Epidemiological Comparison of ACL Injuries on Different Playing Surfaces in High School Football and Soccer

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Background: Anterior cruciate ligament (ACL) injuries are among the most common serious injuries to athletes in the United States. Among high school sports, the highest rates of ACL injury occur in soccer and football.

Purpose: To compare ACL injuries on artificial turf and natural grass using a nationally representative sample of high school athletes participating in football and boys' and girls' soccer.

Study Design: Descriptive epidemiology study.

Methods: ACL injuries among high school athletes participating in football and soccer were obtained from the High School Reporting Information Online surveillance system during the 2007-08 through 2018-19 school years. National estimates and injury proportion ratios (IPRs) with 95% CIs were calculated for ACL injuries that occurred on artificial turf versus natural grass.

Results: A total of 1039 ACL injuries were reported, which represented an estimated 389,320 (95% CI, 358,010-420,630) injuries nationally. There were 74,620 estimated football-related ACL injuries on artificial turf and 122,654 on natural grass. Likewise, 71,877 of the estimated soccer-related ACL injuries occurred on artificial turf and 104,028 on natural grass. A contact-injury mechanism accounted for 50.2% of football-related ACL injuries on artificial turf and 60.8% on natural grass. For soccer-related ACL injuries, a noncontact mechanism predominated on artificial turf (61.5%) and natural grass (66.4%). Among all injuries, ACL injuries were more likely to occur on artificial turf than natural grass in both football (IPR, 1.23 [95% CI, 1.03-1.47]) and girls' soccer (IPR, 1.53 [95% CI, 1.08-2.16]); however, no significant association was found in boys' soccer (IPR, 1.65 [95% CI, 0.99-2.75]). Among lower extremity injuries, ACL injuries were more likely to occur on artificial turf than natural grass in both boys' soccer (IPR, 1.72 [95% CI, 1.03-2.85]) and girls' soccer (IPR, 1.61 [95% CI, 1.14-2.26]); however, the association was not significant in football (IPR, 1.17 [95% CI, 0.98-1.39]).

Conclusion: ACL injuries were more likely to occur (ie, had larger IPRs) on artificial turf than natural grass; however, this relationship was not statistically significant for all sports.

Keywords: anterior cruciate ligament; artificial turf; football; high school athletics; natural grass; playing surface; soccer

Anterior cruciate ligament (ACL) tears are among the most common serious injuries to athletes in the United States. The average time for an athlete to return to competition after primary ACL reconstruction is >7 months, and some of these athletes will reinjure the knee or sustain another injury as a consequence of the ACL tear.[5,13] Besides leading to physical impairment, ACL injuries have negative emotional, social, and economic effects.[23] Annual costs for ACL reconstruction are estimated to be up to $1 billion for high school athletes in the United States.[10] Among high school athletes, female soccer participants and American football participants have the highest ACL injury rates.[10,20]

A growing body of research has investigated the role of field surface as regards ACL injuries, with most such studies focused on collegiate or professional athletes.[1-4,6,14-17] A study of National Collegiate Athletic Association (NCAA) football players demonstrated a higher risk of ACL injuries on artificial turf than natural grass.[3] Studies of NCAA and youth soccer players revealed a higher risk of ACL injury on natural grass compared with artificial turf.[7] In another study, no significant difference in knee-injury rates associated with field surface type was identified among male and female collegiate soccer players.[4] These discordant results as well as the increasing use of artificial turf in high school sports settings highlight the need for more comprehensive studies.

The purpose of this study was to use a nationally representative sample to investigate differences in the

occurrence of ACL injuries and characteristics of the injury event (such as level of play, mechanism of injury, severity, and recurrence) associated with artificial turf versus natural grass among US high school athletes playing soccer (including girls' and boys' soccer) and football. Study findings fill a gap in our knowledge about these injuries that will help inform policy decisions regarding playing surface and ACL injury prevention.

