

Medical report from the 2006 FIFA World Cup Germany

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Objective: To continue the injury surveillance of FIFA-sponsored football tournaments and report on other medical aspects of the 2006 FIFA World Cup.

Design: Prospective epidemiological injury surveillance and descriptive summary of additional medical aspects.

Setting: Major international football tournament.

Participants: National team players, doctors and referees at the 2006 FIFA World Cup Germany.

Main outcome measures: Injury type, location and rate.

Results: 145 injuries were reported for the 64 matches of the 2006 FIFA World Cup Germany—an overall injury rate of 68.7 per 1000 match hours (95% CI 57.5 to 79.9) or 2.3 injuries per match, in comparison with 2.7 injuries per match in the 2002 FIFA World Cup ($p=NS$). Physical examinations before participation uncovered no hidden cardiovascular problems. Once the tournament started, no referees were unable to complete their duties. There were no positive doping tests.

Conclusions: The injury rate for this World Cup was below that of 2002, but consistent with the overall injury rate per match since data collection began in 1998. There continues to be no evidence of systematic doping in international football.

The FIFA World Cup is the largest and most widely watched single sport competition in the world. The size of the viewing audience is staggering, with an estimated 40 billion viewers over the course of the full tournament and 1.5 billion people watching the final match. The outcome of the matches is a source of enormous national pride, and the skill and tactics on display influence play across all cultural, geographical, political and religious boundaries.

In the background of such a high-visibility contest is a well-organised group of medical professionals overseeing the health of not only the players but also the administrative staff, referees and others. The FIFA chief medical officer, his team, the FIFA Sports Medical Committee and the local organising committee (LOC) manage all medical activities before and during the FIFA World Cup. In close collaboration with the LOC chairman and staff, medical coverage at each competition and training venue is organised, with the LOC doctors serving as the liaison medical officers with the local medical facilities and hospitals.

The FIFA Medical Assessment and Research Centre (F-MARC) began the study of injuries during the final rounds of the 1998 FIFA World Cup in France. All subsequent competitions organised by FIFA as well as the football tournaments during the Olympic Games in Sydney and Athens have been monitored.^{1,2} Following the same assessment system during the 2004 Olympic Games, injuries in all 14 team sports competitions (men and women) were analysed to allow comparison between the different team sports using standardised methodology.³

An injury consensus group was established under the auspices of FIFA that, by using a nominal group consensus model approach, identified key topics related to definition of methodology and implementation.⁴ These topics included definitions of injury, recurrent injuries, severity, training and match exposure, as well as criteria for classifying injuries according to location, type, diagnosis and causes. Recommendations were made for the way in which the incidence of match and training injuries should be reported and the checklist of issues and information that should be included in published results of studies of football injuries.⁴ 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 competition as a "time loss" injury. The same system was applied for the assessment of injuries during the 2006 FIFA World Cup Germany.

At the 2006 FIFA World Cup Germany, in addition to the continuing injury assessment study, all on-pitch treatments during matches were recorded digitally and categorised. Furthermore, the pre-participation medical examination that focuses on unknown cardiac disease was required for all players and collected by the FIFA medical office for further investigation. The medical assessment and physical performance of referees was also investigated before the World Cup. Finally, doping controls were performed as a part of the long-term strategy of FIFA's approach to doping in football.⁵

This report summarises the medical activities and results at the 2006 FIFA World Cup Germany.

METHODS

Pre-participation assessment

Pre-competition physical examinations were required for all participants before the final round of the 2006 FIFA World Cup Germany. After the discussion and recommendation set out by the International Olympic Committee, in which FIFA representatives took an active part, the goal was to reduce the risk of player(s) participating in the competition with unknown or undiagnosed heart conditions such as congenital cardiomyopathy, which might become manifest and might, in the worst case, cause sudden cardiac death, as has happened on rare occasions.

The participating team physicians were informed in detail about the aims and objectives of the physical examination at the pre-World Cup workshop held 3 months before the kick-off

Abbreviations: F-MARC, FIFA Medical Assessment and Research Centre; LOC, local organising committee

Table 1 Descriptive characteristics of injury by tournament

Tournament	2002 World Cup Japan/Korea*	2006 World Cup Germany
No of matches	64	64
Response rate, % (n)	100 (128)	100 (128)
Match hours documented	2112	2112
No of injuries	171	145
Injuries per 1000 h	80.96	68.7
Injuries per game	2.7	2.3
Circumstances, % (n/total number)		
Non-contact injuries	27 (45/167)	27 (38)
Contact injuries	73 (122/167)	73 (104)
Contact injury caused by foul	51 (59/115)	61 (57/93)
Foul sanctioned by the referee	52 (28/54)	57 (32/56)
Time, % (n)		
First half	54 (88)	50 (66)
Second half	46 (72+3)	50 (64+2)
Estimated severity of injury, % (n)		
0 Days	33 (53)	30 (39)
1–3 Days	37 (59)	33 (43)
4–7 Days	17 (27)	15 (19)
>1 Week <1 month	11 (18)	18 (23)
>1 Month	2 (3)	5 (7)
Missing	(11)	(14)
Injuries with subsequent absence	107	97
Injuries per 1000 h	50.7	45.9
Injuries per game	1.7	1.5

