

Safety of third-generation artificial turf in male elite professional soccer players in Italian major league

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Accepted for publication 11 January 2016

Our hypothesis is that there are no difference in the injury incidence on artificial turf and natural grass. During the 2011/2012 season, we recorded injuries which occurred to two Italian stadiums equipped with third-generation artificial turf during 36 games (391 players). Data were compared with the injuries which occurred in the same season in two stadiums equipped with natural grass (372 players). We recorded 43 injuries during the playing time (16.7 per 1000 h). About 23 (18.1 per 1000 h) injuries occurred on artificial turf, while 20 (15.2 per 1000 h) on

the natural grass with no statistical differences $P > 0.05$. We recorded 10 (7.87 per 1000 h) contact and 13 (10.23 per 1000 h) non-contact injuries on artificial turf, while 5 (3.8 per 1000 h) contact and 15 (11.4 per 1000 h) non-contact injuries on natural grass $P > 0.05$. The overall relative risk was 1.15; 95% CI: 0.64–2.07). Our study demonstrates a substantial equivalence in injury risk on natural grass and artificial turf in elite professional soccer athletes during official matches.

Soccer is the most popular sport in Italy with 1 108 479 registered players: 14 476 professional players (1%), 474 493 amateur players (43%), and 619 510 players of the youth leagues (56%). According to the Federation International de Football Association (FIFA), there were more than 200 000 professional soccer players and 265 million registered amateur players in the world.

Despite the perception that soccer is a safe sport, it has been characterized as high-risk activity, with several authors reporting that one player will suffer an ACL injury every second season in a professional men's football team (Backx et al., 1991; Junge et al., 2006; Ekstrand et al., 2011a, b; Waldén et al., 2015).

In recent years interest has grown about the various risk factors for injuries and in particular on playing surfaces. Natural grass is the traditional soccer playing surface for professional competition and training, but artificial turf have been increasingly used because they have some advantages: longer playing hours, lower maintenance costs, better resilience to climatic conditions, and multipurpose application compared to traditional fields (Fuller et al., 2007a, b).

The first artificial turf in a soccer stadium was introduced in Sweden in 1975 (Ekstrand et al., 2006). However, playing football on first and second

generation artificial turf had the disadvantage of a distorted bounce and roll of the ball and the risk of injury was greater (Arnason et al., 1996). In 1990s, this negative experience led to the development of a new generation of synthetic surface: the third generation. The aim of this new generation type was to duplicate the playing features of natural grass. It was composed of long (40 mm) and much more widely spread fibers of polypropylene or polyethylene filled with graded silica sand and cryogenically ground rubber granules (Arnason et al., 1996; Meyers, 2010).

From their introduction to their official approval by FIFA in 2004 the third-generation artificial turf were studied from some authors in order to define their safety in youth competitions and professional leagues with no major differences in the incidence, severity, nature, or cause of match injuries sustained on new generation artificial turf and grass (Fuller et al., 2007a, b; Drago et al., 2013).

Despite the advantages of artificial turf for match play also by elite professional teams emerged from previous studies, their usage has been limited because of negative opinions related to older types of artificial turf, continuing subjective perception that more injuries occur on artificial turf than on grass and change of playing style on artificial turf compared with natural grass, with more possession play and

less aggressive defensive play (Fuller et al., 2007a, b; Andersson et al., 2008).

The objective of this investigation was to better understand the injury risk of artificial turf for playing soccer in Southern European countries.

The aim of this study was to investigate the risk of acute injuries in professional soccer players in Italian major league (Serie A) on third-generation artificial turf compared with natural grass.

Our hypothesis is that there are no difference in the injury incidence on artificial turf and natural grass.

Materials and methods

Study population

The study population included all players of the first division professional Italian national soccer league (Serie A). The present study includes data from the entire 2011/2012 season (August 2011 to June 2012).

Injuries recorded occurred during the official matches played in two stadia whose field was equipped with artificial turf (all artificial turfs were FIFA-certified) (391 players) and compared with injuries occurred during the official matches played in other two stadium equipped with natural turf (372 players). During the season 2011/2012, only two teams of the Italian soccer league were equipped with third-generation artificial turf during 36 games played on synthetic field. We chose 36 games played on natural grass for the control group. In order to limit the variability of climatic condition, we selected two teams that played their home games in stadium with natural grass geographically close to those of the study group.

