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The First Decade of Web-Based Sports Injury Surveillance: Descriptive Epidemiology of Injuries in United States High School Football (2005–2006 Through 2013–2014) and National Collegiate Athletic Association Football (2004–2005 Through 2013–2014)

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Context: The advent of Web-based sports injury surveillance via programs such as the High School Reporting Information Online system and the National Collegiate Athletic Association Injury Surveillance Program has aided the acquisition of football injury data.

Objective: To describe the epidemiology of injuries sustained in high school football in the 2005–2006 through 2013–2014 academic years and collegiate football in the 2004–2005 through 2013–2014 academic years using Web-based sports injury surveillance.

Design: Descriptive epidemiology study.

Setting: Online injury surveillance from football teams of high school boys (annual average = 100) and collegiate men (annual average = 43).

Patients or Other Participants: Football players who participated in practices and competitions during the 2005–2006 through 2013–2014 academic years in high school or the 2004–2005 through 2013–2014 academic years in college.

Main Outcome Measure(s): Athletic trainers collected time-loss injury (≥24 hours) and exposure data. Injury rates per 1000 athlete-exposures (AEs), injury rate ratios (IRRs) with 95% confidence intervals (CIs), and injury proportions by body site and diagnosis were calculated.

Results: The High School Reporting Information Online system documented 18 189 time-loss injuries during 4 539 636 AEs; the National Collegiate Athletic Association Injury Surveillance Program documented 22 766 time-loss injuries during 3 121 476 AEs. The injury rate was higher among collegiate than high school (7.29 versus 4.01/1000 AEs; IRR = 1.82; 95% CI = 1.79, 1.86) athletes. Most injuries occurred during competitions in high school (53.2%) and practices in college (60.9%). The competition injury rate was higher than the practice injury rate among both high school (IRR = 5.62; 95% CI = 5.46, 5.78) and collegiate (IRR = 6.59; 95% CI = 6.41, 6.76) players. Most injuries at both levels affected the lower extremity and the shoulder/clavicle and were diagnosed as ligament sprains and muscle/tendon strains. However, concussion was a common injury during competitions among most positions.

Conclusions: Injury rates were higher in college than in high school and higher for competitions than for practices. Concussion was a frequent injury sustained during competitions, which confirms the need to develop interventions to mitigate its incidence and severity.

Key Words: concussion, musculoskeletal injuries, lower extremity injuries

Key Points

- The injury rate was higher in collegiate than in high school football players, although a greater number of injuries were estimated to occur nationally in the latter.
- The injury rate was higher during competitions than during practices; however, large proportions of injuries were sustained during practices.
- Concussions, knee sprains, and ankle sprains were typical injuries sustained during competitions.

Participation in football at the high school and collegiate levels has increased in the past decade. Compared with the 2003–2004 academic year, the number of high school football (11-person) student-athletes in the 2013–2014 academic year increased 5.9% to 1 093 234 individuals.[1] Similarly, in the National Collegiate Athletic Association (NCAA), when compared with the 2003–2004 academic year, the number of collegiate football student-athletes in the 2013–2014 academic year increased 18.9% to 71 291 individuals, whereas the size of the average squad roster grew from 94.1 to 107.4 players.[2] Furthermore, football was the individual sport with the most student-athlete participants at both the high school and collegiate levels.[1,2]

Sports injury-surveillance platforms have been available for tracking the epidemiology of collegiate football–related injuries since the 1970s.[3] However, such data were collected using a pen-and-paper system, in which athletic trainers (ATs) completed hard-copy injury and exposure forms that were faxed or mailed to the NCAA; a staff member then hand entered or scanned the data. Such a pen-and-paper–based system had limitations that burdened those ATs collecting and reporting data, including double data entry that increased the time and resources needed. Starting in the 2004–2005 academic year, the NCAA moved to data collection on a Web-based platform[4] (although this NCAA-based surveillance system has had several names, we herein denote it as the *NCAA Injury Surveillance Program* [ISP]). A year later, High School Reporting Information Online (HS RIO), a Web-based high school sports injury-surveillance system, was launched.[5]

Web-based surveillance platforms are designed to ensure more thorough data collection and thus more valid estimates of injury incidence in sport-related settings. Furthermore, as described in the van Mechelen et al[6] framework, injury prevention benefits from ongoing monitoring of injury incidence, and updated descriptive epidemiology is needed. A previous NCAA-ISP report[7] on the 1988–1989 through 2003–2004 academic years documented competition and practice injury rates of 35.90/1000 and 3.80/1000 athlete-exposures (AEs), respectively. In addition, it is important to use HS RIO data to document injury incidences at the high school level and compare findings between the settings. The purpose of this article was to describe the epidemiology of injuries sustained in high school and collegiate football during the first decade of Web-based sports-injury surveillance (2004–2005 through 2013–2014 academic years).

METHODS

Data Sources and Study Period

This study used data collected by HS RIO and the NCAA-ISP, sports injury-surveillance programs for the high school and collegiate levels, respectively. Use of the HS RIO data was approved by the Nationwide Children's Hospital Subjects Review Board (Columbus, Ohio). Use of the NCAA-ISP data was approved by the Research Review Board at the NCAA.

An average of 100 high schools sponsoring boys' football provided data to the HS RIO random sample during the 2005–2006 through 2013–2014 academic years (2005–2006 was the first year HS RIO collected data). An average of 43 NCAA member institutions (Division I = 20, Division II = 7, Division III = 16) sponsoring men's football participated in the NCAA-ISP during the 2004–2005 through 2013–2014 academic years. The methods of HS RIO and the NCAA-ISP are summarized in the following sections. In-depth information on the methods and analyses for this special series of articles on Web-based sports injury surveillance can be found in the previously published methodologic article.[8] In addition, earlier authors have described the sampling and data collection of HS RIO[5,9] and the NCAA-ISP[4] in depth.

High School RIO

High School RIO consists of a sample of high schools with 1 or more National Athletic Trainers' Association (NATA)–affiliated ATs with valid e-mail addresses. The ATs from participating high schools reported injury incidence and AE information weekly throughout the academic year using a secure Web site. For each injury, the AT completed a detailed report on the injured athlete (eg, age, height, weight), the injury (eg, site, diagnosis, severity), and the injury event (eg, activity, mechanism). Throughout each academic year, participating ATs were able to view and update previously submitted reports with new information (eg, time loss) as needed.

Data for HS RIO during the 2005–2006 through 2013–2014 academic years originated from a random sample of 100 schools that were recruited annually. Eligible schools were randomly selected from 8 strata (12 or 13 schools per stratum) based on school population (enrollment $\leq$1000 or $>$1000) and US Census geographic region.[10] Athletic trainers from these schools reported data for the 9 sports of interest (boys' basketball, baseball, football, soccer, and wrestling and girls' basketball, soccer, softball, and volleyball). If a school dropped out of the system, a replacement from the same stratum was selected.

The HS RIO national injury estimates were calculated from injury counts obtained from the random sample. Because the random sample led to the inclusion of data from schools in various census areas and of various sizes, the national estimates can capture a more accurate estimate of national injury incidence than if a convenience sample had been used. A weighting algorithm based on the inverse probability of participant schools' selection into the study (on the basis of geographic location and high school size) was applied to individual case counts to calculate the national injury estimates.

It is possible that injuries may be underreported by ATs due to competing demands on their time and the dynamic nature of the athletic training facility environment. However, several annual summary reports provided the results of internal validity checks, which matched and compared HS RIO data with data abstracted from other types of clinical records maintained by participating certified ATs in the high school setting. These validity checks have consistently demonstrated sensitivity, specificity, positive predictive value, and negative predictive value above 95% (see annual summary reports available at http://www.ucdenver.edu/academics/colleges/PublicHealth/research/ResearchProjects/piper/projects/RIO/Pages/StudyReports.aspx).

National Collegiate Athletic Association Injury Surveillance Program

The NCAA-ISP depends on a convenience sample of teams, with ATs voluntarily reporting injury and exposure data.[4] Participation in the NCAA-ISP, though voluntary, is available to all NCAA institutions. For each injury event, the AT completes a detailed event report on the injury or condition (eg, site, diagnosis) and the circumstances (eg, activity, mechanism, event type [ie, competition or practice]). The ATs are able to view and update previously submitted information as needed during the course of a season. In addition, ATs also provide the number of student-athletes participating in each practice and competition. Data collection for the 2004–2005 through 2013–2014 academic years is described in the following paragraphs.

