lower risk than players of suffering ligament injuries of the ankle and knee (Woods et al., 2002). There are some anecdotal reports in the media of match officials being assaulted by players or team staff members, but this should not be considered part of a "normal" football match.

Table 2. Injury mechanisms during the pre-season and season in football players (Woods et al., 2002), and expected figures in referees.

Injury mechanism	Players	Referees
Running	X	+
Tackled	X	-
Tackling	X	-
Twisting/turning	X	+
Collision	X	-
Stretching	X	+
Kicked	X	-
Shooting	X	-
Landing	X	-
Passing	X	-
Jumping	X	-
Falling/diving	X	-
Heading	X	-
Use of elbow	X	-
Overuse	X	+

(**x**: documented, **+**: expected, **-**: not expected)

The data presented on total match distance covered, activity changes, and physiological responses best illustrate the physical load on the referee and his two assistants during a football game (Table 1). Similar to the players, the referees are therefore expected to be at risk of non-contact and overuse injuries of the musculoskeletal system. The variety of different motor tasks (running forwards/backwards/sideways, turning, pivoting and sprinting) exposes the referee (and assistant referee) to sprain and strain injuries of the lower extremity. However, since referees do not shoot/pass the ball or jump/land for heading (Table 2), they may experience fewer non-contact injuries than players. Elite football players have been documented to perform repeated-sprint activities of a mean distance of 10-20 m with a mean duration of 2-3 s (Spencer et al., 2005); although the referee (and his assistants) *also* sprint, it is rarely done in the same way. Players carry out explosive bouts of sprinting (often with the additional presence and pressure of an opponent player), whereas the referee performs more prolonged sprints over 30-50 m (e.g. in the case of sudden changes in the playing action) and only few short sprints (Krustrup & Bangsbo 2001). Studies have shown that running/sprinting is the major injury mechanism in about 20% of all injuries, and that running and turning are the major causes of non-contact injuries (Hawkins & Fuller 1999). Non-contact injury mechanisms are the cause of most muscle strains: kicking is often associated with rectus femoris muscle strains, while hamstring and calf strains often occur during sprinting (Hawkins &

Fuller 1999). Indeed, a number of studies have documented hamstring strain injuries due to sprinting in football players (Nielsen & Yde 1989; Askling et al., 2003; Arnason et al., 2008; Croisier et al., 2008). As such, muscle injuries are to be expected also in the referee, although perhaps at a lower frequency than in football players. The same assumption can be made for sprains, such as knee or ankle ligament injuries, which referees may incur due to their various different movement patterns during the match (Table 2).

Differences in the injury patterns of referees and assistant referees may also be expected, due to differences in the typical movement patterns associated with these two adjudicatory roles. The referee's job involves a considerable amount of changing direction, and sprinting at medium-high intensity speeds. During these movements, the dorsal muscle chains (low back, hamstring, calf) have to control the eccentric load, and the knee and ankle joints, the rotational movements. Backwards running, usually performed on the forefoot/toes and a repeated and energy-demanding activity carried out throughout the match, may stress more the thigh and lower leg muscles. Based on the referee's experience, the calf muscles and Achilles tendons are particularly heavily loaded during backwards running with subsequent changes of direction (Collina 2003). The referee displays many of these running styles also with a rotated trunk and head-neck, because his attention must always be focused on the playing action. This implies the need for good body control by the referee; if this is not achieved, there is a potential risk of incurring some strains (groin, thigh, lower leg) or sprains (ankle, knee) of the lower extremity. The movement patterns of the assistant referee are, in contrast, characterized by rapid lateral shuttle runs (often on their toes) and sprints. In this context, the assistant referee must constantly move perpendicular to the second-to-last defending player in order to be able to judge the offside positions. These activities may stress in particular the groin area (with the m. adductors), the hamstrings, the calf (and Achilles tendon), and the knee and ankle joints.

In football players, between 9% (Arnason et al., 1996) and 34% (Nielsen & Yde 1989) of all registered injuries are overuse injuries. In a study on English professional football players, Woods et al. (2002) found that during the pre-season, a significant proportion of injuries were overuse injuries, especially Achilles tendon problems. Achilles tendinopathy is one of the most common overuse injuries that occurs during running (Kannus 1997; Hreljac 2004). Both football players and referees can be considered "runners", even if they perform with a wide variety of activity changes. About 94% of all documented Achilles tendon problems in football players are tendinopathies (Woods et al., 2002).

Because of their repeated activities on the forefoot/toes during backwards and sideways running, the Achilles tendons of both the referee and his assistants are exposed to a considerable load during the match (a similar loading pattern is seen during training), perhaps even to a greater extend than players. Wright and Weyand (2001) found that during backward running the volume of muscle active per unit of force applied to the ground was 10% greater than forward running (at a given speed). Further, the average muscles forces (per unit ground force) at the ankle were greater during backward running. Research has shown that the ankle plantarflexors (complex calf muscle-Achilles tendon) are the primary shock absorbers during the early stance in backward running (DeVita & Stribling 1991).

Table 3. Causes of injury in football players expressed in percentages (the highest values are here reported) of all documented injuries (Junge & Dvorak 2004), and expected figures in referees.

		Players	**Referees**
Trauma	Contact	28 %	0%
	Non-contact	59%	20%
Overuse		34%	80%

Considering that an elite football referee reaches the top level of his officiating career at greater than 40 years of age, it is easy to hypothesize that the chances of incurring overuse-type problems may be relatively high. From a global perspective, the physical and physiological demands during the match and training may be lower for referees than for players; however, when considering the significantly longer career of referees, the repetitive loads may represent a cumulative factor for the development of overuse injuries to a greater extent in referees than in players (Table 3). Age *per se* is a risk factor for injury in footballer players, with studies showing that the incidence of injury increases with age (Inklaar 1994; Dvorak & Junge 2000). Arnason et al. (2004b) found that age and previous injury were the main risk factors for injury among elite football players from Iceland; for example, increased age and previous hamstring strains were the principal risk factors for future hamstring strains. Age as an intrinsic risk factor for injury may therefore also apply to the referee, considering that his officiating career can extend to 45 years of age (the maximum allowable age for referees at the national and international elite level) (Castagna et al., 2007; FIFA 2008b).

The typically amateur or semi-professional status of the referee greatly influences his training possibilities. The reduced training time and, often, the lack of a professional

support team (fitness, medical), combined with the greater ages seen at the elite level, may jeopardize the chances of achieving the optimal physical preparation needed for refereeing in today's football game. It has been reported that training status has a significant effect on the age-related decrement in aerobic fitness (respiratory capacity, exercise performance) (Taylor et al., 2004; Wilmore & Costill 2004). In a study on Spanish elite referees, Casajus and Castagna (2007) showed that older referees were able to limit the typical age-related decrements in both aerobic and anaerobic performance reported for sedentary people. These referees were also able to maintain physical fitness levels that have been suggested to be appropriate for coping with match demands (Castagna et al., 2002; Weston et al., 2006). Interestingly, the elite referees achieved these figures by following a detailed fitness training program, which included intermittent high-intensity training sessions focusing on the development of aerobic/anaerobic power and endurance (Weston et al., 2004; Castagna et al., 2005; Castagna et al., 2007). In a study on the effects of age on fitness performance, Castagna et al. (2005) examined the 36 elite Italian football referees officiating the "Serie A and B" championships of the 1997-98 competitive season. The referees were grouped in the categories "young" (n=12, age 33.5 ± 2.5 yrs), "average" (n=14, age 37.5 ± 1.0 yrs) and "old" (n=10, age 42.0 ± 1.0 yrs) and performed various different fitness tests during the annual pre-season training camp. The "younger" referees had better scores for jump height and the 200 m sprints, but no group effects were found for the 12-minute run and the 50 m sprints. These results were taken to indicate that, through regular and specific fitness training, age-related differences in physical performance can be reduced.

Being strongly related to age, fitness level is hence a key element to consider for the elite football referee. There is evidence that good aerobic fitness has a positive effect on match distance coverage in referees (Castagna & D'Ottavio 2001; Krustrup & Bangsbo 2001; Castagna et al., 2002). A poor physical preparation may not only affect match performance, but may also place the referee at risk of musculoskeletal injury.

In summary, these considerations should help in understanding the kind of injury profile to be expected in the football referee. One unique difference from the player is that the referee has no physical contact with others on the pitch, and hence contact injuries are not expected. Concerning the match physiological demands and responses, there are similarities between referees and football players (i.e. midfielders), illustrating how the referee is subject to a considerable physical and psychological workload in addition to the intense psychological demands of officiating a match. Non-contact injuries, such as

muscle strains (e.g. hamstring) or joint sprains (e.g. knee, ankle), are also expected in referees, but perhaps at a lower frequency than in players. The longer duration of the elite referee's career, his typically non-professional status, and the non-optimal training conditions suggest that overuse injuries may be a problem in football referees.

Aims of the thesis

The overall aim of this thesis was to analyze the extent and characteristics of injuries and musculoskeletal complaints among football referees at different levels of performance.

Namely in:

- Swiss elite referees (Paper I)
- Male referees selected for the FIFA World Cup 2006 (Paper II)
- Female referees selected for the Women's FIFA World Cup 2007 (Paper III)
- Swiss amateur referees of all skill-levels (Paper IV).

The specific aims were:

- To estimate the frequency and incidence of injuries
- To estimate the prevalence of musculoskeletal complaints
- To determine location and type of injuries and musculoskeletal complaints

The following specific questions were addressed. In terms of frequency/incidence of injuries, prevalence of musculoskeletal complaints, and location of injuries/complaints, were there any differences between:

- Referees at different levels of performance?
- Male and female referees?
- Referees and assistant referees?

Methods

Development of the assessment methods

The problem of assessing overuse injuries

A standard injury definition is important when recording and reporting injury in football injury studies; recently an international consensus on the definition (and on other methodological aspects) has been reached (Fuller et al., 2006). The consensus statement relates to both traumatic and overuse injuries; however, there are some practical problems in the assessment of overuse injury due to their nature (gradual onset and recurrent symptoms). Football injuries are usually divided into *acute injuries* and *overuse injuries*, depending on the injury mechanism and the onset of symptoms (Bahr & Maehlum 2004). The majority of the studies deals with *„acute injuries"*; however, the domain of *„overuse injury"*, which accounts for a significant portion of all sports injuries, is less well described. An acute injury is the result of a single traumatic event (i.e. a tendon rupture), and therefore has a sudden onset of symptoms. An overuse injury (i.e. a tendinopathy) is considered to be the result of repetitive micro-traumata, and symptoms occur gradually over time (Figure 1).

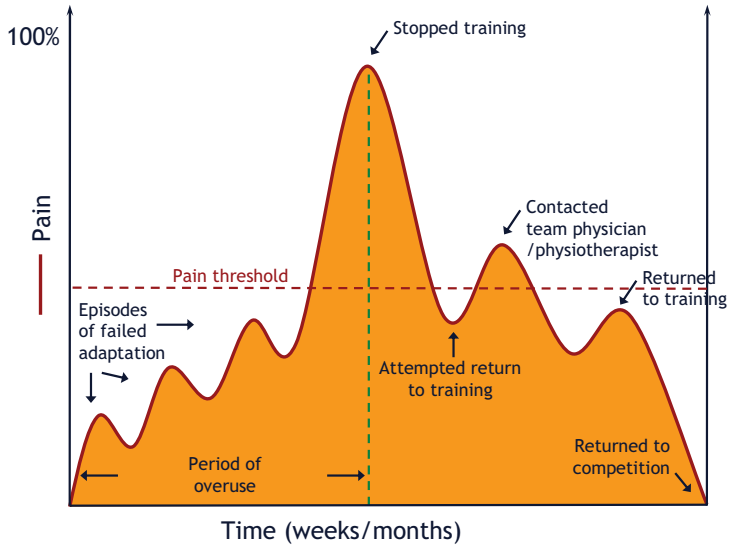

Figure 1. Hypothetical overview of pain and tissue injury in a typical overuse injury. Adapted by permission from Leadbetter by Bahr (Bahr & Maehlum 2004).

In research, definitions and methodologies utilized in football injuries studies are of crucial importance. This ensures the scientific quality, and, if agreement among experts is reached, it allows inter-study comparisons. Recently, Fuller et al. (2006) published a consensus statement paper, on *injury definitions* and data collection procedures in studies of football injuries. An injury was defined as: „*Any physical complaint sustained by a player that results from a football match or football training, irrespective of the need for medical attention or time-loss from football activities. An injury that results in a player receiving medical attention is referred to as a 'medical-attention' injury and an injury that results in a player being unable to take a full part in future football training or match play as a 'time-loss' injury"*. Theoretically, these definitions apply equally to acute and overuse injuries (the definition begins with: *any physical complain sustained*…). However, most scientific studies include time-loss injuries only. In that case, overuse injuries may be neglected or underestimated because they often do not result in any absence from training/game, but rather in performance limitations only. In cases where symptoms exacerbate, an overuse injury may prevent the athlete from training/playing, and cause an absence. The situation is similar with medical-attention injuries; overuse injuries may be underestimated if medical team attention is required before they are recorded. Therefore, in studies with a focus on overuse injuries, an injury definition which includes all complaints, regardless if they cause medical attention or time loss, is recommended.

There are two major problems when recording overuse injuries. The symptoms appear gradually, and their severity fluctuates over time (Bahr & Maehlum 2004). Consequently, it is difficult to report the number of episodes of overuse injuries, because of their chronic nature. Theoretically the definition of *recurrent injury*, as in the consensus statement (Fuller et al., 2006), would apply: „*An injury of the same type and at the same site as an index injury and which occurs after a player's return to full participation from the index injury. A recurrent injury occurring within 2 months of a player's return to full participation is referred to as an 'early recurrence'; one occurring 2 to 12 months after a player's return to full participation as a 'late recurrence'; and one occurring more than 12 months after a player's return to full participation as a 'delayed recurrence*". However, the practical application of this definition is difficult, because it implies that the player would report regularly on any physical complaint.

Beside location and type, *severity* is an important characteristic of an injury. In the consensus statement (Fuller et al., 2006), the severity of the injury is defined as: „*The number of days that have elapsed from the date of injury to the date of the player's return to full participation in team training and availability for match selection"*. Again, this represents a

practical problem when reporting the severity of overuse injuries, because there is often no time loss, even if pain and loss of function may be quite severe. In the area of the Achilles and patellar tendon, researchers have developed specific subjective questionnaires, in order to quantify the severity of overuse injuries (tendinopathies) in these structures. The VISA-A and the VISA-P represent valid and reliable self-reported measures of the clinical severity of Achilles and patellar tendinopathy, respectively (Visentini et al., 1998; Robinson et al., 2001). These questionnaires may be used in both the clinical setting and in research. Although these instruments document the severity of an overuse injury, they do not help the researchers in calculating the magnitude of the overuse injury problem (in a group of athletes).

Usually the frequency of injuries is expressed as the incidence, i.e. the number of injuries occurring during a specific exposure period. However, the unknown onset and the chronic nature and frequent excacerbations and recurrences makes it difficult to *quantify* overuse injuries as the number of injuries per match or per training session. In most cases, exposure data (training and match hours) cannot be associated with overuse injuries, as it is not possible to attribute an overuse injury to a specific training session or match. Either they have to be related to the total exposure or injury risk has to be expressed as the prevalence, i.e. the proportion percentage of players reporting a particular overuse injury at a given time.

Table 4. Characteristics of acute and overuse injuries.

	Acute injury	**Overuse injury**
Cause	Trauma (single episode)	Repetitive micro-trauma(s)
Onset	Sudden	Gradual
Course of symptoms	Acute	Recurrent ("chronic")
Severity	Duration of limited performance	Duration of limited performance and/or intensity of symptoms
Method to quantify (research)	Incidence (number of injuries per exposure)	Prevalence (percentage of players with complaint)

These considerations may raise a question concerning the terminology of "acute" versus "overuse" (Gregory 2002). Both terms are widely accepted in sports medicine (Bahr & Maehlum 2004). However, "traumatic" may be more appropriate than "acute", because it refers to the cause (=trauma) of the injury, as does overuse.

Summarizing the previuos thoughts, it is difficult to formulate an injury definition which could apply to all injuries (traumatic and overuse). The way questions are formulated may have a major impact on the interpretation by the interviewed person. When asking *"Have you sustained an injury …?"*, the player will most likely recall the most serious and acute injuries. On the other side, when asking *"Have you had any complaints… ?/ Have you experienced pain…?*', the athlete will be more likely to list symptomatic body regions, which caused some impairment to or limitation in his sports performance. These symptoms (may) best represent the consequences of the overuse injuries.

Questions related to injuries and complaints should be related to specific time periods, for example: last match, last year, and career. While the rate of acute injuries should be presented as the incidence (number of injuries per exposure), the frequency of complaints should be eypressed as prevalence (percentage of individuals with a specific complaint) in relation to a defined period of time (Table 4).

Development of the questionnaire for this project

The assessment methods were developed based on a recent consensus statement on injury definition and data collection procedures in studies on football injuries (Fuller et al., 2006). Based on these, the questionnaire included separate sections for injuries and musculoskeletal complaints (see Appendix). The referees were first asked, *"Have you suffered any injury caused by refereeing a football match or the training for officiating?"* and then *"Have you had any pain, discomfort or complaints caused by refereeing a football match or the training for officiating?"* (regardless of medical attention or time loss). These questions were repeated for three different time periods (during the last match, in the last 12 months, and in your entire career). The response options for the injury question were "*yes/no"*, and if the referee ticked "yes", we inquired about further details on the injury(ies) during a personal interview. The question concerning complaints was followed by a list of the most common musculoskeletal symptoms (see Appendix). The referees were asked, *"Please indicate the extent to which you suffered from any of the following symptoms",* with answers being given on a 5-point Likert scale (*not at all, a little, moderately, severely, very severely*). This method was adopted because the wording of a question has a major impact on the answers of the respondent; if asked *"Have you sustained an injury?"*, the respondent would be more likely to recall the most serious and acute injuries, but might forget to report

minor injuries or complaints that he does not immediately consider as injuries. The additional question about "*pain, discomfort or complaints*" was included in order to remind the referee of any physical symptoms that he may have experienced during training or a match. The list of symptoms was developed in order to capture overuse injuries.

Study design, participants and procedures

This thesis is based on four papers describing the results of retrospectively and prospectively collected data (in 2006 and 2007) among football referees officiating at different levels of performance (Table 5).

Table 5. Overview of study participants and research design

Study	**Subjects (gender/n)**	**Nationality / Level of refereeing**	**Data collection (year)**	**Research design**
Paper I	Male/66	Swiss / elite	2006	Retrospective
	Female/5 *	Swiss/elite	2006	Retrospective
Paper II	Male/123	International/ pre-selection for FIFA Word Cup™	2006	Retrospective
	Male/63	International/ final selection for FIFA Word Cup™	2006	Prospective
Paper III	Female/81	International/ pre-selection for FIFA Word Cup™	2007	Retrospective
	Female/36	International/ final selection for FIFA Word Cup™	2007	Prospective
Paper IV	Male/481 Female/8 **	Swiss / all levels	2006	Retrospective

** analyzed separately/**included in the overall analysis*

Paper I: Participants & Procedure

All 71 referees (27 match referees and 44 assistant referees) officiating in the Swiss Super and Challenge League (first and second national division; 2005-2006 season) participated in the study. Five female referees were part of this group.

Design and procedure

The study was designed as a retrospective survey. During a training camp organized by the Swiss Referees Association (mid-season break; January 2006), all match referees (MR) and assistant referees (AR) referees were asked to complete a specially developed questionnaire, and were subsequently interviewed in order to gain more detailed information about each injury reported.

The five-page questionnaire covered the following areas: personal characteristics (such as socio-demographics, refereeing qualifications and experience), career history of injuries and musculoskeletal complaints caused by training or refereeing, and other medical problems and time spent in training and in matches.

The interview was based on the injury documentation form published in the recent consensus paper (Fuller et al., 2006). The questions, with pre-defined answers, focused on the location (body part and side), type (overuse injury/trauma and diagnosis), circumstances (training, match and type of activity) and duration of absence from sport for each injury mentioned. Furthermore, the referees were interviewed about the details of the musculo-skeletal complaints recorded in order to classify only acute trauma as injury and overuse injuries as complaints. All interviews were conducted (one-on-one, in a private setting) in either German or French by the first author of the study (MB) and each had an average duration of 10-15 minutes.

Paper II: Participants & Procedure

All 123 MR and AR from 53 National Football Associations worldwide, pre-selected by the FIFA Refereeing Department for officiating during the 2006 FIFA World Cup™ in Germany, were included in the retrospective survey. All referees formed fixed trios

consisting of one MR and two AR. The final group of 21 trios (63 individuals) officiating the 64 matches of the 2006 FIFA World Cup™ were included in the prospective study.

Design and procedure

The retrospective part of the study was carried out in March and April 2006 during two preparation camps (in Frankfurt, Germany) organized for MR and AR by the FIFA Refereeing Department. On the first day of the camps, the referees were asked to complete a questionnaire on injuries and musculoskeletal complaints. Where injuries were declared, a brief personal interview was carried out to expand on the responses given in the questionnaire.

The same questionnaire as in paper I was used. The forms were available in English, Spanish, German and French, the four official FIFA languages, since fluency in at least one of these languages is a prerequisite for selection as a FIFA referee.

