

# Injury risk on artificial turf and grass in youth tournament football

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The aim of this prospective cohort study was to investigate the risk of acute injuries among youth male and female footballers playing on third-generation artificial turf compared with grass. Over 60 000 players 13–19 years of age were followed in four consecutive Norway Cup tournaments from 2005 to 2008. Injuries were recorded prospectively by the team coaches throughout each tournament. The overall incidence of injuries was 39.2 (SD: 0.8) per 1000 match hours; 34.2 (SD: 2.4) on artificial turf and 39.7 (SD: 0.8) on grass. After adjusting for the potential confounders age and gender, there was no difference in the overall risk of

injury [odds ratio (OR): 0.93 (0.77–1.12),  $P = 0.44$ ] or in the risk of time loss injury [OR: 1.05 (0.68–1.61),  $P = 0.82$ ] between artificial turf and grass. However, there was a lower risk of ankle injuries [OR: 0.59 (0.40–0.88),  $P = 0.008$ ], and a higher risk of back and spine [OR: 1.92 (1.10–3.36),  $P = 0.021$ ] and shoulder and collarbone injuries [OR: 2.32 (1.01–5.31),  $P = 0.049$ ], on artificial turf compared with on grass. In conclusion, there was no difference in the overall risk of acute injury in youth footballers playing on third-generation artificial turf compared with grass.

Grass is the traditional playing surface in football both for matches and training on the elite level. However, artificial turfs have inherent advantages such as longer playing hours, lower maintenance costs, better resilience to tough climatic conditions, and multi-purpose application. Because of these benefits, artificial turf is becoming a common playing turf not only among youth but also in professional football.

Since its introduction in the 1970s, artificial turf has been developed and refined continuously. The first and second generations of artificial turfs were hard and shoe-surface traction was high, which made the playing characteristics different from natural grass and the injury risk higher (Engebretsen & Kase, 1987; Árnason et al., 1996). Third-generation artificial turfs were introduced in the late 1990s and consisted of longer and much more spread turf fibers filled with rubber granules. With adjusted hardness and traction, the playing characteristics and player movement patterns on the new turfs resembled those on grass better (Andersson et al., 2008).

However, concerns have been raised that the injury risk of playing on third-generation artificial turfs may still be higher compared with playing on grass. Only a few studies have looked into this; none conducted among adolescent players of both genders. Ekstrand et al. (2006) followed 10 male elite football clubs playing on third-generation artificial turf during three seasons from 2003 to 2005. No

difference in the incidence of match or training injuries was found between artificial turf and grass, although the incidence of ankle sprains on artificial turf was almost twice and lower extremity strains almost half of that found on grass. Fuller et al. (2007a, b) followed male and female college football teams for two seasons in 2005 to 2006 and reported no major difference in the overall risk, severity, nature, or cause of match or training injuries between the two turf types. After following 14–16-year-old females over the 2005 season, Steffen et al. (2007) reported that there was no difference in the overall risk of injury between artificial turf and grass. However, the incidence of severe match injuries on artificial turf was twice that found on grass. Aoki et al. (2010) monitored six teams consisting of 12–17-year-old males in the 2005 season, and observed no difference in the incidence of acute injuries between artificial turf and grass during training or matches. However, training on artificial turf was associated with chronic low back pain.

The aim of this study was to investigate the risk of acute injuries among youth male and female footballers playing on third-generation artificial turf compared with grass.

## Materials and methods

A prospective cohort design was used for the study. Data were collected from 2005 to 2008 in the Norway Cup, which since

its start in 1972 has become one of the largest international youth football tournaments. It is arranged in Oslo in the first week of August every year, with more than 1500 teams and 17000 players participating. The matches are played from 08:00 hours until 20:00 hours for six consecutive days in large recreational areas with more than 40 playing fields.

Five of the fields were covered with third-generation artificial turf. All 11-a-side classes were included, corresponding to boys and girls 13–19 years of age. The play-off matches and 7-a-side matches were excluded because they were played on natural grass only. In order to have a sufficient number of playing fields, most of the 11-a-side fields covered with natural grass are somewhat smaller than the official regulations by the Football Association of Norway (NFF). Over the four tournaments, the study comprised more than 4000 teams and 60000 players; approximately one-third of these were girls.

