A review: The difference in lower extremity injury rates when played on natural grass compared to third-generation artificial turf

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Keywords
Injury, Injury rate, lower extremity, sprain, playing surface, artificial turf, third-generation artificial turf, natural grass, grass

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Introduction

Injuries among the athletic population are very common, and they are inevitable regardless of conditioning, training, strength, flexibility, sport, shoe type, etc. With the need to have every bit of cutting edge technology available, competitive athletes go to any extent to break records and become a part of history to become bigger, better, faster, and stronger. Increased occurrence of injury among the collegiate athletic population should be considered and has received a great amount of attention in the medical community. Field surfaces play a very crucial role in the athletic community. Recent development of artificial playing field surfaces have brought very beneficial aspects to the sporting community; eye appeal, low maintenance, and ability to be utilized year round are among these benefits when compared to natural grass surfaces.

Background

Playing field surface is a very vital factor in every sport, and in turn is part of this technological revolution that is being exhibited in modern times. Every type of playing surface plays a crucial role in injury statistics, whether that is court or field. Artificial turf surfaces were introduced as an alternative to grass to increase durability of playing field surface. Artificial turf allows for easy maintenance, an opportunity for playing surfaces in urban environments, and year-round uniformity of surface. However, there are health concerns such as higher injury rates, greater instance of concussion, contractible bacterial and fungal illnesses, and possible carcinogens.

History of Artificial Turf

Artificial turf was developed in South Carolina in the 1960s by David Chaney, who led a group of researchers in developing the first ever artificial turf. However, it was not until the installation of first-generation artificial turf in the Astrodome that made the name Astroturf a household name in 1966. This turf was not the turf we know today however; the first-generation turf was a green carpet with nylon fibers as grass blades. The modern turf that is popular today is third-generation turf. This turf is not comparable to either of the other two generations, and is the most like natural grass having very convincing synthetic polymer grass blades with rubber granules and sand as infill.
Preference and Cost

For the soccer field, the ideal choice for field surface is natural grass, in terms of the feel of the field, impact reduction, and its impact on the body. In a survey carried out by Martinez et al., asked players which field surface they preferred. Players were found to have a preference for natural turf, stating that they felt that there was a higher reduction of impact, between the ball as well as the body, on natural turf compared to artificial turf. Players preferred that ball velocity is slower on natural grass and that the field playing surface has higher comfort, in terms of heat radiation and retention of moisture. These athletes felt that they tended to feel less muscle soreness and injury on natural grass. This survey shows interesting insight into player preference rather than cost or maintenance statistics.

However, in many cases natural grass is either not affordable or not possible. In colder climates or large facilities opt for artificial turf as a field surface. There is research that says artificial turf is more cost effective than
natural grass turf. In a study by McLeod shows that the cost of natural grass compared to artificial turf are similar when looking at the amount installed. However, when looking at the amount of time used artificial turf was less costly by 3.6 times than natural grass turf which included the cost of installing the artificial turf.\(^7\)

**Pros and Cons of Artificial Turf**

Artificial turf is also well liked for its eye appeal, its lack of bare or wears spots; it has an ability to stay green all year long, its ability to stay even, with no sprinklers or holes. Artificial turf is considered low maintenance in terms of cutting and striping fields. However, cons for artificial turf are that it radiates heat and does not have a good natural feel, it must to be disinfected periodically as it carries pathogens, and line markings are permanent therefore, separate fields may be desired for different sports. In comparison, natural grass field surfaces are heavily affected by adverse weather, need extensive maintenance, adequate drainage, shows wear, and requires routine fertilization\(^8\)-\(^11\). However, natural grass is considered to be safer in having a lower incidence of injury due to its ability to give way when needed and the amount of cushion it offers. Therefore, natural grass surfaces are commonly selected over artificial turf by administration.

