



European Synthetic
Turf Organisation

ESTO MEDICAL AND INJURIES REPORT ON SYNTHETIC TURF AND NATURAL GRASS IN FOOTBALL

INTRODUCTION

The use of synthetic turf for both professional and amateur football is increasing rapidly. Obviously the advantages of synthetic turf such as longer playing hours, lower maintenance costs, better resilience to tough climatic conditions and the multi-purpose application make synthetic turf a valuable alternative to natural grass in most regions of the world.

However when asking football players about their opinion about synthetic turf many are still quite sceptical. One of the main reasons for this lack of acceptance is the prejudice of synthetic turf as causing more injuries and changing the way football is played. The argument of injuries has been true for some of the first and second generation turfs, but manufacturers have reacted and further developed synthetic turf. Third generation synthetic turf is similar to good natural grass in terms of ball behaviour, feel and injury risks. According to Steffen et al. (2007) maintenance routines for synthetic turf have been improved due to the higher usage rates. Further improvements in synthetic turf include better shock absorption systems and underground heating that may attenuate impact forces (Steffen et al., 2007).

In this research paper we will have a closer look on the injury risk comparison between natural grass and synthetic turf. Due to the developments in synthetic turf, studies conducted before 2004 have been excluded from this review.

Different studies that will be considered here found that there is no significant difference of the risk for injury on natural grass compared to synthetic turf.



DEFINITIONS

In order to understand the incidence of injury on synthetic turf and on natural grass some basic definitions have to be discussed. The research paper by Walden, Hägglund and Ekstrand (2005) on injuries in Swedish elite football and the paper by Hägglund, Walden, Bahr and Ekstrand (2005) on the 'UEFA model' for epidemiological study of injuries have been taken as a baseline framework as they provide a clear overview on key definitions and these definitions appear to be the most commonly used.

What is an injury? According to Walden et al. (2005) two basic definitions exist: 1) the time loss injury definition, which considers "any injury occurring during scheduled training sessions or matches causing the player to miss the next training session or match" (Walden et al., 2005:119, based on Ekstrand, 1982). 2) the tissue injury definition takes into account "any tissue damage caused by football regardless of subsequent absence from matches or training sessions" (Walden et al., 2005:119, based on Junge and Dvorak, 2000). A third definition – medical assistance definition – has been added by Hägglund et al. (2005:342), describing an injury that requires medical treatment. All of these definitions have certain advantages and disadvantages but the most important thing is to be consistent in the use of one definition.

For the UEFA studies, it was decided that the time loss definition of injury was suitable for studies at the professional level. Although this definition depends on the frequency of training sessions and matches, the teams at the professional level usually train or compete daily, which minimises the risk of missing less severe injuries. Furthermore, it can be argued that injuries resulting in time lost from training and matches have a substantial impact on the player's health and performance, and also on the performance of the club, and therefore should be recorded. (Hägglund et al., 2005:342)

The next aspect that is crucial in order to compare the severity of injuries on synthetic turf and natural grass is the question of when a player is rehabilitated. Walden et al. (2005:119) recommend to consider a player as "fully rehabilitated when the medical team allowed return to full participation in training sessions or match, but was defined as injured if alternative training was allowed and performed".

Re-injury was defined by Hägglund et al. (2005:343) "as an injury of the same type and location of a previous injury that occurred within two months of the final rehabilitation day of the previous injury".

The differentiation between traumatic injuries – which were caused by acute onset – and overuse injury – which "was defined as a pain syndrome of the musculoskeletal system with insidious onset and without any known trauma or disease that might have given previous symptoms" (Walden et al., 2005:119) – is also important for the understanding of injuries on synthetic turf and natural grass.

According to Walden et al. (2005) the severity of an injury should be classified into slight (a player missing less than 3 days of training and match play), minor (4-7 days), moderate (8-28 days) and major (a player missing more than 28 days of training and match play).

Table 1 shows the classification of traumatic injury types as it has been used by Walden et al. (2005).