During the 2004–2005 through 2008–2009 academic years, ATs used a Web-based platform launched by the NCAA to track injury and exposure data.[4] This platform integrated some of the functional components of an electronic medical record, such as athlete demographic information and preseason injury information. During the 2009–2010 through 2013–2014 academic years, the Datalys Center for Sports Injury Research and Prevention, Inc (Datalys Center, Indianapolis, IN) introduced a common data element (CDE) standard to improve process flow. The CDE standard allowed data to be gathered from different electronic medical record and injury-documentation applications, including the Athletic Trainer System (Keffer Development, Grove City, PA), Injury Surveillance Tool (Datalys Center), and Sports Injury Monitoring System (FlanTech, Iowa City, IA). The CDE export standard allowed ATs to document injuries as they normally would as part of their daily clinical practice, as opposed to asking them to report injuries solely for the purpose of participation in an injury-surveillance program. Data were deidentified and sent to the Datalys Center, where they were examined by data quality-control staff and a verification engine.

The NCAA-ISP includes weights that can be applied to data to generate national estimates that adjust for potential underreporting of injuries poststratification. Sample weights, based on sport, division, and academic year, were applied to each reported injury and AE. Weights for all data were further adjusted to correct for underreporting, consistent with Kucera et al,[11] who estimated that the NCAA-ISP captured 88.3% of all time-loss medical-care injury events in men's and women's soccer. Weighted counts were scaled up by a factor of (0.883^{-1}). Despite the use of NCAA-ISP data from soccer, the weighting was applied to football data under the assumption that underreporting does not vary by sport, year, school, or division. In-depth information on the formula used to calculate national estimates can be found in the previously published methodologic article.[8]

Definitions

Injury. A reportable *injury* in both HS RIO and the NCAA-ISP was defined as an injury that (1) occurred as a result of participation in an organized practice or competition; (2) required medical attention by a certified AT or physician; and (3) resulted in restriction of the student-athlete's participation for 1 or more days beyond the day of injury. Since the 2007–2008 academic year, HS RIO has also captured all concussions, fractures, and dental injuries, regardless of time loss. In NCAA-ISP, multiple injuries occurring from 1 injury event could be included, whereas in HS RIO, only the principal injury was captured. Beginning in the 2009–2010 academic year, the NCAA-ISP also began to monitor all non–time-loss injuries. A *non–time-loss injury* was defined as any injury that was evaluated or treated (or both) by an AT or physician but did not result in restriction from participation beyond the day of injury. However, because HS RIO captures only time-loss injuries (to reduce the time burden on high school ATs), for this series of publications, only time-loss injuries (with the exception of concussions, fractures, and dental injuries as noted earlier) were included.

Athlete-Exposure. For both surveillance systems, a reportable *AE* was defined as 1 student-athlete participating in 1 school-sanctioned practice or competition in which he or she was exposed to the possibility of athletic injury, regardless of the time associated with that participation. Preseason scrimmages were considered practice exposures, not competition exposures.

Statistical Analysis

Data were analyzed using SAS-Enterprise Guide software (version 5.4; SAS Institute Inc, Cary, NC). Because the data collected from HS RIO and the NCAA-ISP are similar, we opted to recode data when necessary to increase the comparability between high school and collegiate student-athletes. We also opted to ensure that categorizations were consistent among all sport-specific articles within this special series. Because methodologic variations may lead to small differences in injury reporting between these surveillance systems, caution must be taken when interpreting these results.

We examined injury counts, national estimates, and distributions by event type (practice, competition), time in season (preseason, regular season, postseason), time loss (1 to 6 days, 7 to 21 days, and more than 21 days, including injuries resulting in a premature end to the season), body part injured, diagnosis, mechanism of injury, activity during injury, and position. We also calculated injury rates per 1000 AEs and injury rate ratios (IRRs). The IRRs focused on comparisons by level of play (high school and college), event type (practice and competition), school size in high school ($\leq$1000 and $>$1000 students), division in college (Division I, II, and III), and time in season (preseason, regular season, and postseason). All IRRs with 95% confidence intervals (CIs) not containing 1.0 were considered statistically significant.

Lastly, we used linear regression to analyze linear trends across time of injury rates and compute average annual changes (ie, mean differences). Owing to the 2 separate data-collection methods for the NCAA-ISP during the 2004–2005 through 2008–2009 and 2009–2010 through 2013–2014 academic years, linear trends were calculated separately for each time period. All mean differences with 95% CIs not containing 0.0 were considered statistically significant.

Table 1. Injury Rates by School Size or Division and Type of Athlete-Exposure in High School and Collegiate Football[a]

Surveillance System and School Size or Division	Exposure Type	Injuries in Sample, No. (%)	National Estimates, No. (%)	Athlete-Exposures	Injury Rate/1000 Athlete-Exposures (95% Confidence Interval)
HS RIO (2005–2006 through 2013–2014)					
≤1000 students	Practice	3003 (43.3)	1 417 004 (44.2)	1 188 575	2.53 (2.44, 2.62)
	Competition	3927 (56.7)	1 787 156 (55.8)	260 103	15.10 (14.63, 15.57)
	Total	6930 (100.0)	3 204 160 (100.0)	1 448 678	4.78 (4.67, 4.90)
>1000 students	Practice	5508 (48.9)	997 706 (49.0)	2 586 927	2.13 (2.07, 2.19)
	Competition	5751 (51.1)	1 040 038 (51.0)	504 031	11.41 (11.12, 11.70)
	Total	11 259 (100.0)	2 037 745 (100.0)	3 090 958	3.64 (3.58, 3.71)
Total	Practice	8511 (46.8)	2 414 710 (46.1)	3 775 502	2.25 (2.21, 2.30)
	Competition	9678 (53.2)	2 827 194 (53.9)	764 134	12.67 (12.41, 12.92)
	Total	18 189 (100.0)	5 241 905 (100.0)	4 539 636	4.01 (3.95, 4.06)
NCAA-ISP (2004–2005 through 2013–2014)					
Division I	Practice	7182 (59.3)	89 545 (59.5)	1 552 554	4.63 (4.52, 4.73)
	Competition	4928 (40.7)	61 067 (40.5)	144 697	34.06 (33.11, 35.01)
	Total	12 110 (100.0)	150 612 (100.0)	1 697 251	7.14 (7.01, 7.26)
Division II	Practice	1609 (58.7)	39 782 (58.5)	411 855	3.91 (3.72, 4.10)
	Competition	1134 (41.3)	28 212 (41.5)	38 338	29.58 (27.86, 31.30)
	Total	2743 (100.0)	67 994 (100.0)	450 193	6.09 (5.86, 6.32)
Division III	Practice	5075 (64.1)	77 251 (63.9)	879 899	5.77 (5.61, 5.93)
	Competition	2838 (35.9)	43 580 (36.1)	94 134	30.15 (29.04, 31.26)
	Total	7913 (100.0)	120 831 (100.0)	974 032	8.12 (7.94, 8.30)
Total	Practice	13 866 (60.9)	206 578 (60.9)	2 844 307	4.88 (4.79, 4.96)
	Competition	8900 (39.1)	132 859 (39.1)	277 168	32.11 (31.44, 32.78)
	Total	22 766 (100.0)	339 436 (100.0)	3 121 476	7.29 (7.20, 7.39)

Abbreviations: HS RIO, High School Reporting Information Online; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.

[a] High school data originated from HS RIO surveillance data, 2005–2006 through 2013–2014; collegiate data originated from NCAA-ISP surveillance data, 2004–2005 through 2013–2014. Injuries included in the analysis were those that (1) occurred during a sanctioned practice or competition; (2) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; and (3) restricted the student-athlete from participation for at least 24 hours past the day of injury. All concussions, fractures, and dental injuries were included in the analysis, regardless of time loss. Data may include multiple injuries that occurred at 1 injury event.