**Biomechanical and Shoe Interactions**

There are many studies that have investigated what characteristics synthetic turf has to have to be comparable to natural grass. In a study by Dick et al. the study broke down statistically what biomechanical torque goes into soccer and its impact on the turf surface. The study looked at shoe interaction with turf to determine the characteristics that make a synthetic more like a natural surface\(^6\),\(^12\). However, this study did state that routine maintenance, weather conditions, soil type, and moisture retention all play big roles in what type of interaction a body will have on a natural surface. Therefore, these variables cannot be simulated consistently enough to get a very accurate read to prove that these interactions are in fact less hazardous on a natural grass surface.\(^1\)

Collective data from biomechanical research indicates that knee injury rates are influenced by shoe and playing field surface interactions. Drakos et al\(^13\) utilized a cadaver ACL with the assistance of biomechanical force distribution analysis to reproduce the force applied to the ACL during axial loading followed by femoral internal rotation. The authors simulated this mechanism with four combinations of shoe to playing surface interaction: AstroTurf to turf shoe, third-
generation artificial turf to turf shoe, third-generation artificial turf to cleats, and natural grass to cleats. There were significantly lower occurrence of ACL tears with the natural grass and cleat combination (P < 0.05). The authors determined that these findings may indicate the high rate of non-contact ACL tears. These findings have also been supported by other studies that determined that new artificial turf surfaces have higher peak torque and less flexible surface tension.\textsuperscript{14,15}

**Purpose of this Study**

Using University electronic medical records dating from 2011 to 2014, with the assistance of a staff member for data collection and categorization, the purpose of this study is to investigate the following questions:

- Is there a difference in the rate of lower extremity sprains on natural grass compared to third-generation artificial turf?
- Is there a difference in the rate of lower extremity sprains on third-generation artificial turf vs. natural grass between teams (Football vs. Women’s Soccer)?
- Is there a difference in the rate of lower extremity sprains by body part (ankle vs. knee) on third-generation artificial turf vs. natural grass?
- Is there a difference in the rate of lower extremity sprains by competition setting (games vs. practice) on third-generation artificial turf or natural grass?

**Common Lower Extremity Sprains**

Common knee sprains that are to be considered in this research study include sprains to the ACL (Anterior Cruciate Ligament), PCL (Posterior Cruciate Ligament), MCL (Medial Collateral Ligament), LCL (Lateral Collateral Ligament), and tears to the meniscus. Common ankle sprains that are to be considered in this research sample are sprains to the ATF (Anterior Talofibular Ligament), CFL (Calcaneofibular Ligament), PTF (Posterior Talofibular Ligament), Anterior Tibiofibular Ligament, Posterior Tibiofibular Ligament, Deltoid Ligament, and Syndesmotic area. These injuries may be attributed to: increased imposed demands on the body by the athlete; variation in injury trends between sports; and field surface interactions.\textsuperscript{12-18}
Methods & Materials

Data Collection

Using the Healthe Athlete™ injury reporting database from the University, with the assistance of a staff member for data collection and categorization, the occurrence of knee and ankle sprains among football and women’s soccer players over the last three years was evaluated to see if differences occurred when comparing surface type. Inclusion criteria for this study are as follows; subjects must be collegiate athletes, between ages of 18-28 years, with a lower extremity sprain injury, specifically of the knee and ankle. A sprain was defined as an injury to a ligament that resulted in laxity to a particular joint. Categories of interest from the University electronic medical records were: body region, body part, injury type, event location, and surface type. There were no personal identifiers used only details of injury, location, date, and possible field conditions of location. There was no informed consent signed by the athletes to participate in this study due to no personal identifiers being used in this study. Archival data was analyzed by a staff member of the University to determine inclusion criteria, was sorted onto an Excel spreadsheet, then data was generated by the publisher of this study.

The University women’s soccer team plays on a natural grass field during a majority of the fall season, with the exception of a few practices and conditioning days being held on the recreational fields of the University which are a third-generation turf surface. For the spring soccer season, the team plays a majority of practices on the recreational fields due to weather constraints. The University soccer team usually practices midday during a majority of both seasons with exception to practice the day before a game, in these instances the team practices in the evening.

