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Epidemiology of Knee Injuries Among Boys and Girls in US High School Athletics

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Background: The knee joint is the second most commonly injured body site and the leading cause of high school sports–related surgeries. Knee injuries are among the most economically costly sports injuries and may require subsequent surgery or extensive and expensive rehabilitation.

Purpose: To report the incidence, risk, and severity of high school knee injuries across sports, genders, and type of exposure.

Study Design: Descriptive epidemiology study.

Methods: During the 2005-2006 and 2006-2007 school years, 100 US high schools were randomly selected for a nationally representative sample. Certified athletic trainers tracked injuries using an online injury surveillance system, High School RIO™, in 9 high school sports.

Results: There were 1383 knee injuries reported during 3 551 131 athlete exposures for a rate of 3.89 knee injuries per 10 000 athlete exposures. Although boys had a higher overall rate of knee injury (rate ratio, 1.38; confidence interval, 1.22-1.55), girls were twice as likely to sustain knee injuries requiring surgery (major knee injuries) than were boys (injury proportion ratio, 1.98; confidence interval, 1.45-2.70) and twice as likely to incur noncontact major knee injuries (injury proportion ratio, 1.98; confidence interval, 1.23-3.19) as were boys. Although illegal play was identified as a contributing factor in only 5.7% of all knee injuries, 20% of knee injuries resulting from illegal play required surgery.

Conclusion: Knee injury rates and patterns varied by sport, gender, and type of exposure. Identified gender differences included differences in injury rates, injury severity, and basic injury mechanism. Further surveillance is crucial for the development of targeted, evidence-based injury prevention strategies to reduce the morbidity and economic impact of knee surgeries.

Keywords: high school; sports; knee; injury; surveillance; epidemiology

More than 25 million students are involved in high school sports annually in the United States, and participation rates are increasing.[9] Although high school sports are promoted to encourage healthy lifestyles, teamwork, sportsmanship, and hard work,[17] physical activities carry a risk for injury. An estimated 2.5 million adolescents visit emergency departments annually with sports-related injuries.[24] Although some injuries like contusions, sprains, and strains require only minimal medical attention, injuries such as fractures, dislocations, and torn ligaments pose a significant economic burden.[4] Knee surgeries alone account for as many as 60% of all sports-related surgeries.[20] Knee injuries requiring surgery are becoming more common in adolescents.[25] They are among the most costly procedures,[2] often involve extensive and expensive subsequent rehabilitation,[4,11] and can increase risk for early onset osteoarthritis.

Because of the need for expensive long-term rehabilitation, knee injury prevention is essential. The current literature on

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sports-related knee injuries, however, is limited. Although many knee injury studies have been published, they are difficult to compare because of differing methodologies, differing definitions of injury, and varying amounts of information about the injuries and the circumstances at the time of injury.[11] Furthermore, many knee injury studies have concentrated only on 1 or 2 sports,[1,2,13,19,22] have included limited populations,[4,6,12] have focused only on damaged ligament injuries,[1,12,18] or have only incorporated the knee as one of numerous body sites injured.[6,10,13,15,20]

In addition, much of the literature has investigated the higher rate of major knee injuries in female compared with male athletes.[¶] Compared with their male counterparts, female athletes are 4 to 6 times more likely to sustain major knee injury.[8] The majority of knee injuries occur without contact, often involving landing, jumping, or pivoting.[7,8,27] The vulnerability of females' knees has been linked to a number of risk factors, including neuromuscular,[7,8] hormonal,[18,21,27] and mechanical differences.[8,21,27] However, the few published studies comparing knee injuries between boys and girls have been limited to specific study populations[15,23] and concentration on the most severe of these injuries (eg, ACL, etc.).[1,15,27]

The goal of this study is to explore the epidemiology of high school knee injuries among athletes across 9 different sports using a nationally representative sample. This study is the first of its kind to compare high school knee injuries by sport and gender. From this analysis, we will identify the incidence, risk, and severity of knee injury in high school athletics and compare injury risk between genders.

