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Research Article

Artificial Turf Injuries: A National Database Study

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Abstract

This study reports the demographics and epidemiology of artificial turf-related injuries resulting in emergency room visits between 2013 and 2022 using the NEISS database. A total of 503 injuries were reported, with the majority in males during sports activities. The most frequently affected body part was the head (36%), and the three most common diagnoses included 88 internal injuries (17%), 88 concussion (17%), and 81 fracture (16%). Concussion was the most common injury related to sport activities. Males were more likely to be diagnosed with fractures, lacerations, foreign bodies, and dislocations while females were more likely to be diagnosed with internal injuries, concussions, contusions, sprains/strains, and dermatitis/conjunctivitis.

Keywords: Orthopaedic injuries; Artificial turf; Epidemiology; Head injury, Safety

Introduction

Artificial turf (AT) was first introduced as an alternative to grass in the mid-1960s and gained popularity in the 70s and 80s due to its easy maintenance [1-4]. The original AT sports fields were made from nylon fibers and criticized for their abrasiveness [1-3]. However, many schools and universities adopted AT due to its low maintenance, all-weather availability, and cost-effectiveness [1,3].

The introduction of Astroturf® (1965) limited the abrasiveness of the field by adding polypropylene or polyethylene connected to a backing material and provided a more grass-like appearance, however, shock absorption and hardness still remained a concern [1,3,4]. Second generation AT, introduced in the 1980's, fields integrated longer fibers to reduce abrasiveness and increase shock absorption [1,4]. Third generation AT fields were introduced in 2000 and featured softer polyethylene and polypropylene fibers and the integration of rubber granules and/or sand to provide better cushion and traction [1-4].

Third-generation fields are the standard for current AT fields, although Hybrid fields, a combination of natural lawn grass with reinforcing synthetic fibers, are environmentally friendly and currently the standard for AT fields [1,4]. Hybrid fields offer the 'feel' of natural grass and the durability of AT [1,4]. Current research efforts are focused on improvements in turf safety and performance [1].

Regardless of these efforts, the majority of articles cite AT as an important culprit for injuries. Their principal factors argued to be associated with AT injuries include surface hardness, lack of shock absorption, friction and abrasiveness, surface temperature, bacterial growth, surface irregularities, surface overuse, and lack of player adaptation [1,5-9].

Many of the cited injuries that athletes sustain on AT are significant season-ending injuries or injuries that can have long-term consequences [1,8,10,11]. Concussions, pulled hamstrings, anterior cruciate ligament (ACL), and other ligamentous injuries have been demonstrated to have a higher prevalence on AT [1,7-11]. AT related injuries can have life-changing effects for young athletes due to time away from school and setbacks in education due to physical impairment or altered cognitive function in the case of concussions [12-14]. The risks are equally as great for professional athletes who that have dedicated their lives to professional sports.

This study investigated AT injuries that occurred between 2013 to 2022 using the National Electronic Injury Surveillance System (NEISS) database and resulted in emergency room visits.

Methods

The National Electronic Injury Surveillance System (NEISS) database was interrogated for injuries associated with AT associated injuries that occurred between 2013 and 2022 [15]. The NEISS database is managed by the United States Consumer Product Safety Commission (CPSC: www.cpsc.gov) and is a statistically validated injury surveillance system that collects and reports national emergency department visits linked to consumer products (in this case AT) or toxicities [15].

Data collected by NEISS includes parameters such as year of injury, age at the time of injury, diagnosis, affected body part, mechanism of injury, product involved, admission status, and other demographic information. This study highlights epidemiological and demographic information of AT-related injuries and included age, race, location of injury, body part injured, diagnosis, and admission status.

The NEISS system gathers data from over 100 hospitals within the United States that have at least six beds and twenty-four-hour emergency department services [15]. These 100 hospitals serve as a stratified sample of the overall population and can be used to estimate the number of injuries that occur nationally [15]. The NEISS data updated daily and is reported on an annual basis. Using the NEISS reported data, we can estimate that approximately 533 patients (95% CI [7,320-16,559]) between 2013 and 2022 visited an emergency department in the United States for AT-related injuries.