In order to avoid bias we chose teams that in the season 2011/2012 did not take a part in European competitions, in fact the midweek matches and the continuous away games could influence the injury incidence. Anthropometric features were similar between the groups as shown in Table 1.

Data collection

The data were collected and compared with the injuries occurred in the same season in two very geographically closed stadium equipped with natural grass, selected in order to avoid possible influence on injuries of different climatic conditions. Data were collected by video analysis and medical staff records. Video analysis was performed through the TV video records of the matches studied, each match was recorded from a minimum of 10 to a maximum of 14 cameras with the following minimum quality requirements: video 16:9 HD 1080i; audio Audio Stereo 2.0 and Multichannel 5.1 (Padulo et al., 2013, 2014, 2015).

Table 1. Anthropometric data

| | Artificial turf | Natural grass |
|--------|------------------|------------------|
| Number | 391 players | 372 players |
| Weight | 76.7 ± 4.6 kg | 77.8 ± 5.1 kg |
| Height | 181.8 ± 5.7 cm | 179.9 ± 5.6 cm |
| BMI | 23.2 ± 0.3 | 23.5 ± 0.2 |
| Age | 27.5 ± 6.6 years | 26.9 ± 7.2 years |

This table shows the Anthropometric features of two groups. There was no difference between groups.

The injury recording involved the match reports drawn after each competition. Immediately after the match, the examiner collected the injury forms according to the UEFA model (Hägglund et al., 2005) and reported them into a database.

The day after tournament started all the injuries were discussed in a plenary meeting where we described the injury mechanism in order to identify the correct mechanism.

We recorded the anatomic location, type, severity, and cause (acute/overuse; contact/non-contact) of injury. Indirect contact injuries were recorded among non-contact injuries. We added the team names and the unique match ID, which allowed for subsequent data extraction, as well as the playing field 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 obtained. The study protocol was approved by the Local Ethics and Experimental Research Committee and it met the requirements of the Declaration of Helsinki. We did not include injuries or other medical conditions occurring outside Serie A 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 their injury incidence was excluded from our study. The injury recording method did not allow for any assessment of injury exacerbations or recurrences.

Definitions

A recordable injury was defined according to the UEFA model as sprain, strain, contusion, and concussion and as contact and non-contact.

Moreover, it was recorded if injury resulting from match play leading to a player being unable to take full part in match play at any time after the injury. In fact we defined as injury: "any physical complaint sustained by a player during a football match that prevented the player from taking a full part in training or match play activities for one or more days beyond the day of injury" (Fuller et al., 2006). Incidence of injuries was expressed as the number of injuries per 1000 h of participation.

Statistical analysis

All the data were analyzed by an individual researcher. The verification of the normality and homogeneity of the variances was assumed by means of the Kolmogorov-Smirnov test and the Leven's statistic, respectively. The probability of developing injury within a specified period of time was calculated as incidence rate (IR) that was recorded as the number of injuries per 1000 player hours of match exposure. Incidence rate ratio (IRR) was used to compare the incidence rates between artificial turf and natural grass.

The comparison between the probability of injury occurring in artificial turf and in natural grass according to the overall players was calculated as relative risk (RR) of incidence. One-way analysis of variance (ANOVA) test was used to measure the effects of artificial turf and natural grass as time × interaction.

All the analyses were conducted using the MedCalc version 10.2.0.0 for Windows. Differences with *P*-values ≤0.05 were

considered to be statistically significant, and all results were expressed with a 95% confidence interval.

A *post hoc* power analysis was performed using G*Power 3 software (Heinrich-Heine-University, Dusseldorf, Germany) according to the incidence rates between artificial turf and natural grass. Assuming: (i) $\alpha = 0.05$, (ii) IR = 18.1 (artificial turf), (iii) IR = 15.2 (natural grass), we determined β value of 0.20 with a study power of 80%.

Results

Exposure

A total of 2580 h of exposure were recorded during the study, 1270 on artificial turf (49.2%), 1310 on natural grass (50.8%) were recorded during the 2011/2012 season of first division professional Italian national soccer league.