METHODS

All high schools with 1 or more National Athletic Trainers Association–affiliated high school certified athletic trainers (ATCs) with a valid e-mail address were invited to participate (n = 4120 in 2005 and n = 3378 in 2006). Those schools agreeing to participate as data reporters (n = 425 in 2005 and n = 316 in 2006) were categorized into 8 sampling strata based on US Census geographic regions[26] and school size (enrollment ≤1000 or >1000). A simple random sample was then used to select schools from each sampling strata to achieve a nationally representative sample of 100 schools. During the first 2 study years, 9 enrolled high schools dropped out of the study. Reasons for withdrawal included ATCs needing to leave schools owing to budget cuts, ATCs with personal/family concerns, and so forth. Each was replaced by another school randomly selected from the same stratum.

ATCs from participating schools reported injury and exposure data for 9 high school sports using the High School Sports-Related Injury Surveillance System, High School RIO™ (Reporting Information Online), for 2 school years, 2005-2006 and 2006-2007. These 9 sports included 5 boys' sports (football, soccer, basketball, baseball, and wrestling) and 4 girls' sports (soccer, volleyball, basketball, and softball).

ATCs from participating schools weekly logged onto the High School RIO™ Web site using a unique study ID number to report athlete exposure (AE) and injury data. Athlete exposure was defined as 1 athlete's participation in a practice or competition. Athlete exposure was reported as the sum of the number of athletes participating in each practice and in each competition every week. Thus, although the AE calculation incorporated the number of practices, the number of competitions, and the number of athletes, these individual values were not collected. Practice/competition lengths were also not captured. Injury was defined as (1) occurring during an organized high school practice or competition, (2) requiring medical attention by an ATC or physician, and (3) resulting in restriction of the athlete's participation in either practice or competition for 1 or more days. Illnesses attributable to sports participation (eg, skin infections, asthma attacks, etc) were also collected by High School RIO™. For each reportable illness or injury, the ATC completed a report form that collected data on athlete demographics, where and when the event occurred, basic event mechanism, length of time until return to play, whether surgery was performed, playing surface, and so forth. The ATCs were able to view, edit, and update previously entered information throughout the study period.

To analyze the data, we used SPSS version 14.0 (SPSS Science Inc, Chicago, Ill) with the complex samples module. With the exception of rates, all calculations used national estimates calculated by assigning a sample weight based on the inverse of the probability of the school's selection into the study (based on the total number of US high schools in each of the 8 sampling strata). We used rate ratios (RRs) and injury proportion ratios (IPRs) to measure the magnitude of associations. The following is an example of the RR calculation comparing the rate of competition knee injuries to the rate of practice knee injuries:

$$\text{Rate ratio} = \frac{(\text{No. competition knee injuries} / \text{No. competition athlete exposures}) \times 10\,000}{(\text{No. practice knee injuries} / \text{No. practice athlete exposures}) \times 10\,000}.$$

The following is an example of the IPR calculation comparing the overall proportion of knee injuries between boys and girls:

$$\text{Injury proportion ratio} = \frac{\text{National estimated no. boys' knee injuries} / \text{National estimated total no. all boys' injuries}}{\text{National estimated no. girls' knee injuries} / \text{National estimated total no. all girls' injuries}}.$$

The χ^2 test and 95% confidence intervals (CIs) were used in statistical analysis, and all 95% CIs for IPRs were adjusted for the sampling plan. The 95% CIs not containing 1.0 and $P < .05$ were considered statistically significant results. This study was approved by the Human Subjects Board of the Research Institute at Nationwide Children's Hospital

RESULTS

General

For the 2 academic years 2005-2006 and 2006-2007, ATCs reported 1383 practice- or competition-related knee injuries occurring in 3 551 131 AEs for an overall rate of 3.89 knee injuries per 10 000 AEs. Knee injury rates are summarized in Table 1. Overall, 226 of the knee injuries required surgery for a rate of 0.64 major knee injuries (major knee

[¶]References 1, 2, 4, 5, 11, 12, 15, 20, 21, 23, 27.

