Football incident analysis: a new video based method to describe injury mechanisms in professional football

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ORIGINAL ARTICLE

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Objectives: To develop and test a new video based method for match analysis that combines football specific and medical information to achieve a better understanding of the injury mechanisms and events leading up to high risk situations.

Methods: Football incident analysis (FIA) is a video based method describing incidents that may result in an injury using 19 variables and categories modified from match analysis. Videos from 35 of 76 (46%) official Norwegian under 21 matches played from 1994 to 1998 were analysed. Two football experts classified each incident on the basis of predetermined criteria, and their results were compared using interobserver and intraobserver reliability tests.

Results: κ correlation coefficients for interobserver and intraobserver agreement were very good for 63% and 95% and good for 37% and 5% of the variables respectively. Fifty two incidents were recorded (1.6 incidents per team per match or 94 per 1000 player hours), and 16 (31%) led to injuries (0.5 injuries per match or 29 injuries per 1000 player hours). FIA results showed that 28 incidents occurred while attacking in midfield zone 2 or the attacking zone, and 24 took place while defending in the defensive zone or midfield zone 1. Midfielders were exposed in 67% of the incidents, mainly in breakdown attacks or during long attacks by the opposing team. Of the 28 incidents during offence, only one was classified as having great potential to score a goal. Most incidents (70%) were the result of tackling duels both in the offensive and defensive playing phases. Of the 21 offensive incidents resulting from tackling duels, in 19 cases the exposed player was unaware of the tackling (passive duellist).

Conclusions: This study shows that football incident analysis is a potentially valuable tool for understanding the events leading up to injuries in football.

Football is the most popular spectator sport in the world. About 250 million licensed players in 204 countries are registered with the Fédération Internationale de Football Association (FIFA), and about 1% participate at the professional level.[1] Football is a complex contact sport that demands physical, physiological, technical, and tactical skills,[2 3] and the risk of injury is considerable. Although differences in study design and injury definitions make a direct comparison between studies difficult, the incidence of injuries among adult male players has been estimated to range between 10 and 35 per 1000 game hours.[4–6]

Although a considerable number of studies have described the incidence and injury pattern (injury type, localisation, and severity) in football,[4 5 7 8] much less is known about risk factors and injury mechanisms. The risk of injury seems to be influenced by age,[4 9–11] sex,[4 12 13] and level of play.[11 14] However, as a basis for injury prevention, more sport specific information is necessary to understand the causes of injury in football.

It is therefore surprising that only six studies on injury prevention in football have been published to date. Ekstrand *et al*[15] showed a significant reduction in the overall number of football injuries through a seven part prevention programme. In a study of female high school students, seven weeks of preseason conditioning significantly reduced the total number of injuries.[16] The risk of ankle injury has been reduced among male players with previous ankle injury by using ankle orthoses[17 18] or balance board training.[18] The rate of injuries to the anterior cruciate ligament was significantly decreased through a programme of balance board training,[19] whereas no significant effect was observed on the rate of injuries to the lower extremities in female players after the introduction of a programme with 10–15 minutes of daily balance board training.[20] However, although these studies show promising effects of various generic interventions, prevention programmes specific to the sport of football have not yet been developed.

In order to suggest preventive strategies specific to football, it is necessary to have detailed information on the injury mechanisms involved. It is difficult to determine injury mechanisms on the basis of information from injured players because of recall bias. As most elite football matches are televised, the use of video recordings instead of player interviews may improve our ability to more objectively identify and understand the injury mechanisms. However, describing the injury situations is a difficult task, because football is a complex game not easily described in quantitative terms, whether attempting to analyse the flow of the game, player to player interaction, or goal scoring opportunities. Nevertheless, video analysis may provide an opportunity to analyse and describe the events typically leading up to an injury situation in football specific terms. Hawkins and Fuller[21] analysed video recordings from 44 of 52 matches in the 1994 World Championships and 181 matches at three levels of professional football in England. They found that 15–29% of incidents resulted from foul play. However, their analysis was limited to studying the effect of foul play on injury risk, and they had limited access to medical information from the incidents described.

