

Kristenson, K., Bjørneboe, J. A., Waldén, M., Ekstrand, J., Andersen, T. E., Hägglund, M. (2015). No association between surface shifts and time-loss overuse injury risk in male professional football. *Journal of Science and Medicine in Sport*, 19, 218-221.

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# **No association between surface shifts and time-loss overuse injury risk in male professional football**

## **Abstract**

**Objectives:** To investigate frequent surface shifts and match play on an unaccustomed surface as potential risk factors for injury in Scandinavian male professional football.

**Design:** Prospective cohort study.

**Methods:** 32 top-division clubs (16 Swedish, 16 Norwegian) were followed during seasons 2010 and 2011. The influence from (1) number of surface shifts (between artificial turf and grass) during five-match sequences, and (2) match play on an unaccustomed surface (other surface than on the home venue) on subsequent overuse injury risk was evaluated with generalised estimating equations (GEE). GEE results are presented with risk ratios and 95% confidence interval (CI). Injury rate was expressed as time loss injuries/1000 hours, and compared between groups with a rate ratio and 95% CI.

**Results:** No association was found between the number of surface shifts and subsequent overuse injury risk (risk ratio 1.01, 95% CI 0.91-1.12). Furthermore, no difference was seen in subsequent overuse injury risk after match play on unaccustomed compared with accustomed surface (risk ratio 1.04, 95% CI 0.78-1.38). Grass clubs (grass installed at home venue) had a lower match injury rate when playing away matches on artificial turf compared with away matches on grass (rate ratio 0.66, 95% CI 0.40-0.89).

**Conclusions:** This study showed no association between surface shifts or playing matches on an unaccustomed surface and time-loss injury risk in professional football, suggesting that clubs and players can cope with such surface transitions.

**Key words:** Epidemiology, Lower extremity, Soccer, Surface, Surveillance.

## **Introduction**

Third-generation artificial turf (AT) is increasingly used as a playing surface for football worldwide, and in the Scandinavian countries AT is used at all levels of play. Previous injury surveillance studies in male and female elite,<sup>1,2,3</sup> male and female intercollegiate,<sup>4,5</sup> and male and female youth level,<sup>6,7,8</sup> have found no overall differences in acute injury rates between natural grass (NG) and AT. However, one study found a decreased overall injury rate on AT in female intercollegiate football,<sup>9</sup> but this study used different injury and exposure definitions compared with previous studies which make comparisons difficult. Recently, data from Scandinavian male professional football showed that clubs with AT installed at their home arenas had higher general injury rates compared with clubs having NG installed at their home arenas, especially regarding overuse injuries.<sup>3</sup> However, this increased injury rate for AT clubs was evident on both playing surfaces, and it was thus suggested that the higher injury rate could not be attributed to high AT exposure per se, but possibly due to more frequent surface shifts among the AT clubs. Owing to different surfaces at clubs' home venues, shifts between playing surfaces frequently occur in Swedish and Norwegian football. Frequent surface shifts has been proposed as a risk factor for football injury,<sup>3,10</sup> but this has not been directly evaluated.

The primary aim of this study in male professional football was to investigate the influence of frequent surface shifts, and from playing matches on an unaccustomed surface, on overuse injury risk. The secondary aim was to evaluate if match play on unaccustomed surface influence injury rates during that particular match. Our hypotheses were that frequent surface shifts are associated with an increased overuse injury risk, and that match play on unaccustomed surface is associated with an increased injury rate in that particular match as well as increased overuse injury risk in the three-day period after the match.

## Methods

In total, 32 clubs in the male professional leagues in Sweden (16 clubs) and Norway (16 clubs) were followed prospectively for two consecutive seasons, 2010 and 2011 (Appendix 1). The study protocol harmonizes with the Declaration of Helsinki and was approved by the Local Ethics Committees in Linköping, Sweden (Dnr: M240-09) and Region Øst-Norge and the Norwegian Social Science Data, Norway (S-06188), respectively.

The development of the study design has been presented previously.<sup>11</sup> Briefly, all players with a first-team contract were invited to participate. Players who were injured at the start of the study were included, but their present injuries were excluded. A player who left a club during the study period was included for as long as he participated. General cohort characteristics have been published previously.<sup>3</sup> To study the injury characteristics of players that mainly participate in club first team matches, only players with exposure from  $\geq$  five first team matches/season were included.

