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Lower incidence of arm-to-head contact incidents with stricter interpretation of the Laws of the Game in Norwegian male professional football

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Abstract

Background: Video analyses reveal that the rate of incidents with a propensity for injury caused by opponent-to-player contact has increased by about 50% from 2000 to 2010 in Norwegian male professional football. The aim of the study was to assess whether a stricter interpretation of the Laws of the Game (red cards for high elbows in heading duels and for late/two foot tackles) could reduce the potential for injuries in Norwegian male professional football.

Methods: A pre-/post-intervention design was employed, where the rate of incidents and injuries from the 2010 season (pre) was compared to the 2011 season (post). An incident was recorded if the match was interrupted by the referee, and the player lay down for more than 15 seconds, and appeared to be in pain or received medical treatment. Time-loss injuries were recorded by the medical staff of each club.

Results: A total of 1421 contact incidents were identified, corresponding to a rate of 92.7 (95%CI: 86.0 to 99.4) in the 2010 season and 86.6 (95%CI: 80.3 to 99.4) in the 2011 season, with no difference between the two seasons. We found a reduction in the incidence of total head incidents (rate ratio (RR): 0.81, 95%CI: 0.67 to 0.99), and head-incidents caused by arm-to-head contact (RR: 0.72, 95%CI: 0.54 to 0.97). We found no difference in tackling characteristics or contact injury rate.

Conclusion: We found no significant differences in the overall rate of incidents after the introduction of stricter rule enforcement. However, the rate of head and arm-to head incidents was lower in the 2011 season.

What this study adds to existing knowledge: Implementation of stricter rule enforcement was associated with a lower incidence of head-incidents caused by arm-to-head contact.

How might it impact on clinical practice in the near future: Increased focus on the effect of rule changes and regulations on injury risk. It might also lead to implementation of stricter rule enforcement in other leagues and tournaments, in order to reduce the number of situations with a high injury potential.

INTRODUCTION

The risk of injury during football matches is 1000 times higher than high-risk industrial occupations,[1] with a time-loss injury incidence in male professional football between 20.3 and 34.8 injuries per 1000 player-match hours.[2-7] A recent study from Norwegian professional football documented an increased incidence of acute match injuries from 2002 to 2007.[8]

Medical staff injury registration has established that between 44% and 59% of all acute match injuries at the club level are caused by player-to-player contact.[3, 7, 9, 10] Previous studies utilizing video analysis to examine the mechanisms of injury in football have found that the most common causes of ankle injuries are tackles from the side, late tackles, two-footed tackles and tackles to the weight bearing limb.[11-13] Arm-to-head contact is the most common cause of head injuries in male professional football.[14] Furthermore, recent video analyses revealed a 50% increase in the rate of incidents due to opponent-to-player contact from 2000 to 2010 in Norwegian male professional football.[15]

Video analyses of incidents leading to injuries in Fédération Internationale de Football Association (FIFA) tournaments showed that the match referee identified 47% of all injuries, and 40% of head injuries as foul play.[16] A study in Norwegian professional football concluded that most referee decisions were correct according to the Laws of the Game, but that there might be a need for more strict interpretation of the Laws of the Game in order to protect players from dangerous play.[17] The need for a reduction of foul play to reduce injury rates in football has therefore been emphasized.[17, 18] As a consequence, The International Football Association Board gave referees the authority to severely sanction fouls that were recognized to be injurious, such as intentional elbows to the head.[19] After this, the incidence of match injuries was significantly lower in the 2010 FIFA World Cup for men compared to the mean incidence found in the three previous World Cups.[20] However, the effect of rule changes and their interpretation have neither been evaluated through prospective injury surveillance systems nor through video analysis, a key element missing in the current sport injury prevention research portfolio.[21]

Therefore, the aim of this study was to assess whether a stricter interpretation of the Laws of the Game could reduce the potential for injuries in Norwegian male professional football.

MATERIALS AND METHODS

Study design

This was a prospective study where we collected videotapes of league matches and injury information prospectively from the same matches prospectively during the 2010 and 2011 seasons to evaluate the effect of stricter rule enforcement by referees. We employed a pre-/post-intervention design, where the rate of incidents and injuries from the 2011 season (post) was compared to 2010 season data (pre).

