Epidemiology of Lower Extremity Injuries among U.S. High School Athletes

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Abstract

Objectives: Despite the health benefits of organized sports, high school athletes are at risk for lower extremity sports-related injuries (LESRIs). The authors documented the epidemiology of LESRIs among U.S. high school athletes.

Methods: Via two-stage sampling, 100 U.S. high schools were randomly selected. During the 2005 school year, LESRIs in nine sports were reported: boys' baseball, football, and wrestling; girls' softball and volleyball; and boys' and girls' basketball and soccer. The authors calculated rates as the ratio of LESRIs to the number of athlete exposures. National estimates were generated by assigning injuries a sample weight based on the inverse probability of the school's selection into the study.

Results: Among high school athletes in 2005, 2,298 of 4,350 injuries (52.8%) were LESRIs. This represents an estimated 807,222 LESRIs in U.S. high school athletes in nine sports (1.33/1,000 athlete exposures). Football had the highest LESRI rate for boys (2.01/1,000) and soccer the highest for girls (1.59/1,000). Leading diagnoses were sprains (50%), strains (17%), contusions (12%), and fractures (5%). The ankle (40%), knee (25%), and thigh (14%) were most frequently injured. Fractures occurred most often in the ankle (42%), lower leg (29%), or foot (18%). Girls with ligamentous knee injuries required surgery twice as often as boys (67% vs. 35%; $p < 0.01$). Girls had 1.5 times the proportion of season-ending LESRIs of boys (12.5% vs. 8%; $p < 0.01$).

Conclusions: While LESRIs occur commonly in high school athletes, team- and gender-specific patterns exist. Emergency department staff will likely encounter such injuries. To optimize prevention strategies, ongoing surveillance is needed.

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Participation in organized athletics during high school has been shown to benefit adolescents in many ways. High school athletes are likely to establish and maintain positive health behaviors, enhance self-esteem, and improve teamwork skills.[1–4] Moreover, participation in high school sports has been associated with an increase in self-reported mental health and physical wellness,[3] a reduction in cigarette smoking, and an increase in vegetable consumption.[4] However, along with increased health benefits comes a risk for sporting-related injuries.[5,6]

Annually, there are an estimated 4.5 million sports- and recreation-related injuries among children and young adults in the United States.[5] The most common sports-related injuries are to the lower extremities, with two thirds occurring among children and young adults (ages 5–24 years).[6] Such injuries represent 20% of all emergency department visits among children and young adults.[6] Given the incidence of sports-related injuries among children and adolescents, clinicians in the pediatric emergency care setting will likely have to address many of these types of injuries.

Prior studies that have provided estimates of sports-related injuries among adolescents and young adults have often drawn their information from national administrative databases taken from medical records.[5,6] Devoid of athletic exposure information, such studies are unable to provide rate data to calculate relative risks among sports or athlete categories.[5,6] To properly address the epidemiology of sports-related injuries, exposure-based prospective studies are required. The authors sought to document the rate, mechanisms, and patterns of lower

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extremity injuries among U.S. high school athletes using data from such a study.

METHODS

Study Design

This project is a secondary analysis of the High School Sports-related Injury Surveillance Study,[7] a prospective observational study sponsored by a grant from the Centers for Disease Control and Prevention. This study was approved by the Columbus Children's Hospital Institutional Review Board.

Study Setting and Population

The High School Sports-related Injury Surveillance Study was conducted during the 2005–06 school year by the Center for Injury Research and Policy at the Columbus Children's Hospital in Columbus, Ohio. One hundred U.S. high schools representative of their region and school size were selected for participation. The sampling technique is further described in detail elsewhere.[7] Briefly, these schools were drawn from eight sampling strata (four strata based on geographic area and two strata based on school size of either $\geq$1,000 or <1,000 students). A total of 425 of the 4,120 certified athletic trainers (ATCs) affiliated with the National Athletic Trainers' Association (NATA) who provided care to high school athletes agreed to participate. Of the 425 schools with ATCs that agreed to participate, 100 schools drawn evenly from the eight sampling strata were randomly selected for participation in this project. If a school dropped out of the surveillance study, a replacement school from the same sampling stratum was enrolled.

Study Protocol

Each week during the 2005–06 academic school year, ATCs at each participating school reported the incidence of sports-related injuries and athletic exposure data for student athletes participating in nine sports: baseball, football, and wrestling (for boys' teams only); softball and volleyball (for girls' teams only); and basketball and soccer (for both boys' and girls' teams) using an Internet-based injury surveillance system created especially for this project (High School Reporting Information Online, R. Dawn Comstock, Columbus, OH).