A representative from each club's medical team was responsible for reporting injury and exposure data to the research group. An injury form was filled in for all injuries with questions regarding injury date, activity (type of match or training), injury type, injury location, injury mechanism and, for acute injuries, whether the injury occurred on AT, NG or any other playing surface (Appendix 2). An exposure form included individual participation in club training and match exposures in minutes and the playing surface (Appendix 3a-3c). Injury and exposure forms were sent to the study group on a monthly basis. To ensure correct data, the study group controllers checked all data sent from the participating clubs within a few days after its arrival. Prompt feedback was sent regularly to all clubs in order to ensure correct data.

The general injury and exposure definitions were consistent with the consensus statement established for injury studies in football.<sup>12</sup> A recordable injury was a time-loss injury, i.e. a physical complaint sustained during football training or match play leading to a player being unable to fully participate in future training or match play. Players were regarded as injured until they were declared fit by the medical team to be able to fully participate in all types of football training and be available for match selection. Acute injuries were defined as injuries with a sudden onset and known cause, whereas overuse injuries had an insidious onset

and no known trauma.<sup>12</sup> A re-injury was defined as an injury of the same type and at the same site as and index injury. Re-injuries and index injuries were handled as two separate injuries in these analyses. Injury severity was based on the number of days of lay-off from football caused by the injury, and were categorised into: slight (0 days), minimal (1-3 days), mild (4–7 days), moderate (8-28 days), and severe injuries (>28 days). Clubs were defined as AT clubs or NG clubs according to the surface installed at their home venues. Accustomed surface was defined as the surface (AT or NG) each club had installed at their home venue and, vice versa, the other surface was defined as unaccustomed surface for that club.

For analyses on the association between frequency of surface shifts, and match play on accustomed vs. unaccustomed surface, and overuse injury risk, a generalised estimating equation (GEE) with a binominal distribution and log link model was used. Each competition match at player individual level was used as an observation. The outcome was any overuse injury  $\leq$  three days after each match observation. First, analysis was made to study potential associations between frequent surface shifts during five-match sequences and subsequent overuse injury risk. For each match observation, the number of surface shifts in the previous match sequence (four previous matches + the match observation) was used as an independent variable. Players with exposure from  $\geq$  four matches in the previous match sequence and the match observation were included. Match frequency in the previous match sequence (days during sequence) and match location at match observation (home/away) were included as covariates. Second, analysis was made to compare the risk of overuse injury when playing matches on accustomed vs. unaccustomed surfaces. In this analysis, players with any exposure at each match observation were included. GEE results are presented with risk ratios and 95% confidence intervals (CI). The GEE approach allowed assessment of potential club clustering effects and within-player variations but none of these were found to significantly affect the outcome of the analyses.

Analyses were also made to compare crude injury rates on accustomed vs. unaccustomed surfaces, at different match locations. This was made by comparing injury rate at a) home matches (AT or NG), b) away matches on AT and c) away matches on NG. These analyses were made for AT and NG clubs, separately. Pre-season football activities in Sweden and Norway (from the beginning of January to the middle or end of March) are largely carried out indoors or outdoors on AT.<sup>3</sup> Therefore, only the

competitive part of each season was included (starting with the primary competition match for each team and season). Injury rate is expressed as the number of injuries/1000 h with 95% CI, using a rate ratio with corresponding 95% CI, and significance was tested with z-statistics.<sup>13</sup> Injury rate data were plotted in histograms and distributions of data were determined by visual inspection. Data were approximately normally distributed, and z-statistics is therefore applicable. All analyses were two-sided and the significance level was set at  $p < 0.05$ .

## Results

A total of 354 094 h (40 955 match h and 313 151 training h) and 2 049 injuries (909 match injuries and 1 140 training injuries) were recorded.

In the analysis of association between the number of surface shifts during a match sequence and subsequent overuse injury risk, 1806 match observations were included. The mean  $\pm$  SD number of surface shifts in the previous match sequence was  $1.9 \pm 1.4$ . No association was found between the number of surface shifts in the previous match sequence and subsequent overuse injury risk (risk ratio 1.01, 95% CI 0.91-1.12).