TABLE 1
Knee Injury Rates per 10 000 Athletic Exposures, High School Sports–Related Injury Surveillance Study, United States, 2005-2007

	Knee Injuries			Athlete Exposures			Rate/10 000 Exposures			Rate Ratio[a] (95% CI)
Sport	Practice	Competition	Total	Practice	Competition	Total	Practice	Competition	Total	
Total	626	757	1383	2 579 337	971 794	3 551 131	2.42	7.79	3.89	3.21 (2.89-3.57)
Boys	484	526	1010	1 763 980	590 257	2 354 237	2.74	8.91	4.29	3.25 (2.87-3.67)
Girls	142	231	373	815 357	381 537	1 196 894	1.74	6.05	3.11	3.48 (2.82-4.28)
Football	288	357	645	769 238	164 102	933 340	3.74	21.7	6.91	5.81 (4.98-6.79)
Soccer										
Boys	59	61	120	232 061	100 858	332 919	2.54	6.04	3.60	2.38 (1.66-3.40)
Girls	48	107	155	213 868	91 091	304 959	2.24	11.74	5.08	5.23 (3.72-7.36)
Volleyball	22	24	46	183 173	96 707	279 880	1.20	2.48	1.64	2.07 (1.16-3.68)
Basketball										
Boys	45	41	86	301 015	122 224	423 239	1.49	3.35	2.03	2.24 (1.47-3.43)
Girls	62	74	136	252 729	104 683	357 412	2.45	7.06	3.80	2.88 (2.06-4.04)
Wrestling	74	49	123	241 312	81 061	322 373	3.06	6.04	3.81	1.97 (1.37-2.83)
Baseball	18	18	36	220 354	112 012	342 366	0.81	1.48	1.05	1.97 (1.02-3.78)
Softball	10	26	36	165 587	89 056	254 643	0.60	2.91	1.41	4.83 (2.33-10.02)

[a]Practice is referent group. CI, confidence interval. This table does not include 7 girls' injuries and 13 boys' injuries that occurred during "other" exposures because "other" athlete exposures were not collected. Thus, total injury numbers in this table may not match total injury numbers reported elsewhere in the text.

injuries defined as those requiring surgery) per 10 000 AEs. For girls, 380 total knee injuries and 85 knee surgeries were reported (3.11 and 0.71 per 10 000 AEs, respectively). For boys, 1023 total knee injuries and 141 knee surgeries were reported (4.29 and 0.60 per 10 000 AEs, respectively). Nationally, an estimated 293 607 knee injuries in boys and 163 539 knee injuries in girls occurred in athletes participating in the 9 sports of interest.

Over all 9 sports, knee injuries were 3 times more likely to occur in competition than in practice (RR, 3.21; CI, 2.89-3.57) (Table 1). Overall, boys had higher rates of knee injury than did girls (RR, 1.38; CI, 1.22-1.55). The highest rates of knee injury per 10 000 AEs were reported for football (6.91), girls' soccer (5.08), wrestling (3.81), and girls' basketball (3.80), whereas the lowest knee injury rates were seen in baseball (1.05) and softball (1.41).

The knee was the second most frequently injured body site among high school athletes (accounting for 15.2% of all injuries), behind only the ankle (20.9%). However, knee injuries accounted for 44.6% of all surgeries, much higher than the body sites with the next highest proportion of injuries requiring surgery: shoulder (8.8%) and hand (7.6%). Most boys' knee injuries were sustained while playing football (58.0% of boys' knee injuries) followed by soccer (21.1%), wrestling (10.2%), basketball (7.2%), and baseball (3.5%). Girls most often injured their knees while playing soccer (56.4%), followed by basketball (23.8%), volleyball (11.0%), and softball (8.8%).

Diagnoses

The most common knee injuries (Table 2) were incomplete ligament tears (32.0%), contusions (15.2%), complete ligament tears (13.2%), torn cartilage (8.0%), fractures/dislocations (5.8%), and muscle tears (5.6%). Other reported diagnoses included tendinitis (4.2%), inflammation (2.0%), and hyperextension (1.3%).

Incomplete ligament tears were most common in football (42.6% of all football knee injuries), wrestling (30.1%), and boys' soccer (29.1%). The sports with the highest proportion of contusions diagnosed were baseball (35.6%), wrestling (17.8%), and softball (17.4%). Complete ligament tears were most frequently diagnosed in volleyball (25.6%), girls' basketball (22.6%), and girls' soccer (22.5%). Torn cartilage was most frequently reported in wrestling (16.1%), girls' basketball (14.9%), and boys' basketball (13.3%). Boys' soccer (11.1%), softball (7.5%), and volleyball (7.5%) most frequently reported dislocation/fracture injuries. Muscle tears were most common in girls' soccer (9.3%), wrestling (7.6%), and volleyball (7.0%).