Match analysis has been widely used for some time among football coaches world wide,[22 23] and more refined computer assisted methods based on video recordings have been developed.[24 25] A better understanding of the injury mechanisms and the events leading up to high risk situations is essential in order to design prevention programmes. Thus, the aim of this study was to develop and test a new video based

Table 1 Variables and categories used in the football incident analysis

Variables and categories	κ Inter	κ Intra
Ball possession *Attack*: a team is in possession, i.e. with ball control and necessary space and time for decision possibilities with the ball *Defence*: the opposing team is in possession, i.e. with ball control and necessary space and time for decision possibilities with the ball	0.85	1.00
Attack type *Set plays*: attacks that start by a set play and finish while players are still in original grouping (free kick, throw in, corner kick, goal kick, penalty kick, kick off, and drop) *Breakdowns*: attacks that start by winning the ball in play and maintaining and/or increasing imbalance in opponent defence throughout the attack *Long attacks*: attacks that start by winning the ball in play or a set play and progress without taking advantage of opponent's imbalance *Long attacks, including long pass*: long attacks with at least one pass that covers a minimum of one third of the playing field, i.e. about 35 m or more (includes goal kicks and clearance)	0.67	0.88
Positioning, i.e. a player's position in relation to the immediate opponent *One on one situation*: one against one (face to face, back to face, different sideways positions) *Not one on one situation*: without involving an opponent player or when one against two or more players	0.80	0.83
Team action before injury risk incident, i.e. type of passing actions by the attacking team before injury risk incident *Long pass*: long pass forwards (35 m or more), long pass from goalkeeper, long clearance, long pass across the field *Short pass*: short pass forwards, short pass backwards, wall pass, short pass from goalkeeper *Flick*: flick using either foot or head *Cross*: a pass from side corridor into the score box *Deflection*: unintentional pass from fellow or opponent player	0.74	0.93
Localisation on the field, i.e. zones on the playing field (fig 1) *Defensive third*: the defending third of the playing field *Midfield zone 1*: the first half of the middle third of the playing field *Midfield zone 2*: the second half of the middle third of the playing field *Attacking third*: the attacking third of the playing field *Score box*: prolongation of the penalty area to half line between 16 m line and the nearest midfield zone	0.84	0.84
Attack effectiveness *Effective attack*: attack that ends up with shooting attempt and shot off target, shot on target, or goal *Non-effective attack*: attack that ends up with none of the above	0.88	1.00
Ball winning situations *At the moment of ball winning*: attempting to regain possession (1st defender) *After ball winning (up to 5 s)*: immediately after regaining possession (1st attacker) *After 2nd ball*: regaining ball after deflection from opponent player (1st attacker) *Not ball winning situations*: attempting to maintain possession (1st attacker) and incidents away from the ball	0.84	0.94
Degree of balance in opponents' defence *Good balance*: Both numerical (i.e. equal or greater number of opponents on the right side of the ball) and positional balance (i.e. pressing, covering and marking defending tasks) are achieved *Average balance*: either numerical or positional balance is achieved *Poor balance*: neither numerical nor positional balance are achieved	0.63	0.88
Player role *1st defender*: pressing defending player on the right side of the ball *Other defender*: all the remaining players of the defending team *1st attacker*: player with the ball on the attacking team *Other attacker*: all the remaining players of the attacking team	0.77	0.97
Player position, i.e. static positions of players on the field based on playing formations (*Goalkeeper, fullback, central defender, wing midfielder, inside midfielder, central midfielder, striker*)	1.00	1.00
Type of individual action with the ball *Dribbling* (including moving with the ball), *heading, receiving the ball, screening tackling, turning, flicking* (using foot or head), *passing, goalkeeper action, shooting, blocking, clearing, ball to body accident, unclear action and no action with the ball*	0.80	0.89
Degree of individual ball control *High level of control*: in control of the ball after receiving it *Low level of control*: not in control of the ball	0.83	0.87
Player's movement direction i.e. movement direction in relation to the opponent's goal (*forward, sideward, backward, no movement*)	0.78	0.90
Player's movement intensity *High intensity*: including sprinting and moderate intensity running *Low intensity*: including jogging, walking and standing	0.81	0.82