Regarding overuse injury risk in the three-day period after matches on unaccustomed vs. accustomed surface, a total of 1915 match observations were included. No difference was seen in overuse injury risk after match play on unaccustomed vs. accustomed surface (risk ratio 1.04, 95% CI 0.78-1.38).

For analyses of injury rate when playing on unaccustomed vs. accustomed surface, 31 443 hours total match exposure (14 992 hours at home arenas, 10 513 hours at away matches on NG and 5 938 hours at away matches on AT), and 699 injuries (327 sustained at home arenas, 253 at away matches on NG and 119 at away matches on AT) were included. NG clubs had a lower total injury rate (rate ratio 0.66, 95% CI 0.49-0.89) when playing away matches on AT compared with away matches on NG (Figure 1). No differences were found when comparing NG clubs injury rates at home matches vs. away matches on AT, or home matches vs. away matches on NG. AT clubs had no differences in injury rate when playing home matches, away matches on AT or away matches on NG (Figure 1).

## **Discussion**

This study showed no association between surface shifts or playing matches on an unaccustomed surface and time-loss injury risk in professional football, suggesting that clubs and players can cope with such surface transitions. Interestingly, clubs normally accustomed to grass were found to have a lower injury rate when playing away matches on AT.

The GEE analysis showed no association between the number of surface shifts in the preceding five-match sequence and subsequent time-loss overuse injury risk. Similarly, no difference was found in overuse injury risk in the three-day period after matches played on unaccustomed compared with accustomed surfaces. Previously, biomechanical studies showed no difference in physiological responses after semi-professional matches,<sup>14</sup> or football-specific exercises for professional players on AT and NG of high quality.<sup>15</sup> Still, remarkably 97% of professional players experience that playing on AT results in greater muscle and joint soreness.<sup>16</sup> It should be acknowledged that a time-loss definition may underestimate the burden of overuse injuries substantially,<sup>17</sup> and we may thus have been unable to observe a possible association between frequent surface shifts and non-time loss overuse injury risk.

The results from this study did not support the hypothesis that match play on unaccustomed surface would be associated with higher injury rates. Interestingly, this study actually suggests the opposite where NG clubs had a decreased injury rate when playing away matches on AT compared with their away matches on NG. A recent study showed that professional NG club players believe that the injury rate is increased when playing on AT, and that some individuals may play with caution on AT due to a fear of sustaining injuries.<sup>16</sup> Perhaps this could lead to a more careful playing style in general when NG clubs play away matches on AT, and could therefore be an explanation to the decreased injury rates observed in this study. These differences could also be due to variations in team tactics when playing on an unaccustomed surface. However, even though 32 clubs were followed for two seasons, the data for competition matches at unaccustomed surface is limited. Therefore, these results need to be confirmed in future studies and may not be generalizable to other levels of football play.

The obvious strength with this study is the large homogenous material from two similar professional leagues and a time-span of two years in a setting with a high frequency of AT clubs. Importantly, the registration of exposure on individual level enabled analysis of surface shifts for each individual player, instead of the shift that only occurred on club level.

The study also has some further limitations than those already discussed. First, the cut-off value to include overuse injuries occurring  $\leq$  three days after matches for overuse injury risk was chosen quite arbitrarily by the authors. However, the rationale was that (i) training sessions scheduled on the day after a match are usually of low intensity, allowing players with minor overuse complaints to participate, and would thus not be included with a shorter time period than three days, (ii) delayed onset muscle soreness usually peak after one to two days,<sup>18</sup> and (iii) the clubs usually play one to two matches per week, thus allowing the same follow-up period for all injuries. Still, it is unknown if the results would have been affected if another threshold was chosen. Second, match result (winning or losing) is known to affect injury rates in elite football,<sup>19</sup> and it is possible that team performance can vary for AT and NG clubs at away matches on unaccustomed surfaces, but this influence was not evaluated in this study. Third, as in most other studies comparing injury rate at different surfaces, all types of AT and all NG conditions were analysed together, even though it is well-known that NG conditions frequently vary depending on grass type, weather condition, stage of season, etc.<sup>20</sup> Additionally, many different brands and types of AT were included and not adjusted for.<sup>3</sup> Lastly, the exposure form did not include information of specific training type or intensity, and we have no data on recovery strategies, even though this potentially could affect injury rates.