Although incomplete ligament tears composed a higher proportion of knee injuries in boys (IPR, 1.50; CI, 1.17-1.93), girls were 2.5 times more likely to sustain complete ligament tears (IPR, 2.60; CI, 1.81-3.74), which is the primary diagnosis requiring knee surgery. Boys and girls had similar proportions of contusions, torn cartilage, muscle tears, and fractures/dislocations.

Severity

Knee injuries most frequently caused an athlete to miss less than 1 week of participation (43.1% of all knee injuries), followed by more than 3 weeks (30.3%), and between 1 and 3 weeks (26.6%) (Figure 1). Surgery was required for 16.8% of all knee injuries. The most common diagnoses requiring surgery (major knee injuries) were complete ligament tears (65.5%), torn cartilage (20.3%), incomplete ligament tears (6.0%), and fractures (2.6%).

TABLE 2
Knee Injury Diagnosis, Time Loss, and Surgery Status by Gender, High School Sports–Related Injury Surveillance Study, United States, 2005-2007[a]

	Overall		Boys		Girls		
	n	%	*n*	%	*n*	%	IPR (95% CI)
Diagnosis							
Incomplete ligament tears	146 363	32.0	106 659	36.4	39 704[b]	24.3	1.50 (1.17-1.93)
Contusions	69 576	15.2	47 986	16.4	21 590[b]	13.2	1.24 (0.87-1.77)
Complete ligament tears	60 176	13.2	24 559[b]	8.4	35 617	21.8	2.60 (1.81-3.74)
Torn cartilage	36 599	8.0	25 128	8.6	11 471[b]	7.0	1.22 (0.76-1.96)
Fractures/dislocations	26 932	5.8	18 303	6.2	8629[b]	5.2	1.18 (0.60-2.35)
Muscle tears	25 194	5.6	13 737[b]	4.7	11 457	7.0	1.50 (0.78-2.88)
Other[c]	91 874	20.2	56 803	19.3	46 528	28.5	
Time loss, wk							
<1	187 292	43.1	129 252	46.5	58 040[b]	37.1	1.25 (1.03-1.52)
1-3	115 448	26.6	80 401	28.9	35 047[b]	22.4	1.29 (0.98-1.70)
>3	131 661	30.3	68 501[b]	24.6	63 160	40.4	1.64 (1.32-2.04)
Required surgery							
Yes	75 573	16.8	35 769[b]	12.4	39 804	24.6	1.98 (1.45-2.70)
No	373 285	83.2	251 600	87.6	121 685	75.4	
Total	457 146		293 607		163 539		1.38 (1.22-1.55)

[a]Data weighted to be nationally representative. CI, confidence interval; IPR, injury proportion ratio.
[b]Group used as referent (eg, for contusions, girls used as referent group).
[c]Other diagnoses include stress fractures, tendinitis, and so forth (diagnoses that accounted for <5.0% of total injuries).

