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# Risk of injury on third-generation artificial turf in Norwegian professional football

Running head: Injury risk on artificial turf in male professional football

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## ABSTRACT

**Background:** Artificial turf is used extensively in both **recreational** and elite football in areas with difficult climatic conditions.

**Objective:** To compare the risk for acute injuries between natural grass and third-generation artificial turf in male professional football.

**Study design:** Prospective cohort study

**Methods:** All injuries sustained by players with a first-team contract were recorded by the medical staff of each club, from the 2004 throughout the 2007 season. An injury was registered if the player was unable to take fully part in football activity or match play.

**Results:** A total of 668 match injuries; 526 on grass and 142 on **artificial turf** were recorded. The overall acute match injury incidence was 17.1 (95% CI: 15.8-18.4) per 1 000 match hours; 17.0 (95% CI: 15.6-18.5) on grass and 17.6 (95% CI: 14.7-20.5) on **artificial turf**. Correspondingly, the incidence for training injuries was 1.8 (95% CI: 1.6-2.0); 1.8 (95% CI: 1.5-2.0) on grass and 1.9 (95% CI: 1.5-2.2) on **artificial turf** respectively. No significant difference was observed in injury location, type or severity between turf types.

**Conclusion:** No **significant** differences were detected in injury rate or pattern between third-generation artificial turf and natural grass in Norwegian male professional football.

## INTRODUCTION

Many regions of the world suffer from climatic conditions that limit natural grass growth throughout the seasons. It is therefore difficult to maintain adequate natural grass pitches both in cold and wet climate zones in the northern hemisphere and in dry areas around the equator. Artificial turf provides for more constant playing conditions, longer playing hours and lower maintenance costs compared to natural grass.[1] Consequently, some national football associations, including the Norwegian, recommend artificial turf for new football pitches.

While there are some studies on the injury risks associated with artificial turf in European football, showing a higher risk of injury compared to natural grass[2, 3], most have been carried out on first- and second-generation artificial turf. However, early turf types displayed characteristics clearly different from those of natural grass, including differences in bounce and roll of the ball. This led to the development of a third-generation of artificial turf types (3GAT), with long grass-like fibres filled with sand and rubber particles, named football turf by FIFA and included in the Laws of the game in 2004.[1]

In 2006, Ekstrand and co-workers published the first study looking at injury risk on artificial turf in male elite football. They found no major differences in injury risk between artificial turf and natural grass except, surprisingly, a higher incidence of ankle sprains on artificial turf.[4] Studies in college and youth football have revealed a similar risk of injury on natural grass compared to artificial turf[5-8], while Steffen and co-workers found a higher risk of severe match injuries on artificial turf.[7] However, in these studies exposure was on a mixture of turf types, including first- and second-generation turf.

The aim of this study was to compare the risk of acute injuries on natural grass to third-generation artificial turf in male professional football, where all teams have access to third-generation artificial turf.

## MATERIALS AND METHODS

### Study design and population

The study population included players with a first-team contract with one of the 14 clubs in the male Norwegian professional league (Tippeligaen). As part of a continuous prospective injury surveillance system established in 2000[9], all injuries sustained were recorded by the medical staff of each club. The present study includes data from 2004 throughout the 2007 season (January – December). Players on trial or youth players without a professional contract were not included. All artificial turfs were FIFA certified. Natural grass used in football in Norway is commonly a mix of rye grass and poa pratensis.

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

### Injury definition and injury form

We used a time-loss definition, in accordance with a recent consensus statement[10], when recording injuries. An injury was registered if the player was unable to take fully part in football activity or match play at least one day beyond the day of injury. If the injury was the result of a specific, identifiable event, it was defined as acute and included in this paper. Overuse injuries were not included, as they could not be attributed to a specific training session or match (and hence, turf type). We designed the injury form according to the consensus statement, including information about the date of injury, the type of activity (match or training) in which the injury occurred, injury location and injury history. We categorized injuries into three severity categories according to the duration of absence from match and training sessions: mild (1-7 days); moderate (8-21 days) and severe (>21 days). We classified the injury diagnoses using Orchard codes.[11]

**Injury registration by medical staff**

A member of the club medical staff, in most cases the physiotherapist, sometimes the team physician, performed the prospective injury registration. Each season we sent a manual, with instructions on how to complete the injury and exposure forms to the club medical staff. The club licence for Norwegian 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. We controlled the injury cards submitted thoroughly. If information was missing or we discovered any other inconsistencies, a member of the study group contacted the medical staff for clarification.