## **Conclusion**

This study showed no association between surface shifts or playing matches on an unaccustomed surface and time-loss injury risk in professional football, suggesting that clubs and players can cope with such surface transitions.

## **Practical implication**

- Scandinavian professional football players seem to cope with the frequent surface shifts that occur during a competitive season with no observed increased risk of time loss overuse injuries.
- Similarly, the professional players in this cohort seem to be able to adapt to match play on unaccustomed surface (other than the home ground surface) with no observed increase in overuse injury risk in the three-day period after the match.
- A recent qualitative study showed that professional football players believe that the injury rate is increased when playing on artificial turf. However, in this study, clubs with grass at their home venue had a decreased injury rate in matches played away on artificial turf.

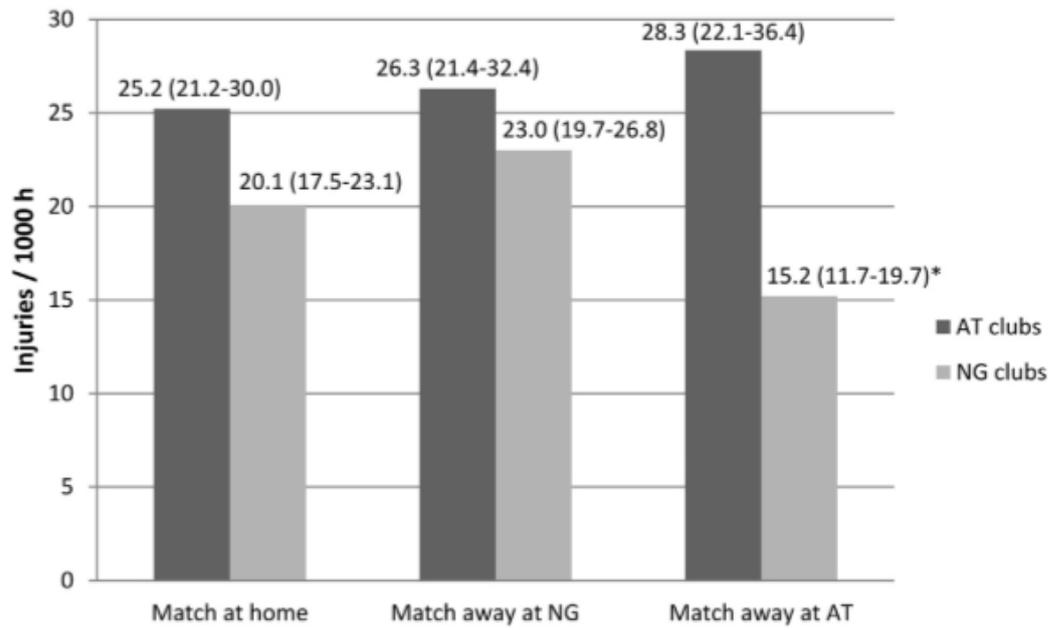
## **Acknowledgements**

We are grateful to all the medical contact persons from both the Swedish and Norwegian clubs for collection of exposure and injury data. Henrik Magnusson (MSc) is greatly acknowledged for statistical advice. The Football Research Group has been established in Linköping, Sweden, in collaboration with Linköping University and through grants from the Union of European Football Associations, the Swedish Football Association, the Football Association Premier League Limited, and the Swedish National Centre for Research in Sports. Karolina Kristenson also received ALF Grants from Region Östergötland. The Oslo Sports Trauma Research Center has been established at the Norwegian School of Sport Sciences through generous grants from the Royal Norwegian Ministry of Culture and Church Affairs, the South-Eastern Norway Regional Health Authority, the International Olympic Committee, the Norwegian Olympic Committee & Confederation of Sport, and Norsk Tipping AS.

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**Figure 1** Match injury rates during the competitive season in professional football with 95% confidence intervals, based on location for match (home or away match), surface at away match and surface at team home venue.

AT: artificial turf; NG: natural grass.

\* $p < 0.05$  compared with NG clubs' away matches at grass.