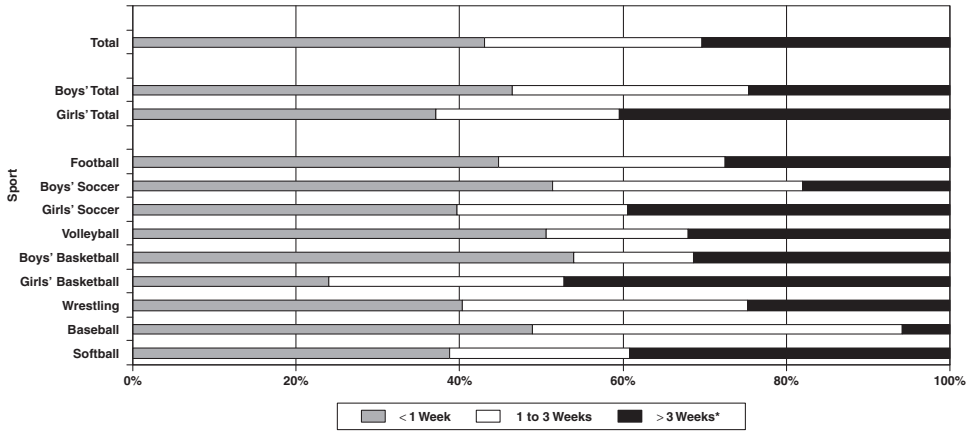

Figure 1. Outcome of knee injury in terms of time loss by gender and sport, High School Sports–Related Injury Surveillance Study, United States, 2005-2007. Data based on weighted national estimates. *Includes season- and career-ending injuries.

Knee injuries that prevented participation for less than a week were most common in boys' soccer (51.3% of all boys' soccer knee injuries), boys' basketball (53.9%), volleyball (50.5%), and baseball (48.9%) (Figure 1). Knee injuries that required participants to miss more than 3 weeks were most frequent in girls' basketball (47.2%), girls' soccer (39.4%), volleyball (30%), and boys' basketball (31.4%). Disqualification for the entire season because of knee injury was also most common in girls' basketball (25.8%), girls' soccer (23.7%), and volleyball (23.0%). Knee surgeries were most common in girls' basketball (36.3%), volleyball (25.9%), and girls' soccer (22.4%) (Figure 2).

Girls were 2 times as likely to require surgery for knee injuries than were boys (IPR, 1.98; CI, 1.45-2.70) and were more likely than were boys to sustain knee injuries that prohibited participation for more than 3 weeks (IPR, 1.64; CI, 1.32-2.04). Conversely, boys were more likely than girls to miss less than 1 week of competition owing to knee injury (IPR, 1.25; CI, 1.03-1.52).

Mechanism

Contact with another person was the most common mechanism of knee injury (52.0%), followed by no contact/overuse (25.4%), contact with the playing surface (15.4%), and contact with a playing apparatus (2.9%). Contact with another person was the leading cause of major knee injury (44.2% of major knee injuries), followed by no contact/overuse (36.6%), contact with playing surface (15.5%), illness

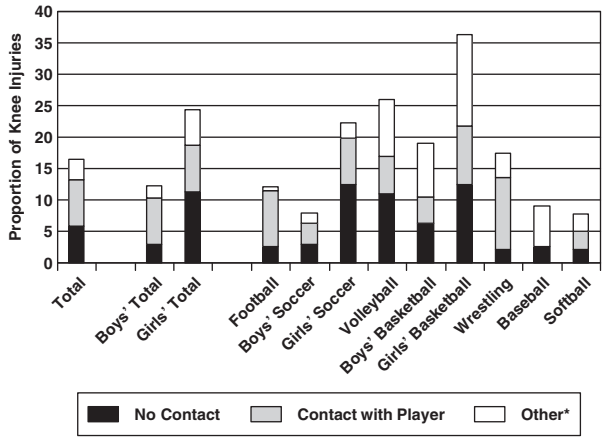

Figure 2. Proportion of knee injuries requiring surgery and general mechanism of injury by gender and sport, High School Sports–Related Injury Surveillance Study, United States, 2005-2007. *Includes contact with playing surface or apparatus.

(1.7%), and contact with the playing apparatus (1.5%). Although illegal play was involved in only 5.7% of all knee injuries, 20% of knee injuries resulting from illegal play required surgery.

Knee injuries caused by contact with another person were most common in football (71.5%), boys' soccer (53.5%), and wrestling (52.4%). Noncontact knee injuries were most common in volleyball (54.4%), boys' basketball (43.1%), girls' soccer (35.2%), and girls' basketball (33.1%). Knee injuries due to contact with the playing surface were more common in baseball (35.8%), wrestling (34.3%), and volleyball (31.7%). Contact with a playing apparatus most frequently caused knee injury in softball (21.7%) and baseball (11.0%). The sports with the highest proportion of knee injuries related to illegal play were boys' soccer (15.3%), girls' basketball (8.8%), girls' soccer (8.0%), and baseball (7.6%).