The University football team practices on both a natural grass practice field and a third-generation artificial turf field surface. The team practices an equal amount of time between both the natural grass field and the artificial turf field surface. Games played at the University are played on the third-generation artificial turf surface however, games on field surfaces at competing team locations were poorly recorded and therefore could not be accounted for by the author of this study.

Data Analysis

Data was collected with the help of a representative of Healthe Athlete™ to compile an Excel worksheet of all injuries that have occurred from 2011-2014. The data was then sorted by a University staff member into tables to determine
the frequency with which they occurred. Correlational analyses were performed to
determine relationships between variables (team: football and women’s soccer;
body part: knee and ankle; type of activity: practice and game; and field surface
type: grass and turf) as well as logistic regression to determine if differences were
seen in rate of injuries on the previously described variables.

Results

In the previous three years (2011-2014) for the University football and
women’s soccer teams there was a total of 636 injuries recorded in the medical
records database. Of these injuries, twenty-two were lower extremity sprains that
were included in the calculations of this research study. Of the twenty-two lower
extremity knee and ankle sprains that occurred nine (40.9%) happened on natural
grass surfaces and thirteen (59.1%) happened on third-generation artificial turf
surfaces.

Variability by Team

When identifying whether there was differences in the rate of injuries for
football compared to women’s soccer players on a natural grass surface and an
artificial turf surface there was a relationship between the team and the field
surface type (natural grass and artificial turf) \( p=0.012 \). In this sample, there was a
significant difference between rate of injuries between teams (football and
women’s soccer) on field surface type \( (p=0.022) \). On the women’s soccer team
there was a total of 8 (36.4%) lower extremity sprains that occurred, of those eight
injuries, 6 happened on grass, and 2 happened on artificial turf. The football team
had a total of 14 injuries that occurred (63.6%), of those fourteen, 3 were on grass
and 11 were on artificial turf. Tables 1 & 2 correspond with this data set.

<table>
<thead>
<tr>
<th></th>
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<th>Ankle</th>
<th>Total</th>
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<td>6</td>
<td>8</td>
</tr>
<tr>
<td>FB</td>
<td>9</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>11</td>
<td>22</td>
</tr>
</tbody>
</table>

Table 1  Number of Injuries  Team X Body Part
Variability by Body Part

Of the two types of sprains, there were an equal number of ankle injuries (50%) as knee injuries (50%). However, there was a negative correlation ($r = -0.462$) between knee and ankle sprains between field surface types ($p=0.030$). Calculations for logistic regression suggest that there was a difference in the rate of injuries between knee and ankle on the two field surface types ($p=0.039$). There were 9 injuries that occurred on grass, 2 were injuries to the knee, 7 were ankle injuries. Artificial turf had a total of 13 injuries, 9 knee injuries, 4 ankle injuries. The women’s soccer team accounted for 2 of the knee injuries and 6 of the ankle injuries. Nine knee injuries and 5 ankle injuries were with football. Tables 3 & 4 correspond with this data set.
Variability in Competition

When analyzing a relationship between injury rates on natural grass and artificial turf between practice and games, there was no relationship between the field surface type and the competition setting \((p=0.081)\). Calculations for logistic regression suggest that there was no difference between practice and games on the given field surface types \((p=0.085)\). Women’s soccer had a total of 4 injuries in practice and 1 injury in a game, however, football had 3 injuries in practice and 7 injured in games. There were an equal amount of knee and ankle injuries sustained in the competition, 5 in practice and 5 in games for both football and women’s soccer, however, there was 2 knee injuries that occurred during practice sessions and 3 ankle injuries during games. When compared directly to field surface type there were 5 injuries that were sustained in practice and 2 in games on a natural grass surface type. There were 2 injuries that occurred during practice sessions and 6 injuries that occurred during a game on third-generation artificial turf. Tables 5 & 6 correspond with this data set.