During the FIFA World Cup (June-July 2006), data on injuries and musculoskeletal complaints were collected prospectively by one physiotherapist (MB) from the medical team. Confirmation of the diagnosis was made by a medical doctor at the referee headquarters in Frankfurt. Every acute injury incurred during match or training was recorded according to the consensus injury definition (Fuller et al., 2006). All musculoskeletal complaints that received medical attention were recorded similarly. The type and number of treatments (physiotherapy, massage, electrotherapy, taping, other) and training modifications (reduced training, such as on an exercise bike or in the pool) were recorded on a daily basis.

Paper III: Participants & Procedure

All 81 female referees (30 MR and 51 AR) from 33 National Associations worldwide, pre-selected for officiating during the FIFA Women's World Cup™ 2007 by the FIFA Refereeing Department, participated in the retrospective survey.

The 36 referees finally selected to officiate the final 32 matches of the FIFA Women's World Cup™ 2007 in China were included in the prospective part of the study.

Design and procedure

The retrospective part of the study was carried out during the three preparation camps in January (Canary Islands, Spain), March (Algarve, Portugal) and May (Zürich, Switzerland) of 2007, organized for female MR and AR by the FIFA Refereeing Department.

On the first day of the two camps in January and March, the 81 pre-selected referees were asked to complete a questionnaire on injuries and musculoskeletal complaints. During the last camp in May, a physiotherapist conducted brief personal interviews with each of the 51 final pre-selected referees, in order to confirm and complete the questionnaire data. The questionnaire was available in English, Spanish, German and French, the four official FIFA languages, since fluency in at least one of these languages is a prerequisite for selection as a FIFA referee.

Data on injuries and musculoskeletal complaints were collected prospectively by one physiotherapist (MB) from the medical team. Confirmation of medical diagnoses was made by a physician at the referee headquarters in Shanghai. Every acute injury incurred during a match or training was recorded according to the consensus injury definition (Fuller et al., 2006). All musculoskeletal complaints that affected the performance of the referees were similarly recorded. The type and number of treatments (physiotherapy, massage, electrotherapy, taping, other) and training modifications (reduced training, such as on an exercise bike or in the pool) were recorded on a daily basis.

Paper IV: Participants & Procedure

A total of 4452 referees were licensed to officiate in the different leagues of the Swiss Football Association (SFA) during the 2005/2006 season. Based on the leagues, they were classified in four groups: "professional/semi-professional" level defined as the two elite leagues (called "Super" and "Challenge") leagues, "high amateur" as the 1st and 2nd leagues, "low amateur" as the 3rd to 5th leagues, and "junior" level as all leagues with players up to 20 years of age.

Design and procedure

The SFA provided a complete list of all 4452 referees and informed the regional Swiss Referee Federations about the impending survey, two months in advance. A random sample of 608 referees was selected, but 86 referees had to be withdrawn from the survey (invalid phone numbers, unwilling to participate, language problems) and 33 were excluded because they were no longer active as referees.

A total of 489 active Swiss referees officiating at all levels were interviewed by telephone with regard to their personal characteristics, such as socio-demographics, refereeing qualifications and time spent in training and in matches, history of injuries and musculoskeletal complaints caused by training or refereeing, and other medical problems.

The structured interviews were based on the questionnaire implemented in the papers I-II-III, but adapted for the needs of a telephone survey. The interviews (average duration, 10 minutes) were conducted in German and French in order to cover the two languages most commonly spoken in Switzerland. The phone survey was carried out by a specialised institute (LINK Institut, Lamprecht & Stamm, Zürich) in May 2006.

Statistical methods

Calculation of exposure time

For all papers, exposure in match and training was calculated based on the information provided in the questionnaire (average matches per year, matches in the last 12 months, average training hours per week in pre-season and during season). Match exposure in the last 12 months was calculated as the total sum of matches officiated by all referees in the last year times 1.5 hours (the minimum duration of a match). Match exposure over the career was calculated by multiplying the number of referees, the average years in refereeing, the average number of games officiated per year and 1.5 hours.

Statistical analysis

The statistical analyses were carried out using SPSS (version 11; SPSS Institute, Chicago, Illinois). Statistical methods applied were frequencies, means and cross-tabulations. Group differences between MR and AR were analysed by chi-square analyses (categorical

data) or unpaired t-tests (continuous variables). Results were reported as the mean and standard deviation (SD) and/or range, unless otherwise noted. For incidence rates, 95% confidence intervals were calculated as the incidence ± 1.96 times the incidence divided by the square root of the number of injuries. P-values of less than 0.05 were regarded as significant.

In Paper I the female referees (n=5) were analysed separately to account for potential gender differences.

In the Papers II and III, the match exposure (in hours) for the prospective surveys was calculated by multiplying the number of games (64 and 32, respectively) by the number of referees (3) and the minimum duration of the game (1.5 hours).

In Paper IV, because of the small number, the 8 female referees were not analyzed separately (and therefore included in the global analysis). Additionally, no MR-AR comparison was possible, because of the absence of the AR-position in the Swiss lower leagues (Paper IV).

Ethics

The University of Zürich, Human Subjects Ethics Committee, granted ethical approval for the four studies. All participants gave their signed informed consent to participate. All data collected were treated strictly confidentially.

Results

Characteristics of the referees (Papers I-IV)

Some of the characteristics of the subjects of the four studies are outlined in Table 6 (for additional information see Papers I-IV).

Table 6. Antropometric characteristics, refereeing experience and number matches in the last year of the study participants

Study	Paper I	Paper II	Paper III	Paper IV
Number of referees	66 *	123	81	489 ***
Age (years)	36	41	35	36.6
mean (range)	(25-45)	(29-45)	(26-44)	(15-73)
Height (cm)	180	178	166	177
mean ± SD	±6	±6	±0.6	±7.2
Weight (kg)	76	76	59	78
mean ± SD	± 6	±7	±6	±11.6
Years since first license	16	19	12	12
mean (range)	(7-25)	(8-32)	(4-25)	(1-20)
National matches in last year	25	28.2	29.9	21.8
(mean ± SD)	±7	±10.3	±21.7	±14.4
International matches in last year	5.1	9	8.3	-
(mean ± SD)	±3.1 **	±3.1	±4.8	

** 5 females were analyzed separately, ** data of the 23Swiss referees with FIFA license,*
**** 8 female referee were included in the overall analysis*

Injuries - retrospective data (Papers I-IV)

Male referees (Papers I, II, IV)

In Paper I, 29 Swiss elite referees (43.9 % of the 66) reported a total of 39 injuries during their careers. Seventeen referees (25.8%) reported an injury during the last 12 months. None of the referees incurred in an injury during the last match. There were no reported

injuries that resulted in less than 2 weeks absence from refereeing, and more than 40% of all injuries caused a time loss between 2 and 4 weeks. More training injuries (n=24; 62%) than match injuries (n=14; 36%) were reported overall. No statistical differences were found between MR and AR for all these figures.

Among the 123 FIFA referees (Paper II), a total of 58 career injuries were reported by 50 referees (40.7%). Six referees (5%) had incurred in an injury during the last 12 months, and none reported an injury during the last match. The majority of the injuries resulted in an absence of 2 to 4 weeks (n=35; 60.4%), while there was no reported injury with less than 2 weeks absence from officiating. More injuries occured in training (n=48; 82.8%) than in matches (n=10; 17.2%). No statistical differences were found between MR and AR for all these figures.

A career total of 155 injuries were reported among 110 referees (22.5%) out of the 489 interviewed Swiss referees of all levels (Paper IV). Forty-four referees (9%) reported an injury during the last year, while five referees (1%) did the same for the last match.

All the injuries caused an absence from officiating up to one week in 14.8% (n=23), from 8 to 14 days in 24.5% (n=38), and from 15 to 30 days in 22.6% (n=35) of the cases. More injuires during matches (n=114; 73.5%) than training injuries (n=41; 16.5%) were overall reported. The proportion of referees reporting injuries during their career increased with age up to 50 years, after which it remained relatively stable (Figure 2).

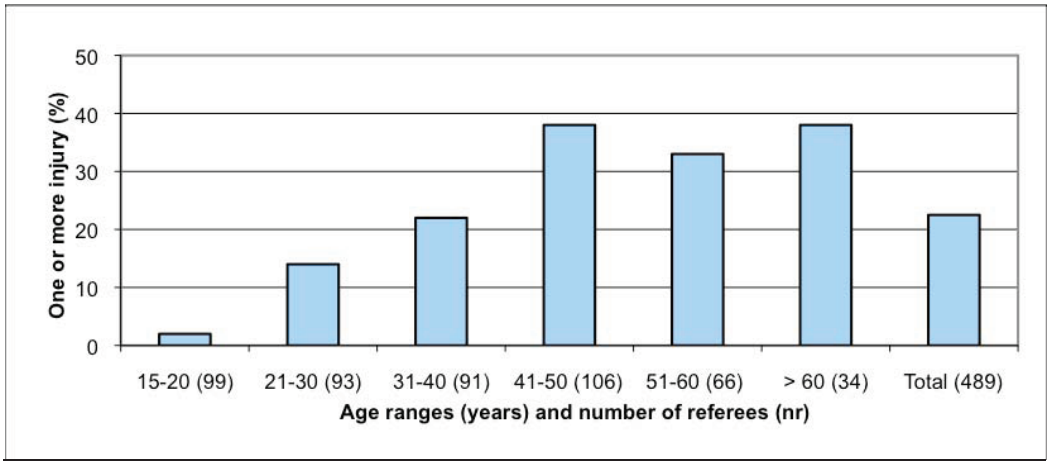

Figure 2. Percentage of Swiss football referees reporting at least one career injury by age group (paper IV).

Female referees (Papers I, III)

Among the 5 Swiss female referees (2 MR and 3 AR) in Paper I, two injuries (by one MR and one AR) were reported in the last 12 months. Both referees suffered a hamstring strain during training.

In Paper III, a career total of 57 injuries were reported by 39 FIFA female referees (48.1% of the 81). Twelve referees (14.9%) had an injury during the last year, while one AR reported an injury during the last game. All reported injuries had resulted in at least two weeks absence from refereeing, with more than 2/3 of all injuires causing an absence of two to four weeks. The number of reported training injuries (n=30; 52.6%) and match injuries (n=27; 47.4%) were similar.

Injuries - prospective data (Papers II, III)

Male referees (Paper II)

At the 2006 FIFA World Cup™, 14 referees (22.2% of the participating 63) suffered an injury during the tournament. In each group (MR and AR) there were 3 match injuries and 4 training injuires.

None of the injuries caused any absence from officiating, but almost all of the injured referees (n=13; 93%) had to reduce or modify their normal training routine for an average of 4.4 days.

Female referees (Paper III)

Nearly 40% (n=14; 38.9%) of the 36 FIFA referees officiating at the FIFA Women's World Cup 2007 incurred an injury during the tournament. More training injuries (n=9; 64.3%) than match injuries (n=5; 35.7%) were documented.

All 14 injured referees had to reduce their normal training routine for an average of 5.6 days, but none of them was kept out of refereeing because of the injury.

During the World Cup™, more female referees (38.9%) than male referees (22.2%) incurred an injury (RR 1.6; 95% CI: 0.95 to 2.56, not significant).

Table 7. Incidence of training and match injuries (retrospectively in the last 12 months/prospectively during World Cup™) and common location of injuries.

Study	Training injuries in last 12 months per 1000 training hrs (95% CI)	Match injuries in last 12 months per 1000 match hrs (95% CI)	Match injuries during World Cup™ per 1000 match hrs (95% CI)	Most common location of injury
Paper	0.4	3.4	-	1.Hamstring
I	(0.1-0.7)	(1.2 – 5.7)		2.Ankle
				3.Calf
Paper	0.4	0.7	-	1.Hamstring
II	(0.2-0.6)	(0.1- 1.3)		2.Calf
				3.Ankle
		-	20.8	1.Hamstring
			(4.2 -37.4)	2.Ankle
				3.Heel
Paper	0.6	2.8	-	1.Hamstring
III	(0.2-0.6)	(1.3 – 4.3)		2.Calf
				3.Ankle
		-	34.7	1.Rectus femoris
			(4.2 –65.1)	2.Hamstring
				3.Calf
Paper	0.1	2.1	-	1.Thigh muscles
IV	(0-0.2)	(1.4 – 2.8)		2.Ankle
				3.Calf

Table 8. Incidence of match and training injuries for Swiss referees with respect to the officating level (paper IV, retrospective data of 12 months)

	Junior N=138	Low-level amateur N=215	High-level amateur N=123	Semi-Pro & professional N=13
Match injuries per 1000 match hrs (95% CI))	0.59 (0.23 to 1.33)	2.57 (1.44 to 3.7)	1.97 (0.67 to 3.27)	5.54 (2.16 to 13.24)
Training injuries per 1000 training hrs (95% CI)	0.02 (0.02 to 0.06)	0.11 (0.03 to 0.19)	0.11 (0.01 to 0.23)	0

Musculoskeletal complaints - retrospective data (Papers I – IV)

Male referees (Papers I, II, IV)

More than 40% (n=28; 42.4%) of the 66 Swiss referees (Paper I) stated that they had had at least one musculoskeletal complaint during the last match. This percentage was lower than during the last 12 months (n= 56; 86.4%) or career (n=60; 90.1%). No significant difference in the frequency of complaints was observed between MR and AR.

Nineteen (17.1%) of the 123 FIFA referees (Paper II) reported at least one musculoskeletal complaint during the last match. In the last 12 months the percantage was 59.4 % (n=73), while during the career it was 62.6% (n=77). No difference was found between MR and AR.

Musculoskeletal complaints were reported by 38 referees (7.8%) of all 489 Swiss referees of all levels (Paper IV). There were more than 10% (n=66; 13.5%) in relation to the last year, and about one quarter (n=126; 25.8%) during the career. The percentage of referees reporting complaints during their career ranged between 21% and 33% in the different age groups, with no specific trend (Figure 3).

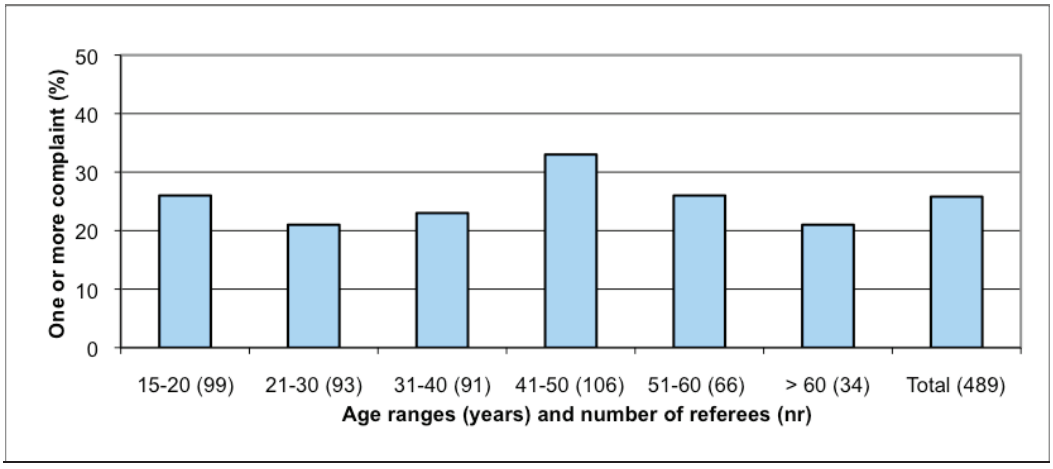

Figure 3. Percentage of Swiss football referees reporting at least one career musculoskeletal complaint by age group.

Female referees (Papers I, III)

The details of the five Swiss elite female referees (Paper I) with complaints are provided in table 4 of paper I.

Thirty-seveen (45.7%) of the 81 FIFA referees (Paper III) reported having had at least one musculoskeltal complaint in the last match. The percentage was around 80% (n=66; 81.5%) for both last year and career. In all figures, AR had significantly more complaints than MR.

Musculoskeletal complaints - prospective data (Papers II-III)

Male referees (Paper II)

More than 30% (n=22; 34.9%) of the 63 FIFA referees officiating during the FIFA World Cup™ 2006 were treated for musculoskeletal complaints during the tournament.

Sixty percent of all complaints were not related to any retrospectively colled data. (details are provided in Table 4 of Paper II).

Table 9. The three most common locations of musculoskeletal complaints in the four studies (Papers I-IV)

Study	Location of complaints (retrospective)	Location of complaints (prospective)
Paper I	1.Hamstring	
	2.Knee	
	3.Achilles tendon	
Paper II	1.Hamstring	
	2.Knee	
	3.Calf	
		1.Low back
		2.Calf
		3.Achilles tendon
Paper III	1.Hamstring	
	2.Calf	
	3.Low back	
		1.Low back
		2.Plantar fascia
		3.Hip
Paper IV	1.Knee	
	2.Low back	
	3.Achilles tendon	

Female referees (Paper III)

During the Women's World Cup 2007, 12 (33.3%) of the 36 FIFA referees were treated for complaints. More than 70% of all documented complaints during the torunament

were not related to any retrospective collecetd data. Details are provided in table 4 of paper III.

Other medical information (Papers I-IV)

The questionnaire included a section on additional medical problems (as asthma, allergies), mediation intake and surgical procedures. The respective frequencies (retrospective data) for the four groups of referees are shown in Table 10.

The reporting of medical problems (such as asthma) and the use of medication in the four groups of referees (Papers I-IV) showed almost the same prevalences (20% and 10% respectively) in Swiss referees (Papers I and IV) and FIFA World Cup™ pre-selected referees (papers II and III). Knee surgery was the most frequently reported surgical intervention in all four referee's group, with a higher prevalence in the Swiss groups compared with the FIFA groups (Table 10). The fact that more than thirty percent of the Swiss amateur referees were also playing club football may have accounted for the larger number of reported knee injuries (Paper IV).

Table 10. Medical problems, medicaments, surgeries among referees (Papers I-IV)

Study	Prevalence of medical problems	Prevalence of medication intake	Prevalence of surgery	Most common surgery locations
Paper I	19.7%	9.1%	30.3%	1.Knee
				2.Ankle
Paper II	14.6%	9.8%	13.8%	1.Knee
				2.Ankle
				3.Achilles tendon
Paper III	18.5%	11.1%	16.1%	1.Knee
				2.Ankle
Paper IV	19.8 %	13.3%	34.2%	1.Knee
				2.Ankle
				3.Achilles tendon

During the two FIFA World Cup™ (Papers II, III), the medical teams at the referee's headquarters provided treatments to those referees with injuries and complaints. The

most common interventions were: physiotherapy, massage therapy, electrotherapy and taping (the details are provided in the table 3 and 4 of the respective papers). The majority of the referees had to reduce or modify the training routine, but none of them was kept out of match officiating.

Discussion

Characteristics of the referees

The personal characteristics (age, height, weight, body mass, years of refereeing experience) of the elite referees (Papers I-III) were similar to those reported in other studies dealing with elite referees officiating at national and international level (Castagna & Abt 2003; Helsen & Bultynck 2004; Mallo et al., 2008a). The referees selected for FIFA World Cup™ (Paper II) were older than the Swiss elite referees (Paper I); this because elite football referees often only reach the top of their career (the selection for the FIFA World Cup is considered to be the ultimate career goal in refereeing) at an age greater than 40 years (Castagna et al., 2007). Compared to their male counterparts involved in the 2006 FIFA World Cup selection, the female referees involved in the FIFA Women's World Cup 2007 (Paper III) were younger (by on average five years), and had a shorter refereeing career. Interestingly, the average number of matches per year (the data of the last 12 months were considered) was almost identical in the three groups.

The 489 Swiss referees of all levels (Paper IV) had a similar average age and shorter experience than their elite colleagues (Paper I). Compared with the FIFA selection (Paper II), they were on average younger and less experienced. However, it has to be considered the age range (15 – 73 years) of this representative sample: there is no age limit for referees officiating in the lower leagues (and at the junior level). Only at the top national leagues level (as in Switzerland) and at the international level (FIFA regulation) the referee's retirement age is set at 45 years. Similarly, because of the different leagues (the referees were classified in four groups), the referees showed different levels of experience and different average number of matches per year (see Table 2 in Paper IV).

Methodological considerations

A critical issue is the different results obtained from the four studies. There is a large discrepancy between the injury incidence rates from the retrospective and prospective data, with values ranging from 0.7 match injuries per 1000 match hours (male, Paper II, in the last 12 months) to 34.7 match injuries per 1000 match hours (female, Paper III, prospective). Differences between the last 12 months and career injury incidence data were also obvious (e.g. no career injuries were reported by the Swiss MRs, Paper I).

Another example is that there were almost the same number of referees reporting musculoskeletal complaints in the last 12 months and during the entire career (Papers I, II, III), despite the evident difference in terms of exposure hours.

Two aspects must be considered to explain these discrepancies. First, the *retrospective design* (and the associated recall bias) is the major limitation of parts of the present studies. Only injuries with at least two weeks duration were reported, and the exposure-related incidence of injuries was substantially higher (Paper II) or similar (Papers I and III) for the preceding 12 months than for the entire career. In fact, the size of the discrepancy when comparing the estimated career incidence with the reported 12-month incidence (especially in Paper II) suggests that as many as 90% of injuries occurring more than 12 months ago may have gone unreported. As such, the incidence of injury is clearly underestimated by the retrospective interviews, and the reported total number of complaints during a career is probably unreliable and should be interpreted with caution. The memory effect and recall bias problem is well documented in the literature. Twellaar et al. (1996) showed that students, when asked to recall all injuries sustained in the preceding three years, had forgotten 54% of their injuries. In comparing prospective and retrospective evaluations of injuries over a 12-month period, Junge and Dvorak (2000) found that only "every third moderate injury and less than 10% of mild injuries were reported in a retrospective questionnaire" and concluded that "the shorter the period of symptoms and the longer ago the injury occurred, the more frequently it was forgotten."