Sports-related injuries were defined as those that resulted from participation in an organized high school athletic practice or competition, required medical attention from an ATC or a physician, and resulted in a restriction from participation in sports for one or more days beyond the day of injury. An athletic exposure was defined as one athlete participating in one practice or competition during which the athlete was exposed to the possibility of a sports-related injury. Injury rates were calculated as the ratio of the number of injuries in a particular category (e.g., sport or practice vs. competition) to the number of athletic exposures in that category. Using the data in this sample, we calculated national estimates for sports-related injuries. To do so, each reported injury was assigned a sample weight based on the inverse of the probability of the school's selection into the study (based on the total number of U.S. high schools in each of the eight sampling strata).

Data Analysis

Data were analyzed using SPSS software version 14.0 (SPSS Inc., Chicago, IL) and EpiInfo version 6.0 (Centers for Disease Control and Prevention, Atlanta, GA). With the exclusion of rate information, all data analyses utilized weighted data to calculate national estimates. Rates of injury were calculated as the ratio of injuries per 1,000 athlete exposures. Rate ratios (RRs) and injury proportion ratios (IPRs) were calculated with 95% confidence intervals (CI). A rate ratio or IPR > 1.00 indicates an association exists, with a CI not including 1.00 considered statistically significant. For example, the calculation comparing the overall rate of injury between boys' and girls' soccer is as follows:

$$RR = \frac{(\text{total no. of boys' soccer injuries} / \text{total no. of boys' soccer athlete exposures}) \times 1{,}000}{(\text{total no. of girls' soccer injuries} / \text{total no. of girls' soccer athlete exposures}) \times 1{,}000}$$

As an example of IPR calculation, the following compares the proportion of season-ending injuries in girls and boys:

$$IPR = \frac{(\text{national estimated no. of girls' season-ending injuries} / \text{national estimated no. of total girls' injuries})}{(\text{national estimated no. of boys' season-ending injuries} / \text{national estimated no. of total boys' injuries})}$$

RESULTS

Overall, there were 4,350 injuries sustained by athletes (24.3% female) participating in the nine sports studied during the 2005–06 academic year. Of the total injuries, 2,298 (52.8%) were to the lower extremities (1.33 per 1,000 athletic exposures). This represents an estimated 807,222 lower extremity injuries sustained nationally by U.S. high school athletes participating in the nine sports studied. Rates of lower extremity injury by sport are presented in Table 1. Football had the highest rate of lower extremity injury for boys (2.01 per 1,000 athletic exposures), while soccer had the highest rate for girls (1.59 per 1,000 athletic exposures). The average age of boys who sustained lower extremity injuries was 16.1 years, while the average age for injured girls was 15.8 years.

A description of injury diagnoses, regions of the body affected, and injury mechanisms is presented in Table 2. Fractures occurred most commonly to the ankle (41.8%), lower leg (29.1%), and foot/toe (18.2%). Additionally, as shown in Figure 1, 5.3% of lower extremity injuries required surgery (6.8% and 4.5% among girls and boys, respectively; p = 0.063; IPR = 1.51; 95% CI = 0.98 to 2.32). Comparing the nine sports, lower extremity fractures sustained in boys' wrestling (9.3%), boys' baseball (8.4%), girls' basketball (7.4%), and girls' soccer (7.3%) most commonly required surgery. Among soccer players, a statistically significantly higher proportion of injuries to girls (7.3%) required surgery compared with boys (2.0%; p = 0.014; IPR = 3.57; 95% CI = 1.20 to 10.61). Among basketball players, 7.4% of girls' injuries

Table 1
Lower Extremity Injury Rates of High School Athletes by Sport, High School Sports-related Injury Surveillance Study, United States, 2005–06 School Year

	No. of Injuries	No. of Exposures	Injury Rate (per 1,000 athlete exposures)
All sports	2,298	1,730,764	1.33
All boys' sports	1,634	1,148,698	1.42
Football	866	431,242	2.01
Soccer	279	153,400	1.82
Basketball	287	218,342	1.31
Wrestling	125	166,279	0.75
Baseball	77	179,435	0.43
All girls' sports	664	582,066	1.14
Soccer	225	141,581	1.59
Basketball	254	186,161	1.36
Volleyball	118	119,235	0.99
Softball	67	135,089	0.50

required surgery, compared with 4.6% of boys' injuries (p = 0.224; IPR = 1.63; 95% CI = 0.74 to 3.58). The most common injury requiring surgery for both girls and boys was knee injuries (78.4% and 72.2%, respectively). However, 67.4% of girls' surgeries were due to ligamentous tears of the knee (e.g., anterior cruciate ligament [ACL] tears) compared with 35.4% of boys' surgeries (p = 0.005; IPR = 1.90; 95% CI = 1.24 to 2.93).