Results

There were 503 total NEISS reported injuries from AT that resulted in emergency room visits between 2013 and 2022. During this time the number of injuries gradually increased, starting with 30 injuries in 2013 and reaching 72 injuries by 2022 (Figure 4). Individuals in their second decade (10-19) of life were the most highly represented with 296 (59%) reported injuries. There were 357 (71%) and 146 (29%) male and female injuries, respectively. Race listed as unknown in 284 (56%) individuals, 141 (28%) were white, 50 (9%) black, and 28 (7%) other. The most commonly injured body was the head 182 (36%) which was significantly higher than both knee, 65 (12%) and lower leg 27 (5%; Figure1a). The most common diagnoses were internal injuries, concussion, and fracture, 88 (17%), 88 (17%) and 81 (16%) respectively (Figure 1b).

Females had a higher incidence of head (40.4% vs. 34.5%) , knee (13.7% vs 12.6%), lower leg (5.5% vs 5.3%), ankle (6.2% vs 4.8%), elbow (3.4% vs 3.1%), face (4.1 vs 2.2%), and upper trunk injuries (2.7 vs 2.0%), while males had a higher incidence of shoulder (5.3% vs 2.7%), hand (3.9 vs 3.4%), wrist (3.9 vs 2.7%), and toe injuries (3.3% vs 0.0%). Females also had a higher diagnostic incidence of internal injuries (21.2 vs 16 %), concussions (18.5 vs 17.1%), contusion (15.8 vs 11%), sprains/strains (10.3 vs 9.8%), and conjunctivitis (1.4 vs. 1.1%), while males had a higher diagnostic incidence of lacerations (5.6 vs3.4%), foreign bodies (3.6 vs 1.4%), dislocations (2.0 vs 1.4%), and fracture (19.3 vs 8.2%). Three hundred and fifteen of 503 injuries occurred during sporting events. The most common injuries during a sporting event were concussions 64, internal injuries 55, and fractures 46 (Figure 2-3).

Sex	**Male 357(71)**			**Female 146(29)**			**Total 503**			
Race	White	Black	Asian	American Indian	Native Hawaiian	Other	Not specified			
	141(238)	50(10)	2(<1)	1(<1)	1(<1)	24(5)	284(56)			
Injuries by Age Decade	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
	92(18)	296(59)	59(12)	22(4)	11(2)	8(2)	6(1)	4(<1)	4(<1)	1(<1)
Age Range (years)	1-97									

Table 1: Study Demographics. *(#) indicates percent of total demographic.

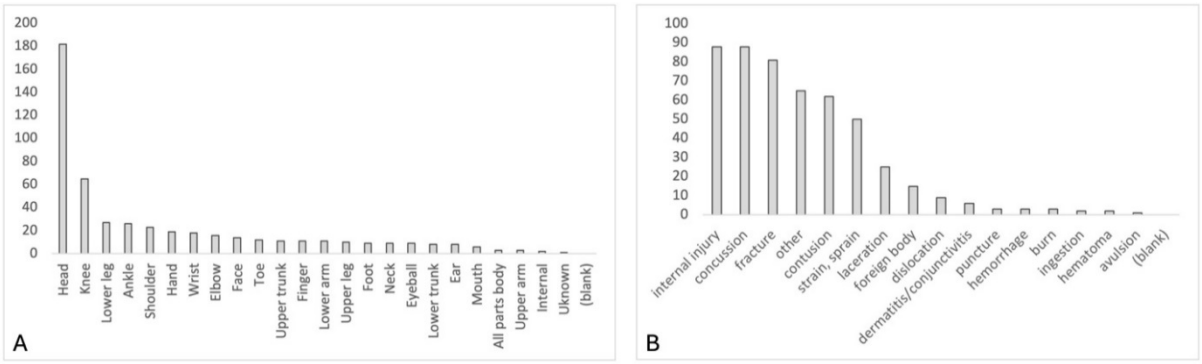

Figure 1: Counts of injuries by body part (A) or diagnosis (B).