Implementation of stricter rule enforcement

During the autumn of 2010 the Football Association of Norway (NFF) and the Norwegian Professional League Association (NTF) met with the project group from the Oslo Sports Trauma Research Center (OSTRC) and members of FIFA-Medical Assessment and Research Centre (F-MARC) to discuss the implementation of stricter rule enforcement in 2011 in the Norwegian male professional league (Tippeligaen).

Video recordings of incidents and injuries from the 2010 season were analyzed and refereeing guidelines were agreed upon according to FIFA regulations. This involved sanctioning of two-foot tackles as well as tackles with excessive force and intentional high elbow with an automatic red card. A total of 15 referees and 25 assistant referees were familiarized with the stricter rule enforcement in meetings at the end of the 2010 season and in a training camp in January 2011.

The plans for stricter rule enforcement were introduced to each of the teams in meetings with referees appointed for the 2011 season. During these one-hour meetings the stricter interpretation of the rules was introduced through video clips, lectures and discussions. After informing the players, the study group and the Head of Refereeing in the Football Association of Norway held a similar meeting for the media. We also organized a press conference which included a high-profile player, manager and FIFA representative a week prior to the start of the season to inform the public.

Video analysis

An “*incident*” was said to occur if the match was interrupted by the referee, the player stayed down for more than 15 seconds, and appeared to be in pain or received medical treatment. We did not include incidents caused by muscle cramps. Each incident was classified according to

predetermined criteria: the cause (opponent-player contact, teammate-player contact, ball-player contact or non-contact), body location involved. A duel was defined as a situation where two opponents challenged each other for ball possession; duels were classified as heading duel, tackling duel or other duel (screening or running). We also categorized the referee's decision (no foul, foul for, foul against) and the referees sanction (no sanction, yellow card, red card). In cases where the referee played "the advantage rule" the decision and sanction was classified depending on the activity of the downed player and the referees sanction. In addition, incidents affecting the head were classified by cause (head-to-head, arm-to-head, trunk-to-head, leg-to-head, in addition head-to-ground/ball/object were listed as head-to-other).

All tackling situations were analyzed using variables used for video analyses of injuries from three FIFA tournaments:[12] the direction of the tackle (tackling player approached from the front, side or behind the tackled player), action during tackle (one-footed tackle, two-footed tackle, use of arm/hand, upper body contact, clash of heads), tackling mode (tackling player staying on feet, sliding in or jumping vertically). In addition, the study group assessed whether the tackle was late (the tackle occurred after the ball had been passed by the tackled player),[13] and whether the tackling player made contact with the ball (prior to or after initial contact with the tackled player) or not. We also classified the tackling situations in two categories; if the tackled player also tackled, it was an active tackling duel. We defined a passive tackling duel as a situation where the tackled player had possession of the ball and he did not tackle.

In addition, we conducted a video analysis of all player-to-player contact situations between players from opposing teams in 32 matches, irrespective of the consequence of the contact. A contact situation was said to occur when there was body contact between two players from opposing teams. We included situations where the players were challenging for ball possession. To select which 16 games to analyze in the two seasons a random draw was made using 20 bowls with a ball for each team, continuing the draw until we had picked one home match and one away match for each team. We registered the type of duel (tackling, heading or other). For heading duels we recorded the type of contact between the two opponents (trunk-trunk, head-head, arm-head and leg-head).

Injury registration

The study population included players with a first-team contract with one of the 16 clubs in the Norwegian male professional league (Tippeligaen). Prior to the 2010 season, the methodology of the UEFA injury study was implemented in the Norwegian professional football league.[7] An injury was registered if the player was unable to take fully part in football activity at least one day beyond the day of injury.[22] The player was considered injured until declared fit for full participation in training and available for match selection by the medical staff. Individual player exposure in training and matches was registered by the clubs medical staff on a standard exposure form.

The injury form was designed according to the consensus statement,[22] including information about the date of injury, the cause of injury (contact or non-contact), the type of activity (match or training) in which the injury occurred, injury location and injury history. We categorized injuries into four severity categories according to the duration of absence from match and training sessions: minimal (1-3 days); mild (4-7 days); moderate (8-28 days); severe (> 28 days).

A member of the club medical staff conducted the prospective injury registration. The club license for Norwegian male professional football clubs requires that a chartered physiotherapist is available for the club and they usually attend all organized team activities, i.e. all training sessions and matches. We collected the forms on a monthly basis and, if needed, we followed up with reminder text messages and phone calls. If information was missing from the injury cards or we discovered any other inconsistencies, a member of the study group contacted the medical staff for clarification. Twelve teams participated in the injury registration during the 2010 season and 14 teams in the 2011 season.