Overall, major knee injuries in girls were twice as likely to occur by noncontact mechanisms compared with boys (IPR, 1.98; CI, 1.23-3.19). Noncontact major knee injuries were seen in similar proportions between boys and girls in basketball (IPR, 1.03; CI, 0.42-2.51; P = .95) and baseball/softball (IPR, 0.93; CI, 0.01-66.9; P = .97). In soccer, although statistically insignificant, girls were more likely to sustain major knee injuries by noncontact than were boys (IPR, 1.49; CI, 0.55-4.09).

The majority of knee injuries sustained during boys' soccer (100%), girls' soccer (99.3%), and football (98.7%) occurred on artificial turf or natural grass. In boys' and girls' basketball (100%) and girls' volleyball (95.7%), the majority of knee injuries occurred on synthetic material or wood. Knee injuries sustained during baseball and softball occurred most commonly on grass (72.3% and 57.9%, respectively) and dirt/clay (23.6% and 42.1%, respectively).

DISCUSSION

This study is the first in a decade to compare knee injuries across 5 boys' sports (football, soccer, basketball, baseball, and wrestling) and 4 girls' sports (soccer, volleyball, basketball, and softball). Results suggest that nationally, 457 146 knee injuries, including 75 573 major knee injuries requiring surgery, occurred during the 2005-2006 and 2006-2007 school years. Knee injury rates and patterns vary by sport, gender, and type of exposure. Identified risk factors for knee injury included illegal play. Without effective interventions, as the number of high school athletes continues to grow, the number of knee injuries and the burden of knee surgeries and subsequent rehabilitation will escalate, leaving these athletes at increased risk of early onset osteoarthritis. Therefore, the identification of knee injury patterns in high school athletics is crucial for the development of essential injury prevention measures.

Overview

This study found an overall knee injury rate of 3.89 per 10 000 AEs in 9 high school sports. Powell and Barber-Foss,[20] who also looked at these 9 sports, reported knee injury rates twice those reported in this study. The large decrease in injury rates is undoubtedly owing to a cumulative effect of multiple factors. Because the study of Powell and Barber-Foss was conducted from 1995 to 1997, part of this decrease in knee injury rates may be attributed to new injury prevention methods or improvements in diagnosis and treatment over the past decade. For example, more minor injuries, which kept players out in the past, may now be treated without any time loss to the athlete. In addition, their study used a slightly broader definition of injury. Although knee injury rates differed, knee injuries as a percentage of all injuries across high school sports were very similar in both studies.

Similar to previous findings,[20] knee injury rates for each of the 9 high school sports were higher in competition than in practice. Knee injuries were 3 times more likely to occur in competition than in practice. In addition, more than two thirds of major knee injuries (67.7%) were sustained during competition. This result is not unexpected as competitions are characterized by greater intensity and physical exertion. Athletes in competition may also be more likely to take risks that increase injury rate.

Across all 9 sports, athletes sustained knee injuries most frequently in football, wrestling, girls' soccer, and girls' basketball, similar to those reported in the study conducted by Powell and Barber-Foss.[20] As expected, football and wrestling, sports with frequent contact between players and contact with the playing surface, had high overall rates of knee injury. Although girls' soccer and basketball do not involve the same amount of contact as football and wrestling, the persistent stress on the knee joint due to accelerating/decelerating, cutting, and landing from a jump in these sports could play as crucial a role in knee injury as does contact with a player or the playing surface.

Gender Differences

Distinct gender differences were found in our study regarding the rates of knee injury, rates of major knee injury, injury severity, and injury mechanism. Although overall knee injury rates were higher in boys than in girls (4.29 and 3.11

per 10 000 exposures, respectively), we found girls had a higher rate of major knee injury (0.71 and 0.64 per 10 000 exposures, respectively), which is consistent with results of previous studies.[21,27] This study also found a disparity in the severity of knee injuries between girls and boys, which supports results found in previous studies.[2,14,15] Complete ligament tears and season-ending knee injuries were much more common in girls' sports, including soccer, basketball, and volleyball. Girls were found to be 2.5 times as likely to completely tear knee ligaments and twice as likely to require knee surgery as boys. The higher rate of major knee injury in girls has been linked to many factors, including structural and neuromuscular differences between genders.[7,8]