Sprain	Acute distraction injury of ligaments or joint capsules
Joint injury	Acute isolated chondral and meniscus lesions
Strain	Acute distraction injury of muscles and tendons
Contusion	Tissue bruise without concomitant injuries classified elsewhere
Fracture	Traumatic break of bone
Dislocation	Partial (subluxation) or complete (luxation) displacement of the bony parts of a joint
Other	Injuries not classified elsewhere. Examples: wound, concussion, etc.

Table 1 (based on Walden et al., 2005:119)

Contact injuries are injuries that result from contact with another player (both from the opponent team and from the own team), while non-contact injuries occur without contact with another player (Soligard et al., 2012:357).

THE UEFA MODEL

In order to ensure comparability between reports not only the definitions need to be clear. The UEFA model developed by the UEFA Medical Committee indicates the design of epidemiological studies as well as the preferred data collection method.

STUDY DESIGN

A prospective cohort design enables the exact measurement of exposure to risk of injury, reduces the risk of recall bias and is more powerful to determine risk factors than a retrospective design (Hägglund et al., 2005:341).

Injury incidence can be expressed, usually as the number of injuries per 1000 hours of participation. Ideally, the exposure record should be individual and based on real exposure time, rather than on an estimate based on attendance during training sessions and matches. (Hägglund et al., 2005:341)

It is also important to include the entire season or several seasons in order to be able to identify risk factors for injury incidence.

DATA COLLECTION

In order to be able to compare the data collected in different studies the UEFA model recommends the use three forms – the baseline form, the exposure registration form and the injury form.

Table 2 provides an overview on the information collected in the different forms.

But who should collect the data? Ideally a member of the medical team should record all information above, meaning that this person needs to be available during all training sessions and matches. To ensure that data is collected in a consistent manner an instruction manual should be prepared including the various definitions, examples of how to fill in the different forms, fictive cases that represent different scenarios in which completing the forms might be difficult (Hägglund et al., 2005:341).

For studies on professional football players all players with a first team contract should be included.

Players with a previous injury should not be excluded. Players with an existing injury at the start of the study should also be included, but that particular injury would not be included in the injury statistics, and the exposure not included until the player is fully cleared for all activities (Hägglund et al., 2005:342)

In case of a player sustaining an end of season injury the player should ideally be followed until rehabilitation. If this is for whatever reason not possible (e.g. the player changes the club) the medical staff should provide an estimated day of return (Hägglund et al., 2005:343).

For players that leave the club during the study the exposure and injury data until the day they leave should be included (Hägglund et al., 2005:343).

Table 2 (based on Hägglund et al., 2005:341)

Form	Data collected
Baseline Form	anthropometric data and previous medical history: age, weight, height, dominant leg, history of previous major injuries and operations can be expanded to include other variables from the preseason evaluation of potential risk factors — training background, playing experience, goniometric measurements, joint laxity measurements, results of fitness tests, player positions
Exposure Registration Form	attendance and individual exposure; weekly or monthly form: all training sessions and matches – individual participation in minutes can be modified – weather conditions, playing surface, information on training content
Injury Form	information about injuries: date of injury, whether the injury occurred during training or match play, the injury type, location, and a measure of injury severity Information about the type and circumstances of injury: contact or non-contact injury, injury mechanisms, playing surface, weather conditions

LITERATURE REVIEW

One of the major studies on incidence, nature and cause of injuries on synthetic turf and natural grass has been conducted by Fuller, Dicke, Corlette and Schmalz. The researchers divided their work into match injuries (Fuller et al., 2007a) and training injuries (Fuller et al., 2007b). They conducted a two-season prospective study of American college and university football teams. For the 2005 season 52 male teams and 64 female teams participated and in 2006 there have been 54 and 72 teams respectively. They found no major difference in the incidence, severity, nature or cause of match and training injuries sustained on new generation synthetic turf and natural grass by either male or female players. Results show that the type and location of injuries might differ according to the surface.