Secondly, the application and the use of the *injury definition* (see Methods) have also influenced the rate of injury reported in the studies. In the retrospective surveys, the referees exclusively reported time-loss injuries, likely because they stated only those injuries really impeding their ability to train regularly or officiate a match. This fact determines per se lower injury rates than the ones obtained with the "physical complaint" or "medical attention" definitions. Adding this to the recall bias associated with the retrospective study design, than the discrepancy of the injuries and complaints data may be explained. During the prospective data collection, the "physical complaint" (and related "medical attention) was applied at its best, because a physiotherapist documented daily all minor injuries and complaints reported by the referees to the medical team. As a consequence, a higher injury rate can be per se expected in this situation. The papers published from the most important football tournaments (FIFA World Cups), using the "physical complaint" definition, showed higher injury rates than

those reported in other papers using the "time-loss" definition (Dvorak et al., 2007, Junge & Dvorak 2007).

Injuries: magnitude of the problem in referees

The percentage of referees reporting at least one career time-loss injury was between 41% and 48% in the three studies dealing with male and female elite referees (Papers I-III). In comparison, there were about 25% of referees officiating the Swiss leagues reporting one or more injuries during their career (Paper IV). Considering the retrospective data of the last 12 months (where the recall bias may have been the same for the participating referees), where only time-loss injuries were reported, the incidence of match injuries in referees ranged between 0.7 and 3.4 injuries per 1000 match hours (Table 7). These figures can be somehow related to the low ranges of reported incidences of training injuries in football players ((Junge & Dvorak 2004), but with the limitation that also contact injuries may be included in the latter group. Because of the methodological problems discussed above, these figures clearly represent an underestimation of the true rate of time-loss injuries.

The comparison of the prospectively collected data (Papers II, III) with those of the players involved in the same tournaments can help in estimate the true injury risk for a football referee. At the 2006 FIFA World Cup™, the incidence of 20.8 match injuries per 1000 match hours in the officiating referees (Paper II) was substantially lower than that reported for the football players involved in the same tournament (68.7 injuries per 1000 match hours). The incidence of non-contact injuries in players (18 injuries per 1000 match hours) seems similar to that of referees, but some of the non-contact injuries in players resulted in absence from training or match (Dvorak et al., 2007).

Similarly, the FIFA female referees involved in the 2007 FIFA Women's World Cup (Paper III) showed a lower incidence of match injuries (34.7 match injuries per 1000 match hours) than the female players involved in seven major FIFA tournaments (67.4 injuries per 1000 match hours) (Junge & Dvorak 2007). During the last FIFA Women's World Cup 2007 the female players had a incidence of match injuries of 71 injuries per match hours, whereas the incidence of non-contact injuries was 10.4 injuries per 1000 match hours (Junge, personal communication) was lower than that of the female referees. At the FIFA tournament level, the percentage of contact injuries was higher in

female (86%) compared to male (73%) players, but in the women's game fewer injuries were caused by foul play (Junge & Dvorak 2007).

Therefore, it seems that the risk of non-contact injuries for an elite referee (female or male) is about similar to or lower than that of a football player. The referee has no risk for contact injuries: this reflects the formulated expected injury profile (see Introduction, page 30), when considering the similarities in the activities patterns (without ball) between players and referees.

Musculoskeletal complaints

During the two World Cups™, almost the same proportion of female (33.3%; paper III) and male (34.9%; Paper II) referees suffered from musculoskeletal complaints requiring medical attention and/or treatment (the details can be found in the Table 4 of the respective papers). But it is important to note that the length of these tournaments is about one month, which is a relatively short observation period for overuse problems.

The percentage of referees reporting at least one musculoskeletal complaint related to the last year and the career ranged from 80% (career, FIFA female; Paper III) to 90% (Swiss elite; Paper I). These figures closely resemble the prevalence of soreness in the lower extremity and back pain observed by Fauno et al. (1993) in a group of international referees.

In Paper II, the number of male FIFA referees reporting complaints was similar for the last year and career (around 60%), indicating the problem of recall bias. Thus, the prevalence of complaints during the career represents is underestimated and should be interpreted with caution (the same situation was found in this group for the retrospective injury data). An alternative explanation for this under-reporting of previous complaints (and injuries) by the male FIFA referees may be the better physical fitness in this elite group.

About 25% of the Swiss referees of all levels reported at least one musculoskeletal complaint during their career (Paper IV). The prevalence of complaints was substantially lower than reported for groups of elite referees (Papers I-III). One possible explanation for this difference concerns the different methodological approaches used to register complaints. While in the studies on high-level referees a list of complaints was provided,

in the study on national referees they were asked an open question and the responses were then categorised into the different locations. The difference might also be partly explained by the higher physical demands of matches and training at national and international level (Castagna et al., 2007).

A comparison with prevalence data of overuse problems in football players is difficult, because of the lack of accurate data in the literature. In a recent review, Junge & Dvorak (2004) reported that "between 9% and 34% of all injuries during the season are classified as overuse injuries". However, it can be possible that the amount of overuse problems (complaints) in football players is underestimated when the time loss injury definition is used to document injuries (as it is the case in the majority of studies).

Therefore, the career prevalence of musculoskeletal complaint in elite male and female referees can be estimated to be at least 90%. This figure may be lower in referees at the lower performance levels (assuming the same recall bias in all four studies).

Relationship between injuries and musculoskeletal complaints

In these studies (Papers I-IV) injuries and musculoskeletal complaints were assessed and analyzed separately, because it was expected that the chronic/recurrent symptoms of overuse injuries would not be reported when asked for injury. Hamstring and calf muscles were the main locations of both injuries and musculoskeletal complaints. These data may reflect the presence of long-term problems in these two muscle groups of the referees (all of them having a long career). However, in the case of low back and Achilles tendon related complaints, there was no association between complaints and injury data. As an example, in Paper I (Swiss elite referees), the results showed that the referee's answers to the injury and musculoskeletal complaints question were complementary (i.e. two referees reported an injury of the Achilles tendon, but 28 referees reported pain in the Achilles tendon). In addition, the diagnoses for the reported injuries did not include typical overuse injuries; thus, the separate assessment of injuries and musculoskeletal complaints provided complimentary information. Therefore, it can be assumed, that complaints in the low back and Achilles tendon might rather reflect symptoms of overuse injuries. The recurrent nature of low back pain and Achilles tendinopathy is well documented in the literature (Cook et al., 2002; Pengel et al., 2003).

In Paper IV (Swiss referees of all levels), thirty referees (6.1%) reported having suffered both injuries and complaints related to refereeing during their career. In only one case was the body part that was injured the same as that for which the complaints were reported (thigh/hamstring); in four other cases an association between injury and complaint could have been suspected (respectively, foot and Achilles Tendon (2 cases), knee and quadriceps (1 case), thigh and knee (1 case)). In all other cases the referees reported only injuries (n=80) or complaints (n=96), or neither of them (n=308). Therefore, the questionnaire proved useful in differentiating between acute and overuse injury.

Location of injuries and complaints

The *injury* locations reported most frequently (hamstring, calf, and ankle) were similar in all four studies (Papers I-IV), showing a consistent injury profile of the referee (male and female) (Table 7) and confirming the expectations based on the activity profile of the referees (see Introduction). Muscle strains (more thigh than calf muscles) and ankle sprains were the most common type of injury across the studies, both retrospectively and prospectively. These two types of injury are also the most common injuries in football players (Junge & Dvorak 2004). It is important to note that, in players, about half of all acute injuries (especially knee and ankle sprains) are caused by foul play (Hawkins & Fuller 1999). The most common non-contact injuries of players, muscles strains of the posterior thigh (= hamstrings), were also common in referees. Football players are on average 15 years younger than referees (especially at the national and international elite level). Arnason et al. (2004b) found that increased age and previous hamstring muscle strains were the main risk factors for hamstring strains in footballers. It can be speculated, that this finding may apply for the referees as well (even more because of the length of their careers). Similarly to the injury data, the four studies (Papers I-IV) showed consistent findings concerning the location of *musculoskeletal complaints*. The most prevalent location of the complaints were the same in male and female referees: hamstrings, calf, low back, knee, and Achilles tendon (Table 9). These findings confirm the specific musculoskeletal complaints profile of the football referee at all levels. The relative distribution of complaints during the two World Cups (where data was collected prospectively) was similar to that reported retrospectively, except that low back pain was reported more frequently (more in male than female FIFA referees). This may be related

to the recurrent nature of low back pain (Pengel et al., 2003), considering that as about 60% of the male FIFA referees already reported this complaint retrospectively.

Levels of performance

The incidence of match injuries in the preceding 12 months reported by male and female referees (Papers I-IV) was similar, except for the FIFA male selection (Paper II) (Table 7). In this latter group, the incidence of match injuries in the last 12 months was considerably lower (tenfold) than in the Swiss elite referees (Paper I). Since memory effects (see „Methodological issues") can be considered to be equal for all studies, a possible response bias due to the selection procedure for the 2006 FIFA World Cup might be an explanation for this finding. For an international FIFA referee, officiating in the World Cup represents the pinnacle of his refereeing career. In view of this, it cannot be ruled out, that some individuals may have held back information when completing the questionnaire, for fear of not being selected. In paper IV, the referees involved at the junior level showed a lower incidence of match injury (last 12 months) than the other referees groups involved in other Swiss leagues (Table 8). However, because this group was significantly younger than the other group, it is not possible to ascertain whether this was an effect of league level or age.

Therefore, it seems that the incidence of match injuries is similar for referees officiating matches for adult players, regardless of the level of performance. Referees of junior leagues are on average younger and have a lower injury rate.

Male versus female referee

During the World Cup™, more female referees (38.9%) than male referees (22.2%) incurred an injury, with a relative risk of 1.6 (not significant) of suffering a match injury. One can only speculate as to the reasons for the apparently higher incidence of injuries in female compared to male FIFA referees. It is possible that the difference is due to a lack of specific physical preparation (in order to match the physiological demands of international refereeing) of the female referees. From an historical perspective, the first FIFA Women's World Cup only took place in 1991 (China), whereas the "male" FIFA World Cup™ was first held in 1930 (Uruguay). Hence, international women's soccer

generally has a shorter history and is still evolving in all aspects of the game including, presumably, refereeing. While male FIFA referees have been systematically supported by expert fitness coaches since 2000, their female counterparts were only enrolled in similar programs in recent years. The group selected for the FIFA Women's World Cup 2007 had only been participating in a structured training program since 2005. This was also evidenced by the questionnaire data, which showed that 83.7 % of the male referees, but less than two thirds (64.2%) of the female referees reported having received advice about their training from qualified personnel (Papers II, III). Other possible reasons for the higher incidence of injury in female referees include the gender difference in fitness level (Lewis et al., 1986) and in neuromuscular characteristics (Rozzi et al., 1999). Finally, another possible explanation, could be the difference between men and women in pain coping and perception (Keogh & Herdenfeldt 2002). As discussed before, the locations of injuries and complaints were similar in male and female referees (Papers I-IV). The relatively high prevalence of headache in women referees (around 30% among FIFA female referees; Paper III) is difficult to explain.

Match Referees versus Assistant Referees

There were no statistical differences in the injury incidence between MR and AR in Papers I-III (male, female referees). Some injury type trends (but no statistical differences) were found to differ between male MR and AR, which may be related to the specific movement patterns on the field of play. MR showed a trend toward more lesions of the knee (meniscus; Paper II), while AR showed a trend toward more lesions of the adductor muscles and groin (Papers I and II). Adductor muscle strains were also observed more frequently in female AR than in MR. This difference may be associated with the significant amount of sideward running (and shuffling) of the AR during the game. As noted for the injuries, there were some trends showing that some complaints were more prevalent in MR (Achilles tendon) than in AR (adductor and calf muscles, groin area), which again may be related to the different physical demands of these refereeing roles.

Conclusions

1. While the retrospective survey results (due to the recall bias) showed an underestimation of the frequency of injury, the prospective data collection indicated that the non-contact injury risk for a football referee can be estimated to be similar to, or slightly lower than, that of a football player. This is not surprising, considering that the activity patterns of the players and referees are similar. The data also confirms that there are no contact injuries in referees, who are not involved in contests for ball possession.

2. The career prevalence of musculoskeletal complaints can be estimated to be around 90% (or even 100%) in the elite male and female referees, whereas this percentage may be lower in referees of lower levels of performance. Due to the lack of scientific data, a comparison with the prevalence of complaints in football players is not possible.

3. The injury types and locations of musculoskeletal complaints were similar among referees at all levels of performance and between genders. The most common injuries were hamstring strains, calf strains and ankle sprains. The most frequent locations of musculoskeletal complaints were the low back, hamstrings, knee, calf and Achilles tendon.

4. The incidence of match injuries was similar for referees officiating match for adult players, regardless of the level of performance. Referees of junior leagues were on average younger and had a lower injury rate.

5. Although there appeared to be a 60% higher risk of injuries among female FIFA referees than their male counterparts at the World Cup level, this difference was not statistically significant.

6. No statistical differences were found between elite referees and assistant referees (both in males and females) concerning injury incidence, prevalence of complaints, and location of injuries and complaints.

Future research

These studies have established the incidence of injuries, prevalence of musculoskeletal complaints and injury profile in male and female football referees of all levels of play.

This is actually the first step in the sequence of injury prevention.

Consequently, future research should focus on the following steps:

- Studies are needed to evaluate risk factors and injury mechanism in referees.
- Moreover, there is a need to develop and implement specific injury prevention programs among male and female referees.
- Research is needed to evaluate the effect of preventive measures in referees.

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Appendix

Surname: _____ Name: _____

Date of birth: _____ Nationality: _____

Height: _____cm Weight: _____kg

I. History of refereeing

First, we would like to know some details about your history of refereeing.

1. When did you receive the first official license for refereeing? _____ (year)
2. When did you receive the FIFA license for refereeing? _____ (year)
3. When did you start refereeing for the **national league**? _____ (year)
4. When did you start refereeing **international matches**? _____ (year)

5. How many **international matches** have you refereed as a match or assistant referee?

	match referee	assistant referee
FIFA World Cup		
Confederation (AFC, CAF, COCACAF, CONMEBOL, OFC, UEFA) Championship/Cup		
Olympic Tournament		
Other international matches		

6. How many international and national matches do you referee on **average per year**?
   International _____ national _____

7. How many international and national matches did you referee **in the last 12 months**?
   International _____ national _____

8. What was the **maximum of matches per week** you refereed in the last 12 months?
   _____

9. Are you currently active as **match** referee or as **assistant** referee?
   ❑ match referee ❑ assistant referee

Now we would like to ask you about injuries and complaints that were caused by refereeing a football match or the training you do preparing for refereeing. We will first ask you about your last match, then about the last 12 months and finally about your entire career. If you still suffer from complaints of a previous injury, please mention these complaints for each relevant time period, however, its details should be described only once in the related section.

II. For the following questions, please consider this LAST MATCH you refereed.

1. **When** was the last match you refereed? _____ (dd/mm/yy)

2. Was the last match you refereed **national** or **international**?
   ❑ national league match ❑ international match

3. Did you incur an **injury** during you last match?
   ❑ no ❑ yes **(> Details will be discussed during the interview)**

4. Did you have any of the following **complaints prior, during or after your last match?**

Headache	❑ no	❑ yes	
Neck pain	❑ no	❑ yes	
Low back pain	❑ no	❑ yes	
Pain in the **hip** joint(s)	❑ no	❑ right	❑ left
Pain in the **groin** region(s)	❑ no	❑ right	❑ left
Pain in the **inner thigh** muscles (adductors)	❑ no	❑ right	❑ left
Pain in the **front thigh** muscles (quadriceps)	❑ no	❑ right	❑ left
Pain in the **back thigh** muscles (hamstrings)	❑ no	❑ right	❑ left
Pain in the **knee** joint(s)	❑ no	❑ right	❑ left
Pain in the **patellar** tendon(s)	❑ no	❑ right	❑ left
Pain in the **calf** muscles	❑ no	❑ right	❑ left
Pain in the **Achilles** tendon(s)	❑ no	❑ right	❑ left
Pain in the **ankle** joint(s)	❑ no	❑ right	❑ left

Others, please specify

_____

III. For the following questions, please consider THE LAST 12 MONTHS.

1. Did you suffer any **injury** caused by refereeing a football match or the preparing training during the last 12 months?
   - ❑ no
   - ❑ yes, namely

   _____

   (> Details will be discussed during the interview!)

2. Have you had **any pain, discomfort or complaints** caused by refereeing a football match or the preparation training during the last 12 months?

Please indicate whether and to what extent you suffered from any of the following symptoms:

	No	a little	moderately	severely	very severely
Headache	❑	❑	❑	❑	❑
Neck pain	❑	❑	❑	❑	❑
Back pain	❑	❑	❑	❑	❑
Pain in the **hip** joint(s)	❑	❑	❑	❑	❑
Pain in the **groin** region(s)	❑	❑	❑	❑	❑
Pain in the **front thigh** muscles (quadriceps)	❑	❑	❑	❑	❑
Pain in the **back thigh** muscles (hamstrings)	❑	❑	❑	❑	❑
Pain in the **inner thigh** muscles (adductors)	❑	❑	❑	❑	❑
Pain in the **patellar** tendon(s)	❑	❑	❑	❑	❑
Pain in the **knee** joint(s)	❑	❑	❑	❑	❑
Pain in the **Achilles** tendon(s)	❑	❑	❑	❑	❑
Pain in the **calf** muscles	❑	❑	❑	❑	❑
Pain in the **ankle** joint(s)	❑	❑	❑	❑	❑

Others, please specify

_____

IV. The following questions apply to your ENTIRE REFEREEING CAREER.

1. Did you suffer any **injury** caused by refereeing a football match or the preparing training during entire refereeing career that have not mentioned yet?
   ❑ no
   ❑ yes, namely

   _____

   (> Details will be discussed during the interview!)

2. Have you ever suffered from any of the following symptoms or **complaints** caused by refereeing a football match or the preparing training during your career (excluding the last 12 months)?

Please indicate whether and to what extent you have experienced:

	No	a little	Moderately	severely	very severely
Headache	❑	❑	❑	❑	❑
Neck pain	❑	❑	❑	❑	❑
Back pain	❑	❑	❑	❑	❑
Pain in the **hip** joint(s)	❑	❑	❑	❑	❑
Pain in the **groin** region(s)	❑	❑	❑	❑	❑
Pain in the **front thigh** muscles (quadriceps)	❑	❑	❑	❑	❑
Pain in the **back thigh** muscles (hamstrings)	❑	❑	❑	❑	❑
Pain in the **inner thigh** muscles (adductors)	❑	❑	❑	❑	❑
Pain in the **patellar** tendon(s)	❑	❑	❑	❑	❑
Pain in the **knee** joint(s)	❑	❑	❑	❑	❑
Pain in the **Achilles** tendon(s)	❑	❑	❑	❑	❑
Pain in the **calf** muscles	❑	❑	❑	❑	❑
Pain in the **ankle** joint(s)	❑	❑	❑	❑	❑

Others, please specify

_____

V. Other medical issues

1. Do you have any other health related or **medical problems** (e.g. allergy, asthma, high blood pressure)?
   ❑ no ❑ yes, please specify_____

2. Do you take any **medication** regularly or occasionally?
   ❑ no ❑ yes, please specify_____

3. Have you ever had an **operation** on the musculoskeletal system (which you have not mentioned yet)?
   ❑ no ❑ yes, on the knee when? _____
   ❑ yes, on the Achilles tendon when? _____
   ❑ yes, on the ankle joint when? _____
   ❑ yes, other operations when? _____

VI. Detail of Training

1. On average how many hours per week do you **train for refereeing**?
   pre-season_____ during the season_____

2. Do you train the entire year or have **breaks**?
   ❑ no breaks ❑ _____weeks break

3. Did you receive any **advice** for the design of your training programme from a qualified professional?
   ❑ no ❑ yes, please specify_____

4. Which **sport(s)** do you frequently practice?
   ❑ no sports ❑ _____
   how many hours per week on average? _____

5. Do you do anything to **prevent** injury or complaints?
   ❑ no ❑ yes, stretching
   ❑ yes, massage
   ❑ yes, other _____

6. Do you have any proposals for **improving the overall preparation** of referees (training advice, shoes, equipment required, …)?

   _____
   _____

Thank you very much!

Papers I - IV

Injuries and Musculoskeletal Complaints in Referees—A Complete Survey in the Top Divisions of the Swiss Football League

Mario Bizzini, MSc,† Astrid Junge, PhD,*† Roald Bahr, MD, PhD,‡ and Jiri Dvorak, MD, PhD*†§*

Objective: To analyze the extent and characteristics of injuries and musculoskeletal complaints in elite football referees and to analyze differences between match and assistant referees.

Design: Retrospective cohort study.

Setting: Training camp organized by the Swiss Referees Association.

Participants: All 71 referees of the 2 top divisions of the Swiss Football League (2005–2006 season).

Interventions: The referees (66 males and 5 females) completed a questionnaire on their personal characteristics, referee qualifications, time spent in training and matches, career history of injuries, and musculoskeletal complaints caused by training or refereeing and were subsequently interviewed about the location, type, circumstances, and consequences of reported injuries.