Table 1 Variables and categories used in the football incident analysis

Variables and categories	κ Inter	κ Intra
Duel type	0.85	0.88
In duel:		
- Heading duel-active (heading actively) and heading duel-passive (unaware of heading duel or attention towards other action with the ball)		
- Tackling duel-active (tackling actively) and tackling duel-passive (unaware of tackling duel or attention towards other action with the ball)		
- Screening duel-active (screening actively) and screening duel-passive (unaware of screening duel or attention towards other action with the ball)		
- Running duel and *other* (pushing, kicking, obstruction, stepping, collision)		
Not in duel: without involving opponent player(s)		
Attention	0.96	0.96
Attention towards primary duellist: player concentrates on immediate opponent		
Attention towards the ball: player concentrates on the ball;		
- On the ground (ball in contact with the playing surface)		
- In the air (ball at head height and upwards)		
- Ball between head height and playing surface		
Attention towards team mate		
- Near (in the vicinity of the ball)		
- Further away (not in the vicinity of the ball)		
Tackling type	0.79	0.88
Being tackled: involving a player that is being tackled by the opponent (from front, from side, from back)		
Not being tackled: involving attacking player that is not being tackled		
Tackling: involving a player that is tackling the opponent (from front, from side, from back)		
Not tackling: involving defending player that is not tackling		
Type of incident risk action	0.80	0.94
Against 1st attacker towards "back room": attempt to stop a player with the ball from penetrating a space behind the last defender (tackling, obstruction, holding)		
Against 1st attacker elsewhere		
Against 1st defender		
Action away from the ball		
Actions against other players (2nd and 3rd attackers and defenders)		
Referee's decision	0.78	0.78
Free kick for		
Free kick against		
Yellow card		
Red card		
No foul called		

Results from interobserver and intraobserver analysis are shown in the right hand columns.

method for match analysis combining football specific and medical information.

METHODS

Videotapes from 35 of 76 (46%) official Norwegian under 21 matches played in the period February 1994 to June 1998 were traced. Of the 35 matches, 17 were official qualification matches for the Olympic Games, European or World Championships, and 18 were friendly matches. Of the 35 videotapes, 30 covered the match in full, whereas five tapes randomly covered 50–80 minutes. The total duration of the video recordings was 3017 minutes.

The videotapes were reviewed by two experienced doctors (TEA and LE), one of them (TEA) being the team doctor of the Norwegian under 21 team. All situations in which the match was interrupted by the referee, or a Norwegian player was on the ground for more than 15 seconds, or the player appeared to be in pain or received medical treatment were noted as an injury risk incident. These incidents, including the playing events leading up to each incident, were transferred to a master videotape.

Football incident analysis (FIA)

Two football coaches with long experience in match analysis reviewed and classified each of the incidents on the master videotape based on predetermined criteria developed during pilot testing, and their results were compared using κ analysis to determine interobserver reliability.[26] One of them reanalysed the tapes three months later to determine intraobserver reliability.

The methodology for match analysis, which is used by soccer coaches to evaluate patterns of play and team and player performance,[24] was modified for this study. FIA is a video based method allowing incidents to be described using 19 variables, each with two or more categories (table 1). FIA describes each incident related to: (*a*) the injured player—for example, playing position, action with the ball, movement direction, and intensity; (*b*) the injured team—for example, the type of relational skill including all types of passes; (*c*) the opposing team—for example, degree of defensive team balance; (*d*) match—for example, match type, match time, playing phase; (*e*) attacking play—for example, attack type, attacking effectiveness; (*f*) defensive play—for example, duel type, tackling type, ball winning; (*g*) playing field—for example, localisation and positioning in one on one situations; (*h*) foul play—for example, foul type, referee's decision.

The playing field was divided into zones and corridors (fig 1). The classification of playing positions was based on a 1:4:5:1 or 1:4:3:3 formation, whichever appropriate for the game in question.

Injury records

Information on injuries was obtained by retrospective review of team medical records by the team doctor (TEA). All