Injury pattern

We registered a total of 43 injuries (16.7 per 1000 h) of which 23 (18.1 per 1000 h) injuries on artificial turf (53.5%) and 20 (15.2 per 1000 h) on natural grass (46.5%). In the artificial turf, we recorded 10 (7.87 per 1000 h) contact injuries (43.5%) and 13 (10.23 per 1000 h) non-contact injuries (56.5%), while in the natural grass we observed 5 (3.8 per 1000 h) contact injuries (35%) and 15 (11.4 per 1000 h) non-contact injuries (65%) (Table 2). Muscle strain was the most common injury (62.7%): 13 (10.23 per 1000 h) on artificial turf (30.2%) and 14 (10.69 per 1000 h) on natural grass (32.5%); only one (0.76 per 1000 h) severe knee sprain (ACL injury) was observed on natural grass (Table 3).

The overall injury IRs were 1.8% (CI 95%: 0.01148–0.02717) and 1.5% (CI 95%: 0.00933–0.02358) on artificial turf and natural grass, respectively. There were no significant difference in the overall risk injury between grass and artificial turf [IRR = 1.18 (CI 95%: 0.623–2.2771), Fisher value = 2.65, $P = 0.576$].

Moreover, there was no significant difference in overall risk injury between artificial turf and in natural grass [RR 1.15 (95% CI: 0.64–2.07) $z = 0.494$, $P = 0.621$].

The mean [standard deviation (SD)] minutes of the match loss by injured players on artificial and grass turf were 50.73 (22.55) and 51.5 (26.68), respectively ($P = 0.92$).

Table 2. Type of injury

| | Artificial turf | Natural grass |
|-------------|------------------|-----------------|
| Contact | 7.87 per 1000 h | 3.8 per 1000 h |
| Non-contact | 10.23 per 1000 h | 11.4 per 1000 h |

We recorded 7.87 per 1000 h contact and 10.23 per 1000 non-contact injuries on artificial turf, while we recorded 3.8 per 1000 h contact and 11.4 per 1000 h non-contact injuries on natural grass.

Table 3. Traumatic injury

| | Artificial turf | Natural grass |
|-------------|------------------|------------------|
| Sprain | / | 0.76 per 1000 h |
| Strain | 10.23 per 1000 h | 10.69 per 1000 h |
| Contusion | 4.72 per 1000 h | 0.76 per 1000 h |
| Fracture | / | / |
| Dislocation | / | / |
| Other | 3.15 per 1000 h | 3 per 1000 h |

In this table are reported the traumatic injuries recorded in our study according to the UEFA model (Hägglund et al., 2005).

Discussion

There is growing interest at all levels of soccer in new generation artificial turf surfaces that use synthetic materials. In fact artificial turf surfaces have some benefits compared with grass in countries where the climatic conditions are unsuitable for the installation and maintenance of good quality grass field. Moreover, the newest fields closely reflect the performance characteristics of grass, which led the FIFA to approve their use for all matches [FIFA, 2005].

Despite the advantages and although many football teams use them to provide year-round, all-weather training facilities, their use for match play by elite professional teams has been limited because of negative opinions related to older types of artificial turf and the continuing perception that more injuries occur on artificial turf than on grass (Andersson et al., 2008).

Biomechanical studies have generally supported increased frictional force on all types of artificial turf, theoretically increasing the risk of injury relative to natural grass (Torg & Quedenfeld, 1971; Dowling et al., 2010; Drakos et al., 2010).

However, these studies were unable to account for the multiple real-world confounders that athletes encounter, such as temperature, field moisture level, field quality, changes in footwear technology, and encounters with other players (Balazs et al., 2015).

Positive preliminary results from the experiences in youth championships encouraged the FIFA to allow artificial turf during international matches and it was included in the Laws of the game in 2004.

From their introduction in official competitions, authors have evaluated the safety of artificial turf about non-contact playing injuries compared with natural grass. Ekstrand (2006) followed 10 male elite football clubs playing on third-generation artificial turf during three seasons from 2003 to 2005 and showed no difference in overall injury number; however, the ankle and lower extremities injury rate was higher on artificial turf. Fuller (2007a) showed no main differences in injury type and overall risk on between the two surfaces after two season follow-up of college football teams. After following 14- to

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. Meyers (2010) monitored 465 collegiate games in three seasons and showed no difference of injuries between two surfaces and in many cases the artificial turf was safer than natural grass. Despite these advantages their use has been limited because of negative opinions and the continuing perception that more injuries occur on artificial turf than on natural grass.