RESULTS

Total Injury Frequency, National Estimates, and Injury Rates

During the 2005–2006 through 2013–2014 academic years, ATs reported a total of 18 189 time-loss injuries in high school football players (Table 1). During the 2004–2005 through 2013–2014 academic years, ATs reported a total of 22 766 time-loss injuries in collegiate football players. These raw data counts represent overall national estimates of 5 241 905 high school injuries (annual average of 582 434) and 339 436 collegiate injuries (annual average of 33 944). The total injury rate for high school football was 4.01/1000 AEs (95% CI = 3.95, 4.06), whereas the total injury rate for collegiate football was 7.29/1000 AEs (95% CI = 7.20, 7.39). The total injury rate was higher in collegiate than in high school (IRR = 1.82; 95% CI = 1.79, 1.86) football.

School Size and Division

At the high school level, the total injury rate was higher in high schools with ≤1000 students than those with >1000 students (IRR = 1.31; 95% CI = 1.27, 1.35; Table 1). At the collegiate level, the total injury rate was higher in Division I than in Division II (IRR = 1.17; 95% CI = 1.12, 1.22). However, Division III had a higher total injury rate than Divisions I (IRR = 1.14; 95% CI = 1.11, 1.17) and II (IRR = 1.33; 95% CI = 1.28, 1.39).

Event Type

Most injuries occurred during competitions at the high school level (53.2%) and practices at the collegiate level (60.9%; Table 1). The competition injury rate was higher than the practice injury rate in both high school (IRR = 5.62; 95% CI = 5.46, 5.78) and college (IRR = 6.59; 95% CI = 6.41, 6.76).

No linear trends were found for the annual injury rates for high school practices (average annual change of –0.05/1000 AEs; 95% CI = –0.11, 0.01) and competitions (average annual change of 0.01/1000 AEs; 95% CI = –0.15, 0.17; Figure). Collegiate injury rates fluctuated more. Decreases occurred in the 2004–2005 to 2008–2009 academic years for practices (average annual change of –0.46/1000 AEs; 95% CI = –0.81, –0.11) and competitions (average annual change of –2.50/1000 AEs; 95% CI = –4.20, –0.81). In contrast, increases occurred in the 2009–2010 through 2013–2014 academic years for practices (average annual change of 0.33/1000 AEs; 95% CI = 0.13, 0.52) and competitions (average annual change of 1.73/1000 AEs; 95% CI = 1.12, 2.34).

Time in Season

In both high school and collegiate football, the majority of injuries occurred during the regular season (high school = 69.3%, college = 59.5%; Table 2). In collegiate football, the preseason had a higher injury rate than the regular season (IRR = 1.29; 95% CI = 1.26, 1.33) and postseason

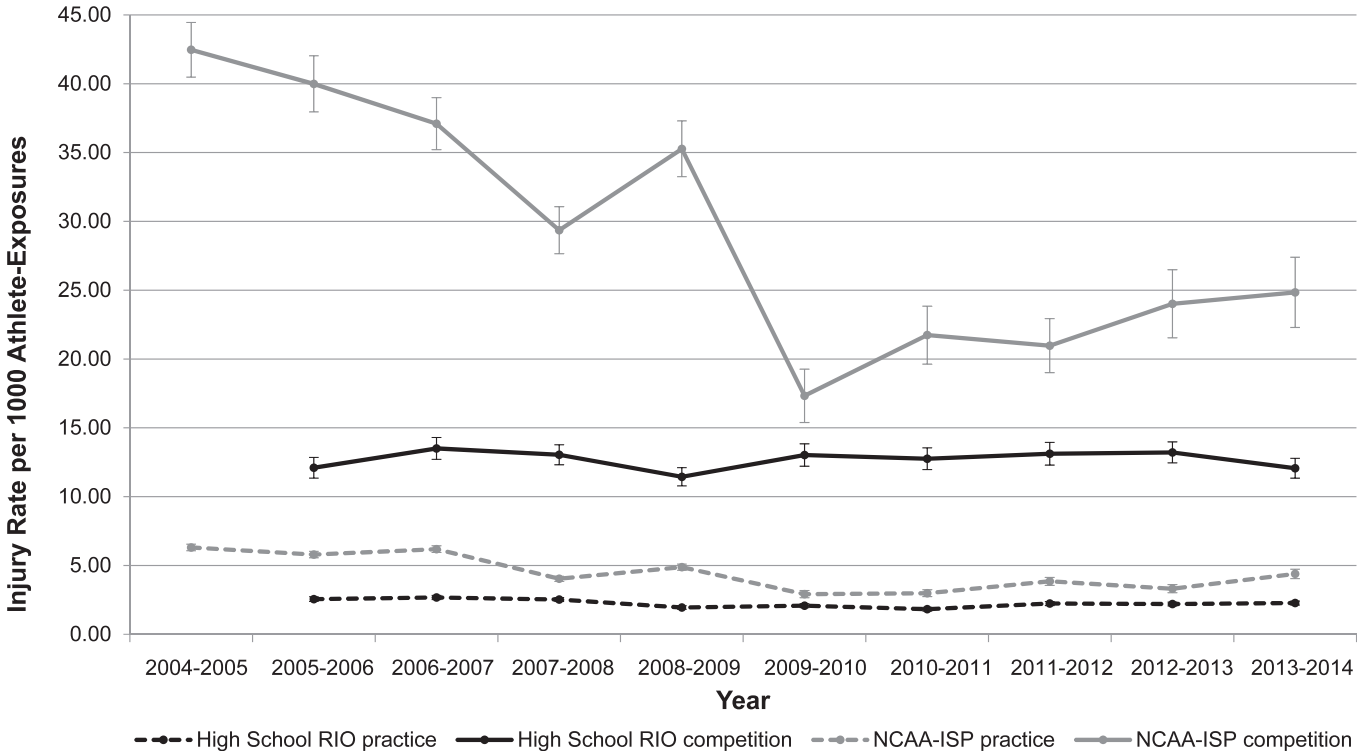

Figure. Injury rates by year and type of athlete-exposure (AE) in high school and collegiate football. Annual average changes for linear trend test for injury rates are as follows: High School Reporting Information Online (HS RIO) boys (practice: −0.05/1000 AEs, 95% confidence interval [CI] = −0.11, 0.01; competition: 0.01/1000 AEs, 95% CI = −0.15, 0.17); National Collegiate Athletic Association Injury Surveillance Program (NCAA-ISP) 2004–2005 to 2008–2009 (practice: −0.46/1000 AEs, 95% CI = −0.81, −0.11; competition: −2.50/1000 AEs, 95% CI = −4.20, −0.81); NCAA-ISP 2009–2010 to 2013–2014 (practice: 0.33/1000 AEs, 95% CI = 0.13, 0.52; competition: 1.73/1000 AEs, 95% CI = 1.12, 2.34). A negative rate indicates a decrease in the annual average change between years, and a positive rate indicates an increase in the annual average change; 95% CIs that include 0.00 are not significant.

(IRR = 2.30; 95% CI = 2.10, 2.51). In addition, the injury rate was higher during the regular season than during the postseason (IRR = 1.77; 95% CI = 1.62, 1.94). Injury rates by time in season could not be calculated for high school because AEs were not stratified by the time in season.