The study was approved by the Regional Committee for Medical Research Ethics, South-Eastern Norway Regional Health Authority, Norway.

### Recording of data

The injury recording involved the team coaches and the referees. Before each match, the referee visited the referee department to receive two injury record forms as well as the scorecard. The referee handed out one injury record form to the coach of each team. The coaches were asked to fill in the form if any injuries occurred during the match. Immediately after the match, the referee collected the injury forms and delivered them to the tournament transport unit. The main task of this unit was to transport the scorecard and injury forms from the playing field to the technical department, where the injury data were plotted into a database by trained personnel.

The team coaches and the referees were informed specifically about the purpose and methodology of the study before the start of the tournament. The referees were provided with a letter detailing the study when they checked in to the referee department. Also, the day before tournament start all the referees were gathered in a plenary meeting where we described the procedures for the injury registration. The referees were also followed up every day by study personnel in the referee department. Every team coach was informed about the study in a letter distributed to them 1 month before attending the tournament, as well as on arrival during check-in.

The injury record form was a bilingual (Norwegian/English) check-box form. The form included instructions on how to record the information. The coaches recorded the location, type, severity, and cause (acute/overuse; contact/non-contact) of injury. The referee completed the team names and the unique match ID, which allowed for subsequent data extraction of the age and gender of the players, as well as the playing field number and turf type (artificial turf or natural grass). No personal data were recorded in the injury forms or stored in the injury database, and informed consent was not obtained.

An injury was defined as any injury, painful condition, or physical complaint sustained by a player in a Norway Cup match, irrespective of the need for medical attention or time loss from football activities (Fuller et al., 2006). We did not include injuries or other medical conditions occurring outside Norway Cup matches. Contact injuries were defined as injuries resulting from contact with another player, whereas non-contact injuries were defined as injuries occurring without contact with another player. Acute injuries were defined as injuries with a sudden onset, associated with a known trauma. Overuse injuries were defined as injuries with a gradual onset and no known trauma. Because overuse injuries have a

gradual onset, they could not be attributed to a particular turf type, and hence, their injury incidence could not be compared between turf types. The injury recording method did not allow for any assessment of injury exacerbations or recurrences. Injuries were grouped into four categories of severity by the coaches according to the expected length of absence from matches and training sessions: minimal (1–3 days); mild (4–7 days); moderate (8–28 days); and severe (>28 days). Match exposure was calculated on a team basis on the assumption that each match involved 11 players and lasted for 40, 50, or 60 min, according to the age class.

### Statistical methods

We used ordinal regression analyses with injuries as the dependent variable to estimate the risk of injury on artificial turf and grass. We used logistic regression analyses in subgroups where the number of injuries was limited. All estimates were adjusted for the potential confounders age and gender. In the regression analyses, tests of interaction between turf type, age, and gender were performed by adding three-way and two-way cross-product terms. If significant interactions were not identified, the three-way cross-product term was eliminated and the procedure was repeated. If significant interactions were still not found, the two-way cross-product terms were eliminated and one-way interactions with injury risk were tested. We used the relative risk (RR) of the injury incidences on artificial turf and grass for comparison with the adjusted odds ratio (OR). Grass was used as a reference group. The summary measure of injury incidence ( $i$ ) was calculated according to the formula  $i = n/e$ , where  $n$  is the number of injuries and  $e$  the sum of exposure expressed in match hours. Injury incidences are presented as means with standard errors. OR and RR are presented with 95% confidence intervals (CI). Two-tailed  $P$ -values  $\leq 0.05$  were regarded as significant. All analyses were conducted in SPSS for Windows, version 15 (SPSS, Chicago, Illinois, USA).

### Results

From the Norway Cup 2005 through 2008, data were collected from 7848 matches; 5491 (70%) played by boys and 2357 (30%) by girls. The total exposure to football was 62 597 match hours; 6022 (10%) on artificial turf and 56 575 (90%) on grass. A total of 2454 injuries were recorded; 206 (8%) on artificial turf and 2248 (92%) on grass. Two hundred seventy-two of the injuries (11%) were expected to lead to absence from training and matches for at least 1 day. Of these, 25 (9%) occurred on artificial turf and 247 (91%) on grass. The descriptive injury and exposure data for both genders and the four age classes are shown in Table 1.