**Exposure registration**

We collected exposure data on a separate form, asking for information about the type and duration of match or training, the number of participants and the surface during the particular training or match. Match exposure for players included all matches between teams from different clubs of players with an A-squad contract. Training exposure was defined as any physical activity carried out under the guidance of a member of the first teams coaching staff. A member of the coaching staff or the medical staff completed the exposure form,

**Statistics**

Results are presented as injury incidence (injuries/1000 hours of exposure) in training and match play. We used a z test and the 95% confidence interval (CI) based on the Poisson model to compare the rate ratio between artificial turf and natural grass. To adjust for the correlation between the dichotomy match/training and both injury and artificial turf/natural grass, overall injury incidence on natural grass/artificial turf was calculated using a stratified analysis by match/training. The pooled estimate natural grass/artificial turf across the strata (match/training) was made by a weighted average using the reciprocal of the variances of the

rates as weights. Rate ratios are presented with natural grass as the reference group. Two-tailed P values $\leq 0.05$ were regarded as significant. All analyses were conducted in SPSS for Windows, version 15 (SPSS, Chicago, Ill).

## RESULTS

A total of 261 541 playing hours; 186 929 (71.5%) on grass and 74612 (28.5%) on artificial turf were registered during the four-year long study period. A total of 1067 injuries were recorded, of which 800 (75%) on grass and 267 (25%) on artificial turf, corresponding to an overall injury incidence of 2.1 (95% CI: 1.9 to 2.3) per 1000 playing hour on natural grass and 2.1 (95% CI: 1.8 to 2.4). There was no significant difference in overall risk of injury between grass and artificial turf (rate ratio: 1.01, 95% CI 0.87 to 1.15).

The total match exposure was 38 976 playing hours; 30927 (79%) on grass and 8049 (21%) on artificial turf. A total of 668 match injuries; 526 (79%) on grass and 142 (21%) on artificial turf was recorded, corresponding to an overall injury incidence during matches of 17.1 (95% CI: 15.8 to 18.4) per 1 000 match hours; 17.0 (95% CI: 15.6-18.5) on grass and 17.6 (95% CI: 14.7 to 20.5) on artificial turf. There was no significant difference between grass and artificial turf during matches (rate ratio: 1.04, 95% CI 0.86 to 1.25).

The total training exposure was 222 565; 156 002 (70%) and 66 563 (30%) on grass and artificial turf, respectively, while there were 399 training injuries, 274 (69%) on grass and 125 (31%) on artificial turf. Correspondingly, the incidence of training injuries was 1.8 (95% CI: 1.6 to 2.0); 1.8 (95% CI: 1.5 to 2.0) on grass and 1.9 (95% CI: 1.5 to 2.2) on artificial turf. There was no significant difference between grass and artificial turf during training (rate ratio: 1.07, 95% CI 0.87 to 1.32).

No significant differences were observed in injury incidence between grass and artificial turf for match (table 1) or training injuries (table 2) in any of the subcategories injury location, severity or injury type (table 1 and 2).

Table 1. Characteristics of acute match injuries. The incidences are reported per 1000 h of exposure (with 95% CI). Rate ratios between injuries on grass and artificial turf are shown with 95% CI, with grass as the reference group (n=668).