The Regional Committee for Medical Research Ethics, Region Øst-Norge and the Norwegian Social Science Data Services approved the study.

Outcome measures and statistics

The primary outcome measure was the overall rate of contact incidents before and after the introduction of stricter rule enforcement in the 2011 season. Secondary outcome measures were the rate of head contact incidents, ankle contact incidents and contact injuries. Our hypothesis was that stricter rule enforcement by the referees would lead to a reduction in the number of incidents, especially head and ankle incidents.

We calculated our sample size using a formula for cohort studies with Poisson outcomes[23] based on incident rates in the 2000 season, i.e. 75 incidents per 1000 player-match hours [24]. An estimated total of 630 incidents per season would provide an acceptable power of 0.9 at the 5% significant level to detect a 30% reduction in the number of incidents.

Correspondingly, an estimate of 180 ankle and head incidents per season would enable us to detect an effect size of 50% for these two categories. Based on an expected incidence of 18 acute injuries per 1000 player-match hours, with 13 participating clubs and assuming that approximately 50% of all injuries would be contact injuries, we expected a total of 50 recorded match contact injuries each season. Thus, we would need a decrease in contact injury incidence of 70% after the introduction of stricter rule enforcement in Norwegian professional football to have a power of 0.9 and a 5% significance level.

Results are presented as the rate of incidents and injuries (injuries or incidents/1000 player-match hours) . We used a z test and the 95% confidence interval (CI) based on the Poisson model to compare the rate ratio between the 2010 season and 2011 season. Rate ratios are presented with the 2010 season as the reference group. Categorical variables were compared using a χ^2 test. A two-tailed p-value of less than ≤ 0.05 was regarded as significant.

RESULTS

Incidents

During the two seasons all 240 matches were analyzed, leading to 7920 player-match hours per season. A total of 1721 match incidents were identified during the two seasons, 868 in 2010 and 853 in 2011. The corresponding overall incident rate was 109.6 per 1000 player-match hours of exposure (95% CI: 102.3 to 116.9) in the 2010 season and 107.7 (95% CI: 100.5 to 114.9) in the 2011 season, with no difference between the two season (rate ratio: 0.98, 95% CI: 0.89 to 1.08). No differences were observed in the rate of opponent-to-player contact, non-contact incidents, teammate-to-player contact or ball-to-player contact (Table 1).

Table 1. Characteristics of incidents (n=1721) from video analysis of all games (n=240 each season).

Rate is reported as the number of incidents per 1000 player-match hours with 95% confidence

intervals (CI). Rate ratios between the 2010 and 2011 seasons are shown with 95% CI, with the 2010 season as the reference group.

	2010		2011		2010 vs. 2011
	Incidents	Rate	Incidents	Rate	Rate ratio
Contact opponent	734	92.7 (86.0-99.4)	687	86.7 (80.3-93.2)	0.94 (0.84-1.04)
Contact teammate	28	3.5 (2.2-4.8)	28	3.5 (2.2-4.8)	1.00 (0.59-1.69)
Non-contact	68	8.6 (6.5-10.6)	91	11.5 (9.1-13.9)	1.34 (0.98-1.83)
Contact ball	32	4.0 (2.6-5.4)	45	5.7 (4.0-7.3)	1.41 (0.89-2.21)
Other	6	0.8 (0.2-1.4)	2	0.3 (-0.1-0.6)	0.33 (0.07-1.65)

Heading and tackling characteristics

We did not detect any difference in the rate of incidents caused by opponent-to-player contact, not for heading nor tackling duels. We found a lower rate of head incidents in the 2011 season compared to the 2010 season (Table 2). We found a reduced incidence of arm-to-head situations in the 2011 season. No differences were found in the incidence of other mechanisms for all head incidents (Table 3) or during heading duels.

Table 2. Characteristics of incidents due to opponent-to-player contact (n=1421) from video analysis of all games (n=240 each season). Incident rate is reported per 1000 player-match hours with 95% CI. Rate ratios between the 2010 and 2011 seasons are shown with 95% CI, with the 2010 season as the reference group.