A description of the number of days lost due to lower extremity injury by sport is shown in Figure 2. Lower extremity injuries most commonly resulted in three to six days off from sports for both boys (30.2%) and girls (31.6%). Overall, 8% of lower extremity injuries sustained by boys resulted in a season-ending injury compared with 12.5% of injuries sustained by girls (p = 0.008; IPR = 1.55; 95% CI = 1.12 to 2.15).

DISCUSSION

This study, conducted in a nationally representative sample of 100 high schools, captured 2,298 lower extremity sports-related injuries, which represent an estimated 807,222 lower extremity injuries sustained by high school athletes nationwide in the nine sports studied. The most common types of injuries were sprains/strains, contusions, and fractures. The most common locations of injury were the ankle, knee, and thigh. Overall, 5.3% of these injuries required surgery. Knee injuries were the most common indication for surgery overall; however, girls required surgical repair for ligamentous knee injuries nearly twice as often as boys.

Among the nine sports studied, football and soccer had the highest rates of lower extremity injuries for boys and girls, respectively. Due to the high degree of contact between players (e.g., tackling and blocking), it is not surprising that boys' football resulted in the highest rate of injury and the highest proportion of postinjury disability. This is consistent with prior research.[8–10] In a comparison of ten high school sports, football had the highest rate of injury cases during either practice or competition. In that study, football had more than 2.5 times the rate of injury cases during competition than any other sport in the study.[8]

Table 2
Diagnosis, Body Region, and Mechanism of Lower Extremity Injuries among High School Athletes, High School Sports-related Injury Surveillance Study, United States, 2005–06 School Year

	Overall (%)	Boys (%)	Girls (%)
Diagnosis			
Ligament sprain	50.0	46.2	57.2
Muscle strain	17.1	18.8	13.9
Contusion	12.1	15.1	6.3
Fracture	5.0	5.0	5.0
Tendon strain	3.1	2.3	4.7
Torn cartilage	2.2	2.5	1.7
Tendonitis	2.0	2.0	1.8
Stress fracture	1.3	1.3	1.2
Dislocation	1.1	1.0	1.3
Other	6.1	5.7	6.9
Body region			
Ankle	40.3	35.2	49.6
Knee	25.3	26.5	23.0
Thigh/upper leg	14.2	15.8	11.2
Lower leg	8.1	8.5	7.6
Foot	7.1	7.5	6.5
Hip	5.0	6.6	2.1
Mechanism			
Contact with another person	48.6	53.5	36.5
No contact (e.g., pulled muscle, overuse, etc.)	24.7	22.4	30.3
Contact with playing surface	20.7	19.0	24.7
Other	6.0	5.1	8.5

In our study, soccer was the leading cause of sports-related injury among girls, although boys had a higher soccer-related injury rate. Despite this, however, girls had a more than 3.5 times greater proportion of soccer-related injuries requiring surgery than boys. Adams and Schiff found that among young adults aged 15–19 years, boys had greater rates of soccer-related knee injuries than girls.[11] However, Leininger et al. found that among children and young adults sustaining soccer-related injuries, girls had 25% more injuries than boys. Boys, however, had injuries requiring surgeries 85% more often than girls.[12]

The most common types of injuries seen in our study were sprains and strains, contusions, and fractures. Other researchers have found similar results.[5,6] Conn et al. reported that approximately one third of lower extremity injuries involved the lower leg or ankle. Sprains and strains accounted for more than half of these injuries, while another 16% were fractures.[5] Burt and Overpeck noted that sprains/strains and fractures were significantly more prevalent among sports-related injury visits treated in the emergency department than non–sports-related injuries.[6]

In our study, fractures were most commonly of the lower leg, ankle, and foot. Overall, 5.3% of lower extremity injuries (6.8% for girls and 4.5% for boys) required surgery. Although the rates of knee surgeries were similar between girls and boys, girls required repairs of ligamentous knee tears at nearly twice the rate for boys. Our results mirror the findings of others.[8,13,14] In a study by de Loes et al, although there were no gender differences among soccer players in the rate of knee injuries, girls had twice the rate of ACL injuries than boys.[13] Powell and Barber-Foss reported that girls required ACL