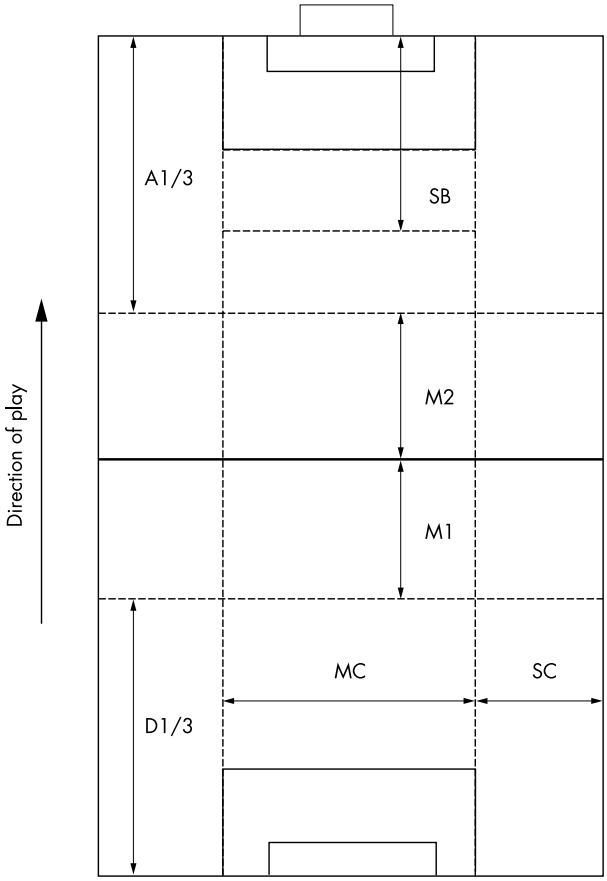

Figure 1 Zones of the playing field. The defensive zone is defined as the defending third of the field (D1/3), midfield 1 is the first half of the middle third (M1), and midfield 2 is the second half of the middle third (M2). The attacking zone is the attacking third (A1/3), and the score box is the zone between the prolongation of the short sides of the penalty area until the half way line between the 16 m line and the line dividing attacking and middle thirds (SB). The side corridor (SC) is one third of the width of the field on each side and the middle corridor is the middle third (MC).

traumatic injuries had been systematically recorded during training camps and matches since February 1994. Each incident identified on the videotapes was cross referenced with the medical records and classified as an injury if the player had been unable to participate in training or match play for at least one day after the incident. Injuries were classified as minor when the player could not practise soccer normally or play matches for one to seven days, moderate if absent for 8–21 days, and serious if absent for more than 21 days.[4] Injuries were classified as contusions, sprains, strains, fractures, or lacerations.

Statistical analysis

κ correlation coefficients were calculated for interobserver and intraobserver agreement.[26] Coefficients of 0.81–1.00 are generally interpreted as very good, 0.61–0.80 as good, 0.41–0.60 as moderate, 0.21–0.40 as fair, and less than 0.20 as poor.[26]

RESULTS

Incidents and injuries

During the 35 matches available for video analysis, 52 incidents were recorded for the Norwegian team—that is, 1.6 incidents per team per match or 94 incidents per 1000 player hours. Of the 52 incidents, 16 (31%) led to traumatic injuries—that is, 0.5 injuries per match or 29 injuries per 1000 player hours. Injuries and incidents were distributed evenly throughout the six 15 minute periods of the game (χ^2, p = 0.50).

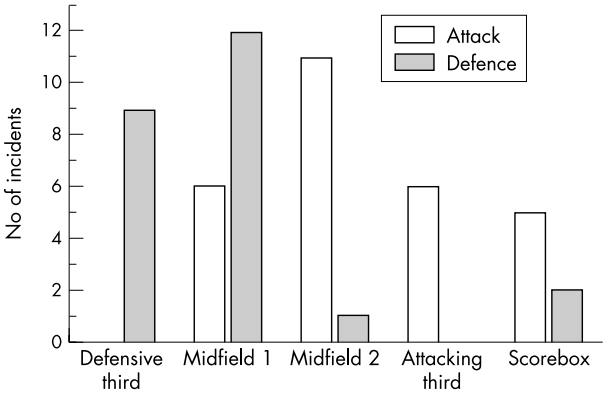

Figure 2 Number of incidents in the different zones of the field during the attacking or defending playing phases (n = 52).

Of the 16 injuries, seven were classified as serious, three as moderate, and six as minor. Most of the injuries affected the lower extremities: four ankle, three foot, three knee, one lower leg, and one thigh injury. In addition, there were three head and one wrist injury. Five of the 16 injuries were sprains, four contusions, four fractures, and three lacerations.

FIA results

The κ analysis showed that reliability was high and within acceptable limits for all the variables used. The inter-rater agreement was good (0.61–0.80) for 10 variables and very good (>0.81) for nine variables. The intrarater agreement was very good for 18 variables and good for one variable.