	2010		2011		2010 vs. 2011
	Incidents	Rate	Incidents	Rate	Rate ratio
Duel type					
Heading duel	215	27.1 (23.5-30.8)	177	22.3 (19.1-25.6)	0.82 (0.68-1.00)
Tackling duel	437	55.2 (50.0-60.4)	424	53.5 (48.4-58.6)	0.97 (0.85-1.11)
Other duel	82	10.4 (8.1-12.6)	86	10.9 (8.6-13.2)	1.05 (0.78-1.42)
Body location					
Head/neck	226	28.5 (24.8-32.3)	184	23.2 (19.9-26.6)	0.81 (0.67-0.99)
Upper extremity	16	2.0 (1.0-3.0)	16	2.0 (1.0-3.0)	1.00 (0.50-2.00)
Trunk	91	11.5 (9.1-13.9)	108	13.6 (11.1-16.2)	1.18 (0.90-1.57)
Lower extremity					
Thigh	39	4.9 (3.4-6.5)	56	7.1 (5.2-8.9)	1.44 (0.95-2.16)
Knee	49	6.2 (4.5-7.9)	39	4.9 (3.4-6.5)	0.80 (0.52-1.21)
Lower leg/ankle	313	39.5 (35.1-43.9)	284	35.9 (31.7-40.0)	0.91 (0.77-1.07)

Table 3. Characteristics of head incidents due to opponent-to-player contact (n=410) from video analysis of all games (n=240 each season). Rate is reported per 1000 player-match hours with 95% CI. Rate ratios between the 2010 and 2011 seasons are shown with 95% CI, with the 2010 season as the reference group.

	2010		2011		2010 vs. 2011
	Incidents	Rate	Incidents	Rate	Rate ratio
All head incidents (n=410)					
Head-to-head	74	9.3 (7.2-11.5)	70	8.8 (6.8-10.9)	0.95 (0.68-1.31)
Arm-to-head	109	13.8 (11.2-16.3)	79	10.0 (7.8-12.2)	0.72 (0.54-0.97)
Shoulder-to-head	10	1.3 (0.5-2.0)	11	1.43 (0.65-2.2)	1.10 (0.47-2.59)
Trunk-to-head	10	1.3 (0.5-2.0)	7	0.9 (0.2-1.5)	0.70 (0.27-1.84)
Leg-to-head	21	2.7 (1.5-3.8)	16	2.0 (1.0-3.0)	0.76 (0.40-1.46)
Other-head	2	-	1	-	-
Heading duel (n=286)					
Head-to-head	68	8.6 (6.5-10.6)	66	8.3 (6.5-10.3)	0.97 (0.69-1.36)
Arm-to-head	84	10.6 (8.3-12.9)	47	5.9 (4.2-7.6)	0.56 (0.39-0.80)
Shoulder-to-head	6	0.8 (0.2-1.4)	3	0.4 (0.0-0.8)	0.50 (0.13-2.00)
Trunk-to-head	2	0.3 (-0.1-0.6)	4	0.5 (0.0-1.0)	2.00 (0.37-10)
Leg-to-head	3	0.4 (0.0-0.8)	2	0.3 (-0.1-0.6)	0.67 (0.11-4.00)
Other-head	0	-	1	-	-

Of the 861 tackling incidents captured during the two seasons, the downed player was passive in 724 (84%) and active in 137 (16%) of the duels. The characteristics of the 724 passive tackling situations are listed in table 4. We found a reduced incident rate of passive tackles from the front. We found no differences for passive tackle actions, tackling mode, tackling

timing or tackles with ball contact. For active tackling duels we found an increased rate of sliding tackles and tackles with ball contact prior to opponent contact in the 2011 season.

Table 4. Tackling characteristics for incidents where the involved player was passive (n=724) from video analysis of all games (n=240 each season). Rate is reported per 1000 player-match hours with 95% CI. Rate ratios between situations in the 2010 and 2011 seasons are shown with 95% CI, with the 2010 season as the reference group.