| | Grass | | Artificial turf | | Artificial turf vs grass |
|---|---|---|---|---|---|
| | Injuries | Incidence | Injuries | Incidence | Rate ratio |
| Injury type | | | | | |
| Fracture | 34 | 1.1 (0.7-1.5) | 7 | 0.9 (0.2-1.5) | 0.79 (0.35-1.78) |
| Sprain | 165 | 5.3 (4.5-6.1) | 57 | 7.1 (5.2-8.9) | 1.33 (0.98-1.79) |
| Knee | 63 | 2.0 (1.5-2.5) | 24 | 3.0 (1.8-4.2) | 1.46 (0.92-2.34) |
| Ankle | 69 | 2.2 (1.7-2.8) | 25 | 3.1 (1.9-4.3) | 1.39 (0.88-2.20) |
| Strain | 157 | 5.1 (4.3-5.9) | 36 | 4.5 (3.0-5.9) | 0.88 (0.61-1.27) |
| Groin | 38 | 1.2 (0.8-1.6) | 6 | 0.7 (0.1-1.3) | 0.61 (0.26-1.44) |
| Hamstring | 55 | 1.8 (1.3-2.2) | 13 | 1.6 (0.7-2.5) | 0.91 (0.50-1.66) |
| Quadriceps | 18 | 0.6 (0.3-0.9) | 5 | 0.6 (0.1-1.2) | 1.07 (0.37-2.88) |
| Calf | 28 | 0.9 (0.6-1.2) | 7 | 0.9 (0.2-1.5) | 0.96 (0.42-2.20) |
| Contusion | 119 | 3.8 (3.2-4.5) | 32 | 4.0 (2.6-5.4) | 1.03 (0.70-1.53) |
| Cut | 12 | 0.4 (0.2-0.6) | 6 | 0.7 (0.1-1.3) | 1.92 (0.72-5.12) |
| Nervous system | 26 | 0.8 (0.5-1.2) | 3 | 0.4 (0.0-0.8) | 0.44 (0.13-1.47) |
| Other | 13 | 0.4 (0.2-0.6) | 1 | 0.1 (-0.1-0.4) | 0.30 (0.04-2.26) |
| Body location | | | | | |
| Head/neck | 61 | 2.0 (1.5-2.5) | 9 | 1.1 (0.4-1.8) | 0.57 (0.28-1.14) |
| Concussion | 42 | 1.4 (0.9-1.8) | 5 | 0.6 (0.1-1.2) | 0.46 (0.18-1.16) |
| Upper extremity | 18 | 0.6 (0.3-0.9) | 3 | 0.4 (0.0-0.8) | 0.64 (0.19-2.17) |
| Trunk | 34 | 1.1 (0.7-1.5) | 12 | 1.5 (0.6-2.3) | 1.36 (0.70-2.62) |
| Lower extremity | | | | | |
| Groin | 48 | 1.6 (1.1-2.0) | 11 | 1.4 (0.6-2.2) | 0.88 (0.46-1.70) |
| Thigh | 107 | 3.5 (2.8-4.1) | 31 | 3.9 (2.5-5.2) | 1.11 (0.75-1.66) |
| Knee | 83 | 2.7 (2.1-3.3) | 26 | 3.2 (2.0-4.5) | 1.20 (0.78-1.87) |
| Calf | 64 | 2.1 (1.6-2.6) | 10 | 1.2 (0.5-2.0) | 0.60 (0.31-1.17) |
| Ankle | 86 | 2.8 (2.2-3.4) | 30 | 3.7 (2.4-5.1) | 1.34 (0.89-2.03) |
| Foot | 25 | 0.8 (0.5-1.1) | 10 | 1.2 (0.5-2.0) | 1.54 (0.74-3.20) |
| Time loss | | | | | |
| 1 to 7 days | 263 | 8.5 (7.5-9.5) | 64 | 8.0 (6.0-9.9) | 0.94 (0.71-1.23) |
| 8 to 21 days | 151 | 4.9 (4.1-5.7) | 39 | 4.8 (3.3-6.4) | 0.99 (0.70-1.41) |
| >21 days | 112 | 3.6 (3.0-4.3) | 39 | 4.8 (3.3-6.4) | 1.34 (0.93-1.93) |

Table 2. Characteristics of acute training injuries. The incidences are reported per 1000 h of exposure with 95% confidence intervals. Rate ratios between injuries on grass and artificial turf are shown with 95% confidence intervals, with grass as the reference group (n=399).