## SUPPLEMENTARY MATERIAL

### Appendix 1. Location, climate zone and surface at home arena for participating clubs.

Country	Team	Location	Climate zone	Surface at home arena
Norway	Sarpsborg 08 FF	Sarpsborg	Warm temperate climate	Artificial turf
Norway	SK Brann	Bergen	Warm temperate climate	Grass
Norway	FK Haugesund <sup>a</sup>	Haugesund	Warm temperate climate	Grass
Norway	IK Start	Kristiansand	Warm temperate climate	Grass
Norway	Viking FK	Stavanger	Warm temperate climate	Grass
Norway	Sogndal IL <sup>b</sup>	Sogndal	Warm temperate climate	Grass
Norway	Aalesunds FK	Aalesund	Warm temperate climate	Artificial turf
Norway	Molde FK <sup>b</sup>	Molde	Warm temperate climate	Grass
Norway	Rosenborg BK	Trondheim	Warm temperate climate	Grass
Norway	Odd Grenland BK <sup>b</sup>	Skien	Snow climate	Artificial turf
Norway	Stabæk IF	Bærum	Snow climate	Artificial turf
Norway	Strømsgodset Drammen	Drammen	Snow climate	Artificial turf
Norway	Lillestrøm SK	Lillestrøm	Snow climate	Grass
Norway	Vålerenga IF	Oslo	Snow climate	Grass
Norway	Hønefoss BK	Hønefoss	Snow climate	Artificial turf
Norway	Tromsø IL	Tromsø	Snow climate	Artificial turf
Sweden	IF Elfsborg	Borås	Warm temperate climate	Artificial turf
Sweden	IFK Göteborg	Göteborg	Warm temperate climate	Grass
Sweden	Helsingborgs IF	Helsingborg	Warm temperate climate	Grass
Sweden	Halmstads BK	Halmstad	Warm temperate climate	Grass
Sweden	Malmö FF	Malmö	Warm temperate climate	Grass
Sweden	BK Häcken	Göteborg	Warm temperate climate	Grass
Sweden	Trelleborgs FF	Trelleborg	Warm temperate climate	Grass
Sweden	Kalmar FF	Kalmar	Warm temperate climate	Grass
Sweden	Mjällby AIF	Sölvesborg	Warm temperate climate	Grass
Sweden	GAIS	Göteborg	Warm temperate climate	Grass
Sweden	Örebro SK	Örebro	Snow climate	Artificial turf
Sweden	Gefle IF	Gefle	Snow climate	Artificial turf
Sweden	IFK Norrköping	Norrköping	Snow climate	Artificial turf
Sweden	Djurgårdens IF	Stockholm	Snow climate	Grass
Sweden	AIK <sup>b</sup>	Solna	Snow climate	Grass
Sweden	Åtvidabergs FF <sup>c</sup>	Åtvidaberg	Snow climate	Grass/Artificial turf

Clubs are categorised into zones according to the Köppen-Geiger Climate Classification System.<sup>12</sup>

<sup>a</sup>Club participated season 2010 only.

<sup>b</sup>Club participated season 2011 only.

<sup>c</sup>Club installed artificial turf during 2010 and was thereafter regarded as an artificial turf club.

Appendix 2. Injury form.






## NFIA Injury Card

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**Name:**  **Code no:**  **Team:**

**Date of injury:**  **Date of return to full participation:**   
(Send injury card even if player is still in rehabilitation)

**Injured body part**

<input type="checkbox"/> Head/face	<input type="checkbox"/> Shoulder/clavicle	<input type="checkbox"/> Hip/groin
<input type="checkbox"/> Neck/cervical spine	<input type="checkbox"/> Upper arm	<input type="checkbox"/> Thigh
<input type="checkbox"/> Sternum/upper back	<input type="checkbox"/> Elbow	<input type="checkbox"/> Knee
<input type="checkbox"/> Abdomen	<input type="checkbox"/> Forearm	<input type="checkbox"/> Lower leg/Achilles tendon
<input type="checkbox"/> Lower back/pelvis	<input type="checkbox"/> Wrist	<input type="checkbox"/> Ankle
	<input type="checkbox"/> Hand/finger/thumb	<input type="checkbox"/> Foot/toe