Time Loss From Participation

In both high school and collegiate football, the largest proportion of injuries resulted in time loss of less than 1 week and ranged from 40.1% for injuries sustained during

Table 2. Injury Rates by Time in Season and Type of Athlete-Exposure in High School and Collegiate Football[a]

		HS RIO (2005–2006 Through 2013–2014)		NCAA-ISP (2004–2005 Through 2013–2014)			
Time in Season	Exposure Type	Injuries in Sample, No. (%)	National Estimates, No. (%)	Injuries in Sample, No. (%)	National Estimates, No. (%)	Athlete-Exposures	Injury Rate/1000 Athlete-Exposures (95% Confidence Interval)
Preseason	Practice	4289 (88.2)	1 227 359 (88.0)	8689 (99.4)	129 266 (99.6)	994 532	8.74 (8.55, 8.92)
	Competition	573 (11.8)	167 992 (12.0)	50 (0.6)	492 (0.4)	1668	29.98 (21.67, 38.28)
	Total	4 862 (100.0)	1 395 351 (100.0)	8739 (100.0)	129 758 (100.0)	996 200	8.77 (8.59, 8.96)
Regular season	Practice	3 934 (31.3)	1 087 562 (30.4)	4877 (36.0)	73 387 (36.1)	1 730 938	2.82 (2.74, 2.90)
	Competition	8 619 (68.7)	2 490 405 (69.6)	8662 (64.0)	129 974 (63.9)	266 625	32.49 (31.80, 33.17)
	Total	12 553 (100.0)	3 577 968 (100.0)	13 539 (100.0)	203 361 (100.0)	1 997 563	6.78 (6.66, 6.89)
Postseason	Practice	246 (35.6)	77 624 (34.3)	300 (61.5)	3925 (62.1)	118 838	2.52 (2.24, 2.81)
	Competition	445 (64.4)	149 009 (65.7)	188 (38.5)	2392 (37.9)	8875	21.18 (18.16, 24.21)
	Total	691 (100.0)	226 633 (100.0)	488 (100.0)	6317 (100.0)	127 713	3.82 (3.48, 4.16)

Abbreviations: HS RIO, High School Reporting Information Online; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.

[a] Excludes 83 injuries reported in HS RIO due to missing data for time in season. Injury rates by time in season could not be calculated for high school as athlete-exposures were not stratified by time in season. High school data originated from HS RIO surveillance data, 2005–2006 through 2013–2014; collegiate data originated from NCAA-ISP surveillance data, 2004–2005 through 2013–2014. Injuries included in the analysis were those that (1) occurred during a sanctioned practice or competition; (2) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; and (3) restricted the student-athlete from participation for at least 24 hours past the day of injury. All concussions, fractures, and dental injuries were included in the analysis, regardless of time loss. Data may include multiple injuries that occurred at 1 injury event.

Table 3. Number of Injuries and Injury Rates by Time Loss and Type of Athlete-Exposure in High School and Collegiate Football[a]

Surveillance System and Time-Loss Category	Practice			Competition		
	Injuries in Sample, No. (%)	National Estimates, No. (%)	Injury Rate/1000 Athlete-Exposures (95% Confidence Interval)	Injuries in Sample, No. (%)	National Estimates, No. (%)	Injury Rate/1000 Athlete-Exposures (95% Confidence Interval)
HS RIO (2005–2006 through 2013–2014)						
1 d to <1 wk	3706 (45.4)	1 082 961 (46.7)	0.98 (0.95, 1.01)	3710 (40.1)	1 089 592 (40.2)	4.86 (4.70, 5.01)
1 to 3 wk	2809 (34.4)	791 265 (34.1)	0.74 (0.72, 0.77)	3180 (34.4)	919 383 (33.9)	4.16 (4.02, 4.31)
>3 wk[b]	1651 (20.2)	446 480 (19.2)	0.44 (0.42, 0.46)	2353 (25.5)	701 944 (25.9)	3.08 (2.95, 3.20)
NCAA-ISP (2004–2005 through 2013–2014)						
1 d to <1 wk	7112 (52.8)	107 416 (54.0)	2.50 (2.44, 2.56)	3812 (44.1)	56 478 (44.2)	10.15 (9.77, 10.52)
1 to 3 wk	3734 (27.7)	54 096 (27.2)	1.31 (1.27, 1.35)	2955 (34.2)	42 332 (33.1)	10.66 (10.28, 11.05)
>3 wk[b]	2625 (19.5)	37 424 (18.8)	0.92 (0.89, 0.96)	1886 (21.8)	29 092 (22.8)	6.80 (6.50, 7.11)

Abbreviations: HS RIO, High School Reporting Information Online; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.

[a] Excludes 780 injuries reported in HS RIO and 642 injuries reported in NCAA-ISP due to missing data for time loss. Percentages may not add up to 100.0 due to rounding error. High school data originated from HS RIO surveillance data, 2005–2006 through 2013–2014; collegiate data originated from NCAA-ISP surveillance data, 2004–2005 through 2013–2014. Injuries included in the analysis were those that (1) occurred during a sanctioned practice or competition; (2) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; and (3) restricted the student-athlete from participation for at least 24 hours past the day of injury. All concussions, fractures, and dental injuries were included in the analysis, regardless of time loss. Data may include multiple injuries that occurred at 1 injury event.

[b] Includes injuries that resulted in time loss over 3 weeks, medical disqualification, the athlete choosing not to continue, the athlete being released from team, or the season ending before the athlete returned to activity.

high school competitions to 52.8% for injuries sustained during collegiate practices (Table 3).

Body Parts Injured and Diagnoses

High School. The most commonly injured body parts during both practices and competitions were the head/face (practices = 17.0%, competitions = 21.2%), knee (practices = 13.3%, competitions = 16.5%), and ankle (practices = 12.2%, competitions = 13.1%; Table 4). The shoulder/clavicle represented 13.1% of competition injuries. The most frequent diagnoses for injuries sustained during practices were ligament sprains (24.2%), muscle/tendon strains (18.1%), and concussions (15.8%; Table 5). The diagnoses cited most often for injuries sustained during competitions were ligament sprains (29.0%), concussions (20.4%), and contusions (14.9%).

College. The most commonly injured body parts during practices were the hip/thigh/upper leg (19.9%), knee (15.3%), shoulder/clavicle (12.1%), and ankle (11.8%; Table 4). The most frequently injured body parts during competitions were the knee (20.2%), ankle (17.0%), and shoulder/clavicle (13.2%). The diagnoses cited most often for both practices and competitions were ligament sprains (practices = 26.0%, competitions = 38.9%), muscle/tendon strains (practices = 25.4%, competitions = 12.6%), and contusions (practices = 10.0%, competitions = 15.4%; Table 5).

Injury Mechanisms

High School. Player-contact mechanisms comprised 56.7% and 74.5% of all injuries incurred during practices and competitions, respectively. The most common injury mechanism during practices was no contact (17.3%), followed by the contact mechanisms of tackling (16.4%) and being tackled (14.3%; Table 6). During competitions, tackling (20.4%) and being tackled (23.8%) were the most frequent injury mechanisms, followed by contact with the playing surface (13.2%).

College. Player-contact mechanisms comprised 50.3% and 74.3% of all injuries incurred during practices and competitions, respectively. The injury mechanism cited most often during practices was no contact (29.7%), followed by the contact mechanisms of blocking (13.5%) and tackling (11.6%; Table 6). During competitions, being tackled (19.9%) and tackling (19.7%) were the injury mechanisms named most often.

Position-Specific Injuries During Competitions

Concussion was the most common injury sustained during competitions for almost every position in high school football (Table 7), usually due to being tackled or tackling. Although concussion was also a frequent competition injury at the collegiate level, it occurred most often only among special-teams players. Ankle sprain was the competition injury seen commonly among college cornerbacks/safeties/defensive backs, defensive linemen, offensive linemen, quarterbacks, running backs, and wide receivers/tight ends. Knee sprain was the most frequent competition injury among linebackers and long snappers. Tackling or being tackled was the injury mechanism cited most often among collegiate cornerbacks/safeties/defensive backs, quarterbacks, running backs, and wide receivers/tight ends, but being blocked or blocking was the most typical mechanism among defensive linemen, linebackers, offensive linemen, and special-teams players.