Main Outcome Measures: Incidence of injuries, frequency of musculoskeletal complaints, type of injuries, and complaints.

Results: A total of 41 injuries during the career were reported by 31 of 71 referees (44%). Injuries were incurred more frequently in training than during matches, and all injuries reported resulted in at least 2 weeks of absence from sport. About a quarter of the referees reported an injury, and almost 90% of the referees reported musculoskeletal complaints caused by refereeing during the preceding 12 months. In male referees, hamstring strains and ankle sprains were the most common injuries, and the hamstrings, knee, Achilles tendon, and calf were the most prevalent locations of musculoskeletal complaints. No significant difference in the incidence of injury or in the frequency of complaints was observed between match and assistant referees.

Conclusions: Future studies should be designed prospectively and should include a larger group of female referees. Regarding the incidence of injuries and frequency of musculoskeletal complaints related to refereeing, prevention programs for football referees should be developed, evaluated, and implemented.

Key Words: soccer, referee, injury, musculoskeletal complaints, incidence

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INTRODUCTION

Football (soccer) is one of the most popular sports worldwide. An official survey ("Big Count 2006") by the Fédération Internationale de Football Association (FIFA) revealed that in 2006 there were, worldwide, more than 840,000 registered referees and assistant referees (ARs).[1] The anthropometric profiles of referees and their movement patterns and physiological demands during match play have been examined in a number of studies.[2–13] In a recent review, Castagna et al[2] summarized the current literature describing the physical and mental demands on the referee. Similar to players, referees show a mixed walking and running profile during the game. However, there are substantial differences in the characteristics of referees and their actions during the game: football referees are rarely full-time professionals, are older than players,[3] and, more importantly, are not meant to have any physical contact with the players. Therefore, it can be expected that referees have a different injury profile from football players, with less risk of acute injuries and a higher proportion of overuse problems.

In reviewing the scientific literature, there are very few peer-reviewed publications on injuries in referees.[14,15] Brukner et al[14] describe a comparison of injuries in Australian rules football players and referees. Although the match demands for football players differ from Australian rules football players, they are similar for referees. All time-loss injuries were recorded during the 22 matches of the 1989 season. A total of 13 injuries were recorded in 50 umpires. The study of Fauno et al[15] investigated the effects of shock absorbing heel inserts on soreness in the lower extremity and back in 91 referees during a 5-day tournament. In the control group, between 16% and 93% of the referees reported soreness, whereas the prevalence was lower in the intervention group. Additionally, 6 acute injuries were reported, resulting in an incidence rate of 4.6 injuries per 1000 referee hours.

Given the paucity of research on injuries of football referees, the aim of the present study was to investigate the injuries and musculoskeletal complaints of all referees

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officiating in the 2 top divisions of the Swiss Football League and to analyze possible differences between match referees and ARs.

METHODS

Design and Procedure

The study was designed as a retrospective survey including all referees officiating in the Swiss Super and Challenge League (first and second national divisions; 2005–2006 season). During a training camp organized by the Swiss Referees Association (mid-season break; January 2006), all match referees (MRs) and ARs were asked to complete a specially developed questionnaire and were subsequently interviewed to gain more detailed information about each injury reported.

The 5-page questionnaire covered the following areas: personal characteristics, such as sociodemographics, refereeing qualifications, and experience; career history of injuries and musculoskeletal complaints caused by training or refereeing; and other medical problems and time spent in training and in matches.

The interview was based on the injury documentation form published in the recent consensus article.[16] The questions, with predefined answers, focused on the location (body part and side), type (overuse injury, trauma, and diagnosis), circumstances (training, match, and type of activity), and duration of absence from sport for each injury mentioned. Furthermore, the referees were asked about the details of the stated musculoskeletal complaints to classify only acute trauma as injury and all overuse injuries as complaints. All interviews were conducted in either German or French by the first author of the study (MB) and each had an average duration of 10–15 minutes.

All participants gave their signed informed consent to participate. The study was approved by The University of Zürich, University Human Subjects Ethics Committee.

Development of the Assessment Methods

The assessment methods were developed based on a recent consensus statement on injury definition and data collection procedures in studies on football injuries.[16] In this consensus statement, an injury was defined as: "Any physical complaint sustained by a player that results from a football match or football training, irrespective of the need for medical attention or time loss from football activities."[16] Theoretically, this definition applies to both traumatic and overuse injuries. However, there are some practical problems in the assessment of overuse injuries due to their nature (gradual onset, recurrent symptoms, and severity fluctuation[17]). Overuse injuries may be assessed by inquiring about musculoskeletal complaints in the given body area.

Based on these considerations, the questionnaire had separate sections for injuries and musculoskeletal complaints. The referees were first asked, "Have you suffered any injury caused by refereeing a football match or the training for officiating?" and then "Have you had any pain, discomfort or complaints caused by refereeing a football match or the training for officiating?" These questions were repeated for 3 different periods (during the last match, in the last 12 months, and in your entire career). The response options for the injury question were "yes/no," and, if the referee ticked "yes," further details on the injuries were inquired about during a personal interview. The question concerning complaints was followed by a list of the most common musculoskeletal symptoms (complete list in Table 3). The referees were asked, "Please indicate the extent to which you suffered from any of the following symptoms," with answers being given on a 5-point Likert scale (not at all, a little, moderately, severely, and very severely). This method was adopted because the wording of a question has a major impact on the answers of the respondent; if asked "Have you sustained an injury?" the respondent would be more likely to recall the most serious and acute injuries but might forget to report minor injuries or complaints that he does not immediately consider as injuries. The additional question about "pain, discomfort or complaints" was included to remind the referee of any physical symptoms that he may have experienced during training or a match. We developed the list of symptoms to capture overuse injuries. The questionnaire was available in German and French to cover the main languages spoken in Switzerland.

Calculation of Exposure Time and Statistical Analysis

Exposure time in match and training was calculated based on the information provided in the questionnaire (average matches per year, matches in the last 12 months, and average training hours per week in preseason and during season). Match exposure in the last 12 months was calculated as the total sum of matches officiated by all referees in the last year times 1.5 hours (the minimum duration of a match). Match exposure over the career was calculated by multiplying the number of referees, the average years in refereeing, and the average number of officiated games per year, and 1.5 hours.

The statistical analyses were carried out using SPSS version 11 (SPSS Inc, Chicago, Illinois). Statistical methods applied were frequencies, means, and cross-tabulations. Group differences between MRs and ARs were analyzed by χ^2 (categorical data) or unpaired t tests (continuous variables). Female referees were analyzed separately to account for potential gender differences. Results are reported as the mean and SD and/or range, unless otherwise noted. For incidence rates, 95% confidence intervals (CIs) were calculated as the incidence $\pm$ 1.96 times the incidence divided by the square root of the number of injuries. P values of less than 0.05 were regarded as significant.

RESULTS

All 71 referees (27 MRs and 44 ARs) of the 2 top divisions of the Swiss Football League participated in the study. Because almost all referees were male (n = 66), the results of the 5 female referees (2 MRs and 3 ARs) are reported in a separate section.

Characteristics of Male MRs and ARs

The average age of the 66 male referees was 36 years (SD, 5.3; range, 25–45 years), and they reported a height of

180 cm (SD, 6 cm) and a weight of 76 kg (SD, 6 kg), resulting in an average body mass index (BMI) of 23.6 (SD, 1.7; range, 19.9–27.7) kg/m^2. Before their refereeing career, the majority (n = 60; 91%) had played football on average for 9.3 years (SD, 4.5 years). For the majority, low-level amateurs were the highest league level in which they had played football (n = 48; 80%), although 11 referees had been high-level football players (17%) and one a semiprofessional. They received their first official license for refereeing on average 16 years ago (range, 7–25 years) and had been officiating in the top 2 divisions of the Swiss Football League for an average of 7.5 years (range, 1–20 years). Seventeen referees (26%) also possessed a FIFA license. No differences between MRs and ARs were observed in their level of experience as players or referees.

During the last 12 months, the MRs had officiated fewer national matches than ARs [22 (SD, 6.8) vs 26 (SD, 7.2); $P < 0.05$]. Seven MRs (28%) and 16 ARs (39%) had also participated in international matches, on average 5.1 matches (SD, 2.9). MRs had spent significantly more hours per week in training than had ARs; 6.4 hours (SD, 2.9) versus 4.7 hours (SD, 2.3; $P < 0.05$), respectively, in the preseason and 5.1 hours (SD, 3.0) versus 3.6 hours (SD, 1.7; $P < 0.05$), respectively, during the season (Table 1).

Injuries Among Male MRs and ARs

A total of 39 injuries throughout their career were reported by 13 MRs (52% of all MRs) and 16 ARs (39%) (not significant) (for details, see Table 2). Four MRs (16%) and 6 ARs (15%) reported 2 injuries but to different body parts. Nine MRs (36%) and 8 ARs (20%) reported an injury during the last 12 months. Hamstring strains (26%) and ankle sprains (26%) were the most common diagnoses in both groups; in ARs, knee cartilage lesions were also frequent.

All referees reported being unable to train the day after their injury; no injuries were reported that resulted in less than 2-week absence from sport. Most injuries resulted in a time loss of either 2–4 weeks (n = 17; 44%) or 5–8 weeks (n = 14; 36%), whereas 8 injuries (21%) resulted in an absence of more than 12 weeks.

Fourteen injuries (36%) (of 5 MRs and 9 ARs) were incurred during matches, whereas 24 (62%; 11 MRs and 13 ARs) occurred during training or warm-up. All 6 match injuries reported by MRs were incurred in the last 12 months, resulting in an incidence of 6.8 match injuries per 1000 match hours (95% CI, 1.4–12.3). For ARs (3 match injuries), the incidence of match injuries in the last 12 months was 1.7 per 1000 match hours (95% CI, 0.2–3.7).

Musculoskeletal Complaints of Male MRs and ARs

A summary of the musculoskeletal complaints reported by male MRs and ARs is provided in Table 3. No referees reported having incurred an injury during the last match, but almost half of the MRs (n = 12; 48%) and 39% of the ARs (n = 16) stated that they had had at least 1 musculoskeletal complaint. In relation to the last 12 months, 23 MRs (92%) and 34 ARs (83%) reported having had some sort of complaint caused by refereeing. Twenty-four referees (96%) and 36 ARs (88%) reported having experienced musculoskeletal complaints at some stage during their entire career. The most prevalent locations were the hamstrings, knee, and Achilles tendon. No significant difference in the frequency of complaints was observed between MRs and ARs.

Characteristics, Injuries, and Musculoskeletal Complaints of Female Referees

Two female MRs and 3 female ARs were officiating in the 2 top divisions of the Swiss Football League. Similar to their male counterparts, their age ranged from 23 to 39 years (mean, 31 years; SD, 6 years); their average height (167 cm; SD, 0 cm), weight (57 kg; SD, 2 kg), and BMI (20.4 kg/m^2; SD, 0.87 kg/m^2) were all substantially lower than those of the male referees. They had received their first official license for refereeing on average 9 years ago (range, 4–22 years), and all also had a FIFA license. The female referees officiated between 20 and 32 national matches per year and between

TABLE 1. Exposure Time, Number and Incidence of Injuries and Frequency of Complaints of 66 Swiss Male Elite Referees

	Match Referees (n = 25)			Assistant Referees (n = 41)		
	Last Match	Last 12 Months	Entire Career	Last Match	Last 12 Months	Entire Career
Exposure time, h						
Match	37.5	877.5	14 040	61.5	1719	27 500*
Training	—	8640*	138 240*	—	10 400*	166 400*
Injuries, No.						
Match	0	5 + 1†	0	0	3	6
Training	—	3	8	—	5	8
Incidence, injuries/1000 h						
Match	0	6.84	0	0	1.74	0.22
Training	—	0.35	0.06	—	0.48	0.05
Complaints, No. (%)						
At least 1	12 (48)	23 (92)	24 (96)	16 (39)	34 (83)	36 (88)

*Estimated.
†One injury occurred after the match.

TABLE 2. Injuries During Their Career of 66 Swiss Male Elite Referees

Injury	Match Referees (n = 25)		Assistant Referees (n = 41)		Total
	Match	Training	Match	Training	
Hamstring strains	2	4	2	2	10
Ankle sprains	2	3	3	2	10
Calf strains	—	1	1	1	3
Meniscus lesions	—	1	1	1	3
Knee cartilage lesions	—	—	—	3	3
Anterior cruciate ligament ruptures	—	—	1	1	2
Achilles tendon partial ruptures	1	—	1	—	2
Rib fractures	1*	1	—	—	2
Clavicle fracture	—	—	—	1	1
Groin strain	—	—	—	1	1
Quadriceps strain	—	—	—	1	1
Knee sprain	—	1	—	—	1
Total	6*	11	9	13	39

*One rib fracture was caused by the referee being attacked after a match and falling.

0 and 6 international matches per year. Similar to their male colleagues, the female referees spent on average 6 h/wk (range, 4–10 h/wk) in training during the preseason period and 5 h/wk (range, 3–6 h/wk) during the season.

One MR (50%) and 1 AR (33%) reported an injury in the last 12 months; both incurred a hamstring strain while sprinting during training. The most prevalent complaint was headache (for details, see Table 4).

DISCUSSION

The present study investigates the characteristics and incidence of injuries and the frequency of musculoskeletal complaints in the entire cohort of all 71 male and female referees of the 2 top divisions of the Swiss Football League.

The Swiss top-level referees included in the present study were similar in age to Italian,[4–8] English,[9,18] Greek,[10] Belgian,[11] and Danish[12,13] elite referees officiating at the national level. Their average BMI was similar to Italian[4–8] and Danish[12,13] referees but was lower than that of English[9] and Greek[10] referees. A BMI value of less than 25 kg/m^2 (average in the Swiss group, 23.6 kg/m^2) is considered to be favorable for refereeing performance[2] and for good health. The Swiss top-level referees were also similar to the Italian[8] and Belgian[11] referees concerning the average number of years officiating at the national level.

Of all male Swiss top-level referees, 29 (44%) reported having incurred at least 1 injury during their career. Almost half of the injuries reported (17 of 39) were incurred in the last 12 months, resulting in an incidence of 6.8 match injuries per 1000 match hours for MRs and 1.7 for ARs. However, when interpreting these data, it must be borne in mind that no injury with a time loss of less than 2 weeks was reported. Thus, the true incidence of injuries may have been underestimated. Nevertheless, the percentage of referees who reported an injury in the preceding year (23%) was similar to that stated by Brukner et al,[14] and the exposure-related incidence of match injuries in the last year (3.45/1000 match hours; 95% CI, 1.20–5.7) was similar to that reported by Fauno et al.[15] For a comparison of the injury profile of referees and football players, only episodes of noncontact injuries with a minimum of 2-week time loss should be regarded. In the data that Junge et al[19] reported from the 2002 FIFA World Cup, the incidence of noncontact injuries with an absence of more than 1 week (2 weeks was not available as a cutoff) was 4.7 per 1000 match hours.

The most frequent types of injury were hamstring strains and ankle sprains (each 26%), with other types of injury each accounting for less than 8% of all injuries. Muscle strains and ligament sprains are also the injuries most commonly documented for football players.[20,21] It is important to note that, in players, about half of all acute injuries (especially knee and ankle sprains) are caused by physical contact with another player.[22,19–24] The most common *non*contact injuries of players—the muscle strains (especially of the posterior thigh)—are also frequent in referees.

The Swiss elite referees incurred more injuries during training (62%) than during the match (39%), which might be explained by the greater exposure time in training than in matches (Table 1). In general, slightly more MRs (52%) than ARs (39%) reported an injury during their career. The incidence of match injuries showed a similar trend, but the difference was not significant due to the smaller numbers. Statistical comparisons between male and female referees were not possible due to the low number of female referees; however, there seemed to be no substantial gender differences in the overall rates or types of injury.

Although no acute *injuries* were reported in relation to the last match, 28 male (42%) referees and 1 female (20%) referee reported having had at least 1 musculoskeletal complaint. In relation to the last 12 months, 86% of the male referees and all female referees reported musculoskeletal complaints caused by refereeing. These figures closely related to the prevalence of soreness in the lower extremity and back pain observed by Fauno et al[15] during a 5-day tournament. The most prevalent locations of these complaints were, in the male referees, the hamstrings, knee, Achilles tendon, and calf; in the 5 female referees, headache was a common symptom. In general, more MRs than ARs reported complaints; however, calf and groin problems were more frequent in ARs. Complaints in the hamstrings reflect the most frequent diagnosis of injuries (hamstring strains); however, for the other locations, there was no association between complaints and injuries. It can therefore be assumed that complaints in the knee and Achilles tendon might rather reflect symptoms of overuse injury. In addition, the diagnoses for the reported injuries did not include typical overuse injuries; thus, the separate assessment of injuries and musculoskeletal complaints provided complementary information.

In the present study, stretching was indicated as the main injury prevention measure by about 40% of the referees. Although the preventive value of stretching is controversial,[25] most athletes consider it important in injury prevention. It was interesting to note that none of the referees mentioned any

TABLE 3. Number and Percentage of Male Referees Reporting Musculoskeletal Complaints

Complaint	Match Referees (n = 25)			Assistant Referees (n = 41)		
	Last Match, No. (%)	Last 12 Months, No. (%)	Entire Career, No. (%)	Last Match, No. (%)	Last 12 Months, No. (%)	Entire Career, No. (%)
Headache	1 (4)	3 (12)	3 (12)	2 (4.9)	4 (9.8)	5 (12.2)
Neck pain	—	2 (8)	4 (16)	—	4 (9.8)	4 (9.8)
Low back pain	2 (8)	11 (46)	11 (46)	4 (9.8)	11 (26.8)	11 (26.8)
Pain in the hip joints	—	4 (16)	5 (20)	1 (2.4)	2 (4.8)	3 (7.3)
Pain in the groin regions	1 (4)	2 (8)	2 (8)	3 (7.3)	9 (22)	9 (22)
Pain in the front thigh muscles (musculus quadriceps femoris)	2 (8)	4 (16)	5 (20)	2 (4.9)	8 (19.5)	10 (24.4)
Pain in the back thigh muscles (hamstrings)	—	3 (12)	4 (16)	1 (2.4)	3 (7.3)	6 (14.6)
Pain in the inner thigh muscles (musculi adductors femoris)	2 (8)	12 (48)	12 (48)	1 (2.4)	11 (26.9)	13 (31.8)
Pain in the patellar tendons	2 (8)	11 (44)	14 (56)	4 (9.8)	17 (41.5)	17 (41.5)
Pain in the knee joints	—	3 (12)	3 (12)	1 (2.4)	2 (4.9)	2 (4.9)
Pain in the Achilles tendons	2 (8)	6 (24)	8 (32)	2 (4.9)	14 (34.1)	15 (36.6)
Pain in the calf muscles	3 (12)	7 (28)	12 (48)	4 (9.8)	12 (29.3)	16 (39.0)
Pain in the ankle joints	1 (4)	3 (12)	5 (20)	—	1 (2.4)	6 (14.6)
Others*	—	—	—	1 (2.4)	2 (4.9)	2 (4.9)

*Others includes shin splints and heel pain.

specific preventive exercises or prevention programs that they engaged in to try to reduce their likelihood of injury. For the most common injuries in referees (hamstring strains and ankle sprain), there is evidence for the effectiveness of preventive programs. Eccentric strengthening has been shown to reduce the incidence of hamstring strains in football players.[26,27] Ankle sprains can be prevented by external ankle supports and balance board training, especially in athletes with previous ankle sprains.[28]

Limitations of the Study and Future Research

The major limitation of the present study is its retrospective design and the associated recall bias. Twellaar et al[29] showed that students, when asked to recall all injuries sustained in the preceding 3 years, had forgotten 54% of their injuries. In comparing prospective and retrospective evaluations of injuries over a 12-month period, Junge and Dvorak[30] found that only "every third moderate injury and less than 10% of mild injuries were reported in a retrospective questionnaire" and concluded that "the shorter the period of symptoms and the longer ago the injury occurred, the more frequently it was forgotten." This seems to explain the results of the present study, in that only injuries with at least 2-week duration were reported, and the exposure-related incidence of injuries was substantially higher for the preceding 12 months than for the entire career. In fact, the size of the discrepancy when comparing the estimated career incidence with the reported 12-month incidence suggests that as many as 90% of injuries occurring more than 12 months ago may have gone unreported. As such, the incidence of injury clearly represents a minimum estimate, and the reported total number of complaints during a career is probably unreliable and should be interpreted with caution. Therefore, future studies should further investigate the injury profile in referees using a prospective design.

In the present study, injuries and musculoskeletal complaints were assessed and analyzed separately because it was expected that the chronic/recurrent symptoms of overuse injuries would not be reported when asked for injury. Furthermore, due to the gradual onset and fluctuation of severity of the symptoms, musculoskeletal complaints might be better expressed as a prevalence than incidence. The results showed that the referees' answers to the injury and musculoskeletal complaints question were complementary (eg, 2 referees reported an injury of the Achilles tendon, but 28 referees reported pain in the Achilles tendon). This approach may be of interest for future studies focusing on athletes who suffer more overuse than acute injuries.