Not only were girls more likely to sustain major knee injury, but they were also twice as likely as boys to incur noncontact major knee injuries. These data support a previous study of contact mechanisms in collegiate soccer and basketball.[1] Although noncontact major knee injuries in our study were more prevalent among girls than boys, gender comparisons within the same sport reveal that some sports have a greater gender gap than do others. In basketball and softball/baseball, girls were not significantly more likely than were boys to incur major knee injuries through noncontact mechanisms. In soccer, however, girls incurred major knee injuries through noncontact mechanisms more often than did boys. Although this comparison was statistically insignificant owing to the limited number of knee surgery cases reported, this finding is likely clinically important, and continued data collection on high school knee injuries will likely prove this comparison statistically significant. Because all 4 sports involve running and planting and because girls incurred noncontact major knee injuries at a higher rate than did boys in soccer, these results may suggest that planting and cutting on natural grass surfaces are more likely to cause serious injury among girls compared with other surfaces. Another potential factor could be cleat length relative to body size. Future research should focus on these and other potential mechanistic differences to better clarify injury risk factors and to direct preventive interventions.

Risk Factors/Recommendations

Illegal activity was identified as a risk factor for major knee injury in high school sports, with 20% of illegal activity–related knee injuries requiring surgery. Although the exact mechanism of the injury is unclear, illegal player-to-player contact appears to be a factor for knee injury among soccer players. In a previous study of soccer injuries, contact during slide tackling was identified as the leading cause of lower leg fractures.[3] Knee injuries caused by foul play in high school sports are preventable. We must change the culture of sports and make it clear to high school athletes that illegal play can cause serious injury to themselves and others. Adherence to rules and improved officiating should reduce the incidence of serious knee injury, especially in soccer.

The gender gap between sports in noncontact major knee injuries deserves further attention. Understanding underlying reasons for this gap may lead to the identification of important risk factors and subsequently the development of effective preventive interventions. One hypothesis is that the type of playing surface is a risk factor for knee injury. Only slight differences between basketball and baseball/softball were observed between the genders. However, girls were more likely to suffer noncontact major knee injuries than were boys in soccer. It may be that girls are more susceptible to the stresses placed on the knee joint by rapid acceleration, deceleration, and cutting movements on natural grass surfaces compared to hard, even surfaces. However, these hypotheses require further study. Addressing the basic physiological differences between genders could lead to targeted interventions to reduce the risk of major knee injury to girls. Prior research has shown that strengthening the muscles around the knee, including the hamstring and quadriceps, may reduce the risk of major knee injuries in girls.[27] In addition, new training techniques, which teach correct dynamic and biomechanical movement, could address neuromuscular differences between boys and girls and thus prevent knee injury.[16]

Limitations

This study, like all studies, has limitations. Only schools that had a National Athletic Trainers Association–affiliated ATC were eligible to participate in this study. This limits the generalizability of our results to all high schools in the United States. However, having only medically trained ATCs filling out the injury reports improved reliable diagnoses and data quality. In addition, only injuries brought to the ATCs' attention that kept the player out for at least 1 competition or practice were captured by this study. This was a necessary limitation to reduce the burden of injury reporting on the ATC. Last, our definition for an AE was limited to an athlete participating in a practice or competition rather than a time-based (ie, hour or minute) measure of participation. It is not feasible for the individual ATCs, responsible for all athletes in all sports at a high school, to record each athlete's participation time in every competition and practice. Despite these limitations, this study is the only current study of a nationally representative sample and presents the most comprehensive data on knee injury among high school athletics to date.

CONCLUSION

Knees are the second most injured body site among high school athletes. The economic impact and morbidity of knee injury and surgery are unequalled. Although a certain level of injury may always be associated with high school sports, the positive health benefits of a physically active lifestyle far outweigh the risk of injury. However, sports injury rates can be decreased through evidence-based targeted interventions. For example, injury prevention efforts such as muscle strengthening and movement training should be implemented to mitigate the rate and severity of knee injury. Continued surveillance of high school injury and monitoring trends over time is essential to fully understand the mechanisms behind major knee injury. Future studies should concentrate on identifying other knee injury risk and protective factors such as the potential impact of the use of artificial turf on knee injury.

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