<table>
<thead>
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</thead>
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<tr>
<td>Ankle</td>
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—Table 4 Number of Injuries Body Part X Competition Setting

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<tr>
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</thead>
<tbody>
<tr>
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<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Football</td>
<td>3</td>
<td>7</td>
<td>10</td>
</tr>
</tbody>
</table>

—Table 5 Number of Injuries Team X Competition Setting
Discussion

The primary focus of this study was to determine whether there was a difference in lower extremity sprains on two field surface types (natural grass & artificial turf), this comparison was extended to determine whether there is a difference in the rate of sprains between teams (Women’s Soccer & Football), body part (ankle & knee), and competition setting (practice & games) on the given field surface type. There was found to be a significant difference between the rate of injury by team on the field surface type ($p=0.022$). Football had a total of 11 sprains on third-generation artificial turf compared to 6 total sprains for Women’s Soccer on natural grass. This indicates that there is a greater risk for lower extremity sprain for football players on artificial turf than grass. However, there is a higher incidence for lower extremity sprain for Women’s Soccer players on natural grass playing field surfaces. Although football practices on both natural grass and third-generation artificial turf equally as determined by expert opinion, there was a higher incidence for injury on third-generation artificial turf. However, Women’s Soccer player hours on the given field surface type was not calculated and, therefore, should not be regarded as evidence. These results are also consistent with current literary findings.

Hershman et al. used the National Football League from 2000-2009 on 2680 games played on both artificial turf and natural grass used player hours to determine whether there was a significant difference in the rate of injury between the two playing field surfaces. The researchers determined that ACL sprains occurred 67% more often on third-generation artificial turf than on natural grass incidence rate = 1.67. Eversion ankle sprains occurred at an incidence rate of 1.31 which equates to 31% more often on third-generation artificial turf than natural grass.

Steffen et al. collected data from 109 teams to determine if there is a difference in the rate of injury on natural grass compared to third-generation

<table>
<thead>
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<th></th>
<th>Grass</th>
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<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practice</td>
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<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Game</td>
<td>2</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>8</td>
<td>15</td>
</tr>
</tbody>
</table>

-Table 6 Number of Injuries  Competition Setting X Surface Type-
artificial turf, this data showed conflicting evidence as data collected in this study. The author determined that there was little difference in the rate of injury when playing on playing on third-generation artificial turf compared to natural grass.\textsuperscript{17} However, Fuller et al. found that there was an increased incidence rate of 3.00 on third-generation artificial turf and 4.21 on grass. Although, this study also goes on the say that there is not significant enough data to determine whether or not third-generation artificial turf has an increased risk of injury than on natural grass.

In a study of NCAA, athletes determined that men had a greater instance of injury on artificial turf for lateral ankle sprains per 1000 player hours. However, women had a higher occurrence for lateral ankle sprains on natural grass per 1000 play hours.\textsuperscript{12} This sample corresponds with the findings of this study. Although the males accounted for in this sample were soccer players this instance is remarkable seeing as there was a similar occurrence in the results of this research study. These similar findings could be due to differences in biomechanics between males and females. However, making a conclusion was difficult seeing as there was no inclusion of biomechanics in this study sample.

Shoe-surface interaction was not accounted for in this study and was a variable that could potentially have a great impact on this these results. Although, there are specific cleats that should be worn for a given field surface type, the University does not exercise this practice. In expert opinion there were instances where the field surface type was changed, however, no shoe interaction variable was altered and therefore, may have impacted the results of this study.