METHODS

Source of Data

This study analyzed data collected through the National High School Sports-Related Injury Surveillance Study, otherwise known as High School Reporting Information Online (RIO). The methods of data collection for RIO have been described in depth in other studies.[12,18] RIO uses a probability sample of high schools with at least 1 certified athletic trainer (AT) affiliated with the National Athletic Trainers Association. RIO randomly chose 100 schools for each year from 8 strata, controlling for geographic region and school size, creating a nationally representative sample of high school athletes in 9 selected sports. A weighting algorithm was used to generate national estimates of injury. When an injury event occurred, ATs documented details in the RIO database, including athlete demographic characteristics, sport, playing surface, level of play, competition versus practice setting, mechanism of injury, timing of injury, and weather conditions. This study was judged to be nonhuman research and waived from approval by the institutional review board at our institution.

Definition of ACL Injury and Athlete-Exposure

In this study, a reportable ACL injury was defined as one that (1) occurred in a school-sanctioned football or soccer competition or practice, (2) required medical attention by an AT or a physician, and (3) resulted in restriction of the student-athlete's participation for at least 1 day beyond the day of injury. ACL injuries, recorded by ATs into the RIO database, included sprains, avulsion fractures, complete tears, and ligament deficiencies. ATs could update the RIO database if new information or updated diagnoses from physicians became available. ATs documented each injury as "initial injury," "recent recurrence (this academic year)," or "prior recurrence (prior to this academic year)"; recent recurrence and prior recurrence were combined into 1

"recurrent injury" category during analysis. Athlete-exposure (AE) was defined as 1 athlete participating in 1 practice or competition.

Study Population and Sex-Comparable Sports

The study population consisted of high school athletes injured while participating in boys' football, boys' soccer, or girls' soccer in academic years 2007-08 through 2018-19. Soccer is considered sex-comparable, based on similarity of play, rules, and equipment.

Categorization of Playing Surface

The RIO database has a categorical variable, "surface," with the following options: artificial-fill, artificial-no-fill, grass, dirt/clay, concrete, indoors, and unknown. For the purposes of this study, artificial-fill and artificial-no-fill were combined into a single category, "artificial turf." Cases involving dirt/clay, concrete, indoors, and unknown were not included in regression models but were included in the descriptive data under "total injuries."

Statistical Analysis

RIO injury sample weights were used to calculate national estimates. Sample weights are based on the inverse probability of selection into the study based on school size and location. Descriptive statistics included national estimates along with 95% CIs. Categorical data were compared using the Pearson chi-square test. Injury rates were calculated as the number of injuries per 100,000 AEs. Data for AEs by type of playing surface were not available in the database; therefore, we were unable to calculate rates of ACL injury by surface type; instead of using rates, we performed comparisons between type of playing surface by using injury proportion ratios (IPRs). An example of an IPR calculation follows:

$$IPR = \frac{\left[\left(\dfrac{No.\,of\,football\,ACL\,injuries\,on\,artificial\,turf}{Total\,No.\,of\,football\,injuries\,on\,artificial\,turf}\right) \times 100\right]}{\left[\left(\dfrac{No.\,of\,football\,ACL\,injuries\,on\,natural\,grass}{Total\,No.\,of\,football\,injuries\,on\,natural\,grass}\right) \times 100\right]}.$$

Robust Poisson regression models were used to calculate IPRs along with 95% CIs using weighted data. IBM SPSS Statistics for Windows, Version 26 (IBM) and SAS 9.4 (SAS Institute) software were used to analyze data. The level of significance was set at $\alpha = .05$.