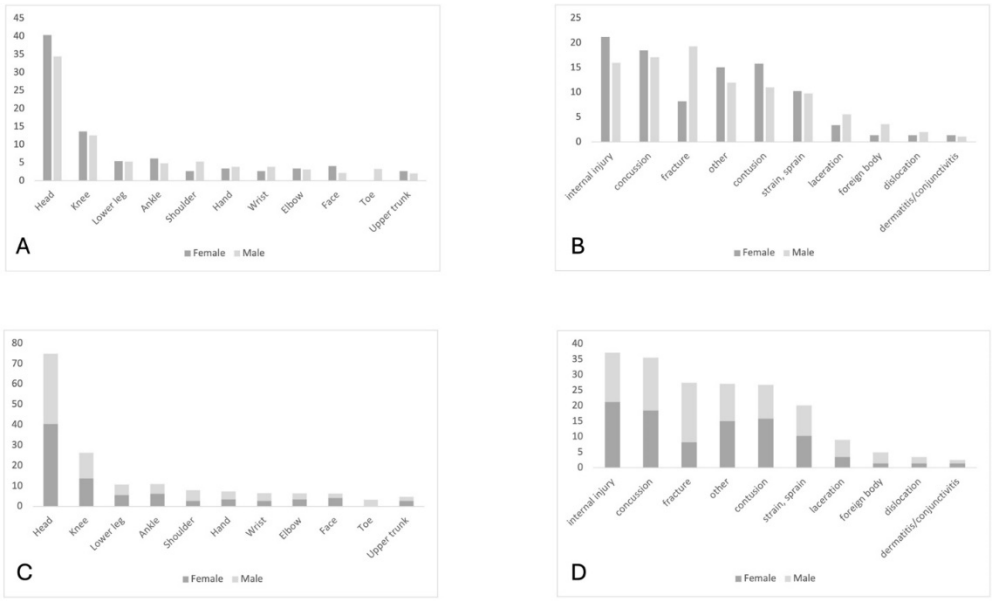

Figure 2: (A & C) Female and male; percentage of injuries by body parts. (B & D) Female and male; percentage of injuries by diagnosis.

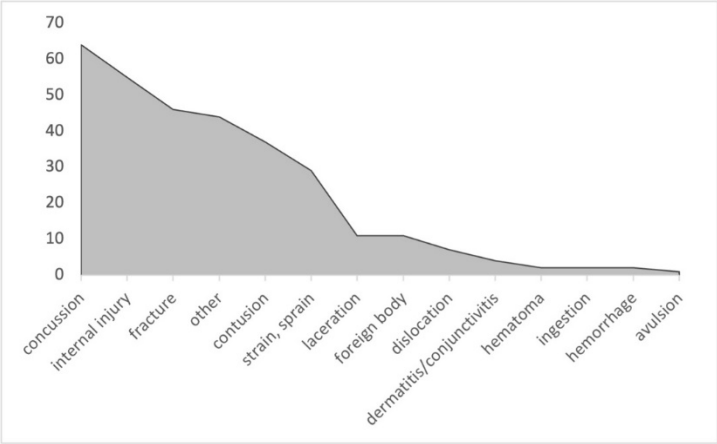

Figure 3: Counts of injuries that occurred at a sporting event.

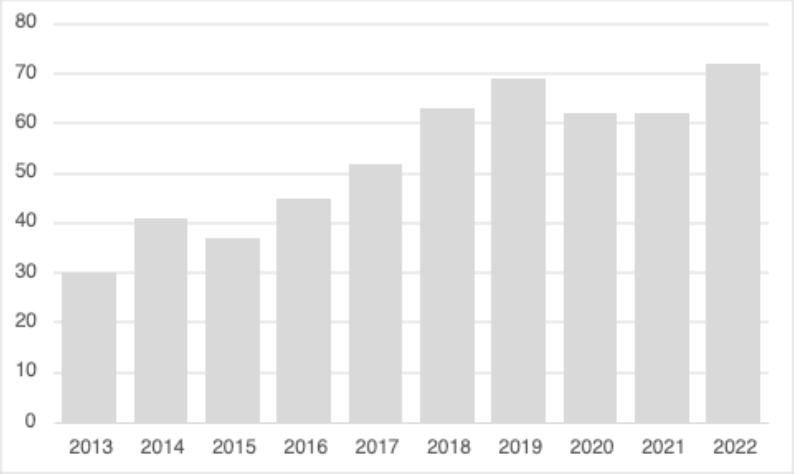

Figure 4: Counts of injuries per year. There is a gradual upward trend in injuries between 2013 to 2022.