**Injury side**

<input type="checkbox"/> Right	<input type="checkbox"/> Left	<input type="checkbox"/> Bilateral/central
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**Type of injury**

<input type="checkbox"/> Concussion	<input type="checkbox"/> Lesion of meniscus/cartilage	<input type="checkbox"/> Haematoma/contusion/bruise
<input type="checkbox"/> Fracture	<input type="checkbox"/> Muscle rupture/tear/strain	<input type="checkbox"/> Abrasion
<input type="checkbox"/> Other bone injury	<input type="checkbox"/> Tendon rupture/tendinopathy	<input type="checkbox"/> Laceration
<input type="checkbox"/> Dislocation/subluxation	<input type="checkbox"/> Synovitis/effusion	<input type="checkbox"/> Nerve injury
<input type="checkbox"/> Sprain/ligament injury	<input type="checkbox"/> Overuse symptoms unspecified	<input type="checkbox"/> Dental injury
<input type="checkbox"/> Other type (specify): <input type="text"/>		

**Diagnosis:**

**Was this a re-injury?**

<input type="checkbox"/> No	<input type="checkbox"/> Yes (give date of return from previous injury) <input type="text"/>
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**Was the injury caused by overuse (gradual onset) or trauma (acute onset)?**

<input type="checkbox"/> Overuse	<input type="checkbox"/> Trauma/acute	<input type="checkbox"/> Not applicable
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**When did the injury occur?**

<input type="checkbox"/> Training	<input type="checkbox"/> Match <input type="text"/> (min. of injury)	<input type="checkbox"/> Not applicable (overuse injury)
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**Indicate type of training or match where injury occurred**

<input type="checkbox"/> Football training (F)	<input type="checkbox"/> Friendly match (F)
<input type="checkbox"/> Other training (O) <input type="text"/>	<input type="checkbox"/> League match (L)
<input type="checkbox"/> Football & other training (FO)	<input type="checkbox"/> UEFA Champions League match (CL)
<input type="checkbox"/> Reserve/youth team training (R)	<input type="checkbox"/> UEFA Europa League match (EL)
<input type="checkbox"/> National team training (N)	<input type="checkbox"/> Other Cup match (C)
	<input type="checkbox"/> Reserve/youth team match (R)
<input type="checkbox"/> Not applicable	<input type="checkbox"/> National team match (N)

**Indicate playing position at time of injury**

<input type="checkbox"/> Goalkeeper	<input type="checkbox"/> Defender	<input type="checkbox"/> Midfielder	<input type="checkbox"/> Forward
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**Indicate surface where injury occurred**

<input type="checkbox"/> Grass (G)	<input type="checkbox"/> Artificial turf (A)	<input type="checkbox"/> Other surface (O) <input type="text"/>	<input type="checkbox"/> Not applicable (overuse injury)
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**Was the injury caused by contact or collision?**

<input type="checkbox"/> No	<input type="checkbox"/> Yes, with other player	<input type="checkbox"/> Yes, with object (specify) <input type="text"/>
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**Injury mechanism**

<input type="checkbox"/> Running/sprinting	<input type="checkbox"/> Jumping/landing	<input type="checkbox"/> Hit by ball	<input type="checkbox"/> Kicked by other player
<input type="checkbox"/> Twisting/turning	<input type="checkbox"/> Falling/diving	<input type="checkbox"/> Collision	<input type="checkbox"/> Blocked
<input type="checkbox"/> Shooting	<input type="checkbox"/> Stretching	<input type="checkbox"/> Heading	<input type="checkbox"/> Use of arm/elbow
<input type="checkbox"/> Passing/crossing	<input type="checkbox"/> Sliding	<input type="checkbox"/> Tackled by other player	<input type="checkbox"/> Other acute mechanism
<input type="checkbox"/> Dribbling	<input type="checkbox"/> Overuse	<input type="checkbox"/> Tackling other player	<input type="checkbox"/> Unknown mechanism

**Injury mechanism (describe in own words)**

**Referee's Sanction** (acute match injuries only)

<input type="checkbox"/> No foul	<input type="checkbox"/> Opponent foul	<input type="checkbox"/> Own foul
	<input type="checkbox"/> Yellow card	<input type="checkbox"/> Red card

**Other comments**