	2010		2011		2010 vs. 2011
	Incidents	Rate	Incidents	Rate	Rate ratio
Tackle direction					
Front	139	17.6 (14.6-20.5)	106	13.4 (10.8-15.9)	0.76 (0.59-0.98)
Side	164	20.7 (17.5-23.9)	186	23.5 (20.1-26.9)	1.13 (0.92-1.40)
Back	75	9.5 (7.3-11.6)	54	6.8 (5.0-8.6)	0.72 (0.51-1.02)
Tackle action					
One-foot	333	42.0 (37.5-46.4)	300	37.9 (33.6-42.2)	0.90 (0.77-1.05)
Two-footed	11	1.4 (0.6-2.2)	4	0.5 (0.0-1.0)	0.36 (0.11-1.14)
Upper body	29	3.7 (2.3-5.0)	31	3.9 (2.5-5.3)	1.07 (0.64-1.77)
Other	5	0.6 (0.1-1.2)	11	1.4 (0.6-2.2)	2.20 (0.76-6.33)
Tackling mode					
Feet	208	26.3 (22.7-29.8)	197	24.9 (21.4-28.3)	0.95 (0.78-1.15)
Sliding in	166	21.0 (17.8-24.1)	142	17.9 (15.0-20.9)	0.86 (0.68-1.07)
Other	4	0.5 (0.0-1.0)	7	0.9 (0.2-1.5)	1.75 (0.51-5.98)
Tackling timing					
Early	206	26.0 (22.5-29.9)	196	24.7 (21.3-28.2)	0.95 (0.78-1.16)
Late	172	21.7 (18.5-25.0)	150	18.9 (15.9-22.0)	0.87 (0.70-1.09)
Contact ball					
Prior to opponent	61	7.7 (5.8-9.6)	64	8.1 (6.1-10.1)	1.05 (0.74-1.49)
After opponent	40	5.1 (3.5-6.6)	43	5.4 (3.8-7.1)	1.08 (0.70-1.65)
No ball contact	277	35.0 (30.9-39.1)	239	30.2 (26.4-34.0)	0.86 (0.72-1.02)

Decision of the referee

The referee decisions for the 1421 incidents are characterized in table 5. We found that a higher proportion of passive tackling duels in the 2011 season resulted in a free-kick being awarded ($p=0.01$). We found no difference in the percentage of free-kicks awarded for all opponent-to-player contact incidents, arm-to-head incidents or arm-to-head incidents in heading duels. We found no difference in the referee's sanctioning of incidents between the two seasons (table 5).

Table 5. Referee decision for different incident types caused by opponent-to-player contact from video analysis of all games ($n=240$ each season). Proportions were compared using a χ^2 test.

	2010		2011		2010 vs. 2011
	Incidents	Percentage	Incidents	Percentage	p-value
Opponent-to-player contact (n=1421)					
Free kick	379	52%	367	53%	0.50
Sanctioned	128	34%	114	31%	0.38
Passive tackling incidents (n=724)					
Free kick	253	67%	262	76%	0.01
Sanctioned	108	43%	103	39%	0.44
Arm-to-head contact (n=188)					
Free kick	38	35%	30	38%	0.66
Sanctioned	6	16%	4	13%	0.89
Arm-to-head contact in heading duels (n=131)					
Free kick	34	41%	17	36%	0.63
Sanctioned	5	15%	1	6%	0.36

Player-to-player contact situations

During the 32 matches analyzed in their entirety, 3547 situations with player-to-opponent contact in duels were identified, 1739 in the 2010 season and 1808 in the 2011 season. The corresponding overall rate of contact situations was 3294 per 1000 exposure h (95% CI: 3139 to 3448) in the 2010 season and 3424 (95% CI: 3266 to 3582) in the 2011 season; thus, no significant difference between the two seasons was found (RR: 1.04, 95% CI: 0.97 to 1.11). We also did not detect any difference in the incidence of heading duels or tackling duels between the two seasons (table 6).

Table 6. Characteristics of player-to-player contact situations (n=3547) from video analysis of 32 randomly picked matches. Situations rate is reported per 1000 player-match hours with 95% CI. Rate ratios between the 2010 and 2011 seasons are shown with 95% CI, with the 2010 season as the reference group.

	2010		2011		2010 vs. 2011
	Situations	Rate	Situations	Rate	Rate ratio
Duel type (n=3547)					
Heading duel	816	1546 (1439-1652)	818	1549 (1443-1655)	1.00 (0.91-1.11)
Tackling duel	651	1233 (1138-1328)	710	1344 (1246-1444)	1.09 (0.98-1.21)
Other duel	272	515 (454-576)	280	530 (468-592)	1.03 (0.87-1.22)

Injury registration

A total of 12 763 player-match hours were registered during the two seasons; 5850 (46%) in 2010 and 6912 (54%) in 2011. A total of 202 acute injuries were recorded, of which 99 in 2010 and 103 in 2011, corresponding to an overall acute injury incidence of 16.9 per 1000 player-match hours (95% CI: 13.6 to 20.3) in 2010 and 14.9 (95% CI: 12.0 to 17.8) in 2011. We found no difference in overall injury incidence between the 2010 season and the 2011 season (rate ratio: 0.88, 95% CI: 0.67 to 1.16). No differences were observed for the incidence of contact or non-contact acute match injuries between the 2010 season and the 2011 season. We found a reduced rate of acute contact injuries of minimal severity. No difference was detected between the two seasons for injury type and injury location (Table 7).