Discussion

The NEISS database indicated that five hundred and three individuals sustained an AT related injury resulting in an emergency department visit between 2013 and 2022. The national estimate of injuries sustained on AT was 11,940. Most of these individuals were male (71%) and in their second decade of life (59%) (ages 10-19). The most common body part affected was the head (36%), and the most common diagnoses were internal injury (17%), concussion (17%), and fracture (16%). Females were more likely to be diagnosed with internal injuries, concussions, contusions, sprains/strains, and dermatitis/conjunctivitis. Males were more likely to be diagnosed with fractures, lacerations, foreign bodies, and dislocations. Interestingly, the incidence of fracture in males was much higher than females, 19.3% to 8.2% (see figures 2A and 2C). The mechanisms responsible for this difference are unknown but we hypothesize that it may be related to contact sports, such as football, which has a higher likelihood of producing fractures than other sports. Other hypotheses include the lack of shock absorption and flexibility of AT compared to natural grass fields. Steffen et al. reported a higher rate of fracture on AT than on grass [9]. This same study also reported a high rate of ankle sprains (RR 1.5, 95% CI 1.0 to 2.2; p=0.06) [9]. Calloway et al. reported that professional soccer players had a 6x higher incidence of ankle fractures on AT and a two-fold higher incidence of Achilles injury when compared to athletes on natural grass [7]. Lastly, a meta-analysis by Gould et al. suggested a higher rate of foot and ankle injuries on both newer generation and older generation turf compared to natural grass [8]. This study also questioned the validity of studies supporting higher injuries on natural grass due to the financial support from artificial turf industries [8]. The study also highlighted that new generation AT may not be limiting injuries as much as expected [8].

Between 2013 to 2022 our data demonstrates a steady increase in injuries (Figure 4.). The upward trend in the injuries suggests a concerning pattern of increasing injuries correlated with an increase in AT implemented into high schools. It is estimated that 1000-1500 AT fields have been implemented each year since 2011 [1-4]. The correlation between an increase in injuries and AT fields should be further studied to confirm that turf fields are responsible for these injuries. Future studies should investigate the rate of fracture on grass fields compared to AT and focus on the location of injury, mechanism of injury, differences between females and males, and prevention strategies.

Our data suggest that internal and head injuries have an increased prevalence in sports conducted on AT. Eighty-eight individuals sustained an internal injury resulting in emergency department visits. Internal injuries were more common in females. Future investigations on the mechanism of injury and prevention strategies should be performed to analyze internal injuries on AT versus grass fields. Concussions still remain a prevalent injury on AT. It is the third most common AT injury overall and the most common sports injury. A landmark study in 2000 published by Guskiewicz et al. investigated 17,529 collegiate and high school football athletes who sustained a concussion concluded that contact with AT appears to be associated with more serious concussions than those on grass [16].

The beneficial claims of AT compared to grass are less maintenance, durability, and cost-effectiveness. The NEISS database, however, data suggests that AT is responsible for more injuries than natural grass fields. The National Football League estimated 500 million dollars were lost due to injuries on AT fields in 2019 [17,18]. This is far more substantial than the cost of grass fields (approximately $500,000 a year) [19]. Although technological advancements in AT continues, efforts focused on maintaining grass fields, even in harsh weather conditions, may be more cost-effective due to injury prevention. A cost analysis study on injury prevention and natural grass maintenance should be performed to help protect players and lower costs. Regardless, it is clear that protective headgear should be required on all high impact or potentially high impart sports.

Limitations of this study include potential underreporting of injuries or bias in injury classification. We could not perform analysis of injuries between natural grass and AT and therefore we cannot make any conclusions that AT is responsible for the reported injuries.

Conclusions

This study reports the epidemiology and demographics of artificial turf (AT)-related injuries between 2013 and 2022 recorded by the National Electronic Injury Surveillance System (NEISS).

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