*Data from Junge *et al.*¹

in Düsseldorf. The medical assessment included a full history and physical examination, with special emphasis on cardiac conditions. A resting electrocardiogram, stress test and blood tests were required for each player as well as an echocardiogram performed and interpreted by a consulting cardiologist. The FIFA medical officers guaranteed absolute confidentiality of the data. The results of all tests of players taking part in the 2006 FIFA World Cup Germany are currently being processed and analysed and will be reported at a later date.

RESULTS

Match injuries

The study of soccer injuries continues to be a fruitful source of inquiry in sports medicine. With such intense pressure on the players, it is not surprising that the highest injury rates in soccer occur during major tournaments. Match injury rates of between 12.8 per 1000 h (male adolescents⁶) and 35.5 per 1000 h (MLS professionals) have been reported⁷. The previous FIFA World Cup was held in 2002 in Korea/Japan, with an overall match injury rate of 51 time-loss injuries per 1000 h or 1.7 time loss injuries per match,^{1,2} demonstrating the more intense competition.

The methods for FIFA tournament injury surveillance have been reported previously in detail.^{1,2} A complete description of the project, definitions and duties of the team physician was discussed with all medical personnel at the pre-World Cup workshop held in Düsseldorf in March 2006. The team physician was required to submit a match summary report on a standard form that asks for the time of injury, location and type of injury, severity (a physician-based estimate of absence), whether the physician felt a foul occurred, whether the referee sanctioned the foul and whether there was treatment (on the field or after the match). Each summary form was faxed to a central office and the data collated.

RESULTS AND DISCUSSION

Reports were received from both team physicians for all 64 matches. A total of 145 injuries were reported, this corresponded to 68.7 injuries per 1000 match hours (95% CI 57.5 to 79.9) or 2.3 injuries per match. The overall rates, severity, location and diagnosis are within published reported ranges. During the 2002 FIFA World Cup Korea and Japan, 171 injuries were reported that

corresponded to 80.96 injuries per 1000 match hours (95% CI 70.7 to 93.1) with an injury incidence per match of 2.7 and an incidence per match of 2.3 for the 1998 FIFA World Cup.^{1,2} For the 18 men's tournaments since 1998, we have recorded an average of 2.7 injuries per match (Junge, 2006, personal communication). The lowest rate for men recorded using this methodology was 1.6 injuries per match for the FIFA Confederations Cup 2005 and the highest was 4.7 for the FIFA U20 World Youth Championships 2001.² Tables 1 and 2 show a comparison of selected data from the 2002 and 2006 FIFA World Cups. This comparison shows that there was a decrease in reported injuries from 2.7 per match to 2.3 per match.

The team physicians estimated that 30% of the injuries would lead to no time loss and a further 33% would lead to 1–3 days lost. The fraction of all injuries leading to 1 week or less time lost was 78%. The injury rate for just time-loss injuries was 45.9 per 1000 h or 1.5 injuries per match.

A total of 104 injuries (73%) were due to contact and 38 (27%) were non-contact (no direct contact with another player) in nature. Of the contact injuries, 61% were felt by the doctors to be due to foul play, but the referee sanctioned only 57% of those injuries. Injuries were equally distributed between the first and second half of play.

The most common locations of injury were, as expected, the lower leg (21%), the ankle (17%) and the thigh (14%). The most common diagnosis was a contusion (51%) followed by muscle strain (15%) and ligament sprain (14%).

DISCUSSION

As previously stated, there were marginally fewer injuries in the 2006 FIFA World Cup than in 2002. Although the greatest reduction in the number of injuries was to the thigh from 2002 to 2006 (table 2), the rates of overall injury to the thigh were not significantly different (2002: 14.2 per 1000 match hours, 95% CI 9.12 to 19.3; 2006: 9.94 per 1000 match hours, 95% CI 5.67 to 14.2). There are several possible reasons for this. First of all, in the 2006 FIFA World Cup the national teams had a longer period for preparation, whereas at the 2002 FIFA World Cup the national teams left almost immediately after the end of the domestic season within their own countries.