Of the 52 incidents recorded, 28 occurred when the team was in the attacking phase (eight injuries) and 24 in the defending phase (eight injuries). Most of the incidents during defence occurred in the defensive zone or midfield zone 1, whereas most of the incidents during offence took place in midfield zone 2 and the attacking zone (fig 2). Midfielders—that is, central midfielder, inside left/right midfielder, and wing midfielder—were exposed in 67% of the incidents. Most of the midfielder incidents occurred in breakdown attacks or during long attacks by the opponent (table 2).

Most of the offensive incidents occurred during breakdown attacks (table 2). Of the 17 incidents that occurred during breakdown attacks, only one took place within the first five seconds after gaining possession of the ball, and in nine cases the player involved had complete ball control. Of the 28 offensive incidents, only one was classified as an attack that ended up with a shooting attempt, a shooting attempt on goal, or a goal, whereas 27 attacks were classified as not effective—that is, with little potential to score a goal (fig 3). In 17 cases a short pass was the last team event before an offensive incident, whereas there were only five incidents after long forward passes. In 19 offensive incidents, the opponent was in good defensive balance at the time of the incident, whereas the opponent team balance was average in eight cases and poor in one (fig 4). The intensity of play was high in 21 of the offensive incidents.

Most defensive incidents occurred during long attacks by the opponent (table 2). Of the 17 incidents that occurred during opponent long attacks, 16 took place at the ball winning moment or within five seconds of the player winning possession of the ball. Of the 24 defensive incidents, two were classified as attacks with shooting attempts, three as attacks with shooting attempts at goal, and 16 as attacks without potential for scoring a goal (fig 3). In 17 cases a short pass was the last opponent team event before an incident, and there were three incidents after a long forward pass (fig 4).

Table 2 Number of incidents during the attacking and defending playing phases for goalkeeper, defenders (i.e. full backs and central defenders), midfielders (i.e. central, inside left/right, and wing midfielders), and striker during different attacking types (i.e. set plays, breakdown attacks, and long attacks) (n=52)

	Goalkeeper	Defenders	Midfielders	Striker	All players
When attacking					
Set play	0	0	4 (2)	0	4 (2)
Breakdown	0	1 (0)	14 (7)	2 (1)	17 (8)
Long attack	0	1 (0)	5 (1)	1 (1)	7 (2)
When defending					
Set play	0	1 (0)	2 (0)	1 (0)	4 (0)
Breakdown	0	2 (0)	1 (0)	0	3 (0)
Long attack	2 (1)	6 (0)	9 (3)	0	17 (4)
Total	2 (1)	11 (0)	35 (13)	4 (2)	52 (16)

The distributions of injuries are shown in parentheses (n=16).

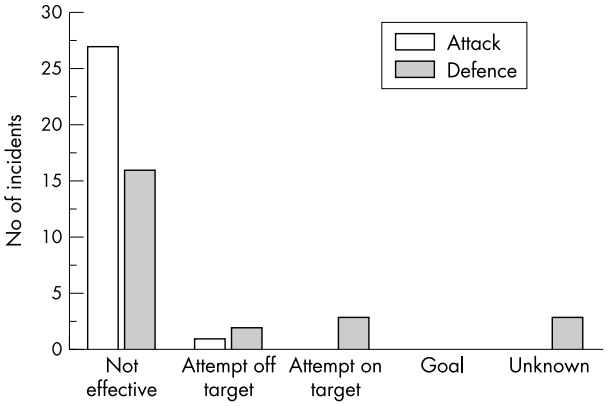

Figure 3 Number of incidents classified according to attack effectiveness—that is, whether the attack was not effective or had potential, that is, an attempt off target, attempt on target, or a goal was scored (n = 52).

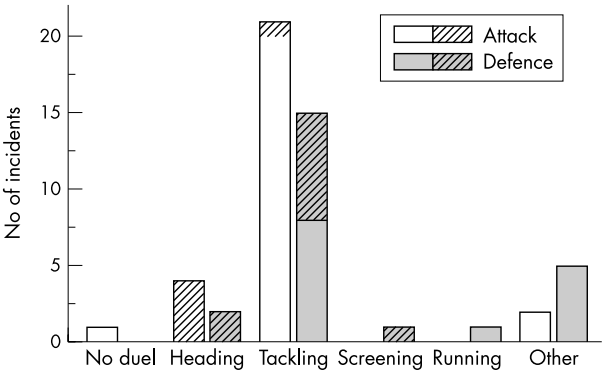

Figure 5 Number of incidents occurring in duels—that is, heading, running, tackling, screening, or other duels (table 1[1])—while in the attacking or defending playing phases. Passive duels are shown as hatched bars (n = 52).