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TABLE 1
Reported Number and National Estimates of ACL Injuries on Artificial Turf Compared With Natural Grass in High School Football and Soccer, 2007-08 Through 2018-19 School Years[a]

Variable	Total Injuries[b]		Artificial Turf		Natural Grass		P^c
	n	National Estimate, n (%)	n	National Estimate, n (%)	n	National Estimate, n (%)	
Football							
All injuries	22,400	6,523,006 (100.0)	8338	2,302,119 (100.0)	13,917	4,179,748 (100.0)	**<.001**
LE injuries	9304	2,681,789 (41.1)	3610	986,217 (42.8)	5635	1,678,350 (40.2)	**<.001**
ACL injuries[d]	697	205,734 (3.2)	281	74,620 (3.2)	389	122,654 (2.9)	
ACL injuries by year							**<.001**
2007-08	58	17,235 (8.4)	13	2443 (3.3)	44	14,494 (11.8)	
2008-09	63	17,454 (8.5)	11	2715 (3.6)	51	14,304 (11.7)	
2009-10	60	20,009 (9.7)	19	5675 (7.6)	41	14,334 (11.7)	
2010-11	60	18,220 (8.9)	19	5299 (7.1)	41	12,921 (10.5)	
2011-12	45	15,833 (7.7)	22	8143 (10.9)	23	7690 (6.3)	
2012-13	63	20,335 (9.9)	24	6442 (8.6)	36	13,143 (10.7)	
2013-14	66	21,999 (10.7)	29	6985 (9.4)	36	14,274 (11.6)	
2014-15	65	15,979 (7.8)	37	8350 (11.2)	26	7287 (5.9)	
2015-16	62	17,124 (8.3)	29	8277 (11.1)	30	7220 (5.9)	
2016-17	50	12,682 (6.2)	20	4458 (6.0)	24	5986 (4.9)	
2017-18	53	14,361 (7.0)	29	8347 (11.2)	18	5154 (4.2)	
2018-19	52	14,503 (7.0)	29	7486 (10.0)	19	5848 (4.8)	
Exposure type							.542
Competition	491	149,992 (72.9)	207	53,093 (71.2)	263	90,288 (73.8)	
Practice	205	55,460 (27.0)	74	21,527 (28.8)	125	32,084 (26.2)	
Soccer							
All injuries	7952	4,386,758 (100.0)	2780	1,448,448 (100.0)	5006	2,847,091 (100.0)	**<.001**
LE injuries	4879	2,710,908 (61.8)	1640	876,410 (60.5)	3141	1,779,922 (62.5)	**<.001**
ACL injuries[d]	342	183,586 (4.2)	138	71,877 (5.0)	186	104,028 (3.7)	
ACL injuries by year							**.023**
2007-08	39	17,718 (9.7)	8	2169 (3.0)	31	15,548 (14.9)	
2008-09	23	8400 (4.6)	6	2267 (3.2)	16	5774 (5.6)	
2009-10	32	14,613 (8.0)	11	2663 (3.7)	21	11,950 (11.5)	
2010-11	22	12,099 (6.6)	5	3562 (5.0)	17	8538 (8.2)	
2011-12	24	17,041 (9.3)	12	7468 (10.4)	11	9409 (9.0)	
2012-13	32	19,894 (10.8)	17	9948 (13.8)	14	9675 (9.3)	
2013-14	37	20,322 (11.1)	13	7275 (10.1)	22	11,738 (11.3)	
2014-15	25	15,622 (8.5)	11	5606 (7.8)	13	9646 (9.3)	
2015-16	22	14,250 (7.8)	12	7358 (10.2)	9	6577 (6.3)	
2016-17	21	11,094 (6.0)	10	7356 (10.2)	8	2525 (2.4)	
2017-18	35	16,977 (9.2)	18	9460 (13.2)	13	6618 (6.4)	
2018-19	30	15,555 (8.5)	15	6746 (9.4)	11	6029 (5.8)	
Sex							.864
Male	99	52,816 (28.8)	39	20,379 (28.4)	57	30,681 (29.5)	
Female	243	130,770 (71.2)	99	51,498 (71.6)	129	73,346 (70.5)	
Exposure type							.662
Competition	286	154,906 (84.4)	121	60,441 (84.1)	152	89,692 (86.2)	
Practice	56	28,680 (15.6)	17	11,437 (15.9)	34	14,336 (13.8)	

[a]Bolded *P* values indicate statistically significant difference between playing surfaces ($P < .05$). ACL, anterior cruciate ligament; LE, lower extremity.
[b]Includes observations for which playing surface was "unknown" or "other" (eg, clay or indoors).
[c]*P* value from Pearson chi-square test excluded observations for which surface was "unknown" or "other" (eg, clay or indoor).
[d]ACL injuries are also included in LE injury frequencies.