Female referees were included in the present study to describe the entire group of referees of the 2 top divisions of the Swiss Football League, but their number was too small to draw conclusions. Future research should also focus on this population. Finally, prevention programs targeting the special

TABLE 4. Musculoskeletal Complaints Among Swiss Female Elite Referees

No.	Referee	Time Period and Related Complaints
1	MR	Last 12 months: pain in the calf muscles and in the Achilles tendon
2	MR	Last 12 months: headache, and pain in the hamstring and in the foot Entire career: headache, pain in the hamstring and in the foot
3	AR	Last 12 months: pain in the hamstring, calf muscle and ankle Entire career: headache, low back pain, and pain in the hamstring, calf muscles and ankle
4	AR	Last 12 months: headache, neck pain and low back pain Entire career: headache, neck pain and low back pain
5	AR	Last match: headache Last 12 months: headache Entire career: headache

MR, match referee; AR, assistant referee.

needs of referees should be developed, implemented, and evaluated.

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Injuries and musculoskeletal complaints in referees and assistant referees selected for the 2006 FIFA World Cup: retrospective and prospective survey

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ABSTRACT

Background: There is a considerable amount of scientific literature on football, but few studies have focused on referees, despite their key role in this sport. Existing studies focus on the physiological demands and training of referees.

Purpose: To analyse injuries and musculoskeletal complaints in referees and assistant referees selected for the 2006 FIFA World Cup.

Study design: Retrospective survey and prospective study.

Methods: During the preparation camps for the 2006 FIFA World Cup in Germany, all 123 referees pre-selected for the tournament completed a questionnaire on injuries and musculoskeletal complaints. During the tournament, the characteristics and consequences of all injuries and complaints incurred by the 63 officiating referees were documented.

Results: More than 40% of the referees reported having incurred an injury and more than 60% having had musculoskeletal complaints during their career. About 20% of the group reported having suffered from musculoskeletal complaints in the last match. During the World Cup, 14 referees (22%) incurred an injury and more than 30% had musculoskeletal complaints. This prospectively collected data showed an incidence of 20.8 injuries per 1000 match hours (95% CI: 4.17 to 37.4). The most common acute injuries were hamstring strains, calf strains, and ankle sprains, while the most frequent locations of complaints were the low back, hamstring and knee.

Conclusion: Considering the injury profile, the prevalence of associated musculoskeletal complaints, and the high physiological demands of refereeing, it appears that injury prevention programmes should be developed and integrated into the fitness training routine of the referee.

The football referee, also considered the 23rd player of a football (soccer) game,[1] is supported by two assistant referees. Together, the three have to ensure that the players follow the Laws of the Game. An official survey (''Big Count 2006'')[2] by the Fédération Internationale de Football Association (FIFA) revealed that in 2006 there were, worldwide, and over all levels of football, more than 840 000 registered referees and assistant referees (about 94% male, 6% female). Compared with the first survey in 2000, there was an increase of 17% in the total number of referees.

Despite the important role of the referee in football, little scientific literature is available on refereeing. In the last 10 years, several studies have examined various physiological aspects of performance and training in connection with football refereeing.[3 4] Similarly to players, referees show a mixed walking and running profile (low, medium and high intensity) during the game. The elite-level referee is exposed to similar physical demands to those placed on a midfield football player. However, referees exhibit several unique characteristics: they are older than the players (by 15–20 years, on average), they are rarely full-time professionals, they don't play the ball, and they normally cannot be substituted during the match. During a competitive match, a referee may cover an average distance of between 9 and 13 km, with 4–18% of this comprising high-intensity activities such as sprinting.[3] Backwards and sidewards running are also typical movements made by the referee during the course of a game. Analysis of between-halves distance coverage has given some conflicting results, but research has generally shown that elite referees adopt various strategies to conserve energy during the game. It can be speculated that the most crucial moments of a game are at the end of each half (especially the second), where the likelihood of mental and physiological fatigue is higher. A referee must be prepared for performing at high intensity (when needed) throughout the match. Elite referees may perform up to 1270 activity changes and make more than 130 decisions during a game[5]; this indicates the high physiological and cognitive demands placed on the referee.

Considering the demands imposed on the cardiovascular and musculoskeletal systems, it is clear that the referee is exposed to a certain risk of injury during the game. Several epidemiological studies have focused on injuries in football players, but there is a lack of knowledge on the injury profile of the football referee.

To the best of our knowledge, only Bizzini *et al*[6] have investigated injuries and musculoskeletal complaints in elite referees. In this retrospective study of 71 referees in the top two divisions of the Swiss Football League the incidence of acute injuries was low, but 90% reported musculoskeletal complaints during their career.[6]

The aim of the present study was to investigate both retrospectively and prospectively the injuries and musculoskeletal complaints of all referees and assistant referees selected for the 2006 FIFA World Cup in Germany.

METHODS

The study included a retrospective survey of injuries and musculoskeletal complaints in all

referees pre-selected for the 2006 FIFA World Cup and a prospective assessment of injury in all referees officiating the final 64 matches of the tournament (9 June – 9 July 2006).

Retrospective survey

The retrospective part of the study was carried out in March and April 2006 during the two preparation camps (in Frankfurt, Germany) organised for referees and assistant referees by the FIFA Refereeing Department. On the first day of the camps, the referees were asked to complete a questionnaire on injuries and musculoskeletal complaints. Where injuries were declared, a brief personal interview was carried out to expand on the responses given in the questionnaire. Although the referees were explicitly informed that the data would be treated absolutely confidentially and only used for scientific purposes, it is possible that some referees may have thought their answers would affect their chances of selection and hence not declared or underplayed their injuries and complaints.

The specially developed, five-page questionnaire, which had proven feasible in a previous study,[6] covered the following areas: characteristics of the referee (such as socio-demographics, refereeing qualifications and experience), injuries and musculoskeletal complaints caused by training or refereeing (related to the last match, the last 12 months, and the entire career), other medical problems and time spent in training and in matches.

All definitions used, methods applied and variables assessed were in accordance with the recent consensus statement on injury definition and data collection procedures in studies of football injuries.[7] The questionnaire comprised one section on (acute) injuries and another on musculoskeletal complaints.[6] First the referee was asked: "*Have you suffered any injury caused by refereeing a football match or the training for officiating*?" The response options were "*yes/no*", and if the referee answered in the affirmative he was requested to give further details about the injury/injuries in a personal interview with the first author (MB). The next question was: "*Have you had any pain, discomfort or complaints caused by refereeing a football match or the training for officiating*?" This question was followed by a list of the most common musculoskeletal symptoms (e.g., low back pain, pain in the Achilles tendon, etc.) with the header "*Please indicate the extent to which you suffered from any of the following symptoms*". The possible responses for each item were graded in terms of subjective severity (*not at all, a little, moderately, severely, very severely*). It was expected that this method would help with the reporting and recording of overuse injuries expressed as musculoskeletal complaints.[6] The questionnaire was available in English, Spanish, German and French, the four official FIFA languages, since fluency in at least one of these languages is a prerequisite for selection as a FIFA referee.

Exposure time was calculated based on the information provided in the questionnaire. Match exposure in the last 12 months was calculated as the total sum of matches officiated by all referees in the last year ×1.5 h (the minimum duration of a match). Match exposure over the career was calculated by multiplying the number of referees, the average years in refereeing, the average number of officiated games per year and 1.5 h. Exposure in training was calculated for season and pre-season separately.

Prospective assessment

Two weeks prior to the tournament (May 25), all selected referees and about 50 staff members were reunited at the referees' headquarters in Frankfurt. A medical team (including one medical doctor, five physiotherapists, and three massage therapists), six fitness instructors, and two sports psychologists looked after the referees until the end of the tournament. A "typical" day for the referee comprised 2 h training on the pitch in the morning, then 1 h of individual training (optional) and 1 h of theory in the afternoon, followed by regeneration/treatment sessions (individual schedules). The referees trained "normally" while they were in the headquarters, but reduced their training programme a day or two before leaving to officiate matches. During the 2006 FIFA World Cup (9 June – 9 July 2006) the match referees (MRs) and assistant referees (ARs) (with the fourth and fifth officials) travelled by air to their appointed matches at the different venues in Germany. For each match, a physiotherapist was present in the stadium. After the match, this physiotherapist phoned the head physiotherapist in Frankfurt, to inform her of any physical problems encountered by the MRs and ARs during the match.

Data on injuries and musculoskeletal complaints were collected prospectively by one physiotherapist (MB) from the medical team. Confirmation of the diagnosis was made by a medical doctor at the referees' headquarters in Frankfurt. Every acute injury incurred during match or training was recorded according to the consensus injury definition.[7] All musculoskeletal complaints that received medical attention were similarly recorded. The type and number of treatments (physiotherapy, massage, electrotherapy, taping, other) and training modifications (reduced training, such as on an exercise bike or in the pool) were recorded on a daily basis. Match exposure for the prospective survey (in hours) was calculated by multiplying the number of games (64) by the number of referees (three) and the minimum duration of the game (1.5 h).

Population

All 123 MRs and ARs, from 53 National Football Associations worldwide, pre-selected by the FIFA Refereeing Department for officiating during the 2006 FIFA World Cup in Germany were included in the retrospective survey (fig 1). All referees formed fixed trios consisting of one MR and two ARs.

Out of the initial group, 27 trios were selected to participate in the final rounds of the 2006 FIFA World Cup. Twenty-two trios were selected to officiate the matches and five trios were appointed as a support group, acting as fourth and fifth officials during the qualification rounds. All referees, except one AR appointed to the support group, had attended the pre-tournament training camp. One of the 22 trios selected to officiate the matches was sent home before the start of the Word Cup because the MR arrived with a knee injury (meniscal lesion) that was aggravated during the first training session. The final 21 trios officiating the matches of the 2006 FIFA World Cup were included in the prospective study.

The study was approved by the University of Zürich, University Human Subjects Ethics Committee. All the subjects gave their signed informed consent to participate.

Statistical analysis

The statistical analyses were carried out using SPSS (version 11; SPSS Institute, Chicago, Illinois). Results are reported as the mean and standard deviation (SD) and/or range, unless otherwise noted. Group differences between MRs and ARs were analysed by χ^2 (categorical data) or unpaired t tests (continuous variables). For incidence rates, 95% confidence intervals were calculated as the incidence ± 1.96 times the

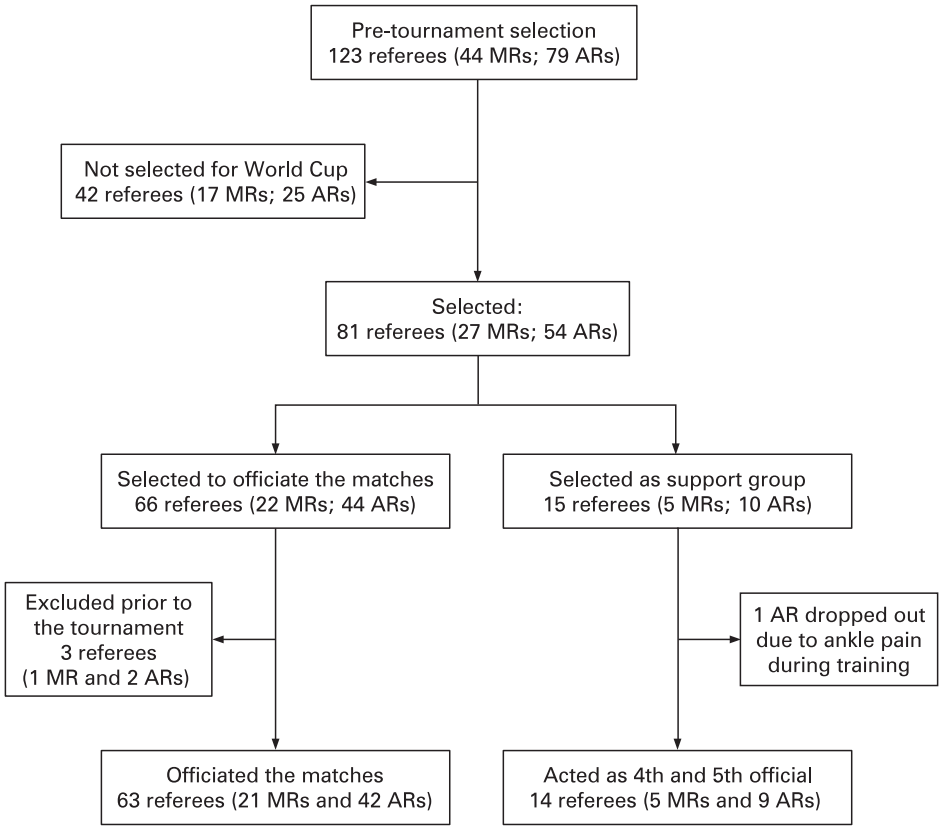

Figure 1 Selection procedure for the match referees (MRs) and assistant referees (ARs) for the 2006 FIFA World Cup.

incidence divided by the square root of the number of injuries. p Values of less than 0.05 were regarded as significant.

RESULTS

Characteristics of the referees

All 44 MRs and 79 ARs selected for the 2006 FIFA World Cup preparation camps participated in the retrospective part of the study. The referees had a mean age of 41 (SD 3.7, range 29–45) years, height 178 (SD 6, range 160–195) cm, weight 76 (SD 7, range 58–92) kg, and BMI 23.8 (SD 1.3, range 20.2–27.1) kg/m^2. They had received their first official licence for refereeing on average 19 (SD 5, range 8–32) years ago, and had been officiating in their top national leagues for 13 (SD 4, range 7–26) years. They had been in possession of a FIFA licence for an average of 8 (SD 3.3, range 1–15) years, during which time they had also been officiating international matches. Per year, the referees officiated on average 28.9 (SD 10.3, range 10–70) national matches and 9.0 (SD 3.1, range 1–20) international matches. In the 12 months prior to the World Cup, they had officiated on average 28.2 (SD 10, range 3–60) national matches and 11.0 (SD 4.4, range 1–25) international matches. The referees trained 7.1 (SD 3.4, range 1–16) h per week before the season and 6.1 (SD 2.44, range 1–15) h per week during the season. More than 80% of the referees reported that they had received advice for their training from a qualified professional, and almost 60% of them declared that they did not practise any other sporting activities besides refereeing and training for refereeing. No significant differences between MRs and ARs were observed for any of these variables.

Retrospectively reported injuries

A total of 58 injuries throughout their career were reported by 50 (40.7%) referees, with no difference between MRs and ARs: 18 MRs (40.9% of all MRs) and 32 (40.5%) ARs. Eight (6.5%) referees reported two injuries: two (4.5%) MRs and four (5.1%) ARs had incurred one injury in the last 12 months and another during their career, and two (4.5%) MRs had incurred both injuries during their career. In both groups, the most prevalent diagnoses were calf strains and ankle sprains. Meniscus lesions of the knee were also frequent in MRs, and strains of the hamstrings, quadriceps and adductor muscles in ARs (for details see table 1).

All reported injuries resulted in at least 2 weeks of absence from sport. Most injuries resulted in an absence of 2 to 4 weeks (35; 60.4%) or 5 to 8 weeks (15; 25.7%), while eight (13.8%) injuries resulted in an absence of 12 weeks or more.

More injuries occurred during training (48; 82.8%) than in matches (10; 17.2%), with no difference between MRs and ARs. Information about the injury situation was provided for 32 (55.2%) injuries. Sprinting (n = 17; 53%), turning (n = 8; 25%) and changing direction without turning (n = 7; 21.8%) were the most frequent causes of injury. Sixteen injured referees (32% of all injured referees) considered that the type of shoes (n = 8) or the quality of the pitch (n = 8) played a role in their injury.

Two (4.5%) MRs and three (3.8%) ARs reported a match injury in the last 12 months, resulting in an incidence of 0.7 match injuries per 1000 match hours (95% CI: 0.1 to 1.3), with no difference between the groups. Concerning the entire career, the incidence was 0.1 match injuries per 1000 match hours for MRs (95% CI: 0 to 0.1), and 0.2 for ARs (95% CI: 0 to 0.3).

Retrospectively reported musculoskeletal complaints

None of the referees reported having incurred an injury during the last match, but nine (20.4%) MRs and 12 (15.2%) ARs stated that they had had at least one musculoskeletal complaint.

In relation to the previous 12 months, 25 (56.8%) MRs and 48 (60.8%) ARs reported having had some sort of musculoskeletal

Table 1 Injuries reported by referees during their career

	Match referees		Assistant referees		
	n = 44		n = 79		
	Game	Training	Game	Training	Total
Hamstring strain		2	3	9	14
Calf strain	1	5	1	5	12
Ankle sprain	1	4	1	3	9
Quadriceps strain		2		5	7
Adductor strain		1		3	4
Meniscus lesion		3	1		4
Anterior cruciate ligament rupture and meniscal tear		2			2
Knee sprain			1	1	2
Partial rupture/rupture of Achilles tendon	1			1	2
Anterior cruciate ligament rupture				1	1
Groin strain				1	1
Total	3	19	7	29	58

complaint due to officiating; the corresponding figures in relation to the entire career were 28 (63.6%) MRs and 49 ARs (62%). In both groups, the most prevalent locations for injury were the hamstrings, knee, calf and Achilles tendon. ARs were twice as likely to report low back pain as MRs. For a detailed description of musculoskeletal complaints, see table 2.

Other retrospective information

Six (13.6%) MRs and six (7.6%) ARs had undergone surgery of the knee, one (2.3%) MR and three (3.8%) ARs had had an operation on the ankle, and one (2.3%) MR had received surgery on the Achilles tendon. Four (9.1%) MRs and eight (10.1%) ARs reported medical problems, mainly asthma and allergies. Six (13.6%) MRs and 12 (15.9%) ARs reported that they were taking medication regularly.

When asked whether they did anything to prevent injuries or complaints, 91 (74%) referees (33 (75.0%) MRs and 58 (73.4%) ARs) stated that they performed stretching exercises, and more than half (54.5%; 31 (70.5%) MRs and 33 (41.8%) ARs) reported regularly receiving massage, while 22.8% (14 in each group) declared that they adopted other measures (sauna, gym, etc.).

Referees officiating during the 2006 FIFA World Cup

All 63 referees selected for officiating as MR or AR during the World Cup were included in the prospective study (see fig 1). No differences between this group and the remaining 60 referees were observed in their characteristics, except for their history of complaints: two of the referees in the group selected for active participation had reported complaints involving the quadriceps during their career, compared with 11 (18.3%) who had reported such complaints in the remaining group ($p<0.05$); twice as many in the non-selected group (21 (35%)) as in the selected group (11 (17.5%)) had reported complaints involving the calf during their career ($p<0.05$).

During the 2006 FIFA World Cup, half of the referees (49.2%, 10 MRs and 21 ARs) received treatment because of a new injury and/or musculoskeletal complaints. Five referees (MR1, MR2, MR3, MR6, AR7) presented both acute injuries and musculoskeletal complaints, but in different locations, except for MR2, who had been treated for low back pain before he sustained the injury (see tables 3 and 4). In total, 199 physiotherapy sessions, 132 massage therapy sessions, 96 electrotherapy applications, and 37 tapings were performed in treating the injuries and

Table 2 Number and percentage of referees reporting musculoskeletal complaints

	Match referees			Assistant referees		
	n = 44			n = 79		
Location of complaints	Last match n (%)	Last 12 months n (%)	Entire career n (%)	Last match n (%)	Last 12 months n (%)	Entire career n (%)
Head	1 (2.3)	1 (2.3)	3 (6.8)	1 (1.3)	5 (6.3)	5 (6.3)
Neck	1 (2.3)	2 (4.5)	2 (4.5)	–	6 (7.6)	6 (7.6)
Low back	–	3 (6.8)	4 (9.1)	1 (1.3)	13 (16.5)	15 (19)
Hip	–	2 (4.5)	2 (4.5)	–	1 (1.3)	3 (3.8)
Groin	–	2 (4.5)	3 (6.8)	1 (1.3)	3 (3.8)	4 (5.1)
Adductors	–	6 (13.6)	6 (13)	–	8 (10.1)	8 (10.1)
Quadriceps	1 (2.3)	2 (4.5)	3 (6.8)	1 (1.8)	10 (12.7)	10 (12.7)
Hamstring	1 (2.3)	5 (11.4)	10 (22.9)	1 (1.3)	12 (15.2)	12 (15.2)
Knee	3 (6.8)	7 (15.9)	8 (18.2)	3 (3.8)	17/21.5	17 (21.5)
Patellar tendon	–	2 (4.5)	4 (9.1)	1 (1.3)	7 (8.9)	7 (8.9)
Calf	2 (4.5)	6 (15.6)	14 (31.8)	4 (5.1)	14 (17.8)	18 (22.8)
Achilles tendon	–	1 (2.3)	7 (15.9)	2 (2.5)	6 (7.6)	9 (11.4)
Ankle	–	4 (9.1)	3 (6.8)	1 (1.3)	7 (8.9)	7 (8.9)
Others*	2 (4.5)	–	1 (2.3)	–	–	1 (1.3)

*"Others" includes: shin splints, heel pain.