#### Injury pattern on artificial turf and grass

The overall incidence of injuries was 39.2 (SD: 0.8) per 1000 match hours; 34.2 (SD: 2.4) on artificial turf and 39.7 (SD: 0.8) on grass. The incidence of time loss injuries was 4.3 per 1000 match hours; 4.2 (SD: 0.8) on artificial turf and 4.4 (SD: 0.3) on grass. The incidence of injuries for boys was 31.3 (SD: 2.6) and

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38.8 (SD: 1.0) per 1000 match hours on artificial turf and grass, respectively. For girls, the incidence was 42.7 (SD: 5.3) and 41.9 (SD: 1.6) injuries per 1000 match hours on artificial turf and grass, respectively. After adjusting for the potential confounders age and gender, there was no difference in the overall risk of injury (OR: 0.93; 95% CI: 0.77–1.12;  $P = 0.44$ ) or in the risk of time loss injury (OR: 1.05; 95% CI: 0.68–1.61;  $P = 0.82$ ) between artificial turf and grass.

The injury rates for most subcategories of injury types and locations were similar on artificial turf and grass (Table 2). However, while there was no difference in the risk of ankle sprains between the two

surfaces (rate ratio: 0.39; 95% CI: 0.12–1.23), the risk of ankle injuries overall was almost half on artificial turf compared with on grass. In contrast, the rate of injuries to the back and spine, as well as to the shoulder and clavicle, was twice as high on artificial turf compared with on grass. There was no difference in the injury rate for subcategories of expected absence from match and training between the turf types.

Interestingly, the occurrence of abrasions and lacerations was low on both artificial turf and grass, and no difference was seen between the two surfaces.

Table 1. Descriptive injury and exposure data for both genders and the four age classes

Age class	Exposure			Injuries		
	Boys	Girls	Total	Boys	Girls	Total
13 years	9095	2601	11 696	309	102	411
14 years	12 154	4576	16 730	559	210	769
15–16 years	16 945	8163	25 108	640	312	952
17–19 years	6028	3036	9064	175	147	322

## Discussion

The main findings of this prospective cohort study were that there was no difference in the risk of acute injuries overall or acute time-loss injuries between boys and girls playing tournament football on third-generation artificial turf compared with grass. This is the first study to assess the relationship between the turf types and risk of injury in both male and female youth football.

Table 2. Number, incidence, and risk of acute injuries on artificial turf and grass