RESULTS

ACL Injuries in High School Football and Soccer by Playing Surface

A total of 1039 ACL injuries were reported from 2007-08 through 2018-19 among high school athletes participating in football and soccer, which represented an estimated 389,320 (95% CI, 358,010-420,630) ACL injuries nationally (Table 1). Football and soccer accounted for 52.8% (n = 205,734) and 47.2% (n = 183,586) of these ACL injuries, respectively. The average annual rates of ACL injury (injuries per 100,000 AEs) were 12.05 for football, 4.63 for boys' soccer, and 13.27 for girls' soccer (Figure 1). Of
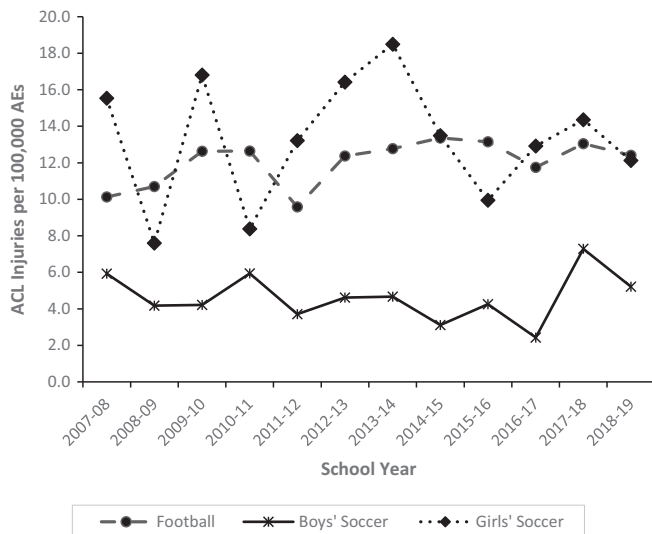
Figure 1. Rate of anterior cruciate ligament (ACL) injuries in high school football and soccer by sport and school year. AE, athlete-exposure.

an estimated 205,734 ACL injuries among football participants, the playing surface was recorded in 197,532 (96.0%) cases, among which 37.8% (n = 74,620) occurred on artificial turf, 62.1% (n = 122,654) occurred on natural grass, and 0.1% (n = 258) occurred on "unknown" surface. Likewise, of an estimated 183,586 ACL injuries among soccer participants, the playing surface was recorded in 177,747 (96.8%) cases, among which 40.4% (n = 71,877) occurred on artificial turf, 58.5% (n = 104,028) occurred on natural grass, and 1.0% (n = 1842) occurred on an "other/unknown" surface. Among soccer ACL injuries on artificial turf, girls' soccer accounted for 71.6% of injuries. Similarly, on natural grass, girls' soccer represented 70.5% of soccer ACL injuries. Most ACL injuries were complete tears, representing 75.6% (n = 140,450) of football, 72.9% (n = 35,281) of boys' soccer, and 79.4% (n = 91,349) of girls' soccer ACL injuries.

Exposure Type and Contact Versus Noncontact Mechanism

ACL injuries were more common in competition than practice, regardless of playing surface (Table 1). Football injuries occurred primarily during competition on both artificial turf (71.2%) and natural grass (73.8%). ACL injuries in soccer followed a similar pattern with a higher proportion of injuries occurring during competition on both artificial turf (84.1%) and natural grass (86.2%).