For match injuries:

The three most common injuries on [synthetic] turf for men (ankle lateral ligament complex tear, hamstring tear, concussion) and women (ankle lateral ligament complex tear, concussion and anterior cruciate ligament tear) were the same as those on grass (Fuller et al., 2007a:i22f.)

For training injuries:

For men, the three most common injuries on grass were ankle lateral ligament complex, hamstring and adductor tears while on [synthetic] turf they were ankle lateral ligament complex, quadriceps and adductor tears; for women the three most common injuries on grass were ankle lateral ligament complex, quadriceps and hamstring tears and on [synthetic] turf ankle lateral ligament complex and hamstring tears and concussion (Fuller et al., 2007b:i30)

However the overall conclusion made was, that risks of injury to male and female footballers on synthetic turf are not significantly different from the risks experienced on natural grass.

Ekstrand, Timpka and Hägglund (2006) analysed the risk of injury in elite football played on synthetic turf versus natural grass. They took into consideration 10 elite European clubs – from Sweden, Finland, Norway, Austria, the Netherlands and Scotland - that had installed third generation synthetic turf and teams from the Swedish Premier League playing on natural grass as a control group. In their research they considered injury incidence in training and match play, injury severity and incidences of various injury types. When analysing exposure and injuries of nearly 500 players between February 2003 and January 2005 they did not find any evidence of greater risk of injury when playing on synthetic turf compared to playing on natural grass.

They found that the risk of sustaining an injury during match play was even lower on synthetic turf than on natural grass and also the incidence of lower extremity strains was lower on synthetic turf compared to natural grass (Ekstrand et al., 2006:978).

Soligard, Bahr and Andersen (2012) analysed the injury risk on synthetic turf compared to natural grass in youth football. They considered Norwegian youth teams – both male and female – that took part in Norway Cup tournaments between 2005 and 2008. They found no difference in the overall risk of injury or in the risk of time loss injury, but a lower risk of ankle injuries and a higher risk of back and spine and shoulder and collarbone injuries when playing on synthetic turf. This means that the overall risk of injury was comparable between synthetic turf and natural grass, but that the location and type of injury might differ according to the playing surface.

In their paper from 2010 Børneboe, Bahr and Andersen researched the risk of injury on third-generation synthetic turf in Norwegian professional football. They studied 14 clubs from the Norwegian Tippeligaen between 2004 and 2007 and found no significant difference in injury location, type or severity when comparing synthetic turf and natural grass.

The comparison of studies from different regions should give an indication whether the comparable injury risk between synthetic turf and natural grass is real or whether it is more a 'Scandinavian' phenomenon. Almutawa, Scott, George and Drust (2014) conducted a pilot study among Saudi National Team footballers. They compared the injury data from the Gulf Cup, which took place in December 2010 in Yemen on synthetic turf, with the information retrieved during the Asian Cup, which has been played in January 2011 in Qatar on natural grass. 82 injuries occurred during the Asian Cup and 72 injuries during the Gulf Cup resulting in an incidence rate of 56.1 per 1000h of exposure and 37.9 per 1000h respectively. The incidence rate for training, game and all football exposure injury rates were higher when playing on natural grass compared to synthetic turf.

LITERATURE REVIEW

The authors also speculated about potential reasons for the higher injury incidence on natural grass:

- 1) a study-specific bias due to lower absolute numbers of players, injuries and exposure,
- 2) the fact that the two discrete competitions (Gulf and Asian Cup) had different opponents,
- 3) the Saudi National team was more successful on

synthetic turf (Finalists) compared to grass (did not advance from group stage) thus providing a greater cumulative training and play exposure, and

- 4) the perceived higher status of the Asian Cup on grass may also have led to more competitiveness and injury risk taking behaviours (Almutawa et al., 2014:50)

Table 3 gives an overview about training, game and total player exposure, injury frequency and injury incidence at the Gulf Cup and at the Asian Cup.