Table 3 Characteristics and consequences of acute injuries during the 2006 FIFA World Cup and injuries and complaints reported retrospectively during the survey carried out 3 months earlier

Referee	Type of injury during 2006 World Cup	Match or training injury	Type and frequency of treatment	Days of reduced training	Injuries reported retrospectively in March/April 2006	Complaints reported retrospectively in March/April 2006
MR1	Heel open wound	M	Taping (8)	6	None	None
MR2	Low back muscle strain	M	Physiotherapy (8)			Quadriceps (lm)
			Massage (6)	5	None	Low back (lm, 12, ca)
			Electrotherapy (4)			Adductors (lm, 12, ca)
MR3	Elbow contusion	M	Physiotherapy (4)	0	Calf strain (ca)	Head, neck (lm, 12, ca)
			Taping (4)		Hamstring strain (ca)	Calf (lm, 12, ca)
			Electrotherapy (4)			Hamstring (lm, 12, ca)
						Low back (lm, 12, ca)
MR4	Rib contusion	T	Taping (5)	2	None	None
MR5	Ankle ligament sprain	T	Physiotherapy (10)	7	None	None
			Taping (10)			
			Electrotherapy (5)			
MR6	Hamstring muscle strain	T	Physiotherapy (7)			
			Massage (8)	5	Ankle sprain (12)	Ankle (12)
			Electrotherapy (6)			
MR7	Heel contusion, plantar fascia	T	Massage (6)	4	Meniscus lesion (ca), Achilles rupture (ca)	Knee (ca)
			Electrotherapy (5)			Achilles (ca)
AR1	Rectus femoris muscle strain	M	Physiotherapy (10)			
			Massage (8)	6	Ankle sprain (prior to 2006 FIFA World Cup)	Low back (12, ca)
			Electrotherapy (7)		Adductor strain (ca)	Adductors (12, ca)
AR2	Hamstring muscle strain	M	Physiotherapy (15)		Calf strain (12)	Calf (12, ca)
			Massage (12)	10	Hamstring strain (ca)	Hamstring (12, ca)
			Electrotherapy (10)			
AR3	Knee ligament sprain (MCL)	M	Physiotherapy (8)	4	Meniscus lesion (ca)	Head, neck (ca)
			Electrotherapy (6)			
AR4	Hamstring muscle strain	T	Physiotherapy (5)	3	None	None
			Massage (6)			
AR5	Calf muscle strain	T	Physiotherapy (6)			Calf (lm, 12, ca)
			Massage (5)	3	None	Hamstring (12, ca)
			Electrotherapy (5)			
AR6	Ankle sprain	T	Physiotherapy (5)	5	Calf strain (12)	Ankle (ca)
			Taping (5)		Hamstring strain (ca)	
AR7	Thoracic muscle strain	T	Physiotherapy (5)	1	Ankle sprain (ca)	Achilles tendon (12, ca)
			Electrotherapy (4)			Ankle (12, ca)

AR, assistant referee; ca, career; lm, last match; M, match; MR, match referee; T, training; 12, last 12 months.

musculoskeletal complaints of the referees (for details see tables 3 and 4).

Injuries during the 2006 FIFA World Cup

During the World Cup, 14 (22.2%) referees incurred an injury during a match (6; 42.9%) or training (8; 57.1%) (for details, see table 3).

In each group (MRs and ARs) there were three injuries during matches and four during training. However, this equated to a two fold greater frequency of injuries in MRs (7; 33.3%) than in ARs (7; 16.7%). The match injuries resulted in an incidence of 20.8 per 1000 match hours for all referees (95% CI: 4.2 to 37.4); for the MRs, the incidence was 31.3 injuries per 1000 match hours (95% CI: 0 to 66.8) and for the ARs, 15.6 injuries per 1000 match hours (95% CI: 0 to 33.2). None of the injuries caused any absence from officiating. However, 13 of the 14 injured referees had to reduce or modify their normal team training on the pitch for an average of 4.4 days (range 0–10). The treatment of these injuries required a total of 83 physiotherapy sessions, 56 electrotherapy applications, 51 massage therapy sessions, and 31 tapings.

While in MRs the most frequent diagnosis was contusion, in ARs five out of seven injuries were strains. Only one MR (MR2) incurred an injury in the same location as that where he had previously reported having complaints (low back), but the injury was a newly incurred muscle strain and not an aggravation of his pre-existing low back pain. In contrast, four ARs incurred an injury in the same location as that where they had previously suffered injuries and/or complaints. AR3, who suffered a knee collateral ligament strain during the 2006 FIFA World Cup, had already undergone surgery on the same knee due to a meniscus lesion more than a year ago.

Musculoskeletal complaints during the 2006 FIFA World Cup

During the World Cup, 22 (34.9%) referees were treated in connection with 30 musculoskeletal complaints (table 4), with

Table 4 Musculoskeletal complaints during the 2006 FIFA World Cup and reported retrospectively during the survey carried out 3 months earlier

Referee	Complaint during 2006 World Cup	Days of reduced training	Type and frequency of treatments	Complaints reported retrospectively in March/April 2006
MR1	Low back	0	Physiotherapy (11) Massage (9)	None
MR2	Low back, calf	0	Physiotherapy (7) Massage (9)	Quadriceps (lm) Low back (lm, 12, ca) Adductors (lm, 12, ca))
MR3	Knee	2	Physiotherapy (6) Electrotherapy (5)	Head, neck (lm, 12, ca) Calf (lm, 12, ca) Hamstring (lm, 12, ca) Low back (lm, 12, ca)
MR6	Achilles tendon	0	Physiotherapy (5) Electrotherapy (5)	Ankle (12)
MR8	Low back	0	Physiotherapy (3) Massage (5)	Ankle (12) Knee (ca) Knee surgery
MR9	Calf	1	Physiotherapy (4) Massage (4)	Neck (12) Knee (12) Calf (Ca)
MR10	Knee	0	Physiotherapy (3) Electrotherapy (3)	Hip (12, ca) Hamstring (12, ca) Knee (12, ca) Calf (ca) Knee surgery
AR7	Low back, calf	0	Physiotherapy (7) Massage (6)	Achilles tendon (12, ca) Ankle (12, ca)
AR8	Low back, shoulder	0	Physiotherapy (5) Electrotherapy (4)	None
AR9	Low back	0	Physiotherapy (2) Massage (7)	Low back (ca)
AR10	Low back	0	Massage (5)	Low back (12, ca) Knee (12)
AR11	Low back, hamstring, Adductor	2	Physiotherapy (8) Massage (8)	Low back (12, ca)
AR12	Low back	3	Physiotherapy (12) Massage (13)	Low back (ca) Quadriceps (12) Hamstring (12, ca) Knee (12) Hip (ca)
AR13	Low back	0	Massage (6)	Low back (ca)
AR14	Calf	0	Massage (5)	Adductors (12, ca)
AR15	Calf, Achilles tendon	0	Physiotherapy (10) Electrotherapy (7)	Achilles tendon (12)
AR16	Achilles tendon	0	Physiotherapy (5) Electrotherapy (10)	Achilles tendon (12, ca)
AR17	Thoraco-cervical spine	0	Physiotherapy (7)	Head (lm, ca) Calf (lm, 12, ca) Achilles tendon (lm, 12, ca) Low back (12, ca)
AR18	Thoracic spine, ribs	0	Physiotherapy (3)	Knee (12, ca) Achilles tendon (ca)
AR19	Ankle	3	Physiotherapy (5) Electrotherapy (4) Taping (6)	Head (12) Neck (12) Low back (12) Calf (ca)
AR20	Shoulder	0	Physiotherapy (7)	Knee (12)
AR21	Knee	2	Physiotherapy (6) Electrotherapy (6)	Knee (ca) Knee surgery

AR, assistant referee; ca, career; lm, last match; MR, match referee; 12, last 12 months.

no difference between ARs and MRs. The treatment of these musculoskeletal complaints required a total of 116 physiotherapy sessions, 81 massage therapy sessions, 40 electrotherapy applications, and six tapings.

The most frequent complaint was low back pain (33.3%), followed by complaints involving the calf (16.7%) and Achilles tendon (10.0%). The majority of referees suffering from low back pain during the World Cup (60%) had reported this

symptom previously. Two referees (MR10 and AR24) treated because of knee pain had already undergone surgery on the same knee. Also, two of the three referees suffering from Achilles tendon pain (AR18, AR19) had had the same complaint during the previous 12 months. In total, 60% of the complaints treated during the World Cup were not related to any injury or complaint reported in the retrospective questionnaire.

DISCUSSION

In the present study, injuries and musculoskeletal complaints of all referees pre-selected for the 2006 FIFA World Cup were investigated both retrospectively and prospectively. In effect, this was a study of 63 of the world's best referees. The personal characteristics (age, BMI, experience of refereeing) of this group were almost identical to those reported in other studies dealing with elite referees officiating in international football tournaments.[8 9] However, the mean age of this referee group was higher than that of referees performing at national level only,[6 10–13] since elite football referees often only reach the top of their career (which may mean selection for the FIFA World Cup) at ages greater than 40 years.[3]

The retrospective part of the study followed the methodology of a previous study on Swiss elite referees.[6] Similarly to the latter study, 41% of the referees in the present study reported an injury during their career, and also only injuries resulting in at least 2 weeks absence were reported. The problems associated with retrospective surveys (i.e. memory effects) have been previously described.[14 15] Since only moderate to severe injuries were reported, the true incidence of injuries may have been underestimated. The locations and types of injuries reported by the FIFA referees were also similar to those reported by the Swiss referees.[6] Hamstring strains, calf strains, and ankle sprains accounted for more than 60% of all reported injuries throughout the referees' careers. Muscle strains and ligament sprains are also the injuries most commonly documented for football players.[16 17] However, football players are on average 15 years younger than international referees[3 4]; Arnason *et al*[18] found that increased age and previous hamstring strains were the main risk factors for hamstring strains in footballers. The FIFA referees reported more injuries during training (82.8%) than during the match (17.2%). This finding is in accordance with the study of Bizzini *et al* on Swiss elite referees,[6] and might be explained by the greater exposure time in training than in matches.

In the present study, the incidence of match injuries in the last 12 months was considerably lower (tenfold) than that reported for elite Swiss referees.[6] Since memory effects (a limitation within any retrospective study design) can be considered to be equal for both studies, a possible "answer bias" due to the selection procedure for the 2006 FIFA World Cup might be an explanation for this finding. For an international FIFA referee, officiating in the World Cup (the most important football event in the world) represents the pinnacle of the refereeing career. In view of this, we cannot rule out the possibility that certain individuals may not have answered the questionnaire entirely honestly.

About two-thirds of the referees reported having had some sort of musculoskeletal complaint during their career. Similar numbers of referees reporting musculoskeletal complaints with respect to the last 12 months and the entire career indicate the problems of recall bias. Thus, the prevalence of complaints during the career clearly represents a minimum estimate and should be interpreted with caution. In the study of Bizzini *et al*[6] on elite Swiss referees, 86% reported having had some sort of complaint in the last 12 months caused by refereeing. An alternative explanation to the deliberate under-reporting of previous injuries and complaints by the FIFA referees in the retrospective part of the study may be better physical fitness in this elite group.

What is already known on this topic

Football referees play an important role in a football match; however, little is known about their injury profile.

What this study adds

The incidence of injuries reported retrospectively was low, but half of the referees received treatment during the World Cup because of a new injury and/or musculoskeletal complaints.
The most common acute injuries were hamstring strains, calf strains, and ankle sprains, while the most frequent locations of complaints were the low back, hamstring and knee.

In the present study, the main areas affected by musculoskeletal complaints were the hamstrings, knee, calf, Achilles tendon and low back, confirming the findings of Bizzini *et al*.[6] In a study dealing with shock-absorbing soles, Fauno *et al*[19] also found that the calf, thigh, low back, Achilles tendon and knee were the most common locations for overuse symptoms in a group of 91 referees officiating in a 5-day football tournament.

During the 2006 FIFA World Cup, all acute injuries and musculoskeletal complaints of referees were documented prospectively. Six match injuries and eight training injuries were recorded. Though none of these resulted in absence from officiating, all except one injured referee had to reduce or modify their training regimen. The incidence of 20.8 match injuries per 1000 match hours was substantially lower than that reported for the football players involved in the same tournament (68.7 injuries per 1000 match hours).[20] The incidence of non-contact injuries in players (18 injuries per 1000 match hours) seems similar to that of referees, but some of the non-contact injuries in players resulted in absence from training or match.

During the 2006 FIFA World Cup tournament, one-third of the 63 officiating referees presented musculoskeletal complaints. The relative distribution of the complaints was similar to that reported retrospectively, except that low back pain was reported more frequently in the tournament. Sixty per cent of the referees presenting with low back problems had already reported this complaint in the retrospective questionnaire, confirming the well-known recurrent nature of low back pain.[21 22] Nonetheless, the prevalence was lower than in cross-country skiers and rowers, and similar to that in orienteers and non-athletic controls.[23]

Even though all the referees who suffered an injury during the 2006 FIFA World Cup were — after optimal medical and therapeutic care — still able to perform in the tournament, these data clearly show that the referee and his assistants are also exposed to a relatively high risk of injury during the match. The physiological and psychological demands on elite referees are high, and this group of athletes deserves more attention in relation to technical and physical preparation for the game. Future studies should investigate the possibility of developing specific injury prevention programmes for the referee and assistant referee.

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Female soccer referees selected for the FIFA Women's World Cup 2007: survey of injuries and musculoskeletal problems

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ABSTRACT

Background: Few studies have examined the physiology, training and more recently injury profile of the soccer referee, and these have involved almost exclusively male referees.

Purpose: To analyse the frequency and characteristics of injuries and musculoskeletal problems in female referees selected for the FIFA Women's World Cup 2007.

Study design: Retrospective and prospective descriptive epidemiological study.

Methods: During the preparation camps a few months before the FIFA Women's World Cup 2007, all 81 preselected female referees completed a questionnaire on injuries and musculoskeletal problems. During the final 32 matches of the tournament in China, all injuries, musculoskeletal problems and related treatment of the 36 officiating referees were documented.

Results: Almost 50% of the referees reported having incurred at least one injury during their career that had led to time loss from the game. In the previous 12 months, 13 (16%) referees reported having sustained an injury and 64 (79%) reported musculoskeletal problems related to refereeing. During the World Cup and 14 (39%) referees incurred an injury and 17 (33%) were treated for musculoskeletal problems. The commonest location of injuries and problems were hamstrings, quadriceps, calf and ankle. The prospectively collected data found an incidence of 34.7 match injuries per 1000 match hours (95% CI 4.2 to 65.1).

Conclusion: Top-level female referees are exposed to an even greater risk of injury and/or musculoskeletal problems related to officiating than are male referees. Considering the growth of women's soccer, injury prevention programmes should be specifically developed for female referees.

Women's soccer has grown considerably in recent years. The official FIFA Big Count 2006 survey found that 26 million of the 265 million players actively involved in soccer, worldwide, were women and girls.[1] From 2000 to 2006 the number of registered female soccer players in FIFA's (then) 207 member associations (countries) increased by >50% to 4.1 million, whereas the number of registered men players increased by 21% to 34.2 million.

In accordance with the Laws of the Game, official soccer matches are officiated by a match referee and two assistant referees. In 2006, there were 840 000 referees and assistant referees registered at the national level worldwide, of whom approximately 10% (85 000) were woman.[1] Compared with the FIFA Big Count 2000, this represented an increase of almost 50% in the number of female referees compared with just 11% for male referees. The 81 female referees preselected for the FIFA Women's World Cup 2007 represented 0.95% of the total number of registered female referees worldwide, whereas the respective percentage of the 123 male referees preselected for the 2006 FIFA World Cup was 0.16%.

In recent years, the physiological aspects of soccer refereeing have been described in detail for the men's game.[2 3] Research has shown that, during a match, international male referees cover an average distance of between 9 and 13 km, with a low percentage of high-intensity activities but a high number of activity changes and a great deal of decision-making. Published studies on women's soccer are rare,[4] and there are no peer-reviewed articles dealing with any aspects of performance in female referees. A study by Krustrup *et al*[5] found that the female player covered on average about 10 km during a soccer match, whereas malep layers averaged between 10 km and 14 km. The distance covered at high-intensity running (>15 km/h) by female players is lower than that of male players (1.3 km versus 1.9–2.4 km, respectively). Nevertheless, the exercise intensity as measured using the heart rate is similar between men and women. As the physical match activity of the referee is partly related to that of the players,[6] one may speculate that the match demands for female referees are similar to those for male referees in terms of internal load (exercise intensity) but lower for external load.

Only two studies have investigated injuries and musculoskeletal problems in elite referees.[7 8] In a retrospective study of 71 Swiss elite male referees,[8] 27% of the referees reported a time-loss injury (3.45 per 1000 match hours; 95% CI 1.2 to 5.7) and almost 90% reported musculoskeletal problems caused by refereeing during the preceding 12 months. The second study included the world's best 123 referees selected for the 2006 FIFA World Cup in Germany.[7] The retrospective data found a lower incidence of match injuries in the previous year (0.7 per 1000 match hours; 95% CI 0.1 to 1.3) and a lower prevalence of musculoskeletal problems (59%). The prospective study during the tournament found an incidence of 20.8 injuries per 1000 match hours (95% CI 4.17 to 37.4) and 35% of the referees were treated due to musculoskeletal problems. The locations of injuries and musculoskeletal problems were similar in both studies: hamstring, calf, ankle, lower back, and knee. Comparable information on injuries and

musculoskeletal problems of female referees has only been reported for five female referees officiating in the two top divisions of the Swiss Football League.[8]

The aim of this study was to investigate the injuries and musculoskeletal problems of female referees and assistant referees selected for the FIFA Women's World Cup 2007 in China and to compare the results with those previously reported for male referees officiating at the 2006 FIFA World Cup.

METHODS

All subjects gave their written informed consent to participate and the study was approved by the University of Zürich ethics committee. The study included a retrospective survey of injuries and musculoskeletal problems in all female match referees (MRs) and assistant referees (ARs) preselected for the FIFA Women's World Cup 2007 and a prospective assessment of injury in all female referees officiating the final 32 matches of the tournament.

The selection of the study population, the study design and the data collection methods were identical to those used in a previous study[7] of male MRs and ARs preselected for the FIFA 2006 World Cup, to enable comparison of male and female referees of a similar skill level under comparable circumstances.

Population

All 81 female referees (30 MRs and 51 ARs) from 33 National Associations worldwide, preselected for officiating during the FIFA Women's World Cup 2007 in China by the FIFA Refereeing Department, were included in the retrospective survey. Of the initial group, 42 (14 MRs, 27 ARs) were ultimately selected for the FIFA Women's World Cup 2007. Six referees (1 MR, 5 ARs) were sent home after failing the physical tests 1week before the start of the tournament. The remaining 36 referees (13 MRs, 23 ARs) officiating at the final 32 matches of the FIFA Women's World Cup 2007 were included in the prospective part of the study.

Retrospective study

The retrospective part of the study was carried out during the three preparation camps in January (Canary Islands, Spain), March (Algarve, Portugal) and May (Zürich, Switzerland) organised for female MRs and ARs by the FIFA Refereeing Department.

On the first day of the two camps in January and March, the 81 preselected referees were asked to complete a questionnaire on injuries and musculoskeletal problems. During the last camp in May, a physiotherapist conducted brief personal interviews with each of the 51 final preselected referees to confirm and complete the questionnaire data. Although the referees were explicitly informed that the data would be treated in complete confidence and only used for scientific purposes, it was considered possible that some referees might have thought their answers would influence their chances of selection and hence played down or did not declare their injuries and problems.

All definitions used, methods applied and variables assessed were in accordance with the recent consensus statement on injury definition and data collection procedures in studies of soccer injuries,[9] and have been described in detail by Bizzini *et al*[7 8] The five-page questionnaire covered the referee's characteristics of the referee (such as sociodemographics, refereeing qualifications and experience), injuries and musculoskeletal problems caused by training or refereeing (related to the last match, the previous 12 months and the entire career), other medical problems, and time spent in training and in matches. The questionnaire was available in English, Spanish, German and French, the four official FIFA languages, as fluency in at least one of these languages is a prerequisite for selection as a FIFA referee.

Prospective assessment

Two weeks before the tournament (August 27), the 42 selected referees and about 30 staff members were reunited at the referees' headquarters in Shanghai, China. A medical team (including one medical doctor, one physiotherapist and four massage therapists), two fitness trainers and one sports psychologist took care of the referees until the end of the tournament. A ''typical'' day for the referee comprised 1.5–2 hours of training on the pitch in the morning, then 1 hour of individual training (optional) and 1 hour of theory in the afternoon, followed by regeneration/treatment sessions (individual schedules). The referees trained ''normally'' while they were in the headquarters, but reduced their training programme a day or two before leaving to officiate matches. During the FIFA Women's World Cup 2007 (10–30 September 2007) the MRs and ARs (with the fourth official) travelled by air or rail to their appointed matches at the different venues in China. The physical condition of the MRs and ARs officiating at a match was checked by the medical team upon their return to the headquarters in Shanghai.

Data on injuries and musculoskeletal problems were collected prospectively by one physiotherapist (MB) from the medical team. Confirmation of medical diagnoses was made by a physician at the referees' headquarters in Shanghai. Every acute injury incurred during a match or training was recorded according to the consensus injury definition.[9] All musculoskeletal problems that affected the performance of the referees were similarly recorded. The type and number of treatments (physiotherapy, massage, electrotherapy, taping, other) and training modifications (reduced training, such as on an exercise bike or in the pool) were recorded on a daily basis.

Calculation of exposure time

For the retrospective study, exposure time was calculated based on the information provided in the questionnaire. Match exposure in the previous 12 months was calculated as the sum of matches officiated by all referees in the previous year multiplied by 1.5 hours (the minimum duration of a match). Match exposure over the career was given by: the number of referees × the average years in refereeing x the average number of games officiated per year × 1.5 hours.[8] Exposure in training was calculated for the season and preseason separately. For the prospective survey, match exposure (in hours) was calculated by multiplying the number of games (32) by the number of referees (3) by the standard number of hours per game (1.5).