A contact mechanism accounted for 50.2% of football-related ACL injuries on artificial turf and 60.8% on natural grass (Table 2). For soccer-related ACL injuries, a noncontact mechanism predominated on artificial turf (61.5%) and natural grass (66.4%). This association with a noncontact mechanism was observed for both boys' soccer (51.2% on artificial turf and 56.5% on natural grass) and girls' soccer (65.5% on artificial turf and 70.6% on natural grass).

Injury Mechanism

Among the estimated 195,511 (95.4%) football-related ACL injuries for which a specific mechanism was recorded, the top 3 most common injury mechanisms were rotation around a planted foot/inversion (24.0%), being tackled (23.8%), and tackling (14.8%). The ranking of mechanism was the same on artificial turf, with rotation around a planted foot/inversion (27.0%) being the most frequent mechanism, followed by being tackled (22.2%) and tackling (15.1%). On natural grass, being tackled was the most common mechanism (24.8%), followed by rotation around a planted foot/inversion (22.1%), tackling (14.6%), and being blocked (14.6%).

Among the estimated 177,747 (96.8%) soccer-related ACL injuries where specific mechanism was recorded, the top 3 most common injury mechanisms were rotation around a planted foot/inversion (46.0%), contact with another player (27.4%), and stepped on/fell on/kicked (5.4%). Rotation around a planted foot/inversion was the most common mechanism on both artificial turf (44.2%) and natural grass (47.7%), followed by contact with another player (22.9% on artificial turf and 29.9% on natural grass) and stepped on/fell on/kicked (8.9% on artificial turf and 3.0% on natural grass).

Injury Severity

Although no statistically significant difference was found between the types of playing surface, most football ACL injuries resulted in >3 weeks of time loss from sports participation (85.5% on artificial turf vs 79.3% on natural grass; $P = .123$). In addition, most of these injuries went on to require surgery (78.8% on artificial turf vs 76.7% on natural grass; $P = .567$). Furthermore, these ACL injuries commonly involved injury to another knee structure (59.4% on artificial turf vs 60.2% on natural grass; $P = .857$), such as a meniscus, medial collateral ligament, or lateral collateral ligament. Most football ACL injuries were first-time injuries (92.0% on artificial turf vs 92.8% on natural grass; $P = .237$).

Although no statistically significant difference was found between the types of playing surface, most soccer ACL injuries resulted in >3 weeks of time loss from sports participation (83.1% on artificial turf vs 85.9% on natural grass; $P = .444$). Most of these injuries required surgery (78.1% on artificial turf vs 75.5% on natural grass; $P = .681$) and were associated with an injury to another knee structure (57.3% on artificial turf vs 46.4% on natural grass; $P = .130$). Soccer ACL injuries were predominantly first-time injuries (89.6% on artificial turf vs 88.6% on natural grass; $P = .814$).

Injury Proportion Ratio

Among all injuries, ACL injuries were more likely to occur on artificial turf than natural grass in both football (IPR, 1.23 [95% CI, 1.03-1.47]) and girls' soccer (IPR, 1.53 [95% CI, 1.08-2.16]); however, boys' soccer did not show a significant association between ACL injuries and playing surface

TABLE 2
Characteristics of ACL Injuries on Artificial Turf Compared With Natural Grass in High School Football and Soccer, 2007-08 Through 2018-19 School Years[a]