Another possible explanation is the stringent application of the laws of the game by the referees, particularly in the case of head injuries. Fuller's study on the influence of tackle parameters on the propensity for injuries in international football concluded that the laws of football relating to tackling should be reviewed to provide greater protection from injury by reducing the overall level of risk and, in particular, by protecting players from tackles with the highest propensity to cause injury.⁸ The vertical jump with use of the arm to tackle the opposing player was identified as causing severe injuries to the head.⁹ Based on F-MARC data, the International Football Association Board gave referees the authority to severely sanction what were felt to be injurious fouls such as intentional elbows to the head.

There were fewer head injuries reported in the 2006 FIFA World Cup than in the 2002 tournament (table 2). Thirteen head injuries were registered at the 2006 FIFA World Cup (6.15 per 1000 player hours; 95% CI 2.86 to 9.49) compared with 25 in 2002 (11.83 per 1000 player hours; 95% CI 7.19 to 16.46). Only one concussion occurred in 2006, whereas four were recorded in 2002, but concussions are among the most under-reported of all injuries. Although the overall head injury rates were not statistically different, the practical difference was important. This decrease was felt to support the importance of scientific evidence as a convincing factor for the guardians of the laws of the game, the interpretation by referees, and finally, the importance of interdisciplinary collaboration between the different professions to reduce the incidence of injuries. A study of

Table 2 Frequency of injury by location and type for the World Cup 2002 and 2006

Location and diagnosis	World Cup 2002*		World Cup 2006	
	No of injuries		No of injuries	
	All	With absence	All	With absence
<i>Head</i>	25	5†	13	4
Concussion	4	1	1	1
Fracture of os nasalis	1	1	0	0
Contusion	11	1	7	2
Laceration	9	2†	5	1
<i>Upper extremity</i>	8	3†	12	5†
Fracture	1	1	1	1
Luxation/dislocation	0	0	2	1†
Muscle strain/rupture	1	1	0	0
Sprain	1	1	2	1
Contusion	4	0†	7	2†
Laceration	1	0	0	0
<i>Trunk</i>	6	6	15	11†
Muscle strain/rupture	1	1	2	2
Sprain	1	1	0	0
Tendonitis	1	1	0	0
Contusion	3	3	12	8†
Muscle pain	0	0	1	1
<i>Hip</i>	2	2	1	1
Strain	1	1	0	0
Contusion	1	1	1	1
<i>Groin</i>	9	8	6	4†
Muscle strain/rupture	8	8	3	1†
Tendonitis	1	0	0	0
Labial impingement	0	0	1	1
Contusion	0	0	1	1
Tightness	0	0	1	1
<i>Thigh</i>	30	26	21	16†
Muscle strain/rupture	18	18	10	10
Tendonitis	2	2	0	0
Contusion	10	6	9	4†
Cramps	0	0	2	2
<i>Knee</i>	22	15†	18§	17‡
Ligament rupture	1	1	1	1
Lesion of meniscus	1	1	2	2
Sprain	5	3†	7‡	7‡
Tendonitis	1	1	2	1
Rupture of tendon	0	0	1	1
Contusion	13	8	5	5
Deep wound	1	1	0	0
<i>Lower leg</i>	29	15†	30	19†
Muscle strain/rupture	5	5	4	3
Contusion	24	10	19	13
Tendonitis	0	0	1	0
Laceration	0	0	1	0†
Others	0	0	5	3
<i>Ankle</i>	25	19†	24‡	16††
Sprain	16	13†	16‡	12††
Contusion	8	6	8	4
Laceration	1	0	0	0
<i>Foot</i>	14	8†	6	5
Fracture	1	0†	0	0
Strain	1	1	0	0
Sprain	1	1	0	0
Contusion	9	6†	5	4
Laceration	1	0	0	0
Unclear (possible fracture)	1	0†	0	0
Others (blisters)	0	0	1	1
<i>Unclear</i>	1	0†	0	0
Contusion	1	0†	0	0

*Data from Junge *et al*¹; †information is missing for at least one injury; ‡one time-loss injury was a combination of a knee sprain and an ankle sprain.

future tournaments will offer valuable information on the significance of changing rates of head injury.

Some data show that injuries increase over the course of a match, and this is attributed to fatigue. In this tournament, injuries increased in the first half, but varied within the second half, not approaching the level seen in that final 15 minutes of the first half.

The on-pitch treatments recorded during play were compared against the written injury reports from the team physicians. Ideally, the team physician should have reported all on-pitch treatments recorded on video. However, when the videos were compared with the written reports, only about half of the injuries treated on the pitch were listed on the physician's report as an injury. There are several possible reasons for this discrepancy. Possibly, there was inconsistent application of definitions of injury by the individual team physicians, but this was probably a minor factor as all team doctors participated in the 2006 FIFA World Cup workshop held in Düsseldorf, March 2006, where details and specific injury definitions were stated and agreed upon. It is also possible that the team physician simply forget to record an injury. Finally, it is possible that some on-pitch treatments were for injuries that were fabricated for a variety of tactical reasons. Further study is needed to determine reasons for this discrepancy.