Table 3 (Almutawa et al., 2014:49)

Training, game and total player exposure, injury frequency and injury incidence at the Gulf Cup (3G) and Asian Cup (Grass) football tournaments				
	Gulf Cup (3G)		Asian Cup (Grass)	
Players (n)	31		32	
Training sessions (n)	54		48	
Average training duration (min)	64 + 23		54 + 26	
Total training exposure (min)	107,136		82,944	
Training injuries (n) ^a	34	8	47	16
Training injury incidence (per 1000 h exposure) ^a	19.0	4.5	34.1	11.6
Games (n)	7		6	
Average game duration (min)	90		90	
Total game exposure (min)	6930		5940	
Game injuries (n) ^a	38	10	36	10
Game injury incidence (per 1000 h exposure) ^a	329	86.6	363	101
Total exposure (min)	114,066		88,884	
Total injury (n) ^a	72	18	83	26
Total injury incidence (per 1000 h exposure) ^a	37.9	9.5	56.1	17.6

^a Data for injury frequency and incidence is presented in first column to reflect all injuries and in the second column to reflect the smaller number of injuries that lead to players missing game or training time.

The authors concluded that “if anything, the use of [synthetic turf] may slightly reduce the risk for most injuries, although the limited sample size of the current study should be noted” (Almutawa et al., 2014:51).

In her study on collegiate women’s soccer Meyers (2013) found a significantly lower total injury incidence rate and a lower rate of substantial injuries when playing on synthetic turf as compared to natural grass. She analysed female soccer athletes from 13 universities over 5 competitive seasons, comparing synthetic turf and natural grass.

The FIFA U-17 World Championships 2005 in Peru were the first international football tournament to

be played completely on synthetic turf. It took place in five venues – four of them got a new synthetic pitch for the tournament and the fifth has been build new. Already at the FIFA U-17 World Championships 2003 in Finland one venue had been equipped with synthetic turf. In order to address the risk of injuries on synthetic turf compared to natural grass FIFA’s Sports Medical Committee (F-MARC) has compared injury data from the tournament in Peru with data from previous U-17 tournaments.

Very little difference in the incidence, nature and cause of injuries observed during games played on [synthetic] turf compared with those played on grass [has been found] (Fuller, 2006)

LITERATURE REVIEW

Table 4 shows the comparison of incidence and severity of injuries.

Table 4 (Fuller, 2006)

Playing surface	Incidence of injury (No. of injuries/ 1,000 player-hours)	
	All	Time-loss
Natural grass	77	28
Football turf	79	26

Steffen, Andersen and Bahr (2007) analysed the risk of injuries on synthetic turf and natural grass on the case of young female football players. 113 Teams competing in the U-17 league system in the southeast regions of Norway have been studied during the eight-month season in 2005. A total of 2020 players participated in the study, resulting in a total exposure to football of 142,721 hours. The researchers did not find any significant difference in the incidence of acute injuries on synthetic turf compared to natural grass.

Ford, Manson, Evans, Myer, Gwin, Heidt Jr and Hewett (2006) addressed the question of in-shoe foot loading patterns on synthetic turf and natural grass. The researchers found that there are differences in peak pressure and relative load in different parts of the foot depending on the surface and the movement, but generally "when the movements were compared on synthetic turf versus natural grass the total force time integral was not different" (Ford et al., 2006:437).

In 2011 Ekstrand, Hägglund and Fuller published a study in which they compared injuries of male and female football players sustained on synthetic turf and natural grass. They analysed 15 male and 5 female teams playing their home matches on synthetic turf. There was no significant difference in the nature of overuse injuries or in the incidence rate of injuries between synthetic turf and natural grass both for men and for women. Ekstrand et al. (2011) did also find no difference in the body location of injuries.