Variable	Artificial Turf		Natural Grass		P^b
	n	National Estimate, n (%)	n	National Estimate, n (%)	
Football					
Time-loss duration[c]					.123
≤ 3 wk	42	10,390 (13.9)	79	24,104 (19.7)	
>3 wk	236	63,824 (85.5)	307	97,239 (79.3)	
Disqualified for season	129	31,037 (42.9)	173	48,905 (40.9)	
Injury mechanism					**.020**
Contact	138	37,472 (50.2)	230	74,523 (60.8)	
Noncontact	143	37,148 (49.8)	159	48,131 (39.2)	
Surgery					.567
Yes	217	58,779 (78.8)	292	94,041 (76.7)	
No	64	15,841 (21.2)	97	28,613 (23.3)	
Involvement					.857
ACL only	125	30,268 (40.6)	158	48,770 (39.8)	
ACL with other injury	156	44,352 (59.4)	231	73,885 (60.2)	
First-time injury[d]					.237
Yes	258	68,671 (92.0)	361	113,781 (92.8)	
No	20	5031 (6.7)	28	8873 (7.2)	
Soccer					
Time-loss duration[c]					.444
<3 wk	26	11,380 (15.8)	33	12,165 (11.7)	
>3 wk	108	59,696 (83.1)	149	89,399 (85.9)	
Disqualified for season	62	25,415 (36.5)	95	50,232 (49.4)	
Injury mechanism					.479
Contact	59	27,694 (38.5)	71	34,955 (33.6)	
Noncontact	79	44,183 (61.5)	115	69,073 (66.4)	
Surgery					.681
Yes	104	56,135 (78.1)	138	78,572 (75.5)	
No	34	15,742 (21.9)	48	25,456 (24.5)	
Involvement					.130
ACL only	61	30,662 (42.7)	101	55,809 (53.6)	
ACL with other injury	77	41,215 (57.3)	85	48,218 (46.4)	
First-time injury[d]					.814
Yes	121	64,375 (89.6)	162	92,174 (88.6)	
No	13	5866 (8.2)	20	7816 (7.5)	

[a]Bolded *P* value indicates statistically significant difference between playing surfaces ($P < .05$). ACL, anterior cruciate ligament.
[b]*P* value from Pearson chi-square test excluded observations for which surface was "unknown" or "other" (eg, clay or indoors).
[c]May not add to 100.0% because injuries with severity categorized as "other" were excluded from table.
[d]May not add to 100.0% because observations for which first-time injury was categorized as "unknown" or "other" were excluded from table.

TABLE 3
IPR of ACL Injuries on Artificial Turf and Natural Grass Among All Injuries and Lower Extremity Injuries in High School Football and Soccer, 2007-08 Through 2018-19 School Years[a]

Sport	National Estimate, n (%)[b]		IPR of ACL Injuries (95% CI)	
	Artificial Turf	Natural Grass	All Injuries[c]	LE Injuries[d]
Football	74,620 (3.0)	122,654 (2.4)	1.23 (1.03-1.47)	1.17 (0.98-1.39)
Boys' soccer	20,379 (3.2)	30,681 (1.9)	1.65 (0.99-2.75)	1.72 (1.03-2.85)
Girls' soccer	51,498 (5.7)	73,346 (3.8)	1.53 (1.08-2.16)	1.61 (1.14-2.26)

[a]ACL, anterior cruciate ligament; IPR, injury proportion ratio; LE, lower extremity.
[b]Percentage represents proportion of all injuries accounted for by ACL injuries.
[c]Proportion of ACL injuries to all injuries on natural grass was the reference group.
[d]Proportion of ACL injuries to lower extremity injuries on natural grass was the reference group.

(IPR, 1.65 [95% CI, 0.99-2.75]). When the association of playing surface with ACL injury was evaluated among lower extremity injuries, ACL injuries were more likely to occur on artificial turf than natural grass in both boys' soccer (IPR, 1.72 [95% CI, 1.03-2.85]) and girls' soccer (IPR, 1.61 [95% CI, 1.14-2.26]); however, there was no significant association in football (IPR, 1.17 [95% CI, 0.98-1.39]) (Table 3).

DISCUSSION

To our knowledge, this is the first study to compare differences in ACL injuries on artificial turf and natural grass using a nationally representative sample of high school athletes participating in football and boys' and girls' soccer. Overall, artificial turf was associated with a higher proportion of ACL injuries than was natural grass. However, some comparisons were not statistically significant (boys' soccer when we included all injuries and football when we included only lower extremity injuries), which weakened the evidence for this association in our study. Previous research on NCAA football and soccer echoes this discordance in findings.[3,7] In addition, football accounted for a larger number of ACL injuries than soccer in this study, and soccer had a greater proportion of ACL injuries occurring on artificial turf versus natural grass than football. Among high school football and soccer players with ACL injuries, the type of playing surface did not have a statistically significant effect on injury to another knee structure, time loss from sports participation, or need for surgery.