Care for the referee

A critical element of any match is the referee. The physical workload on the referee is extensive,¹⁰ approaching running volumes consistent with midfielders. This on its own is impressive, but is even more remarkable when one considers that the referee is consistently older than the players he must arbitrate. Yet, there were no instances where a referee became ill, injured or otherwise unable to continue with his duties. Nevertheless, the referee as an athlete is at risk for injury and a number of minor (ie, no match time-loss injuries, but maybe some reduced training time/intensity) complaints or injuries were reported. Among the referees, there were two contusions, two muscle strains, two joint sprains and two foot injuries (blister, fasciitis). Among the assistant referees there were five muscle strains and three joint sprains (Bizzini, 2006; personal communication). The referees did report a number of complaints (mostly overuse complaints that led to no time loss), including low back pain, Achilles' tendon injuries and the occasional lingering muscle injury. One referee arrived at pre-World Cup training with a meniscal injury that was exacerbated in training, prohibiting him from continuing preparations. All referees who completed training (as previously outlined by Weston *et al*¹¹) for the 2006 FIFA World Cup remained fit and healthy for the entire competition despite the few problems stated.

Doping controls

FIFA follows the standards of practice set out by the World Anti-Doping Agency. FIFA first instituted testing at the 1970 FIFA World Cup held in Mexico, and doping has not been a major problem in soccer in all the years since.

Urine samples for doping controls were collected from two randomly selected players from each team after each match. With four players per match and 64 matches, a total of 256 urine samples were tested following procedures outlined by the FIFA Doping Control Regulations 2006. Of the four urine samples collected at each game, one randomly chosen sample was also analysed for erythropoietin. In addition, each team underwent random, unannounced screening, adding 224 more controls during preparation for the finals. When all samples are summed (qualifying matches, training preparation, actual competition), a total of 480 samples were analysed.

Positive doping tests in FIFA competitions are extremely rare. In the period between 1994 and 2005, a total of only four samples tested positive; one for ephedrine and pseudoephedrine in 1994,

What is already known on this topic

- The injury rate for football is highest in major international competitions.
- Little is known about the health of the referee at these competitions,
- Little is known about trends in doping at major competitions.

What this study adds

- Further data on the rate and nature of injury at the 2006 FIFA World Cup Germany using an established injury reporting protocol are presented.
- There is no evidence of systematic doping.
- Referees were able to continue their duties with little consequence of injury.

one for cannabis and one for nandrolone during the FIFA World Youth Championship 2003, and one for ephedrine in Angola in the qualification matches for the 2006 FIFA World Cup. Together with the 480 new tests before and during the 2006 FIFA World Cup, a total of 3811 samples have been analysed, showing an overall incidence of 0.1% over the past 12 years. During the Olympics in Athens, there were 27 positive samples among individual sport Olympic athletes and none within the team sports. The FIFA approach to doping in football and the statistical analysis of positive samples has been reported elsewhere.⁵

Collaboration with the two accredited laboratories in Cologne and Kreischa was outstanding. Both laboratories ran additional shifts that allowed them to report all results within 24 h. With only a few days between matches, it is critical to have a fast result in case a player with a positive test has to be disqualified. The work by the laboratories was most efficient and deserves credit and recognition. It proved once more the importance of the laboratories as equal partners in the fight against doping.

Owing to the joint effort of the FIFA Sports Medical Committee, team physicians, players and laboratories, this was the third consecutive doping-free FIFA World Cup. These results support the strategy of the Sports Medical Committee, which is based on prevention and education. All footballers should take this as an example and resist the temptation to use forbidden substances or methods: There is no place for doping in football.

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COMMENTARY

This report from the FIFA medical committee is a superb overview of the athletic medical issues from World Cup 2006. In addition to the comprehensive and meticulous injury surveillance, the authors identify new methods that have had a major impact on the game and the sport. First, the organising medical committee, after the sudden death of a player in a previous tournament, took the bold step of mandating that all players undergo stress ECGs and echocardiograms. This commitment will one day prevent the untimely death of athletes. Second, multidisciplinary evaluation of head injuries has led to a consensus of concepts and to policy change. As a consequence, the rules of the game were changed by the FIFA executive committee once they identified that elbow to head contact was a major cause of concussions. Third, the continuous commitment to doping control has ensured that the World Cup and other tournaments are, and will be, drug free. This paper is an excellent exposé, highlighting these important issues in soccer.

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