	Artificial turf		Grass		RR (95% CI)	Adjusted OR (95% CI) <sup>†</sup>
	Injuries	Incidence	Injuries	Incidence		
<i>Injury type</i>						
Contusion	83	13.8 ± 1.5	883	15.6 ± 0.5	0.88 [0.71–1.11]	0.91 [0.69–1.19]
Sprain	6	1.0 ± 0.4	123	2.2 ± 0.2	0.46 [0.20–1.04]	0.52 [0.23–1.18]
Strain	13	2.2 ± 0.6	168	3.0 ± 0.2	0.73 [0.42–1.28]	0.88 [0.50–1.52]
Fracture	2	0.3 ± 0.2	14	0.2 ± 0.1	1.34 [0.31–5.91]	1.31 [0.30–5.78]
Dislocation	1	0.2 ± 0.2	20	0.4 ± 0.1	0.47 [0.06–3.50]	0.47 [0.06–3.49]
Abrasion/laceration	5	0.8 ± 0.4	55	1.0 ± 0.1	0.85 [0.34–2.13]	0.89 [0.36–2.25]
<i>Injury location</i>						
Lower body	116	19.3 ± 1.8	1596	28.2 ± 0.7	0.68 [0.57–0.82]**	0.81 [0.66–1.01]
Foot	25	4.2 ± 0.8	276	4.9 ± 0.3	0.85 [0.57–1.28]	1.05 [0.70–1.58]
Ankle	26	4.3 ± 0.8	476	8.4 ± 0.4	0.51 [0.36–0.76]**	0.59 [0.40–0.88]**
Lower leg	14	2.3 ± 0.6	189	3.3 ± 0.2	0.70 [0.40–1.20]	0.71 [0.41–1.24]
Knee	28	4.6 ± 0.9	314	5.6 ± 0.3	0.84 [0.57–1.23]	0.96 [0.65–1.42]
Thigh	12	2.0 ± 0.6	236	4.2 ± 0.3	0.48 [0.27–0.85]*	0.69 [0.41–1.15]
Hip	4	0.7 ± 0.3	48	0.8 ± 0.1	0.78 [0.28–2.17]	0.99 [0.39–2.50]
Groin	7	1.2 ± 0.4	57	1.0 ± 0.1	1.15 [0.53–2.53]	0.85 [0.34–2.13]
Upper body	88	14.6 ± 1.6	601	10.6 ± 0.4	1.38 [1.10–1.72]**	1.23 [0.93–1.61]
Back/spine	18	3.0 ± 0.7	76	1.3 ± 0.2	2.23 [1.33–3.72]**	1.92 [1.10–3.36]*
Stomach/chest	10	1.7 ± 0.5	108	1.9 ± 0.2	0.87 [0.46–1.66]	1.02 [0.54–1.90]
Arm/hand/fingers	11	1.8 ± 0.6	65	1.1 ± 0.1	1.59 [0.84–3.01]	1.16 [0.62–2.18]
Shoulder includes clavicle	7	1.2 ± 0.4	29	0.5 ± 0.1	2.27 [0.99–5.18]	2.32 [1.01–5.31]*
Neck	4	0.7 ± 0.3	53	0.9 ± 0.1	0.71 [0.26–1.96]	2.19 [0.83–5.80]
Head	38	6.3 ± 1.0	270	4.8 ± 0.3	1.32 [0.94–1.86]	1.23 [0.84–1.80]
<i>Severity</i>						
Minimal injuries (1–3 days)	17	2.8 ± 0.7	150	2.7 ± 0.2	1.07 [0.65–1.76]	1.12 [0.66–1.89]
Mild injuries (4–7 days)	6	1.0 ± 0.4	39	0.7 ± 0.1	1.45 [0.61–3.41]	1.50 [0.63–3.56]
Moderate injuries (8–28 days)	1	0.2 ± 0.2	37	0.7 ± 0.1	0.25 [0.04–1.85]	0.28 [0.04–2.05]
Severe injuries (> 28 days)	1	0.2 ± 0.2	21	0.4 ± 0.1	0.45 [0.06–3.33]	0.49 [0.07–3.69]

\* $P < 0.05$ , \*\* $P < 0.01$ .

<sup>†</sup>Adjusted for age and gender.

RR, relative risk; CI, confidence intervals; OR, odds ratio.

The main results are consistent with the conclusions in previous studies evaluating the risk of injury on third-generation artificial turfs and grass in male elite players (Ekstrand et al., 2006), male and female college players (Fuller et al., 2007a, b), 14–16-year-old female players (Steffen et al., 2007), and 12–17-year-old male players (Aoki et al., 2010). The only significant difference in injury pattern in the current study was a lower risk of ankle injuries on artificial turf and a higher risk of back and spine injuries, as well as injuries to the shoulder and clavicle. However, interpretation of these differences in injury pattern should be made with caution. The comparison of injury incidences between surfaces for specific injury subgroups is restricted by small numbers, and the possibility of type II error resulting from limited data must be considered. Furthermore, 43% of the injuries were recorded with missing injury mechanism data (data not shown), indicating that the coaches must have found this difficult to determine. Hence, considering the low validity of the injury mechanism data, further analyses were omitted.

The two main factors involved in surface-related football injuries are the friction between the surface and the shoe and the stiffness of the surface (Nigg & Yeadon, 1987). Although the grass fields in Norway Cup are mowed before the start of the tournament, they are often characterized by a soft, but uneven surface. Such rough field conditions can play a role in an injury mechanism for ankle sprains, which may explain the increased risk of ankle injuries found on grass. Contrary, Ekstrand et al. (2006) found that elite male players had a higher risk of ankle injuries on artificial turf. However, the grass fields in professional football are assumedly of much higher standard than the grass fields in this youth amateur football tournament.

Minor abrasions and friction burns have been reported to be more common on artificial turf, albeit on older generations (Winterbottom, 1985; Nigg & Segesser, 1988; Ekstrand & Nigg, 1989; Gaulrapp et al., 1999). However, using the broad injury definition we could examine this, and our findings indicate that such injuries were not a problem with the new generation of artificial turfs. Furthermore, it should be noted that although “third-generation artificial turf” is the collective term for the latest artificial surfaces, there are several manufacturers who deliver various brands of artificial turfs. The brands may have dissimilar surface stiffness and friction, depending on the fiber length and thickness, the type and amount of rubber granules, and whether an optional shock-absorbing rubber pad is molded underneath the surface.