There was found to be a significant difference between knee and ankle sprains on the different field surface types, with 9 knee sprains occurring on third-generation artificial turf and 7 ankle injuries on natural grass ($p=.039$). These results indicate that there was a significant difference in the rate that a given body part was injured on one field surface type compared to the other. There is literature that corresponds with the findings of this research article. Soligard et al. collected data from 60,000 players in four consecutive years in the Norway Cup tournament which included male and female soccer players. The researchers found that ankle injuries occurred at a rate of almost 50% higher on third-generation artificial turf than on natural grass. Of 502 total ankle injuries that occurred 476 involved natural grass surface types, 26 were on third-generation artificial turf. Incidence rates for this sample were 8.4 and 4.3 respectively, this evidence concludes that there is a difference in the rate of ankle injuries on artificial turf compared to natural grass.\textsuperscript{18} However, current research on the difference in the rate of knee injury rates on artificial turf compared to natural grass is inconsistent and needs to be further researched in order to make a solid determination.
This sample indicates that there is a difference in the body part and the field surface type. Possible variables that were not accounted for were biomechanics, field surface tension, and shoe-surface interactions. These variables have a large impact on this data, however, would need extensive research to simulate these types of variables for the population given. Environmental factors are nearly impossible to manipulate. Therefore, simulation of this particular variable may not be reasonable.

There was no difference between the rate of injuries in a given competition setting and field surface type \( (p=.085) \). There was a total of 15 injuries that were recorded with a competition setting, of those natural grass accounted for 5 practice injuries and 2 game injuries. Artificial turf tallied 2 practice injuries and 6 game injuries. The University Football team plays all home games on an artificial turf playing surface. Due to strict inclusion criteria, the sampling size was limited; therefore, inferences to be made in regards to a population to generalize this sample are limited.

**Conclusion**

Since its development in the early 1960s, artificial turf has made drastic changes in composition. These changes have played a crucial role in the rate of injuries that have occurred in this field playing surface type. Earlier versions of artificial turf have been proven to have a higher rate of injury compared to natural grass, this statistic is due to the low pile carpet like fibers and lack of infill that are present in modern turf. Third-generation artificial turf is rapidly gaining popularity throughout the world; this is due to its easy maintenance, eye appeal, and less fear of hazards. It has even been found to be a more cost-effective way to provide a functional recreational area without the upkeep. Although grass is more traditional, it succumbs so weather and has to have routine water and clipping to look presentable.

This study compared the rate of lower extremity sprains taken using a medical record database utilizing records from the University Women’s Soccer and Football teams over a span of 3 years (2011-2014). This data was then used to determine whether there is a difference in lower extremity sprains on the two surface types (third-generation artificial turf vs. natural grass). These results were then extended out to determine whether there was a difference in sprains between teams (Women’s Soccer vs. Football), body part (ankle vs. knee), and competition setting (practice vs. game).

There was found to be a significant difference in the rate of lower extremity sprains between teams and the different field surface types. This data shows that there is a higher occurrence of sprains for Football on artificial turf.
Therefore, it is advised that a lower extremity rehabilitation program may be implemented for football teams who are utilizing third-generation artificial turf as a playing field surface. However, a possible rehabilitation program for Women’s Soccer may be advised when natural grass is utilized as a playing field surface, as a preventative approach. Although these instances of injury may be from another cause, biomechanics or shoe-surface interactions, these variables were not included in this research study and should be examined further.

There was found to be a significant difference between knee and ankle sprains on the different field surface types. Third-generation artificial turf is the common variable in 9 knee sprains, and natural grass is the common variable in 7 ankle sprains. This statistic may be due to; biomechanical differences and force distribution in individuals, surface tension, and shoe-surface interaction. However, these variables were not included in this research study and a follow-up should be completed for further results. Consequently, the strict inclusion criteria used to determine the rate of injury by competition setting led to limited sampling of this data set. As a result, the inferences in regards to generalization are limited. Therefore, teams utilizing third-generation artificial turf and natural grass as a playing field surface should implement rehabilitation techniques as a preventative measure, including proprioceptive exercises, stretching, and strengthening exercises to lower the risk of knee and ankle sprains respectively.
References