DISCUSSION

Understanding the epidemiology of injury among high school and collegiate football players is crucial for multiple reasons. First, football is the most popular sport in terms of numbers of student-athletes participating at both the high school and collegiate levels.[1,2] Second, as previously

Table 4. Number of Injuries, National Estimates, and Injury Rates by Body Part Injured and Type of Athlete-Exposure in High School and Collegiate Football[a]

	Practice			Competition		
Surveillance System and Body Part Injured	Injuries in Sample, No. (%)	National Estimates, No. (%)	Injury Rate/1000 Athlete-Exposures (95% Confidence Interval)	Injuries in Sample, No. (%)	National Estimates, No. (%)	Injury Rate/1000 Athlete-Exposures (95% Confidence Interval)
HS RIO (2005–2006 through 2013–2014)						
Head/face	1439 (17.0)	401 907 (16.7)	0.38 (0.36, 0.40)	2044 (21.2)	595 092 (21.1)	2.67 (2.56, 2.79)
Neck	255 (3.0)	71 033 (3.0)	0.07 (0.06, 0.08)	281 (2.9)	80 953 (2.9)	0.37 (0.32, 0.41)
Shoulder/clavicle	926 (10.9)	270 620 (11.2)	0.25 (0.23, 0.26)	1263 (13.1)	371 252 (13.2)	1.65 (1.56, 1.74)
Arm/elbow	323 (3.8)	88 359 (3.7)	0.09 (0.08, 0.09)	404 (4.2)	123 067 (4.4)	0.53 (0.48, 0.58)
Hand/wrist	998 (11.8)	288 139 (12.0)	0.26 (0.25, 0.28)	952 (9.9)	280 602 (10.0)	1.25 (1.17, 1.32)
Trunk	619 (7.3)	177 484 (7.4)	0.16 (0.15, 0.18)	498 (5.2)	147 667 (5.2)	0.65 (0.59, 0.71)
Hip/thigh/upper leg	898 (10.6)	259 831 (10.8)	0.24 (0.22, 0.25)	628 (6.5)	183 989 (6.5)	0.82 (0.76, 0.89)
Knee	1124 (13.3)	303 646 (12.6)	0.30 (0.28, 0.32)	1589 (16.5)	461 360 (16.4)	2.08 (1.98, 2.18)
Lower leg	358 (4.2)	102 147 (4.2)	0.09 (0.08, 0.10)	428 (4.4)	122 948 (4.4)	0.56 (0.51, 0.61)
Ankle	1037 (12.2)	289 090 (12.0)	0.27 (0.26, 0.29)	1266 (13.1)	362 819 (12.9)	1.66 (1.57, 1.75)
Foot	286 (3.4)	89 432 (3.7)	0.08 (0.07, 0.08)	224 (2.3)	64 802 (2.3)	0.29 (0.25, 0.33)
Other	214 (2.5)	65 626 (2.7)	0.06 (0.05, 0.06)	76 (0.8)	22 911 (0.8)	0.10 (0.08, 0.12)
NCAA-ISP (2004–2005 through 2013–2014)						
Head/face	1293 (9.3)	21,009 (10.2)	0.45 (0.43, 0.48)	893 (10.0)	14 665 (11.0)	3.22 (3.01, 3.43)
Neck	415 (3.0)	5844 (2.8)	0.15 (0.13, 0.16)	350 (3.9)	4 928 (3.7)	1.26 (1.13, 1.40)
Shoulder/clavicle	1671 (12.1)	24 808 (12.0)	0.59 (0.56, 0.62)	1176 (13.2)	17 034 (12.8)	4.24 (4.00, 4.49)
Arm/elbow	298 (2.2)	4423 (2.1)	0.10 (0.09, 0.12)	277 (3.1)	4153 (3.1)	1.00 (0.88, 1.12)
Hand/wrist	783 (5.7)	11 305 (5.5)	0.28 (0.26, 0.29)	537 (6.0)	8129 (6.1)	1.94 (1.77, 2.10)
Trunk	928 (6.7)	14 269 (6.9)	0.33 (0.31, 0.35)	545 (6.1)	7907 (6.0)	1.97 (1.80, 2.13)
Hip/thigh/upper leg	2758 (19.9)	40 397 (19.6)	0.97 (0.93, 1.01)	941 (10.6)	13 629 (10.3)	3.40 (3.18, 3.61)
Knee	2119 (15.3)	31 534 (15.3)	0.74 (0.71, 0.78)	1797 (20.2)	27 720 (20.9)	6.48 (6.18, 6.78)
Lower leg	500 (3.6)	7656 (3.7)	0.18 (0.16, 0.19)	399 (4.5)	5774 (4.4)	1.44 (1.30, 1.58)
Ankle	1641 (11.8)	24 240 (11.7)	0.58 (0.55, 0.60)	1512 (17.0)	22 199 (16.7)	5.46 (5.18, 5.73)
Foot	668 (4.8)	10 139 (4.9)	0.23 (0.22, 0.25)	377 (4.2)	5430 (4.1)	1.36 (1.22, 1.50)
Other	792 (5.7)	10 956 (5.3)	0.28 (0.26, 0.30)	96 (1.1)	1291 (1.0)	0.35 (0.28, 0.42)

Abbreviations: HS RIO, High School Reporting Information Online; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.

[a] Excludes 59 injuries reported in HS RIO due to missing data for body part. Percentages may not add up to 100.0 due to rounding error. High school data originated from HS RIO surveillance data, 2005–2006 through 2013–2014; collegiate data originated from NCAA-ISP surveillance data, 2004–2005 through 2013–2014. Injuries included in the analysis were those that (1) occurred during a sanctioned practice or competition; (2) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; and (3) restricted the student-athlete from participation for at least 24 hours past the day of injury. All concussions, fractures, and dental injuries were included in the analysis, regardless of time loss. Data may include multiple injuries that occurred at 1 injury event.

established, injury rates in football are typically higher than in other sports.[5,12,13] Consequently, participation in football is estimated to result in the largest proportion of total injuries sustained by high school and collegiate athletes.[5,12,13] Third, comparisons between high school and collegiate football have been limited, with most authors focusing on catastrophic injuries[14,15] or concussions.[16,17] In our study, we estimated that averages of 582 434 high school and 33 944 collegiate football injuries occurred annually. Understanding epidemiologic differences in football injuries across the high school and collegiate levels is an important first step in developing targeted risk-reduction interventions.[6]

Comparison with Previous Research

Data on high school football injuries from previous academic years were not readily available. The data that exist provide injury rates that use a player-hours or player-games denominator rather than AEs.[18–20] However, one study[21] based on data from the 1995–1997 seasons revealed competition and practice injury rates of 26.4/1000 AEs and 5.3/1000 AEs, respectively. These injury rates are more than double those we report (12.67/1000 AEs and 2.25/1000 AEs, respectively). Collegiate football injury data are more readily available. Overall, the injury rates we demonstrated are lower than those reported by Powell and Dompier[13] for schools in Divisions I through III during the 2000–2001 through 2001–2002 academic years (range = 9.3/1000 AEs to 10.4/1000 AEs). However, the authors of an NCAA-ISP report[7] for the 1988–1989 through 2003–2004 academic years documented competition and practice injury rates of 35.90/1000 AEs and 3.80/1000 AEs, respectively; our competition injury rate was lower (32.11/1000 AEs), but our practice injury rate was higher (4.88/1000 AEs). Comparisons with previous research should be cautious due to variations in data-collection procedures and the definitions of *injury* and *exposure*. A sharp decline in the collegiate competition injury rate was observed between 2008–2009 and 2009–2010, which coincided with a change in the NCAA-ISP data-collection procedures.[4] Increases occurred in more recent years, yet no linear trends were evident across the study period for high school football injury rates. Despite the promising findings that high school and collegiate football injury rates were lower than those reported by earlier investigators, our results nevertheless

Table 5. Number of Injuries, National Estimates, and Injury Rates by Diagnosis and Type of Athlete-Exposure in High School and Collegiate Football[a]