| | Grass | | Artificial turf | | Artificial turf vs grass |
|---|---|---|---|---|---|
| | Injuries | Incidence | Injuries | Incidence | Rate ratio |
| Injury type | | | | | |
| Fracture | 13 | 0.1 (0.0-0.1) | 5 | 0.1 (0.0-0.1) | 0.90 (0.32-2.53) |
| Sprain | 114 | 0.7 (0.6-0.9) | 43 | 0.6 (0.5-0.8) | 0.88 (0.62-1.26) |
| Knee | 38 | 0.2 (0.2-0.3) | 22 | 0.3 (0.2-0.5) | 1.36 (0.80-2.29) |
| Ankle | 48 | 0.3 (0.2-0.4) | 17 | 0.3 (0.1-0.4) | 0.83 (0.48-1.44) |
| Strain | 101 | 0.6 (0.5-0.8) | 52 | 0.8 (0.6-1.0) | 1.21 (0.86-1.69) |
| Groin | 15 | 0.1 (0.0-0.1) | 10 | 0.2 (0.1-0.2) | 1.56 (0.70-3.48) |
| Hamstring | 37 | 0.2 (0.2-0.3) | 16 | 0.2 (0.1-0.4) | 1.01 (0.56-1.82) |
| Quadriceps | 23 | 0.1 (0.1-0.2) | 14 | 0.2 (0.1-0.3) | 1.43 (0.73-2.77) |
| Calf | 10 | 0.1 (0.0-0.1) | 6 | 0.1 (0.0-0.2) | 1.41 (0.51-3.87) |
| Contusion | 34 | 0.2 (0.1-0.3) | 21 | 0.3 (0.2-0.5) | 1.45 (0.84-2.49) |
| Cut | 1 | | 0 | | |
| Nervous system | 4 | | 2 | | |
| Other | 7 | | 2 | | |
| Body location | | | | | |
| Head/neck | 8 | | 1 | | |
| Concussion | 6 | | 1 | | |
| Upper extremity | 16 | 0.1 (0.1-0.2) | 5 | 0.1 (0.0-0.1) | 0.73 (0.27-2.00) |
| Trunk | 19 | 0.1 (0.1-0.2) | 10 | 0.2 (0.1-0.2) | 1.23 (0.57-2.65) |
| Lower body | | | | | |
| Groin | 21 | 0.1 (0.1-0.2) | 10 | 0.2 (0.1-0.2) | 1.12 (0.53-2.37) |
| Thigh | 74 | 0.5 (0.4-0.6) | 35 | 0.6 (0.4-0.7) | 1.11 (0.74-1.66) |
| Knee | 52 | 0.3 (0.2-0.4) | 27 | 0.4 (0.3-0.6) | 1.22 (0.76-1.94) |
| Calf | 22 | 0.1 (0.1-0.2) | 10 | 0.2 (0.1-0.2) | 1.07 (0.50-2.25) |
| Ankle | 52 | 0.3 (0.2-0.4) | 21 | 0.3 (0.2-0.5) | 0.95 (0.57-1.57) |
| Foot | 10 | 0.1 (0.0-0.1) | 6 | 0.1 (0.0-0.2) | 1.41 (0.51-3.87) |
| Time loss | | | | | |
| 1 to 7 days | 152 | 1.0 (0.8-1.1) | 50 | 0.8 (0.5-1.0) | 0.77 (0.56-1.06) |
| 8 to 21 days | 74 | 0.5 (0.4-0.6) | 45 | 0.7 (0.5-0,9) | 1.43 (0.98-2.06) |
| >21 days | 48 | 0.3 (0.2-0.4) | 30 | 0.5 (0.3-0.6) | 1.47 (0.93-2.31) |

## DISCUSSION

The aim of this study was to compare the risk for acute injuries between natural grass and third-generation artificial turf in male professional football. We could not detect any significant differences between turf types for training or match injuries, nor in any injury subcategory. This is in accordance with previous studies comparing the risk of injury on third-generation artificial turf to natural grass.[4-8]

A limitation of this study is that we were not able to compare the risk of overuse injuries on artificial turf to that on natural grass. There are two main obstacles to making such a comparison. One limitation is that a significant proportion of overuse injuries do not lead to time loss from sports participation; players often continue training and playing games even when limited by pain and reduced function. Studies based on surveillance data, such as the present, are usually based on an injury definition requiring time loss from football, and therefore lead to a significant underestimation of overuse injuries in the population.[12] Second, overuse injuries are defined as being the result of repeated micro-trauma without a single, identifiable event responsible for the injury.[10] Therefore, even if a "physical complaint"-definition were used, an overuse injury cannot be attributed to one specific training session or match and, hence, to one of the two turf types in question. To date, there is no obvious solution to these challenges. If appropriate methods are developed to quantify overuse injuries in athletes[12], it may be possible to compare teams who play and train on one turf type entirely, although it would be difficult to control for confounding factors in such a study. Also, there may be an association between increased risk of overuse injuries and lack of adaptation or frequent changes in playing surface.[2, 13-15]