The principal finding in this study was that the injury risk, for elite players of the main Italian

Championship is not changed significantly when playing football on third-generation artificial turf surfaces compared with playing on natural grass. The overall injury incidences were similar on the two surfaces and the incidences of injury recorded in our study are comparable to other studies of elite level football in Europe (Arnason et al., 1996).

In fact the results confirm that there is no evidence of a greater risk of injury when football was played on artificial turf compared with natural grass. The results show that injury risk on artificial turf is increased of 20% but it is not statistically significance. In our study, there are no major differences between the nature or cause of injuries sustained on artificial turf and grass in male elite football players and suggest that the risks of injury to male elite football players on new generation artificial turf surfaces are not significantly different from the risks experienced on grass.

Results of our study are in accordance with ones of previous studies in elite male football players, but are in contrast with findings of recent studies on athletes of the American Football in which Dragoo et al. (2013) and Hershman et al. (2012) reports a higher incidence of ankle and Anterior Cruciate Ligament injuries on artificial grass. However, the different type of sport with specific pattern of movements on the artificial field could influence the overall injury incidence.

The substantial equivalence of injury rate in elite soccer matches on artificial turf and natural grass could be explained by the maximum playing intensity of the athletes during the matches of the Italian Serie A on both surfaces. In fact, we considered only accidents occurring during the official matches in order to study the unpredictability of the game movements and the sudden changes of direction. In this way, we excluded interruptions typical of the training, the athletic preparation and the exercises for specific athletic movements. Moreover, we compared soccer teams that in the examined season did not take a part at the European international championships with a limitation of the bias due to the numerous matches played during the week and away games.

At our knowledge this study is the first that compared the injury incidence in the artificial fields in professional elite athletes in Southern European countries and the first on the Italian major League (Serie A), even if some studies of the Northern European countries and in United States are present in literature (Arnason et al., 1996; Fuller et al., 2007a, b; Bjørneboe et al., 2010; Meyers, 2010; Ekstrand et al., 2011a, b; Hershman et al., 2012; Dragoo et al., 2013; Balazs et al., 2015). In fact the spread of artificial turf in Southern European countries is still limited and their usage is restricted to amateur competition, because there is still the subjective opinion of many professional players that more injuries occur on artificial field.

However, our study has some limitation. First we have a small study population, because only two clubs of the Italian major Championship played their home matches on the third-generation artificial turf during the last season. Moreover, we did not record the injury incidence during training, but this was our methodological choice. In fact our purpose was to verify the injury incidence during the official matches of the top Italian Championship.

Another limitation is the choice to not record the recurrent injuries. Some authors showed that recurrent injuries cause significantly longer absences than non-recurrent injuries; however, Ekstrand (2011b) demonstrated that their incidence in top-level clubs in Europe is lower than previous studies, because top-level clubs have greater medical support, providing for more personalized rehabilitation of injured players.

Finally, our methodology does not allow to evaluate difference in specific injuries patterns and anatomic locations also due to the small study population.

Despite our study show an increase of 20% in injury incidence in artificial turf, this results are not statistical significant.

Despite the limitations, our results are in line with those of recent authors that demonstrate a substantial equivalence in injury risk on natural grass and artificial turf in elite professional athletes during official matches.

Data of our study confirm the initial hypothesis, but more study could be carried on the Southern European Soccer teams in order to confirm our results.

Brief perspective paragraph

At our knowledge this study is the first that compared the injury incidence in the artificial fields in professional elite athletes in Southern European countries and the first on the Italian major League (Serie A), even if some studies of the Northern European countries and in United States are present in literature (Arnason et al., 1996; Fuller et al., 2007a, b;

Bjørneboe et al., 2010; Meyers, 2010; Ekstrand et al., 2011a, b; Hershman et al., 2012; Dragoo et al., 2013; Balazs et al., 2015).

The results of this study demonstrate that the use of artificial turf is safe even in the Italian football

championship and its use can be effective also in southern European countries.

Key words: Artificial turf, injury risk, sports traumatology.

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