Of the 82 acute contact injuries reported to have occurred during league matches, 47 (57%) were identified through video analysis. Of these 47 injuries, 9 (19%) were classified as minimal, 13 (28%) as mild, 13 (28%) as moderate and 12 (26%) as severe. Of the 35 acute contact injuries not identified on video, 10 (29%) were classified as minimal, 10 (29%) as mild, 13 (37%) as moderate and 2 (5%) as severe.

Table 7. Characteristics of acute match injuries (n=202) recorded through the injury surveillance system. Rate is reported per 1000 h of match exposure (with 95% CI). Rate ratios between injuries in the 2010 and 2011 season are shown with 95% CI, with the 2010 season as the reference group.

	2010		2011		2010 vs. 2011
	Injuries	Rate	Injuries	Rate	Rate ratio
Contact opponent	44	7.5 (5.3-9.7)	38	5.5 (3.7-7.2)	0.73 (0.47-1.13)
Contact teammate	2	-	1	-	-
Non-contact	52	8.9 (6.5-11.3)	61	8.8 (6.6-11.0)	0.99 (0.69-1.44)
Contact ball	1	-	3	-	-
Contact injuries (n=82)					
Injury type					
Fracture	3	-	2	-	-
Joint & ligament	18	3.1 (1.7-4.5)	14	2.0 (1.0-3.1)	0.66 (0.33-1.32)
Concussion	3	-	4	-	-
Contusion	18	3.1 (1.7-4.5)	18	2.6 (1.4-3.8)	0.85 (0.44-1.63)
Other	2	-	0	-	-
Body location					
Head/neck	5	0.9 (0.1-1.6)	7	1.0 (0.3-1.8)	1.19 (0.38-3.73)
Upper extremity	3	-	5	-	-
Trunk	1	-	6	-	-
Lower extremity					
Hip/groin	1	-	2	-	-
Thigh	9	-	3	-	-
Knee	10	1.7 (0.6-2.8)	5	0.7 (0.1-1.4)	0.42 (0.15-1.24)
Lower leg	3	-	3	-	-
Ankle	8	1.4 (0.4-2.3)	6	0.9 (0.2-1.6)	0.64 (0.22-1.83)
Foot	4	-	1	-	-
Time loss					
Minimal	15	2.6 (1.3-3.9)	4	0.6 (0.0-1.1)	0.23 (0.08-0.68)
Mild	11	1.9 (0.8-3.0)	12	1.7 (0.8-2.7)	0.92 (0.41-2.09)
Moderate	10	1.7 (0.6-2.8)	16	2.3 (1.2-3.4)	1.35 (0.62-2.98)
Severe	8	1.4 (0.4-2.3)	6	0.9 (0.2-1.6)	0.64 (0.22-1.83)

- Due to small numbers statistics were not computed

DISCUSSION

This is the first study to evaluate the effect of stricter interpretation of the Laws of the Game on the risk of match injury in male professional football. The main finding of the study was that there was a reduction in the rate of head incidents, and head-incidents caused by arm-to-head contact. We found, however, neither a difference in the overall incident rate between the two seasons, nor in the rate of tackling incidents.

Ideally, a reduction of contact injuries would serve as end-point. However, with an expected total of 50 contact injuries, the effect of the stricter rule enforcement would have required a 70 % decrease in injury incidence in order to detect it. We therefore chose incident rate as our primary outcome and measure of injury risk. The 15-s cut-off was chosen because that was thought to be long enough to avoid incidents where players intentionally stayed down either to rest, simulate an injury or to delay playing time. However, only 47 of the 1421 (3%) incidents resulted in an injury recorded by the medical staff. In addition, video analysis did not capture 35 of the injuries recorded by the medical staff. Despite this, we do believe incidents serve as a surrogate measure of injury risk, as the incidents represents events with a propensity for injury [12, 24, 25]. There is also a possibility of a type II error resulting from small numbers, especially when comparing incidences in subcategories of injuries and incidents, such as for a location, mechanism, type or severity.