Statistical analysis

The statistical analyses were carried out using SPSS V.11. Descriptive data are reported as the mean (SD) and/or range, unless otherwise stated. Group differences between MRs and ARs were analysed by χ^2 (categorical data) or unpaired t tests (continuous variables). For incidence rates, 95% confidence intervals were calculated according to the formula 95% CI = incidence ± 1.96 × (incidence/square root [number of incidents]). Significance was set at $p < 0.05$.

RESULTS

Population characteristics

The study comprised 81 referees preselected for the FIFA Women's World Cup 2007 (mean age 35 (SD 4.4) years, range 26 to 44 years; height 1.66 (0.06) m, range 1.52–1.76 m; weight 59 (SD 6) kg, range 42 to 72 kg; and body mass index 21.4 (1.8) kg/m^2, range 17.7 to 25.3 kg/m). They had received their first official licence for refereeing on average 12 years (range 4–25 years) before the study and had officiated for 9 years (range 2–23 years) in their top national leagues. They had held a FIFA licence for an average of 6 years (range 1–12 years), during which time they had also been officiating at international matches. Per year, the referees officiated on average at 32.8 (SD 20.2) national and 7.0 (4.4) international matches. In the 12 months before the World Cup, they had officiated on average at 29.9 (21.7) national matches and 8.3 (4.8) international matches. The referees officiated on average 2.8 (1.2) matches/week and trained 7.5 (3.1) hours/week before the season and 6.0 (2.9) hours/week during the season. Almost two-thirds of the referees (64.2%) reported that they had received advice about their training from qualified personnel and 69.1% declared that they did not practice any other sporting activities apart from refereeing and training for refereeing. No significant differences between MRs and ARs were seen for any of these variables.

Retrospectively reported injuries

In total, 57 injuries (in matches and training over the career) were reported retrospectively by 15 MRs (50% of the MRs) and 24 ARs (47.1% of the ARs). One AR reported four injuries, 2 MRs reported three injuries, 11 (8 ARs, 3 MRs) reported two injuries and 25 (15 ARs, 10 MRs) referees reported one injury. All reported injuries had resulted in at least 2 weeks of absence from sport. Most injuries had resulted in an absence 2–4 weeks (42; 73.7%) or 5–8 weeks (11; 19.3%), although four injuries (0.1%) had resulted in an absence of 12 weeks or more.

A similar number of injuries had occurred during matches (27; 47.4%) and training (30; 52.6%). In both MRs and ARs, the most prevalent diagnoses were (in decreasing order) hamstring strains, calf strains, ankle sprains and quadriceps strains; adductor strains were reported only by AR (table 1).

Four (13.3%) MRs and eight (15.7%) ARs reported having had an injury in the previous year (one AR had two injuries) and one AR during the last game.

The incidence of match injuries was 0.6 per 1000 match hours (95% CI 0 to 1.2) for the entire career, 2.8 per 1000 match hours (95% CI 1.3 to 4.3) over the previous 12 months, and 8.2 per 1000 match hours (95% CI 2.6 to 13.9) in relation to the last match.

Retrospectively reported musculoskeletal problems

Almost 80% of the referees (22 MRs, 42 ARs; $p>0.05$) reported having had some sort of musculoskeletal problem related to officiating, during their entire career. The figures were similar for the previous 12 months. In total, 37 referees (45.7%; 14 MRs, 23 ARs; $p>0.05$) reported having had at least one problem during the last match that they officiated. In both MRs and ARs, the most prevalent locations of problems over the entire career were the hamstrings, calf, low back and knee (table 2). Problems with the Achilles tendon and ankle in MRs and problems with the adductors in ARs were also common. Headache, which strictly speaking should not be considered a musculoskeletal problem, also ranked highly, with a prevalence of 36.6% in MRs and 23.5% in ARs. Compared with MRs, ARs reported more problems in the adductors ($p<0.05$) and knee ($p<0.05$) in the previous 12 months, but not during their career (table 2).

Other retrospective information

Two MRs and three ARs had undergone surgery; in one MR and two ARs this was on the ankle. Additionally, two MRs and six ARs reported having had other operations (three caesareans and one each of appendix removal, hernia, nose, muscle and foot operations). Five MRs and 10 ARs reported medical problems (mostly asthma and allergies). When asked whether they did anything to prevent injuries or musculoskeletal problems, 62 (76.5%) referees stated that they performed stretching exercises, 43 (53.1%) reported receiving massage and 33 (40.7%) indicated that they undertook other measures (eg, visiting a sauna or gym).

Referees officiating during the FIFA Women's World Cup 2007

All 36 referees selected for officiating as MRs (n = 14) or ARs (n = 22) during the Women's World Cup were included in the

Table 1 Injuries reported by FIFA female referees during their career

	Match referees (n = 30)		Assistant referees (n = 51)		
	Game	Training	Game	Training	Total
Hamstring strain	4	3		7	14
Calf strain	3	1	4	2	10
Ankle sprain	3	2	3	1	9
Quadriceps strain	–	2	2	2	6
Adductor strain	–	–	–	4	4
Knee sprain	–	–	–	2	2
Patellar tendon partial tear	–	–	2	–	2
Achilles tendon partial tear	1	–	1	–	2
Low back muscle strain	–	–	1	1	2
Toe fracture	–	1	1	–	2
Stress fracture metatarsal bone	–	1	–	–	1
Plantar fascia partial tear	1	–	–	–	1
Low back herniated disc	–	–	–	1	1
Meniscus lesion	–	–	1	–	1
Total	12	10	15	20	57

Table 2 Number and percentage of referees reporting musculoskeletal problems

	Match referees (n = 30)			Assistant referees (n = 51)		
Location of problems	Last match, n (%)	Previous 12 months, n (%)	Entire career, n (%)	Last match, n (%)	Previous 12 months, n (%)	Entire career, n (%)
Head	3 (10.0)	10 (33.3)	11 (36.6)	4 (7.8)	12 (23.5)	12 (23.5)
Neck	–	2 (6.6)	3 (10.0)	3 (5.9)	8 (15.7)	9 (17.6)
Low back	2 (6.6)	3 (10.0)	7 (23.3)	3 (5.9)	14 (27.4)	14 (27.4)
Hip	3 (10.0)	4 (13.3)	4 (13.3)	3 (5.9)	3 (5.9)	5 (9.8)
Groin	–	–	4 (13.3)	–	3 (5.9)	6 (11.8)
Adductors	–	1 (3.3)	3 (10.0)	4 (7.8)	12 (23.5)	12 (23.5)
Quadriceps	2 (6.6)	3 (10.0)	5 (16.6)	2 (3.9)	10 (19.6)	10 (19.6)
Hamstring	3 (10.0)	8 (26.6)	9 (30.0)	7 (13.7)	19 (37.3)	19 (37.3)
Knee	1 (3.3)	1 (3.3)	7 (23.3)	3 (5.9)	12 (23.5)	12 (23.5)
Patellar tendon	2 (6.6)	2 (6.6)	5 (16.6)	2 (3.9)	5 (9.8)	5 (9.8)
Calf	4 (13.3)	9 (30.0)	10 (33.3)	4 (7.8)	14 (27.4)	14 (27.4)
Achilles tendon	2 (6.6)	4 (13.3)	7 (23.3)	2 (3.9)	7 (13.7)	7 (13.7)
Ankle	2 (6.6)	3 (10.0)	8 (26.6)	2 (3.9)	6 (11.8)	8 (15.7)
Others*	1 (3.3)	4 (13.3)	4 (13.3)	3 (5.9)	4 (7.8)	4 (7.8)

*Including shin splints and heel pain.

prospective study. No significant differences between this group and the remaining, non-selected 45 referees were seen in relation to their personal characteristics or the percentage that were previously injured or had a history of musculoskeletal problems, except that headache was reported less often by the referees who were selected.

During the World Cup, more than half of the referees (61.1%, 10 MRs and 12 ARs; $p>0.05$) received treatment. Treatment was given in connection with 14 injuries and 17 musculoskeletal problems. Four ARs (AR1, AR3, AR4, AR9) were treated for both injuries and musculoskeletal problems (in two cases, AR4 and AR9, the injury and problem were connected). In total, 146 physiotherapy sessions, 129 massage therapy sessions, 107 applications of electrotherapy and 20 tapings were carried out in treating the injuries and musculoskeletal problems (tables 3, 4).

Injuries during the FIFA Women's World Cup 2007

During the FIFA Women's World Cup 2007 tournament, 14 referees (38.9%) incurred an injury during a match (n = 5; 35.7%) or training (n = 9; 64.3%). The five match injuries resulted in an incidence of 34.7 match injuries per 1000 match hours (95% CI 4.2 to 65.1), equivalent to approximately 1 injury in 20 matches.

Strain of the rectus femoris muscle was the most common injury (n = 5; 35.7%), followed by hamstring strain, calf strain and ankle sprain (each twice). Four (80%) of the five match injuries were muscle strains; the latter also comprised 56% of all training injuries ($p>0.05$). None of these injuries resulted in absence from officiating. However, all 14 referees had to reduce or modify their training regimen for an average of 5.6 days (range 2–10). The treatment of these injuries required 80 physiotherapy sessions, 62 massage therapy sessions, 68 applications of electrotherapy and 20 tapings.

In 12 out of 14 cases, no relationship was found between the tournament injury and previous injuries reported in the questionnaire. Two referees who sustained a rectus femoris muscle strain during the tournament (one MR during a match and one AR during training) had a history of a quadriceps muscle lesion in the previous year (table 3).

Musculoskeletal problems during the FIFA Women's World Cup 2007

During the Women's World Cup 2007, 12 referees (33.3%; 5 MRs, 7 ARs) were treated in connection with 14 problems. Two referees (MR10, AR9) reported two different problems. The commonest locations of musculoskeletal problems were the lower back muscles, plantar fascia, hip joint (three cases each), psoas/adductor muscles and calf muscles (two cases each). Muscle tightness was identified as the cause of the problem in about half the cases. The treatment of these musculoskeletal problems required 60 physiotherapy sessions, 67 massage therapy sessions and 39 applications of electrotherapy.

In four cases (MR8, MR10, AR9, AR12), the referees sustained problems of a similar nature to those that had already been declared in the retrospective questionnaire (two concerning the hip joint and two concerning the calf muscles). However, >70% of all documented problems during the World Cup were not related to any previously reported injury or musculoskeletal problem (table 4).

DISCUSSION

To our knowledge, this is the first published study describing the injuries and musculoskeletal problems of femle soccer referees. Previously, the only data available on female referees were those reported as part of a retrospective survey of all referees officiating in the top two divisions of the Swiss Football League, which included five female referees.[8] The present study includes a retrospective survey of the world's 81 best female match referees and assistant referees preselected for the FIFA Women's World Cup 2007, and a prospective assessment of all 36 female referees involved in the final stage of the tournament.

The protocol adopted in the present study was the same as that previously described for studies on Swiss elite referees[8] and referees selected for the 2006 FIFA World Cup,[7] to enable comparison with these earlier studies. The five female referees officiating in the top two divisions of the Swiss Football League reported (retrospectively, over their career) two hamstring strain injuries in training and no match injuries, and headache was the most prevalent problem.[8] Despite the small number of subjects, this tends to concur with some of the findings of the present study.

Compared with their male counterparts involved in the 2006 FIFA World Cup,[7] the female referees involved in the FIFA Women's World Cup 2007 were younger (by a mean of 5 years) and had a shorter career refereeing both national matches (by 7 years) and international matches (by 2 years). However, the average number of matches per year was almost identical in

Table 3 Characteristics and consequences of acute injuries during the FIFA Women's World Cup 2007 and previous injuries and problems reported retrospectively in the survey carried out earlier the same year

Referee	Type of injury during Women's World Cup	Match or training injury	Type and frequency of treatment	Days of reduced training	Previous injuries or problems reported retrospectively in January to May 2007	
					Injury	Problem
MR1	Rectus femoris muscle strain	Match	Physiotherapy (8); massage (6); electrotherapy (7)	10	Quadriceps strain (ca)	Quadriceps (ca)
MR2	Rectus femoris muscle strain	Match	Physiotherapy (5); massage (6); electrotherapy (4)	7	No	No
MR3	Knee ligament sprain (MCL)	Training	Physiotherapy (5) Taping (4) Electrotherapy (4)	4	Achilles partial tear (12) Plantar fascia partial tear (ca)	Hamstring (lm, 12, ca) Achilles (lm, 12, ca) Calf (12, ca) Low back (ca) Knee surgery (ca)
MR4	Heel contusion	Training	Electrotherapy (4); taping (3)	2	No	Knee surgery (ca)
MR5	Calf muscle strain	Training	Physiotherapy (4); massage (5); electrotherapy (4)	4	No	No
AR1	Ankle sprain	Match	Physiotherapy (9) Taping (8), electrotherapy (7)	5	Adductors (12)	Adductors (12, ca) Calf (12, ca)
AR2	Hamstring muscle strain	Match	Physiotherapy (6); massage (6); electrotherapy (5)	9	No	Knee (12, ca)
AR3	Rectus femoris muscle strain	Match	Physiotherapy (9) Massage (8) Electrotherapy (6)	7	Calf strain (lm) Achilles partial tear (ca)	Calf (lm, 12, ca) Hamstring (12, ca) Knee (12, ca) Achilles (ca)
AR4	Thoracic spine blockage	Training	Physiotherapy (3) Massage (3)	2	Hamstring strain (12) Calf strain (ca)	Hamstring (12, ca) Calf (ca)
AR5	Rectus femoris muscle strain	Training	Physiotherapy (7) Massage (5) Electrotherapy (7)	5	No	Quadriceps (12, ca) Hamstring (12, ca) Calf (12, ca) Ankle (12, ca) Knee (ca)
AR6	Ankle sprain	Training	Physiotherapy (5); taping (5); electrotherapy (4)	8	Hamstring (12)	Hamstring (12, ca)
AR7	Hamstring muscle strain	Training	Physiotherapy (9); massage (8); electrotherapy (5)	6	No	Adductors (lm, 12, ca)
AR8	Rectus femoris muscle strain	Training	Physiotherapy (5);, massage (5); electrotherapy (4)	5	Quadriceps strain (12)	Quadriceps (12, ca)
AR9	Calf muscle strain	Training	Physiotherapy (11) Massage (10) Electrotherapy (7)	5	Calf (12)	Hamstring (12, ca) Calf (12, ca)

12, Previous 12 months; AR, assistant referee; ca, career; lm, last match; MR, match referee.

male and female FIFA-referees. The female FIFA referees reported spending a similar number of hours to the male referees in training and preparing to officiate, but compared with their male counterparts, fewer female referees were instructed by a qualified person (64% women vs 84% men). A higher proportion of female referees (69%) than male (42%) referees reported practising other sports as part of their training or as a recreational activity.

The incidence of match injuries per 1000 match hours, reported retrospectively for the previous 12 months, was 0.69 (95% CI 0.09 to 1.29) for the 123 male referees selected to officiate at the 2006 FIFA World Cup[7] and 2.8 (95% CI 1.3 to 4.3) for the 81 female FIFA referees. No male referees but one female AR reported having incurred an injury during the last match of the tournament. A higher incidence of injury was seen not only in the retrospectively reported data, but also in the prospective survey; during the World Cup tournaments, more female referees (38.9%) than male referees (22.2%) incurred an injury (relative risk 1.6; 95% CI 0.95 to 2.56).

One can only speculate as to the reasons for the higher incidence of injuries in female referees compared with male referees. It is possible that the difference is due to a lack of specific physical preparation (to match the physiological demands of international refereeing) of the female referees. From a historical perspective, the first FIFA Women's World Cup only took place in 1991 (China), whereas the "male" FIFA World Cup was first held in 1930 (Uruguay). Hence, international women's soccer generally has a shorter history and is still evolving in all aspects of the game including, presumably, refereeing. Although male FIFA referees have been systematically supported by expert fitness coaches since 2000, their female counterparts have only been enrolled in similar

Table 4 Musculoskeletal problems during the FIFA Women's World Cup 2007 and reported retrospectively during the survey carried out earlier the same year

Referee	Reported problem during World Cup 2007	Days of reduced training	Type and frequency of treatments	Previous problems reported retrospectively in January May 2007
MR6	Plantar fascia tightness	1	Massage (6) Electrotherapy (6)	Hip (lm, 12, ca) Quadriceps (lm) Hamstring (12, ca)
MR7	Low back muscle tightness	0	Physiotherapy (7) Massage (9)	Hip (12) Hamstring (12) Calf (12)
MR8	Hip joint impingement (FAI), with low back muscle tightness	0	Physiotherapy(12) Massage (6)	Hip (lm,12,ca) Hamstring (lm,12,ca) Calf (lm,12,ca) Ankle (lm,12,ca)
MR9	Psoas and adductor muscle tightness	1	Physiotherapy (5) Massage (6) Electrotherapy (4)	Head (ca) Calf (12) Hamstring (ca)
MR10	Hip joint hypomobility, with psoas and low back muscle tightness Calf muscle tightness	3	Physiotherapy (7) Massage (5) Electrotherapy (7)	Head (12) Calf (lm, 12, ca) Ankle (ca) (Ankle surgery)
AR1*	Piriformis, gluteal and low back muscle tightness	1	Physiotherapy (5) Massage (3)	Head (lm) Adductors (12) Calf (12)
AR3*	Psoas and adductor muscle tightness	0	Physiotherapy (8) Massage (6) Electrotherapy (6)	Calf (lm, 12,ca) Hamstring (12,ca) Knee (12,ca) Achilles (ca)
AR4*	Upper thoracic spine hypomobility	0	Physiotherapy (3) Massage (2)	Hamstring (12,ca) Calf (ca)
AR9*	a) Low back and b) calf muscle tightness	0	Physiotherapy (5) Massage (4) Electrotherapy (4)	Hamstring (12, ca) Calf (12, ca)
AR10	Plantar fascia tightness	2	Massage (5) Electrotherapy (5)	Low back (12) Hamstring (ca)
AR11	Plantar fascia tightness	0	Massage (7) Electrotherapy (7)	Hip (lm, 12, ca) Hamstring (lm, 12, ca) Ankle (lm, 12) (Ankle surgery)
AR12	Hip joint impingement (FAI), with psoas and low back muscle tightness	0	Physiotherapy (8) Massage (8)	Head (lm) Hip (lm, 12, ca) Groin (ca) (Knee surgery)

12, Previous 12 months; AR, assistant referee; ca, career; FAI, femoro-acetabular impingement; lm, last match; MR, match referee.

programmes in recent years. The group selected for the FIFA Women's World Cup 2007 had only been participating in a structured training programme since 2005. This was also evidenced by the questionnaire data, which found that 83.7% of the male referees, but fewer than two-thirds (64.2%) of the female referees reported receiving advice about their training from qualified personnel. Other possible reasons for the higher incidence of injury in female referees include the gender difference in fitness level[10] and in neuromuscular characteristics.[11] Finally, another possible explanation could be the difference between men and women in pain perception and coping with pain.[12]

The injury locations reported most often in the retrospective survey (calf, hamstring and ankle) were similar in men and women. Muscle strains were the commonest type of injury in both groups, accounting for >50% of all injuries. In both men and women, adductor muscle strains were seen more often in ARs than MRs. This figure may be associated with the significant amount of sideways running of ARs during the game. Concerning the circumstances of injury, in the retrospective questionnaire female referees reported having incurred more injuries during match-play than did male referees (47% versus 17% of all injuries, respectively), but during the World Cup tournaments, the incidences were similar for both (35.7% versus 42.9% of all injuries, respectively).

In the retrospective questionnaire, musculoskeletal problems in the previous 12 months were reported by >80% of the female referees compared with 59% of the male referees. In contrast, during the two World Cup tournaments, almost the same proportion of female (33.3%) and male (34.9%) referees sustained musculoskeletal problems requiring medical attention.

The locations most often affected by musculoskeletal problems were the same for men and women: hamstring, calf, lower back and knee. There were also some trends showing that certain problems were more prevalent in MRs (Achilles tendon) and in ARs (adductor muscles), which may be related to the different physical demands of these refereeing roles.[2 8] The relatively high prevalence of headache in women referees

What is already known on the topic

- Women's football has grown considerably in recent years and several studies have analysed on injuries of female players.
- Despite the important role of the referee in football, no study has focused on injuries of female referees.

What this study adds

- Almost 50% of the referees reported having incurred at least one time-loss injury during their career and 39% incurred an injury during the FIFA Women's World Cup 2007.
- The commonest diagnoses were hamstring strains, calf strains and ankle sprains.
- The incidence of injuries was higher in woman than male referees but the diagnosis were similar.

(around 30%) is difficult to explain. The causes for headache (not really a musculoskeletal problem, per se) are often multifactorial, but one could speculate that the psychological pressure of officiating at important matches may play a role in women's soccer.

In both male and female referees, the injuries and musculoskeletal problems sustained during the World Cup tournament caused no absence from officiating, but did result in a few days of reduced training. This minimal loss of time from the game is probably attributable to the team of experts (doctors, physiotherapists, massage therapists) responsible for the medical care of the referees.

The results of this study show that female referees – even more than male referees – are exposed to a certain risk of injury and/or development of musculoskeletal problems related to officiating. International referees are required to meet the demands of modern women's soccer, which is evolving rapidly in terms of intensity and speed. The role of the referee should not be considered to be any different from that of the players: they have to be specifically prepared to perform at high level throughout the whole game. Injury prevention measures should therefore be integrated into their training programmes. We conclude that there is a need to develop specific injury prevention programmes for female match and assistant referees.