A strength of the study is that it spanned across four consecutive tournaments from 2005 to 2008, including almost 8000 matches and more than 60 000

match hours. Furthermore, the time span of our data collection minimized the risk of biased results with respect to the playing fields being influenced by a certain weather condition. Throughout the four tournaments, the players played both on soft and slippery surfaces resulting from rain, as well as on harder surfaces with more friction resulting from sun and dry weather conditions.

The number of matches played during the Norway Cup tournament (almost 2000 11-a-side matches played in less than a week) makes it difficult to survey the injury frequency strictly using medically trained personnel. The main limitation of the study is that the data collection depended on the coaches and the referees. Although they received information detailing the injury recording procedures, they were not medically trained to ensure good validity and reliability in determining the presence of injury, let alone determining the diagnosis and prognosis. The results concerning the type and severity of injury must therefore be interpreted with caution. Furthermore, when studying epidemiology or etiology of football injuries the time loss definition of injury is most commonly used. However, we used the broader definition of injury from the consensus statement, which includes all painful conditions or physical complaints irrespective of the need for medical attention or time loss from football activities (Fuller et al., 2006). A limitation of this definition is that it will include a number of physical complaints and bodily conditions that may not result in significant negative consequences for the player. Even so, in the current study this definition was likely to provide better reliability in the data collection, compared with using the time loss definition, which would rely on the coaches' ability to estimate whether an injury would lead to absence from training and matches.

To examine to which degree the coaches recorded all occurring injuries according to the injury definition, we conducted a compliance study in the 2005 tournament. Three physicians from our research center observed and recorded all physical complaints and other events possibly related to injury in 49 randomly selected matches. In cases where it was difficult to ascertain whether an injury had occurred, the physician contacted and interviewed the respective player immediately after the match. The results showed that the coaches recorded less than half of the injuries that occurred (data not shown). With respect to internal validity, however, we could not detect any systematic errors in the coaches' recording of injuries on the two turf types.

In conclusion, there was no difference in the overall rate of acute injury among boys and girls playing on third-generation artificial turf compared with grass.

### Perspectives

The current study supports the findings in previous studies addressing the risk of injury on artificial turf and grass in football. Although there are some conflicting results regarding subgroups of injuries, the overall risk of acute injury appears to be similar on the two surfaces. However, the significance of artificial turf in the etiology of overuse injuries is still uncertain. For instance, it has been speculated that higher ground stiffness in particular can have an influence on overuse injuries (Hort, 1977; Ekstrand & Nigg, 1989). Furthermore, in Norway Cup all teams play on both artificial turf and grass, and continuously switch between the two surfaces. Studies assessing the injury risk on previous generations of artificial turf have discussed whether players' lack of adaptation to a surface and rapid changes between different types of playing surfaces is a precursor to overuse injury, such as lower limb and lower back pain (Ekstrand & Gillquist, 1983; Engebretsen & Kase, 1987; Ekstrand & Nigg, 1989; Hagel et al., 2003). However, such theories are hard to test in epidemiological studies using the traditional methodology to record injuries. By definition, overuse injuries occur over time with a gradual onset, and the traditional study design and methodology does not allow for attribution of overuse injury to a specific event or a particular turf type. Even if a player first experience symptoms during a specific match, the injury may have gradually been incurred as a result of long-term exposure to another turf type, rapid changes between different turf types, or other factors. To investigate whether overuse injuries are associated with a specific turf type, the ideal design would be a randomized controlled trial where

players are randomized to train and play matches exclusively on either artificial turf or grass. For practical reasons, such a study is not feasible and will probably never occur. A more realistic approach would be to compare teams training and playing their home matches on artificial turf to teams who mainly train and play on grass (Ekstrand et al., 2006; Aoki et al., 2010). In planning new studies, one should in any case consider adopting novel methodology developed to record and quantify the risk and severity of overuse injuries in sport (Bahr, 2009). Through more advanced statistical modeling, it may also be possible to detect if there is an increased injury risk associated with rapid switches in playing surface.

**Key words:** risk factors, surface, injures, adolescence, hardness, friction.

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