Surveillance System and Diagnosis	Practice			Competition		
	Injuries in Sample, No. (%)	National Estimates, No. (%)	Injury Rate/1000 Athlete-Exposures (95% Confidence Interval)	Injuries in Sample, No. (%)	National Estimates, No. (%)	Injury Rate/1000 Athlete-Exposures (95% Confidence Interval)
HS RIO (2005–2006 through 2013–2014)						
Concussion	1337 (15.8)	371 666 (15.5)	0.35 (0.34, 0.37)	1966 (20.4)	572 714 (20.3)	2.57 (2.46, 2.69)
Contusion	922 (10.9)	267 011 (11.1)	0.24 (0.23, 0.26)	1436 (14.9)	415 037 (14.7)	1.88 (1.78, 1.98)
Dislocation[b]	348 (4.1)	98 395 (4.1)	0.09 (0.08, 0.10)	492 (5.1)	139 848 (5.0)	0.64 (0.59, 0.70)
Fracture/avulsion	945 (11.1)	250 750 (10.4)	0.25 (0.23, 0.27)	1127 (11.7)	331 922 (11.8)	1.47 (1.39, 1.56)
Laceration	50 (0.6)	15 602 (0.7)	0.01 (0.01, 0.02)	71 (0.7)	21 551 (0.8)	0.09 (0.07, 0.11)
Ligament sprain	2054 (24.2)	579 101 (24.1)	0.54 (0.52, 0.57)	2801 (29.0)	815 897 (29.0)	3.67 (3.53, 3.80)
Muscle/tendon strain	1536 (18.1)	441 077 (18.3)	0.41 (0.39, 0.43)	878 (9.1)	256 624 (9.1)	1.15 (1.07, 1.23)
Other	1292 (15.2)	382 602 (15.9)	0.34 (0.32, 0.36)	876 (9.1)	263 960 (9.4)	1.15 (1.07, 1.22)
NCAA-ISP (2004–2005 through 2013–2014)						
Concussion	1136 (8.4)	18 583 (9.1)	0.40 (0.38, 0.42)	834 (9.4)	13 823 (10.4)	3.01 (2.80, 3.21)
Contusion	1360 (10.0)	19 651 (9.7)	0.48 (0.45, 0.50)	1363 (15.4)	19 242 (14.5)	4.92 (4.66, 5.18)
Dislocation[b]	255 (1.9)	3782 (1.9)	0.09 (0.08, 0.10)	178 (2.0)	2489 (1.9)	0.64 (0.55, 0.74)
Fracture/avulsion	531 (3.9)	8130 (4.0)	0.19 (0.17, 0.20)	548 (6.2)	9071 (6.8)	1.98 (1.81, 2.14)
Laceration	72 (0.5)	1043 (0.5)	0.03 (0.02, 0.03)	31 (0.4)	385 (0.3)	0.11 (0.07, 0.15)
Ligament sprain	3533 (26.0)	52 820 (26.0)	1.24 (1.20, 1.28)	3458 (38.9)	51 629 (38.9)	12.48 (12.06, 12.89)
Muscle/tendon strain	3457 (25.4)	52 327 (25.7)	1.22 (1.17, 1.26)	1120 (12.6)	17 332 (13.1)	4.04 (3.80, 4.28)
Other	3247 (23.9)	47 131 (23.2)	1.14 (1.10, 1.18)	1350 (15.2)	18 691 (14.1)	4.87 (4.61, 5.13)

Abbreviations: HS RIO, High School Reporting Information Online; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.

[a] Excludes 58 injuries reported in HS RIO and 293 injuries reported in NCAA-ISP due to missing data for diagnosis. Percentages may not add up to 100.0 due to rounding error. High school data originated from HS RIO surveillance data, 2005–2006 through 2013–2014; collegiate data originated from NCAA-ISP surveillance data, 2004–2005 through 2013–2014. Injuries included in the analysis were those that (1) occurred during a sanctioned practice or competition; (2) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; and (3) restricted the student-athlete from participation for at least 24 hours past the day of injury. All concussions, fractures, and dental injuries were included in the analysis, regardless of time loss. Data may include multiple injuries that occurred at 1 injury event.

[b] Includes separations.

emphasize the need for continued examination. Our study can prompt the generation of hypotheses regarding risk factors and prevention programming that may result in changes in injury rates. However, as denoted in the van Mechelen et al[6] framework, future researchers may benefit from using injury surveillance to directly evaluate injury-prevention programs. It is imperative that nonsurveillance research also continues to address factors associated with football-related injury so that injury-prevention interventions can be developed to help decrease the incidence, severity, and short- and long-term effects of football injuries.

Comparing Injury Rates in High School and Collegiate Football

Few authors have compared high school and collegiate football injury patterns. One group[22] assessed HS RIO and NCAA-ISP data collected during the 2005–2006 academic year, finding a higher injury rate in collegiate than in high school football. Our results involving multiple years of data confirm that finding. The intensity of play may be greater in collegiate versus high school football, and collegiate players as a population possess greater body mass and speed, which has been associated with increased injury risks in other contact sports.[23–25] Older and more experienced players may be more likely to have had a higher volume of exposure to high-risk conditions, which would increase the likelihood of having sustained previous injuries. Most injuries do not prevent athletes from continuing to participate in competitions and practices,[12,13,21] which may result in unrecognized increases in injury susceptibility that persist into the future. Also, a higher injury risk has been documented in previously injured football players compared with uninjured players.[26–28] However, a history of injury may actually be an indicator of a deficiency in some normally protective mechanism that existed before the first injury occurred.[29] Further research is needed to better delineate the multifaceted network of risk factors associated with injury in high school and collegiate football. Moreover, future investigators should consider how injured players may perceive and disclose their injuries differently by severity and how these risk factors are associated with resulting injury severity. Such knowledge will help to ensure better efforts in primary, secondary, and tertiary injury prevention (ie, reducing injury incidence, increasing injury disclosure, and improving injury management to reduce severity, respectively).

Variations in AT coverage may also explain differences in the injury incidences between high school and collegiate football. The NCAA *Sports Medicine Handbook*[30] advocates AT coverage for all sports at its member institutions, which is essential for the early recognition and immediate care of injuries. Approximately 70% of US high school athletic programs receive some level of AT coverage, but only 37% have access to at least 1 full-time AT.[31] Part-time

Table 6. Number of Injuries, National Estimates, and Injury Rates by Mechanism of Injury and Type of Athlete-Exposure in High School and Collegiate Football[a]

Surveillance System and Mechanism of Injury	Practice			Competition		
	Injuries in Sample, No. (%)	National Estimates, No. (%)	Injury Rate/1000 Athlete-Exposures (95% Confidence Interval)	Injuries in Sample, No. (%)	National Estimates, No. (%)	Injury Rate/1000 Athlete-Exposures (95% Confidence Interval)
HS RIO (2005–2006 through 2013–2014)						
Tackling	1356 (16.4)	384 574 (16.4)	0.36 (0.34, 0.38)	1935 (20.4)	557 303 (20.2)	2.53 (2.42, 2.65)
Being tackled	1182 (14.3)	333 934 (14.3)	0.31 (0.30, 0.33)	2259 (23.8)	662 538 (24.0)	2.96 (2.83, 3.08)
Blocking	999 (12.1)	283 158 (12.1)	0.26 (0.25, 0.28)	1123 (11.9)	321 367 (11.6)	1.47 (1.38, 1.56)
Being blocked	548 (6.6)	159 749 (6.8)	0.15 (0.13, 0.16)	1003 (10.6)	311 057 (11.3)	1.31 (1.23, 1.39)
Other player-player contact	607 (7.3)	150 332 (6.4)	0.16 (0.15, 0.17)	738 (7.8)	206 456 (7.5)	0.97 (0.90, 1.04)
Contact with surface	1090 (13.2)	299 304 (12.8)	0.29 (0.27, 0.31)	1248 (13.2)	360 710 (13.1)	1.63 (1.54, 1.72)
Contact with ball	133 (1.6)	38 949 (1.7)	0.04 (0.03, 0.04)	39 (0.4)	14 155 (0.5)	0.05 (0.04, 0.07)
Contact with blocking sled/dummy	82 (1.0)	20 830 (0.9)	0.02 (0.02, 0.03)	0 (0.0)	0 (0.0)	0.00
Contact with other playing equipment	157 (1.9)	42 347 (1.8)	0.04 (0.04, 0.05)	134 (1.4)	35 913 (1.3)	0.18 (0.15, 0.21)
Contact with out of bounds object	9 (0.1)	2494 (0.1)	<0.01 (0.00, <0.01)	3 (0.0)	624 (0.0)	<0.01 (0.00, 0.01)
No contact	1430 (17.3)	410 068 (17.5)	0.38 (0.36, 0.40)	857 (9.0)	250 796 (9.1)	1.12 (1.05, 1.20)
Overuse/chronic	402 (4.9)	132 920 (5.7)	0.11 (0.10, 0.12)	75 (0.8)	21 733 (0.8)	0.10 (0.08, 0.12)
Illness/infection	281 (3.4)	79 939 (3.4)	0.07 (0.07, 0.08)	61 (0.6)	17 235 (0.6)	0.08 (0.06, 0.10)
NCAA-ISP (2004–2005 through 2013–2014)						
Tackling	1588 (11.6)	22 029 (10.9)	0.56 (0.53, 0.59)	1735 (19.7)	23 946 (18.4)	6.26 (5.97, 6.55)
Being tackled	1260 (9.2)	17 324 (8.6)	0.44 (0.42, 0.47)	1749 (19.9)	24 857 (19.1)	6.31 (6.01, 6.61)
Blocking	1848 (13.5)	27 186 (13.5)	0.65 (0.62, 0.68)	1206 (13.7)	17 943 (13.8)	4.35 (4.11, 4.60)
Being blocked	1078 (7.9)	15 661 (7.8)	0.38 (0.36, 0.40)	992 (11.3)	14 319 (11.0)	3.58 (3.36, 3.80)
Other player-player contact	1098 (8.0)	18 760 (9.3)	0.39 (0.36, 0.41)	845 (9.6)	14 569 (11.2)	3.05 (2.84, 3.25)
Contact with surface	1047 (7.7)	16 590 (8.2)	0.37 (0.35, 0.39)	793 (9.0)	13 114 (10.1)	2.86 (2.66, 3.06)
Contact with ball	133 (1.0)	1931 (1.0)	0.05 (0.04, 0.05)	32 (0.4)	401 (0.3)	0.12 (0.08, 0.16)
Contact with blocking sled/dummy	84 (0.6)	1025 (0.5)	0.03 (0.02, 0.04)	0 (0.0)	0 (0.0)	0.00
Contact with other playing equipment	31 (0.2)	455 (0.2)	0.01 (0.01, 0.01)	12 (0.1)	128 (0.1)	0.04 (0.02, 0.07)
Contact with out of bounds object	14 (0.1)	220 (0.1)	<0.01 (0.00, 0.01)	4 (0.1)	45 (<0.1)	0.01 (0.00, 0.03)
No contact	4065 (29.7)	61 016 (30.3)	1.43 (1.39, 1.47)	1237 (14.1)	18 230 (14)	4.46 (4.21, 4.71)
Overuse/chronic	668 (4.9)	9683 (4.8)	0.23 (0.22, 0.25)	103 (1.2)	1566 (1.2)	0.37 (0.30, 0.44)
Illness/infection	758 (5.5)	9721 (4.8)	0.27 (0.25, 0.29)	80 (0.9)	950 (0.7)	0.29 (0.23, 0.35)