When analyzing the incidence of injury as a function of injury type, the incidence of muscle rupture/ strains in matches for males were lower on [synthetic] turf than on grass but the difference did not reach significance (Ekstrand et al., 2011:827)

Aoki, Kohno, Fujiya, Kato, Yatabe, Morikawa and Seki (2010) conducted a comparative study on the incidence of injury among adolescent soccer players on synthetic turf and natural grass. They analysed 6 Japan Football Association affiliated teams – two of these using primarily synthetic turf for training, three using primarily natural grass and one team only training on natural grass. As all teams are located in the same district it has been assumed that weather conditions are comparable and therefore can be excluded as confounder for injury incidence. 301 players in the age group between 12 and 17 years participated in this research. Teams were grouped according to the turf they use predominantly (at least 80% of training exposure), resulting in four teams in the 'natural grass' group and two teams in the 'synthetic turf' group.

An interesting finding was that teams in the 'synthetic turf' group spent significantly longer time with training. One reason for this is obviously the higher usability of synthetic turf compared to natural grass.

The longer training hours caused a slightly higher, but not significantly different, rate of chronic pain for the 'synthetic turf' group (Aoki et al., 2010:4). However the researchers could not rule out differences in individual player training hours and physical maturity level that could also explain the chronic pain.

Andersson, Ekblom and Krustrup (2008) addressed movement patterns, technical standards and player impressions of elite footballers comparing synthetic turf and natural grass. In their study they used different methods including video analysis to evaluate movement patterns and technical standards and questionnaires to address player impressions. They found no significant difference between synthetic turf and natural grass in terms of total distance covered, high-intensity running, number of sprints, standing tackles or headers per game. However they found fewer sliding tackles, more short passes and midfield-to-midfield passes on synthetic turf – indicating the change in the play of the game caused by synthetic turf. Even though statistics in movement patterns did not show significant differences players – especially male players – had a negative overall impression of synthetic turf, claiming poorer ball control and greater physical effort. Female players, which were more used to synthetic turf, were rather neutral towards the surface. For them the game in general, the physical strain of the game, the difficulty in making a precise pass, controlling the ball or taking a shot did not differ between surfaces. They reported that it was even easier for them to run with the ball and to pass the ball when playing on synthetic turf (Andersson et al., 2008:118).

LIMITATIONS OF EXISTING RESEARCH

Especially older research studies were limited by their inconsistent design, definitions and data collections, but when applying the UEFA model this problem should be overcome in the future.

Generally it is difficult to isolate the one cause of the injury and the conditions at the same time of injury. Normally an injury results from a combination of factors so it becomes nearly impossible to say with certainty that the surface has some influence. The results have been shown that the incidence of injuries in the majority of cases did not differ significantly between synthetic turf and natural grass, meaning that it was statistically not possible to find a direct connection between the surface and the injury.

The attempts made in the UEFA model by taking down information on weather conditions, surface and the situation in which an injury is sustained is a step to reduce confounders, but especially individual factors such as health of the player cannot be addressed for the individual cases. Other aspects such as adequate shoes for the respective surface on the other hand should be easy to solve.

Another limitation of all studies is the data collection. Even with clear guidelines on how to take down which injury biases cannot be completely avoided. Bjørnboe, Flørenes, Bahr and Andersen (2011) found in a study conducted throughout the 2007 season among players in the Norwegian professional football league that even specially trained medical staff does not report all injuries that occurred correctly. They compared prospective injury registration by medical staff with retrospective interviews with the players and found "that medical staff reports underestimated the incidence of time-loss injuries by 19% for the 3-month study period as a whole" (Bjørnboe et al., 2011:717). On the other hand the researchers also found "that 30% of the injuries registered by the medical staff were not reported by the players, indicating that there is a significant recall bias associated with retrospective player interviews" (Bjørnboe et al., 2011:717). For them "the main challenge with injury surveillance is to get the medical staff to fill out the injury form in the first place" (Bjørnboe et al., 2011:719).

Validity of the research studies is further decreased by the limited sample sizes. Injury incidence is measured in 1000h of football exposure and studies normally get a high enough exposure. The total amount of injuries however is normally not high enough to reach significance levels of $p < 0,05$. This is in particular the case when segmenting injuries by severity, type or location. Therefore it has rarely been possible to find any significant relationship between injuries and a certain surface.