With an RCT not being possible, a pre-/post-intervention design was employed, where data from the 2011 season was compared to 2010 season data. There have been no other changes in the Norwegian male professional league system or style of play that we can think of which could explain the observed reduction in head incidents, or head incidents caused by arm-to-head contact.

We conducted a separate video analysis where 32 games were analysed for all situations involving opponent contact. In this analysis we found no difference in the overall incidence of player-to-player contact between the two seasons. We could not detect any difference in the incidence of heading or tackling duels, nor the incidence of arm-to-head contact in heading duels. Thus, there is no reason to assume that the reduced incidence of head incidents and head incidents caused by arm-to-head contact was due to an overall change in the style of play or intensity of play in matches from the 2010 to the 2011 season.

Previous studies on injury mechanisms in football have found that most ankle and head injuries are caused by player-to-player contact.[11, 13, 14] The most common cause of head

injuries is heading duels, with subsequent arm-to-head contact or head-to-head contact.[12, 14] Incidents and injuries caused by head-to-head contact are normally not deliberate, while arm-to-head incidents sometimes are. Therefore, we introduced a stricter rule interpretation, explicitly sanctioning intentional high elbows with an automatic red card, to reduce the rate of head incidents. We found a reduced frequency of contact head incidents. It is therefore encouraging that the incidence of arm-to-head contact incidents was reduced after the introduction of stricter rule enforcement.

For ankle injuries, the most common cause of contact injury is being tackled to the weight bearing limb, involving lateral and medial forces and the tackler staying on his feet.[11-13] Therefore, we focused on the sanctioning of two-foot tackles as well as tackles with excessive force with an automatic red card. Still, we found no difference in characteristics for passive tackles between the two seasons, indicating that the intervention did not change player behavior in these situations. Correspondingly, we were not able to reduce the rate of lower leg/ankle incidents.

One question is of course whether the referees actually did award free kicks and sanctions as intended, with a straight red card for two-foot tackles, tackles with excessive force and intentional high elbows. We found that a free-kick was awarded in a higher proportion of the passive tackling incidents in the 2011 season; however, no difference was found in the sanctioning. We were not able to observe any difference in the decision making or the sanctioning of arm-to-head incidents.

We had no referee panel to evaluate the decisions of the referees; thus, we are not able to assess whether the decisions were correct according to expert opinion. Fuller et al. (2004) found that referees identified only 40% of head/neck injuries as foul play during FIFA tournaments.

During the 2010 and 2011 season, all straight red cards (4) were given for tackling incidents and no straight red cards were given for arm-to-head contact. This might indicate that it is more difficult for the referees to recognize arm-to-head incidents and that the reduction in head incidents and arm-to-head incidents was due to changes in player behavior.

Since the 2006 season, the fourth official has become an integral part of the officiating team and the role is to advise the match referee. In addition, UEFA has in recent tournaments introduced two goal-line officials to ensure that the Laws of the Game are upheld, especially

within the penalty box. The expansion of the refereeing team may help to ensure stricter rule enforcement.

In an assessment of player error as an injury causation factor in international football it was found that human error during tackling, inadequacies in the Laws of the Game and/or their application by match referees were equally responsible for the high levels of injury observed.[26] In a study of psychological characteristics of football players Junge et al. [27] found that players have insufficient respect for the Laws of the Game and its regulation. In addition, nearly all players were ready to commit a “professional foul” if necessary and a majority stated that concealed fouls were a part of the game. However, we have not evaluated player attitudes to stricter rule enforcement, but it is possible that the increased focus on the potential of injury through arm-to-head contact and the stricter rule enforcement have changed their attitude towards safer behavior in heading duels.

The injury incidence in Norwegian male professional football is lower than the Champions League level.[7, 8] In addition, epidemiological studies on the risk of injury in male professional football have indicated that the injury rate is slightly higher during international matches.[5, 7, 20, 24, 28-31] Video analysis of injuries and incidents with a high potential of injury has not been evaluated in leagues with a higher injury rate compared to Tippeligaen. We therefore suggest that a similar approach to stricter rule enforcement is included and evaluated in a league or tournament with higher injury risk.

In summary, we found no differences in the overall rate of incidents after the introduction of sanctioning of two-foot tackles as well as tackles with excessive force and intentional high elbow with an automatic red card. However, the rate of head incidents caused by player-to-player contact and the rate of arm-to-head incidents was lower in the 2011 season after implementation of stricter rule enforcement.

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