Abbreviations: HS RIO, High School Reporting Information Online; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.

[a] Mechanism of injury excludes 438 injuries reported in HS RIO and 306 injuries reported in NCAA-ISP due to missing data or athletic trainer reporting *Other* or *Unknown*. Percentages may not add up to 100.0 due to rounding error. High school data originated from HS RIO surveillance data, 2005–2006 through 2013–2014; collegiate data originated from NCAA-ISP surveillance data, 2004–2005 through 2013–2014. Injuries included in the analysis were those that (1) occurred during a sanctioned practice or competition; (2) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; and (3) restricted the student-athlete from participation for at least 24 hours past the day of injury. All concussions, fractures, and dental injuries were included in the analysis, regardless of time loss. Data may include multiple injuries that occurred at 1 injury event.

AT coverage at the high school level could result in underreporting of injuries, although recent researchers[32] did not find a difference in time-loss football injury rates between high school programs with full-time versus outreach ATs. To our knowledge, no data are available to document the football injury incidence at high schools lacking AT coverage. Although future investigators must address the possible association between AT coverage and the reported and actual incidences of injury in high school football players, our findings may nonetheless highlight the importance of having ATs present to provide care for the numerous injuries that can result from football participation.

Event Type

In both high school and collegiate football, competition injury rates were higher than practice injury rates, which is consistent with previous findings.[7,18–20,22] At the collegiate level, the competition versus practice IRR of 6.59 was lower than the 9.4 reported[7] for the 1988–1989 through 2003–2004 academic years. The competition versus practice IRR at the high school level (5.62) was also slightly lower than that reported earlier.[21] Powell[33] demonstrated similar findings for collegiate football players' knee injuries and advocated a focus on preventing injuries during competitions. However, Dick et al[7] noted that practices presented a much greater volume of at-risk exposure time than did competitions. Similarly, our findings suggested that for every competition, there are approximately 5 and 10 practices in high school and collegiate football, respectively. Because practices accounted for large proportions of injuries (46.8% and 60.9%, respectively), and the most common injury mechanisms differed between competitions (tackling and being tackled) and practices (no contact), we advocate football injury-prevention strategies that address risk factors for a spectrum of injury mechanisms across both competition and practice.

Table 7. Most Common Injuries Associated With Position in Competitions in High School and Collegiate Football[a]

	HS RIO (2005–2006 Through 2013–2014)			NCAA-ISP (2004–2005 Through 2013–2014)		
Position	Most Common Injuries	% Injuries Within Position	Most Frequent Mechanism of Injury for This Injury Within Position	Most Common Injuries	% Injuries Within Position	Most Frequent Mechanism of Injury for This Injury Within Position
Cornerback/safety/ defensive back	Concussion	22.5	Tackling	Ankle sprain	13.0	Tackling
	Ankle sprain	8.9	No contact	Concussion	11.7	Tackling
	Knee sprain	6.4	Tackling	Hip/thigh/upper leg strain	8.7	No contact
Defensive line	Concussion	20.0	Tackling	Ankle sprain	17.2	Being blocked
	Knee sprain	11.7	Being blocked	Knee sprain	13.6	Being blocked
	Ankle sprain	10.0	Being blocked	Concussion	6.3	Tackling
Kicker/punter	Concussion	17.9	Being tackled	Hip/thigh/upper leg strain	27.4	No contact
	Hip/thigh/upper leg strain	13.1	No contact	Ankle sprain	8.2	Tackling
	Knee sprain	11.9	Being tackled			
Linebacker	Concussion	20.5	Tackling	Knee sprain	13.8	Being blocked
	Ankle sprain	10.2	No contact, tackling (tied)	Ankle sprain	12.7	Tackling
	Knee sprain	9.1	Tackling	Concussion	8.3	Tackling
Long snapper	Concussion	30.0	Tackling, being tackled, being blocked (tied)	Knee sprain	21.9	No contact
	Knee sprain	20.0	Blocking	Concussion	12.5	Being blocked
	Hand/wrist fracture	20.0	Blocking			
Offensive line	Concussion	16.2	Blocking	Ankle sprain	23.9	Blocking
	Knee sprain	15.4	Blocking	Knee sprain	19.7	Blocking
	Ankle sprain	15.4	Blocking	Concussion	5.9	Blocking
Quarterback	Concussion	18.7	Being tackled	Ankle sprain	14.9	Being tackled
	Ankle sprain	9.4	Being tackled	Concussion	12.5	Being tackled
	Knee sprain	7.4	Being tackled	Knee sprain	10.0	Being tackled
Running back	Concussion	16.7	Being tackled	Ankle sprain	18.9	Being tackled
	Ankle sprain	16.4	Being tackled	Knee sprain	13.5	Being tackled
	Knee sprain	9.5	Being tackled	Concussion	7.5	Being tackled
Special Teams	Concussion	38.5	Being blocked	Concussion	19.2	Being blocked
	Knee sprain	10.5	Being blocked	Ankle sprain	11.1	No contact
				Knee sprain	9.7	Being blocked
Wide receiver/ tight end	Concussion	18.2	Being tackled	Ankle sprain	14.8	Being tackled
	Ankle sprain	11.1	No contact	Knee sprain	10.0	Being tackled
	Knee sprain	10.1	Being tackled	Shoulder sprain	9.8	Contact with surface
				Concussion	9.0	Being tackled

Abbreviations: HS RIO, High School Reporting Information Online; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.

[a] Excludes 510 competition injuries reported in HS RIO and 174 competition injuries reported in NCAA-ISP due to position not being indicated. The table reads as follows: for the cornerback/safety/defensive back position in high school, concussions comprised 22.5% of all competition injuries to that position. The most common mechanism of injury for this specific injury for this specific position was tackling. High school data originated from HS RIO surveillance data, 2005–2006 through 2013–2014; collegiate data originated from NCAA-ISP surveillance data, 2004–2005 through 2013–2014. Injuries included in the analysis were those that (1) occurred during a sanctioned practice or competition; (2) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; and (3) restricted the student-athlete from participation for at least 24 hours past the day of injury. All concussions, fractures, and dental injuries were included in the analysis, regardless of time loss. Data may include multiple injuries that occurred at 1 injury event.