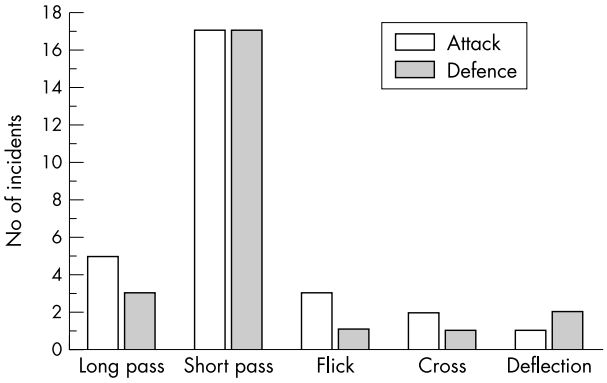

Figure 4 Number of incidents classified according to the final team event by the attacking team before the incident—that is, whether this was a long pass, short pass, flick, cross pass, or a deflection (n = 52).

Most incidents (70%) were the result of tackling duels (fig 5). Of the 21 offensive incidents resulting from tackling duels, in 19 cases the exposed player was unaware of the opposing player or engaged in another activity (passive duellist). In eight incidents the exposed player was tackled from the front, in seven from the side, and in four incidents from the rear. Of the 15 defensive incidents resulting from tackling duels, the exposed player was the active duellist in seven cases and the passive in eight cases. Of the seven active tackling duels, the exposed player was tackling from the front in five cases and from the side in two cases.

In 27 (52%) of the incidents, no free kick was awarded by the referee, 14 led to a free kick for the exposed player, and one led to a free kick against. Eight incidents resulted in a yellow card, whereas no red card was shown. In two incidents the decision of the referee was not known.

DISCUSSION

The main outcome of this study was that FIA has been developed as a reliable tool to analyse and describe video recordings of incidents and injuries in football specific terms. Although soccer is a complex game in which it is difficult to classify the various playing actions and player interactions, the inter-observer and intraobserver reproducibility for most variables developed during pilot testing of FIA was high (table 1).

It should be noted that this study has some limitations, which must be taken into account when interpreting the results. It is a retrospective study, and the number of games and thus incidents and injuries are few. Therefore we have not presented data breakdowns for all variables and categories, because there would be very few cases in each category. Also, all the incidents included were taken from one team, the Norwegian under 21 team. The patterns observed may be a reflection of the playing style of this particular team. Care should be taken not to extrapolate these results to international under 21 football in general or other levels of play. In fact, one of the characteristics of the playing style of the Norwegian team is

the focus on intensive and well balanced defensive play, combined with quick breakdown attacks whenever they gain possession of the ball. It is therefore not surprising that the incidents follow the same pattern. However, the main objective of this study was to develop FIA as a descriptive tool, and further studies are necessary with larger samples of incidents involving many teams, at both the international and national level.

Keeping these limitations in mind, the analysis of the 52 incidents included showed that they were evenly distributed between the attacking and defensive phases of the game. Most of the offensive incidents occurred during breakdown attacks—that is, attacks that start by winning the ball from the opponent and where the opponent defence is out of balance—usually in the midfield zones. Most of the defensive incidents occurred during long attacks in the defensive zone or midfield 1. Midfielders accounted for nearly 70% of the incidents, and 70% were the result of tackling duels—most with high intensity, where the exposed player was unaware of the opponent player tackling him. Few of the incidents were classified as attacks with goal scoring opportunities. In other words, although the study is small, these results challenge some of the myths surrounding the mechanisms of acute football injuries—for instance, that all player positions are at equal risk of injury and that incidents mainly occur as professional fouls in or near the score box to prevent a scoring opportunity or goal. Most authors have stated that the player position does not seem to influence the injury rate,[5] and in two other studies strikers[27] and defenders[21] have been seen to be most prone to injury. The present results suggest that most incidents result from the "war of the midfield area", where the aim is either to win the ball when the opponent is on the attack and unbalanced defensively, or to stop the opponent having won the ball from exploiting his tactical advantage.