Competing interests: None.

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Injuries of football referees: a representative survey of Swiss referees officiating at all levels of play

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The purpose of this study was to investigate the frequency and characteristics of injury and musculo-skeletal complaints in Swiss football referees of all levels. A representative sample of 489 Swiss referees was interviewed regarding their socio-demographic characteristics, refereeing qualifications, time spent in training and in matches, history of injuries and musculo-skeletal complaints caused by training or refereeing, and other medical problems. A total of 110 referees (22.5%) reported having suffered at least one injury related to officiating, and 126 referees (25.8%) at least one refereeing-related musculo-skeletal complaint. Thigh strains and ankle sprains were the most frequent injuries, with the most frequent locations of complaints being the knee and lower back. The incidence of match injuries in the last 12 months was on average 2.06 per 1000 match hours; the incidence of training injuries was substantially lower (0.09 per 1000 training hours). The injury rates were similar for referees officiating at an adult level, but lower at a junior level. In comparison with elite football referees, the incidence of training injuries and the prevalence of musculo-skeletal complaints were lower in amateur referees. Nevertheless, preventive programs are indicated for referees at all levels, especially when considering the length of a referee's career.

The referee, with his two assistant referees, plays an important role in the game of football. The "big count" of the Fédération Internationale de Football Association (FIFA) revealed over 840 000 registered referees and assistant referees in 2006 (FIFA, 2007).

Some studies reporting the injury profile of football referees have been published recently, but they have focused exclusively on elite referees at the international level (Bizzini et al., 2008a, b) or at the national level (Bizzini et al., 2009). A complete survey of all 71 officials of the two top divisions of the Swiss Football League revealed an incidence of match injuries of 3.5 per 1000 match hours, and almost 90% of the referees reported musculo-skeletal complaints in the last year (Bizzini et al., 2009). In a retrospective study of male ($n = 123$) and female ($n = 81$) referees selected for the FIFA World Cups™ 2006 and 2007, a lower injury rate and fewer complaints were reported; however, the data collected prospectively during the competitions showed a substantially higher incidence of match injuries (20.8 and 34.7 per 1000 match hours, respectively) (Bizzini et al., 2008a, b).

Similar to the case for players, the number of elite referees is small when compared with the number involved in amateur football. In Switzerland, the 71 referees officiating in the two top divisions represented 1.6% of 4452 registered referees (including 105 female referees) of the Swiss Football Association (SFA) during the season 2005/2006. Moreover, the 204 male and female referees selected for the recent FIFA World Cups™ represented only 0.02% of all registered referees in the 208 National Member Association of FIFA worldwide.

In view of the lack of research in amateur football referees, the aim of the present study was to investigate the incidence of injury and musculo-skeletal complaints in a representative sample of all amateur football referees in one country.

Method

A total of 4452 referees were licensed to officiate in the different leagues of the SFA in the season 2005/2006. Based on the leagues, they were classified into four groups: "professional/semi-professional" level, defined as the two elite leagues (called "Super" and "Challenge") leagues, "high-amateur" as the first and second leagues, "low-amateur" as the third–fifth leagues, and "junior" level as all leagues with players up to 20 years of age. There is no age limit for referees, with the exception of the two top leagues, where the referees' retirement age is set at 45 years. For none of them, was refereeing the primary paid work.

The SFA provided a complete list of all 4452 referees and informed the regional Swiss Referee Federations about the impending survey 2 months in advance. A random sample of 608 referees was selected, but 86 referees had to be withdrawn from the survey (invalid phone numbers, unwilling to participate, language problems) and 33 were excluded because they were no longer active as referees.

A total of 489 active Swiss referees officiating at all levels were interviewed by telephone with regard to their personal characteristics, such as socio-demographics, refereeing qualifications and time spent in training and in matches, history of injuries and musculo-skeletal complaints caused by training or refereeing, and other medical problems.

The structured interviews were based on a questionnaire that had been implemented in previous studies on referees (Bizzini et al., 2008a, b, 2009), but specially adapted for the needs of a telephone survey. The questionnaire had separate sections for (acute) injuries and musculo-skeletal complaints. First, the referee was asked: "Have you suffered any injury caused by refereeing a football match or the training for officiating?" The question was repeated for three time periods (the last match, the last 12 months, and the entire career), and if the referee answered in the affirmative, he/she was requested to give further details about the injury(ies), such as location, type, and duration of absence. The section on musculoskeletal complaints was introduced with a short explanation as to how one distinguished "injuries" from "complaints" and some examples of complaints were given (low back pain, pain in the Achilles tendon, etc.). If the referee stated that he/she "had any pain, discomfort or complaints caused by refereeing a football match or the training for officiating," he/she was asked to give further details (such as location, intensity, cause, and consequences with respect to training and officiating). The interviews (average duration, 10 min) were conducted in German and French in order to cover the two languages most commonly spoken in Switzerland. The phone survey was carried out by a specialized institute (LINK Institut, Lamprecht & Stamm, Zürich) in May 2006.

The University of Zürich, University Human Subjects Ethics Committee, granted ethical approval for this study.

Calculation of exposure time and statistical analysis

Exposure time in match and training was calculated based on the information provided in the survey (number of matches in the last 12 months, average training hours per week during the pre-season and during the season). Match exposure during the last 12 months was calculated as the total sum of matches officiated by all referees in the last year times 1.5 h (the minimum duration of a match).

Statistical analyses were carried out using SPSS (version 11; SPSS Institute, Chicago, Illinois, USA). The statistical methods applied were frequencies, means, and cross-tabulations. Results are reported as the mean and standard deviation (SD) and/or range, unless otherwise noted. For incidence rates, 95% confidence intervals (CI) were calculated as the incidence ± 1.96 times the incidence divided by the square root of the number of injuries.

Results

Characteristics of referees

The 489 referees (481 men, eight women) had a mean age of 36.6 years (range 15–73, SD 14.9 years). Their mean height was 177.1 cm (range 150–201, SD 7.2), body weight, 78.2 kg (range 43–120, SD 11.6), and body mass index (BMI), 24.9 kg/m^2 (range 13.0–37.2, SD 3.4).

The referees had received their official license from the SFA on average 12 years (range 1–20, SD 8.1) ago, but approximately 40% ($n = 197$) of the referees had received it within the last 5 years. Thirteen (2.6%) referees officiated matches in the (semi-) professional league; for 123 (25.2%) referees, their highest level was upper amateurs, and for 215 (44.0%), lower amateurs. One hundred and thirty-eight (28.2%) referees officiated in the junior league. The referees had officiated on average 24.4 matches per year (range 1–90, SD 13.8) during their career, and 21.8 matches during the last 12 months (range 0–96, SD 14.4). They trained on average 4.8 h a week (range 0–20, SD 11.1), with no difference between in-season training and before/after season training. About 10% of the referees stated that they performed no specific training at all. About one-third ($n = 141$, 30.9%) of the referees played football in an amateur club at the time of the survey. While only 6.8% of the referees ($n = 33$) had never played football, 90.2% ($n = 435$) had played at an amateur level and 2.9% ($n = 14$) in semi-professional and professional leagues.

One in five referees ($n = 97$, 19.8%) reported general medical problems, mainly allergies (8.1%), high blood pressure (5.9%), and asthma (3.2%). Sixty-six referees (13.3%) stated that they regularly took medication because of their health problems. Every third referee ($n = 167$; 34.2%) had undergone surgery for a musculo-skeletal problem, 33 (6.8%) of them more than once. The most common locations for their surgical interventions were the knee (20%), the ankle (4.5%), and the Achilles tendon (2%).

Injuries during career

A total of 155 career injuries were reported, with more injuries during matches ($n = 114$; 73.5%) than during training (Table 1). The top five injured body parts were the ankle, thigh, lower leg, knee, and Achilles tendon (Table 1). Muscle lesions mostly occurred in the thigh and lower leg. Ligament lesions were prevalent at the ankle and knee joints. Meniscal and chondral lesions were documented for the knee joint. Tendon problems (i.e. acute tendonitis) occurred almost exclusively in the Achilles tendon. Thigh muscle strain (26.3%) was the most common match injury, followed by ankle sprain (14.9%) and calf strain (14.0%). Ankle sprain was the most frequent training injury (11.4%).

In the majority of injuries ($n = 91$, 79.8%), the injured referee was able to finish the match. In almost a quarter of the match injuries ($n = 24$, 23.5%), the match was interrupted, and in most of these cases ($n = 23$; 20.2%), the referee could not finish the match and had to be substituted by the fourth

Table 1. Diagnosis of career injuries, given separately for match and training

Localization and type	Number of injuries		
	Total	Match	Training
Head/neck	1		
Concussion	1	1	
Trunk	5		
Strain	1	1	1
Contusion	1	1	
Other	3	2	
Upper extremity	1		
Strain	1	1	
Hip/groin	3		
Strain	3	2	1
Thigh	39		
Strain	37	30	7
Other	2	2	
Knee	22		
Lesion of the meniscus	10	4	6
Sprain	9	5	4
Other	3	3	
Lower leg	24		
Strain	19	16	3
Other	5	5	
Achilles tendon	13		
Acute tendonitis	9	7	2
Lesion of the tendon	2	2	
Other	2	2	
Ankle	41		
Sprain	31	18	13
Fracture	2	1	1
Other	8	6	2
Foot/toe	6		
Contusion	4	3	1
Other	2	2	
Total	155	114	41

official. In 96 (61.9%) cases of injury, the referee sought a medical examination, and in 53 (34.2%) cases, sick-leave was granted.

The vast majority of injured referees were not able to officiate ($n = 141$; 91%) or train ($n = 137$; 88.4%) the day after the reported injury. Absence from matches was up to 1 week in 23 (14.8%) cases, from 8 to 14 days in 38 (24.5%) cases, from 15 to 30 days in 35 (22.6%) cases, from 31 to 60 days in 17 (11%) cases, from 61 to 120 days in 12 (7.7%) cases, and >4 months in 12 (7.7%) cases.

A total of 110 referees (22.5%) reported having suffered at least one refereeing-related injury during their career. The majority ($n = 75$; 68.2%) of them reported a single injury, while 35 (31.8%) referees had incurred two or more injuries. The proportion of referees reporting injuries during their career increased with age up to 50 years, after which it remained relatively stable (Fig. 1).

Musculo-skeletal complaints during career

A total of 158 musculo-skeletal complaints during the career were reported by 126 referees (25.8%). The

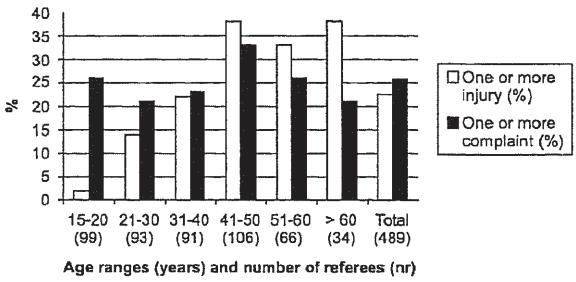

Fig. 1. Percentage of Swiss football referees by age group, reporting at least one career injury and at least one musculo-skeletal complaint.

percentage of referees reporting complaints ranged between 21% and 33% in the different age groups, with no specific trend (Fig. 1). The most frequent localizations were the knee ($n = 35$; 22.2%), low back ($n = 34$; 21.5%), Achilles tendon ($n = 18$; 11.4%), and groin ($n = 12$; 7.6%). All other body locations accounted for <7% of all complaints, i.e. they were declared by <1% of the referees.

The intensity of the complaint was rated as "very severe" in 21 cases (13.3%), "severe" in 37 cases (23.4%), "moderate" in 67 cases (42.4%), and "minor" in 33 (20.9%) cases. In seven cases (4.8%), the referee was not able to finish the match because of the severity of the physical symptoms. In 64 cases (40.5%), the referee visited a physician for the complaint.

The majority of complaints ($n = 115$, 71.9%) did not impede the referees from (potentially) officiating a match the next day, but 40.6% of the complaints ($n = 64$) affected the ability to train. Absence from training was between 1 and 3 days in 13 cases (8.2%), between 4 and 7 days in 14 cases (8.9%), between 8 and 21 days in 25 cases (15.8%), between 22 and 56 days in seven cases (4.4%), and for >8 weeks in three cases (1.9%).

Relationship between injuries and musculo-skeletal complaints

Thirty referees (6.1%) reported having suffered both injuries and complaints related to refereeing during their career. In only one case was the body part that was injured the same as that for which the complaints were reported (thigh/hamstring); in four other cases, an association between injury and complaint could have been suspected (foot and Achilles Tendon (two cases), knee and quadriceps (one case), thigh and knee (one case), respectively). In all other cases, the referees reported only injuries ($n = 80$) or complaints ($n = 96$), or neither of them ($n = 308$).

Table 2. Characteristics of referees, exposure, injuries, and complaints in the last 12 months with respect to the officiating level

	Junior ($n = 138$)	Low-level amateur ($n = 215$)	High-level amateur ($n = 123$)	Semi-Professional and professional ($n = 13$)	Total ($n = 489$)
Age (mean ± SD)	25.7 ± 12.6	40.7 ± 13.8	41.2 ± 12.9	51.1 ± 10.1	36.6 ± 14.9
Years of license (mean ± SD)	5.9 ± 5	13.2 ± 7.7	16.1 ± 7.9	23 ± 4.6	12 ± 8.1
Average number of matches (mean ± SD)	16.2 ± 11.6	24.1 ± 14.1	24.8 ± 16.9	18.5 ± 11.3	21.8 ± 14.4
Average number of training hours (mean ± SD)	6.1 ± 14.7	4.8 ± 13.2	4.7 ± 4.2	4.7 ± 2.8	4.8 ± 11.1
Number of match injuries (n)	2	20	9	2	33
Training injuries (n)	1	7	3	0	11
Incidence of match injuries (injuries per 1000 match hours, and 95% CI)	0.59 (95% CI: 0.23 to 1.33)	2.57 (95% CI: 1.44 to 3.7)	1.97 (95% CI: 0.67 to 3.27)	5.54 (95% CI: 2.16 to 13.24)	2.06 (95% CI: 1.36 to 2.76)
Incidence of training injuries (injuries per 1000 training hours, and 95% CI)	0.02 (95% CI: 0.02 to 0.06)	0.11 (95% CI: 0.03 to 0.19)	0.11 (95% CI: 0.01 to 0.23)	0	0.09 (95% CI: 0.04 to 0.23)
Number of referees with complaints related to match (n [%])	15 (10.9)	26 (12.1)	18 (14.6)	1 (7.7)	60 (12.3)
Number of referees with complaints related to training (n [%])	1 (0.7)	2 (0.9)	1 (0.8)	2 (15.4)	6 (1.2)

CI, confidence interval.

Injuries and musculo-skeletal complaints in the preceding year

The exposure times, as well the number and incidence of injuries in the last 12 months are presented in Table 2. A higher incidence of match injuries was observed in referees officiating the matches of adult players than in those refereeing junior league matches. However, referees officiating junior matches were significantly younger than referees of adult leagues. Compared with the incidence of match injuries, the incidence of training injuries was low in all categories (Table 2). Sixty (12.3%) referees reported musculo-skeletal complaints in connection with officiating, but only six (1.2%) in association with training.

Five injuries were incurred during the last match by five referees (two low-level amateur, two high-level amateur, one junior level), yielding an injury incidence rate of 6.82 injuries per 1000 match hours (95% CI: 0.85–12.79). One referee was not able to finish the match and had to be substituted because of the severity of his calf strain. Musculo-skeletal complaints related to the last match were reported by 7.8% of all referees ($n = 38$), and two of them (0.4% of all referees) were not able to finish the last match because of the severity of their Achilles tendon symptoms.

Discussion

This study is a retrospective phone survey of the injuries and musculo-skeletal complaints of a representative sample of 489 football referees officiating in all Swiss leagues. The study followed the methodology of previous studies (Bizzini et al., 2008a, b, 2009); the limitations of the retrospective design, especially the associated recall bias for career data, have been discussed in these publications. The referees included in the present study were similar in age, height, weight, years of experience, and weekly training hours to the 91 referees involved in an international youth football 5-day tournament (Fauno et al., 1993). They also had a similar average age to the 71 referees of the two top divisions of the Swiss Football League, but a slightly higher BMI and on average a shorter experience in refereeing compared with that group (Bizzini et al., 2009). They were, however, on average younger and less experienced than referees pre-selected for FIFA World Cups™ (Bizzini et al., 2008a, b).

The reporting of medical problems (such as asthma) and the use of medication in the representative group of Swiss referees showed almost the same prevalence (20% and 10%, respectively) as in Swiss elite referees (Bizzini et al., 2009) and FIFA World Cup™ pre-selected referees (Bizzini et al., 2008a, b). Knee surgery was the most frequently reported surgical intervention, similar to the findings for the Swiss elite group, but the incidence was higher than in the FIFA pre-selected referees (Bizzini et al., 2008a, b, 2009). The fact that >30% of the amateur referees were also playing club football may have accounted for the larger number of reported knee injuries.

In the present study, a quarter of the referees reported having suffered one or more refereeing-related injuries during their career. This is approxi-

mately half as many as those at the elite level (Swiss elite: 44%, selection for the 2006 FIFA World Cup™: 40%; selection for the FIFA Women's World Cup™ 2007: 50%) (Bizzini et al., 2008a, b, 2009). In the representative sample of the present study, fewer training injuries (21%) than match injuries (79%) were reported, which contrasts with the situation for the elite referees (Swiss elite: 62% training injuries; FIFA selection: 82% training injuries). This may be explained by the greater number of hours spent in training by the elite referees compared with the amateur referees of the present study.

The incidence of match injuries in the preceding 12 months reported by the referees in the present study (2.06 per 1000 match hours; 95% CI: 1.36–2.76) was similar to that previously reported for Swiss elite referees (3.45 per 1000 match hours; 95% CI: 1.20–5.7) and the pre-selected referees for the FIFA Women's World Cup™ 2007 (2.8 per 1000 match hours; 95% CI: 1.3–4.3) (Bizzini et al., 2008a, b, 2009). In the present study, the referees involved at the junior level showed a lower incidence of match injury than the other referee groups. However, because this group was significantly younger than the other groups, it is not possible to ascertain whether this is an effect of league or age. Previous studies have shown that increasing age is associated with a higher incidence of match injuries in football players (Arnason et al., 2004). Interestingly, the incidence of match injuries in the small group of referees officiating at a semi-professional or a professional level was similar to that reported for Swiss elite referees (Bizzini et al., 2009) and for a group of international referees (Fauno et al., 1993). The incidence of injury in the last match (6.8 per 1000 match hours; 95% CI: 0.85–12.75) was similar to that reported for the pre-selected referees for the FIFA Women's World Cup™ 2007 (8.2 per 1000 match hours; 95% CI: 2.6–13.9) (Bizzini et al., 2008a) and the international youth football tournament (4.6 per 1000 match hours, 95% CI not provided) (Fauno et al., 1993). In contrast, the referees selected for the FIFA World Cup™ 2006 had a reported incidence of 0.7 match injuries per 1000 match hours (95% CI: 0.1–1.3) in the last 12 months, and no injury in the last match (Bizzini et al., 2008b).

In the present study, the incidence of training injuries in the last 12 months was substantially lower than that in all previous studies (Swiss elite referees: 0.42 per 1000 training hours; 95% CI: 0.13–0.71, selection for the FIFA World Cup™ 2006: 0.41 per 1000 training hours; 95% CI: 0.21–0.61, selection for the FIFA Women's World Cup™ 2007: 0.63 per 1000 training hours; 95% CI: 0.22–0.64) (Bizzini et al., 2008a, b, 2009). This might be explained by the higher number of training hours (on average, over 6 h/week), combined with the higher intensity and quality of training in the Swiss elite referees and the selected referees for the two FIFA World Cups™. The most common types of injury (strains of the hamstring and calf, and sprains of the ankle and knee) were, however, the same in the present survey as in previous studies on elite referees (Bizzini et al., 2008a, b, 2009).

In this survey, about a quarter of the referees reported at least one musculo-skeletal complaint during their career. The prevalence of complaints was substantially lower than reported previously for groups of elite referees, where it ranged from 60% to 90% (Bizzini et al., 2008a, b, 2009). One possible explanation for this difference concerns the different methodological approaches used to register complaints. While in the previous studies on high-level referees a list of complaints was provided, in the present study, the referees were asked an open question and the responses were then categorized into the different locations. The difference might also be partly explained by the high demands of matches and training at the national and the international level (Castagna et al., 2007; MacMahon et al., 2007). The most prevalent localizations of musculo-skeletal complaints (knee, low back, Achilles tendon, and calf) were, however, similar in amateur and elite referees (Bizzini et al., 2008a, b, 2009). These findings confirm the specific musculo-skeletal complaints' profile of the football referee at all levels.

Perspectives

The incidence of match injuries is similar for referees officiating matches for adult players, regardless of the level of play. Referees of junior leagues are on average younger and have a lower injury rate. The rate of training injuries is substantially lower in amateur than professional referees. However, the career of a referee officiating at all levels may continue beyond the limit of 45 years of age (the limit set for the international career of elite referees), so that they experience longer exposure to matches and training. The implementation of prevention programs within the training routine may help all referees in minimizing musculo-skeletal problems over the years.

Key words: soccer, amateur level, referees, injuries, musculo-skeletal complaints.

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