The majority of studies focus on traumatic injuries that result from a specific, identifiable event and can therefore be retraced to a specific situation and playing conditions. Overuse injuries on the other hand are caused by repeated micro-trauma without being able to retrace the injury to a specific situation. Therefore it is in particular difficult to evaluate whether more overuse injuries occur on synthetic turf or on natural grass. This difficulty is further enhanced by the fact that players normally switch between synthetic turf and natural grass from time to time, e.g. when training on one surface and having away matches on the other. Bahr (2009) also emphasizes that the commonly used 'time-loss definition' of injuries might underestimate the risk of overuse injuries as these normally do not result in a player missing training sessions or matches and are often not even treated. It might also be the case that an injury that appears to be traumatic is in reality the consequence of a long-term process, as the player acknowledges the symptoms after a specific event or movement. According to Bahr (2009:967) "repetitive low-grade forces exceeding the tolerance of the tissues cause overuse injuries".

DISCUSSION

What can be said after comparing a huge number of research studies comparing injury incidence on synthetic turf and natural grass is that the risk of obtaining an injury on synthetic turf is not significantly higher than on natural grass. By now a good quality synthetic turf with at least FIFA 1* certification is as good as a natural turf, depending on the quality of the natural turf often even better. The prejudices of obtaining more injuries on synthetic turf are still a leftover from first – and second generation synthetic turfs.

The comparison of injury incidence did not differ significantly for any subgroup – neither related to gender, age group or level of professionalism nor to the region in which football is played. Differences might occur when comparing third generation synthetic turf with first or second generation turf, as the developments within synthetic turf have been tremendous. For this reason research studies dating back before 2004 and therefore analysing cases from before 2000 approximately have been excluded from this research study, even though in many papers the authors have cited older studies where synthetic turf appeared to be more risky than natural grass.

The risk of obtaining an injury did however differ between training sessions and match play, indicating

that during the competitive season training sessions might be less intense and focus more on recovery after matches and/or technical practice before the next match (Walden et al., 2005)

A key finding from the studies analysed in this paper is that the type and location of injuries might differ between synthetic turf and natural grass, even though these findings have also not been statistically significant. A conclusion for players, coaches and physiotherapists should therefore be that prevention of injuries should be adjusted according to the playing surface. This includes among others different types of shoes, duration of training sessions – as usability of synthetic turf is much higher than on natural grass there could be a tendency towards longer training sessions, which could increase the risk of injuries – and also the content of training sessions, as playing football on synthetic turf definitely changes the play from a technical and strategic point of view.

Even with more research being done on specific cases the likelihood for a player to obtain an injury might depend much more on his/her physical condition than on any environmental circumstance. Therefore research should try to identify key factors that foster injuries and these findings should then be applied to every player individual.

CONCLUSION

The existing prejudices of synthetic turf as causing more injuries than natural grass need to be considered as a main reason for player's aversion towards synthetic turf. Especially players that used to play on older generations synthetic turf might be right in this assumption, but diverse case studies have shown that there is no statistical evidence that this prejudice is anyway true. Obviously the opposite might even be the case, meaning that players get less injuries playing on synthetic turf than on natural grass. Probably in a few years, when more players are used to synthetic turf and have experienced that they do not get more injuries, these prejudices will be wiped out.

Even in the studies compared in this paper it became evident that younger generations of football players are much more positive towards synthetic turf as they experienced the benefits of the surface.

For any club or community thinking about replacing old turfs or building up completely new grounds synthetic turf should be a valuable option. The advantages of today's synthetic turf by far outweigh its disadvantages and in particular injury risk does not depend too much on the surface.

It can be concluded that Synthetic Turf keeps defending itself hence the years of scientific research and publications globally. The reality is that there is more scientific literature on synthetic turf than natural grass. What is good natural grass? What is the normal situation of natural grass in professional and amateur football? Should the scientists and experts now focus on comparisons with good natural grass and poor natural grass in football, maybe that is where more injuries occur between the variety of what is natural grass?

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