One strength of this study was the four-year follow up, and the high number of acute time-loss injuries registered compared to other studies on the same topic. This means that the 95%

confidence interval for the rate ratio between grass and artificial turf was quite narrow; ranging from 0.87 to 1.15. Nevertheless, there still is a possibility of a type II error resulting from limited data, especially when comparing the incidences in subcategories of injuries (e.g. for a specific injury location, type or severity). We did observe a trend towards an increased risk of knee and ankle sprains on artificial turf, albeit only during matches. Ekstrand et al.[4] found a significant difference and Steffen et al.[7] a trend towards an increased risk of ankle sprains on artificial turf. Ekstrand et al.[4] also saw a trend towards a reduced risk of muscle injuries on artificial turf; there was no indication of this in our study. Eleven ACL injuries occurred during match (9 on natural grass and 2 on artificial turf), 3 during training (2 on NG and 1 on 3GAT). Our injury surveillance system was started in 2000, prior to the consensus statement.[10] Therefore, the severity categories we have used differ from the consensus statement. We observed a trend towards increased representation of training injuries with moderate severity (8-21 days) when playing on artificial turf. Studies from elite and youth football found a tendency towards an increased risk of severe injuries on artificial turf.[4, 7] In contrast, Fuller and co-workers[5, 6], found no significant difference in severity, nature or cause of injuries between natural grass and artificial turf. At the other end of the severity spectrum are abrasions and friction injuries, which have been reported to be more common on first-generation artificial turf[14], but were unlikely to be captured using our time-loss injury definition. However, Soligard et al.[8], recording all physical complaints in an adolescent football tournament, found no significant difference in the risk of abrasions between artificial turf and natural grass. In summary, although the data from the current study indicate that there is no clinically meaningful difference in the overall risk for acute injuries, even larger studies or meta-analyses are needed to reach firm conclusions regarding specific injury types, such as knee sprains or ACL tears.

A recent methodological study showed that the medical staff fail to report/capture about 20% of all time-loss injuries in Norwegian professional football.[16] However, no significant difference was found related to surface when the injury was sustained, injury type, severity, nor body part.[16] Thus, the overall injury incidence in this study is probably underestimated, but this should not interfere with our comparison between artificial turf and natural grass.

It should be noted that first- and second-generation artificial turf had different playing characteristics from natural grass, which may explain the increased injury risk observed in older studies. Shoe-surface friction and surface stiffness are the two main factors involved in surface-related injuries.[17] Third-generation artificial turfs used in elite football are thoroughly tested before they are certified by FIFA as football turfs, i.e. approved for use in professional football. FIFA's football turf certification regulates that shoe-surface friction and surface stiffness are within a specified range.[1] The current study is the first to only include 3GAT certified by FIFA. Due to the climate in Norway football is mainly played from April until the end of October. The competitive season in the professional league starts in mid-March and end early in November, with a preseason period from January. Surface traction is less in rainy weather and may also depend on temperature, but we have not collected weather information for the games played. However, most of the stadiums with artificial turf are watered before the game and during the halftime break in order to lower the traction forces.

Andersson et al.[18] compared the movement patterns and ball skills on third-generation artificial turf to that on natural grass, and found no significant difference in running activities and technical standards. However, they also found that fewer sliding tackles and more short passes were performed when playing on artificial turf, which partly may explain the negative attitude of male players towards playing on artificial turf.[18]

High rotational traction is considered to be a risk factor for injuries to the lower extremities, and artificial turf has significantly higher peak torque and rotational stiffness than natural

grass in American football.[19] However, a shoe with a turf-style cleat produces a significantly lower torque than other shoes.[19] Generally, grass-style shoes have longer and fewer cleats, while turf-style shoes have shorter and rounder cleats. However, we are unable to control for type of shoe used when injured in our analysis.

In conclusion, no significant differences were detected in injury rate or pattern between third-generation artificial turf and natural grass in Norwegian male professional football.

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