Common Injuries and Injury Prevention

A variety of injuries were documented among high school and collegiate football players, including concussions, knee sprains, ankle sprains, and shoulder injuries. Our findings are consistent with previous reports.[7,22,34,35] Thus, the proper management and care of injured athletes, alongside the identification of preexisting risk factors, is integral not only to ensuring proper return to play but also to mitigating the risk of future injury.

Football has typically had one of the highest concussion rates among high school and collegiate sports.[17,36–39] Because football has the largest student-athlete population and squad size per team,[1,2] appropriate medical coverage during football competitions and practices to immediately diagnose and manage concussions is essential. As of 2014, all 50 states and the District of Columbia have enacted concussion-related legislation for high school football; however, the content of the legislation within each state varies.[40] Also, a recent policy statement by the American Academy of Pediatrics[41] recommended teaching of proper tackling techniques and enforcing rules that discourage improper technique. In April 2010, the NCAA Executive Committee adopted a new policy[30] that mandated each member institution's concussion-management plan include the following: (1) annual concussion education for athletes,

(2) immediate removal from play if a concussion is suspected, (3) elimination of same-day return to play of a concussed athlete, and (4) a clearance process by a medical professional for return to play.[30,42] Although reporting appears to have increased since implementation of the new policy,[43] minimal changes in players' knowledge of concussion have been documented in other sports.[44] The NCAA, some collegiate athletic conferences, and various state high school associations have adopted policies that recommend or mandate limiting contact between players during preseason practice sessions.[45–48] The change in methods of the NCAA-ISP at the beginning of the 2009–2010 academic year makes it difficult to evaluate the effects of the 2010 policy through longitudinal analysis; for more recent policies, insufficient postenactment data and the resulting low statistical power may restrict the ability to detect changes in reporting and incidence. Due to the limited evaluation of such policies, future research is warranted.

Alongside concussions, other common injuries were sprains and strains, particularly to the ankle, knee, and shoulder. Previous authors[49,50] identified high levels of exposure to game conditions, low back dysfunction, and poor endurance of the core musculature as strong predictors for the occurrence of sprains and strains among collegiate football players. Research in the past decade[51] has particularly emphasized the potential effects of ankle sprains, including the financial burden and long-term outcomes such as reinjury, chronic ankle instability, posttraumatic osteoarthritis, and decreased quality of life. Because many of these concerns are not exclusive to ankle sprains,[52–58] prevention measures for nonconcussive injuries must also be addressed. Sports including soccer and lacrosse have used ankle taping or bracing, strengthening of the lower leg musculature, and preventive exercise programs that include core strengthening and hip mobility to reduce the frequency of lower extremity injuries[59–63]; such programs should be implemented and evaluated in football. Furthermore, programs that teach proper blocking and tackling techniques have been associated with fewer head impacts and lower injury rates during practices.[64–66] Proper technique may also decrease the incidence of shoulder injuries, most of which are due to tackling or blocking.[67]

In addition to injury-specific prevention measures, rule changes and the role of illegal plays must be considered.[68] Historically, the most well-known rule change associated with decreased injury incidence is the ban on *spearing* (intentional use of the top of the head as a point of contact), which has decreased the incidence of spinal cord injuries since the late 1970s.[69] However, rule changes need to be evaluated not only for their effectiveness but also for any unintended adverse consequences. In a recent study[70] using football data from the NCAA-ISP, the authors found that the implementation of the targeting rule (ie, forbidding the initiation of contact with the crown of a helmet and the targeting of defenseless players in the head and neck area) was associated with an increased lower extremity injury rate. The researchers[70] noted that the targeting rule may have inadvertently caused football players to tackle lower, thereby placing the lower extremity at greater risk for contact and injury; however, they were not able to specifically examine how the rule directly influenced coaching and player behaviors. Thus, along with outcome evaluations that focus on how injury-prevention interventions affect injury incidence, process evaluations that focus on adoption and adherence are needed.

Lastly, it is important to note the variations in injury distributions by level of play that we found. For example, concussions were the most common injury across all playing positions in high school and were mostly due to tackling or being tackled. However, lower extremity injuries were the most frequent injuries in almost all collegiate positions, with both contact and noncontact being typical injury mechanisms. At the same time, commonalities were found across offensive skill positions, such as quarterback, running back, and wide receiver, in high school and collegiate football; concussions and knee/ankle sprains due to being tackled were common across all 3 positions, suggesting that these positions may be vulnerable to injury as opposing players attempt to impede their offensive plays. Our findings highlight that injury prevention cannot use a one-size-fits-all approach; rather, it must be targeted by level of play and position.

In fact, injury prevention in football requires acknowledging the multiple levels of influence that may contribute to injuries. This should extend beyond approaches that focus on the athlete or policy and legislation. Other important levels of influence are the interpersonal, in which communication and relationships among parents, coaches, teammates, and team medical staff should advocate injury reporting, prevention, and management, and the socioenvironmental, in which cultural factors should be examined to build social norms that encourage safer game play and sportsmanship. As posited by the socioecological model,[71] injury-prevention programming that carefully considers the many levels of influence (eg, individual, interpersonal, environmental, policy) may enact greater change and positive effects.

Limitations

Our findings may not be generalizable to other playing levels, such as youth, middle school, and professional football, nor to collegiate football programs at non-NCAA institutions or high schools without NATA-affiliated ATs.[13] Furthermore, we were unable to account for factors potentially associated with injury occurrence, such as AT coverage, implemented injury-prevention programs, and athlete-specific characteristics (eg, previous injury, functional capabilities). Also, although HS RIO and the NCAA-ISP are similar injury-surveillance systems, it is important to consider the variations that do exist between the systems; this is most evident in the fact that HS RIO used a random sample, whereas the NCAA-ISP used a convenience sample. In addition, differences may exist between high school and college in regard to the length of the season in total, as well as the preseason, regular season, and postseason; the potentially longer collegiate season may increase the injury risk. We calculated injury rates using AEs, which may not be as precise an at-risk exposure measure as minutes, hours, or total number of game plays across a season.[72] However, collecting such exposure data is more laborious than collecting AE data and may be too burdensome for ATs collecting data for both HS RIO and the NCAA-ISP.

Although our study is one of the few to examine injury incidence across multiple levels of play (eg, high school versus college and competitions versus practices), we were unable to examine differences between starters and nonstarters in competitions; analyses that group both types of players may confound and thus weaken the possible exposure-outcome association for some known injury risk factors.[73,74] Differences may also exist among the freshman, junior varsity, and varsity teams due to differences in maturation status.[75] Playing positions may vary in their physical demands and the resulting injury risk. The AEs were not collected by position, preventing the calculation of position-specific injury rates.

CONCLUSIONS

Sport-related injury-surveillance data have previously been used to develop targeted injury-prevention interventions in football.[4] Many similarities exist in the injury patterns of high school and collegiate football players, with concussions, knee sprains, ankle sprains, and shoulder injuries being common injuries. However, important differences also exist: for example, blocking or being blocked was the typical mechanism for the most common injuries to several playing positions in college, whereas tackling or being tackled was the typical mechanism of injury for the most common injury among all positions in high school. Injury rates were higher in collegiate than in high school football and in competitions than in practices at both levels. These differences highlight the need for level- and event-specific injury-prevention programming among football players. Clinically, the need for AT coverage of football at the high school and collegiate levels is imperative given the large student-athlete population[1,2] and football's high incidence of injury compared with other sports.[5,12,13] Future clinical researchers may wish to examine how increasing medical coverage for football (eg, increased AT staff) may benefit the health and safety of football student-athletes, particularly because the average team size in football is larger than that in all other sports. In addition, although numerous policies and programs related to reducing the incidence and severity of common injuries such as concussions and ankle sprains are available, examining the factors that may facilitate or hinder adoption and adherence are recommended.

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