Since artificial turf was designed in 1966, advancements in design and manufacturing have been made to reduce injuries.[9] First-generation turf consisted of a short-fiber, dense nylon carpet, with an elastomeric foam pad installed between the carpet backing and the underlying soil.[9] The second generation of artificial turf included a shock-absorbing pad beneath the carpet that contained longer fibers compared with the first generation.[9] Third-generation turf, which is the surface most commonly played on today, is composed of longer fibers with granular material filling in spaces between the fibers.[9] Additional studies are needed to understand why artificial turf may be associated with increased risk of ACL injuries.

Some high school officials may have a misconception that artificial turf requires little maintenance. However, third-generation turf that is being used daily can require weekly maintenance to ensure a safe field environment.[9] Prior studies have revealed the importance of artificial turf field maintenance as a critical factor in athlete safety.[9] The database used for this study did not include data on the generation of the artificial turf or field maintenance.

In addition, the type of natural grass used as a playing surface appears to play a role in ACL injuries. In a direct comparison of 2 commonly used types of grass, perennial ryegrass (*Lolium perenne*) was associated with fewer ACL injuries than bermudagrass (*Cynodon* sp).[17] Further investigation of the association of ACL injuries with other commonly used types of grass, such as seashore paspalum (*Paspalum vaginatum*), Kentucky bluegrass (*Poa pratensis*), and tall fescue (*Festuca arundinacea*), is needed. The study database did not include data on the type of natural grass.

The type of shoe worn by the athlete has been shown to be associated with ACL injury risk through its influence on the amount of rotational and translational force an athlete experiences.[8,11,21] Translational force is the horizontal force required to overcome the resistance between the shoe outsole (studs) and playing surface.[21] Rotational force is the force required to release the studs through the playing surface in a rotational manner. An increase in translational force is linked to better athletic performance, whereas a higher level of rotational force is linked to greater risk of lower extremity injury.[21] The study database did not include data on shoe type worn.

Preventive neuromuscular training has been used to reduce ACL risk and commonly includes balance training, strength training, plyometrics, and proximal control.[19] A meta-analysis calculated that preventive neuromuscular training resulted in a 50% reduction in ACL injury risk in all athletes and a 67% risk reduction of noncontact ACL injuries in females, and noncontact ACL injuries were common in our study.[22] We were unable to ascertain whether any of the athletes in our study participated in preventive neuromuscular training; however, such participation could have influenced study findings. When feasible, athletes should participate in injury-prevention programs or incorporate key elements into their ongoing training.

Study Limitations

This study had several limitations. Data for athletes' exposures by type of playing surface were not available; therefore, we were unable to calculate rates of ACL injury by surface type; IPRs were calculated instead. The number of ACL injuries was relatively small in some subcategories in this study; this should be considered when interpreting national estimates. Most ACL injuries in this study were complete tears; however, subanalyses by ACL injury severity were not carried out because of small sample sizes of less severe injuries. Although the generation of artificial turf, type of natural grass, soil quality, amount of field maintenance, type of shoes worn, and preventive neuromuscular training may influence ACL injury risk, data regarding these factors were unavailable in our study. Despite these limitations, this study used a nationally representative sample of high school athletes to collect ACL injury data via strict data quality procedures. The RIO database has been used in >100 peer-reviewed publications, attesting to its high quality.

CONCLUSION

ACL injuries were more likely to occur (ie, had greater IPRs) on artificial turf than on natural grass; however, this relationship was not statistically significant for all sports. Given the potential severity and lifelong effects of ACL injury and the increasing use of artificial turf in high school

athletics, further research on injury risk and protective factors associated with playing surfaces is warranted.

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