The validity of using the definition of incident as we have—that is, match stopped because a player appeared to be injured or received medical attention—as the unit of analysis can also be questioned. It may be that in some cases players were simply simulating an injury to gain some tactical advantage. However, the fact that as many as one in three incidents resulted in a time loss injury suggests that the situations selected were associated with an appreciable risk of injury. This does not mean that our definition of incident gives a description of all situations taking place during a game with susceptibility of an injury. This is probably not the case. We have analysed several of the games, and found that there are 120–150 situations in each game where there is player to player contact. In addition, we know that some injuries occur without contact between players. However, it should be noted that we could not find any case of a contact injury in the medical records that was not identified through the video analysis. The quality of the TV production—for example, the number of cameras and camera angles used—is obviously also a factor that could prevent us from discovering all injuries or from providing a precise analysis of the events.

Few other studies have looked at injuries among international and professional football players, but the incidence, localisation, and type of injury found in our study correspond to findings in earlier studies.[21 27–30] The incidence of time loss injuries was high—nearly 30 injuries per 1000 player hours—compared with elite national levels in some studies,[4 5 31] but corresponds well with other studies of professional and elite players.[5 29 30] However, the definition of injury and interpretation of absence varies between studies and makes it difficult to compare results.[4 5 32] In agreement with numerous studies,[4 5 33] lower leg injuries such as ankle and knee sprains were the most common, but it appears that the ratio of more serious and moderate injuries to minor injuries may be higher than in lower divisions or adolescent football.[4 5]

It is essential to understand the causes of sports injuries before potentially effective preventive measures can be suggested. It is important to realise that causation in most cases is multifactorial: injuries are often the result of a combination of internal risk factors (player characteristics), external risk factors (such as environmental and equipment characteristics), and injury mechanisms.[6 34 35] Injury mechanisms have traditionally been described in purely biomechanical terms—that is, the kinematics and kinetics of the injured limb at the time of injury. In our opinion, the description of injury mechanisms must include an analysis of the events leading up to the injury situation to be comprehensive. FIA has been developed with this in mind—to assess complex interactions leading to situations with a high risk of injury. One finding that should be explored further in the context of injury prevention is that, in most of the tackling incidents, the player seemed not to be fully aware of the situation, but had his attention directed to another player, the field of play, or the ball. If this is shown to be the case in future larger scale studies, it may be possible to specifically train players to be more aware of the playing situation around them to avoid "surprise" tackles.

We do not propose that FIA should be used routinely to analyse all the games of a particular football club or national team, but that it should primarily be used as a research tool. However, FIA has been developed from an established method for match analysis. Coaches routinely use this method to analyse team and individual performance in games. In addition, a computerised system is available, the Mastercoach system, which merges digital video with statistical information on each incident. The advantage of the computerised system is that it speeds up the analysis—a trained observer needs only 90 minutes to analyse the performance of one team in one match. Another advantage is that the coach can use the system to train players to perform better in tactical video sessions. When larger databases of injuries and high risk incidents have been established, the system could also be adapted to enable coaches to train players to become aware of the characteristics of potential injury situations, such as specific tackling or heading situations. We are currently evaluating the effect of this approach to injury prevention in a cohort of football players.

The role of the referees and their interpretation of the rules during a match can also be assessed more effectively with FIA. Hawkins and Fuller[21 29] have shown that about one in four injuries result from foul play in professional football, a result that compares well with the present results. However, whether the rule interpretation of the referees was adequate in situations classified as non-fouls has not been examined.

Video analysis can also be a powerful tool in the analysis of the mechanics of specific injury types such as ankle, knee, and head injuries. The little information that we have at present on the mechanisms of these injury types is mainly from player interviews, a method limited by recall bias. Systematic collection of videotapes for biomechanical analysis of ankle, knee, and head injuries could result in a more precise understanding of the causes of injuries in football. Video analysis has been used by McIntosh *et al*[36] to describe the dynamics of concussive head impacts in rugby and Australian rules football.

Conclusion

This study shows that video analysis of incidents is a potentially valuable tool for understanding the events leading up to injuries in football.

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Take home message

It is difficult to describe and classify the various playing actions and player interactions in football. Therefore little is known about the playing situations leading up to injuries. Football incident analysis has been developed to describe incidents with a high risk of injury, and appears to be a valuable instrument that can help us to understand the mechanism of football injuries.

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