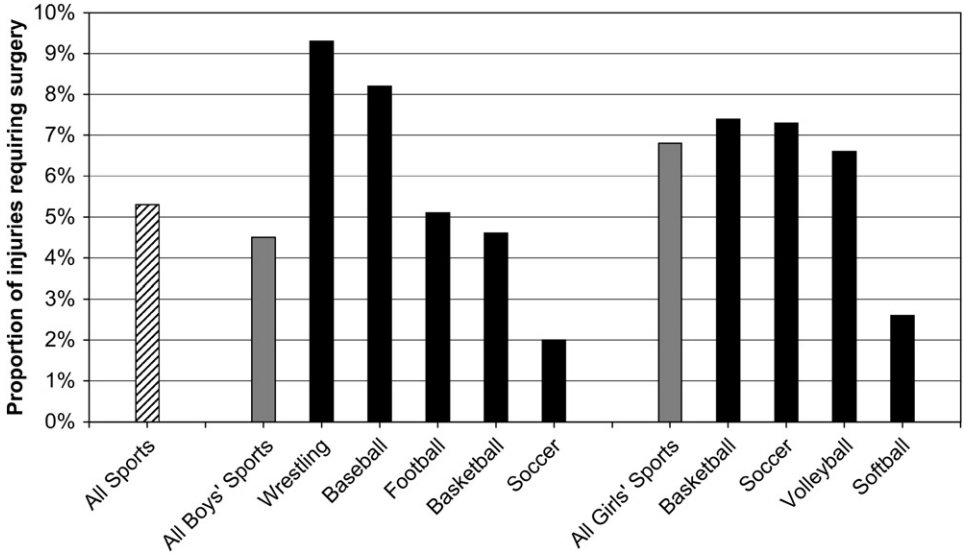

Figure 1. Proportion of lower extremity injuries requiring surgery among high school athletes, High School Sports-related Injury Surveillance Study, United States, 2005–06 school year.

surgery more than three times more often than boys.[14] Although no single definitive etiology for such gender differences has been determined, anatomic, biomechanical, hormonal, and other differences have been cited.[15–18] Some research suggests that plyometric conditioning, strength training, and other neuromuscular training techniques may prevent such injuries.[19,20] Additional research is needed to further delineate the causes of these gender differences, as well as the best countermeasures to prevent these injuries.

LIMITATIONS

In this project, data collection was limited to nine sports, and only high schools whose athletes had access to an NATA-certified ATC were included in the sampling design. While this may affect the generalizability of our findings, the limitation was acceptable due to the desire to use only medically trained reporters to improve data quality. Furthermore, only time-loss injuries brought to the attention of the ATC were included. While the use of time loss as a measure of injury has restrictions because this definition excludes less severe injuries, this was a necessary limitation to reduce the reporting burden placed on participating ATCs. Additionally, injuries that were treated at a physician's office or emergency department and that were not reported to the team's ATC were not captured. Despite these limitations, to the best of our knowledge this study presents the most comprehensive comparison of lower extremity injury rates and patterns of injury among a nationally representative sample of high school athletes to date.

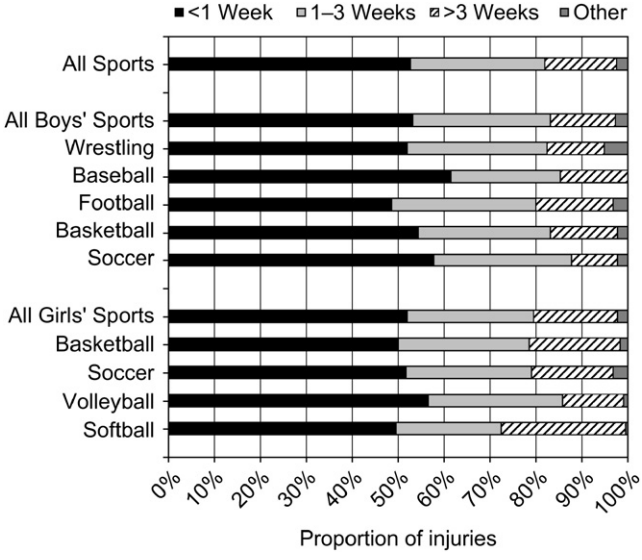

Figure 2. Days lost due to lower extremity injuries among high school athletes, High School Sports-related Injury Surveillance Study, United States, 2005–06 school year.

CONCLUSIONS

Injuries are a common consequence of participation in high school sports. This study demonstrates there are team-specific as well as gender-specific lower extremity injury patterns that coaches, trainers, and emergency care providers alike should be aware of. Knowledge of such injury risk factors can be beneficial to health care providers during injury diagnosis and treatment. Additionally, understanding the mechanisms of injury and risk factors for injury is essential if targeted injury prevention interventions are to be developed. Additional research studies are necessary to fully understand the mechanisms of lower extremity injuries, a crucial step toward mitigation of the number and severity of these injuries among high school athletes. Surveillance systems such as High School Reporting Information Online are critical for supplying the quality data needed to conduct such studies.

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