The First Decade of Web-Based Sports Injury Surveillance: Descriptive Epidemiology of Injuries in US High School Boys’ Soccer (2005–2006 Through 2013–2014) and National Collegiate Athletic Association Men’s Soccer (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 boys’ and men’s soccer injury data.

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

Design: Descriptive epidemiology study.

Setting: Online injury surveillance from soccer teams of high school boys (annual average = 100) and collegiate men (annual average = 41).

Patients or Other Participants: Boys’ or men’s soccer players who participated in practices and competitions during the 2005–2006 through 2013–2014 academic years in high school and the 2004–2005 through 2013–2014 academic years in college, respectively.

Main Outcome Measure(s): Athletic trainers collected time-loss (≥24 hours) injury 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: High School Reporting Information Online documented 2912 time-loss injuries during 1 592 238 AEs; the National Collegiate Athletic Association Injury Surveillance Program documented 4765 time-loss injuries during 686 918 AEs. The injury rate was higher in college than in high school (6.94 versus 1.83/1000 AEs; IRR = 3.79; 95% CI = 3.62, 3.97). Injury rates increased with smaller school size for high schools and were higher in Division I than in Divisions II and III. The injury rate was higher during competitions than during practices in both high school (IRR = 3.55; 95% CI = 3.30, 3.83) and college (IRR = 3.45; 95% CI = 3.26, 3.65). Most injuries were to the lower extremity. However, concussion was a common injury, particularly in collegiate goalkeepers and at all positions for high school players. Concussions accounted for more than one-fifth of injuries in high school games.

Conclusions: Injury-prevention interventions should be tailored to reflect variations in the incidence and type of injury by level of competition, event type, and position.

Key Words: concussions, student-athletes, injury prevention

Key Points
- The rate of injury in collegiate men’s soccer exceeded that of high school boys’ soccer.
- At both levels of play, most injuries were to the lower extremity.
- At the high school level, concussions accounted for more than one-fifth of competition injuries.
Soccer is one of the most popular sports, with worldwide estimates of 265 million participants in 2006. In the United States, the sport has traditionally been less culturally significant than baseball, football, and basketball; however, the number of players at the high school and collegiate levels has steadily increased in the past decade. Compared with the 2003–2004 academic year, the number of high school boys’ soccer student-athletes in the 2013–2014 academic year increased 19.3% to 417,419.2 Similarly, in the National Collegiate Athletic Association (NCAA), when compared with the 2003–2004 academic year, the number of collegiate men’s soccer student-athletes in the 2013–2014 academic year increased 27.5% to 23,602.3 Given the growth in the number of participants, we require data on the incidence and nature of injuries in the sport, so that injury-prevention interventions can be appropriately tailored to the needs of the population.

The NCAA has used injury surveillance to acquire collegiate sports injury data since the 1980s. Although this NCAA-based surveillance system has had several names, we herein denote it as the NCAA Injury Surveillance Program (ISP). Since the 2004–2005 academic year, the NCAA has used a Web-based platform to collect collegiate sports injury and exposure data via athletic trainers (ATs).4 A year later, High School Reporting Information Online (HS RIO), a similar Web-based high school sports injury-surveillance system, was launched.5

As denoted in the van Mechelen et al framework, injury prevention benefits from ongoing monitoring of injury incidence, and updated descriptive epidemiology is needed. A previous NCAA-ISP report7 for the 1988–1989 through 2003–2004 academic years documented men’s soccer competition and practice injury rates of 18.75 and 4.34, respectively, per 1000 athlete-exposures (AEs). However, over the past decade, numerous efforts to implement injury prevention in soccer have occurred; these include programming specific to soccer8–10 as well as across all sports (eg, concussion legislation).1,13,14 In the same way, documenting injuries through high school sports injury surveillance is important for establishing injury incidence estimates and comparing findings between the high school and collegiate settings. The purpose of this article is to summarize the descriptive epidemiology of injuries sustained in high school boys’ and collegiate men’s soccer 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, OH). Use of the NCAA-ISP data was approved by the Research Review Board at the NCAA (Indianapolis, IN).

An average of 100 high schools sponsoring boys’ soccer 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 41 NCAA member institutions (Division I = 15, Division II = 6, Division III = 20) sponsoring men’s soccer 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 paragraphs. 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.13 In addition, earlier publications have described the sampling and data collection of HS RIO5,14 and the NCAA-ISP4 in depth.

High School RIO

High School RIO consists of a sample of high schools with 1 or more National Athletic Trainers’ Association–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 (age, height, weight, etc), the injury (site, diagnosis, severity, etc), and the injury event (activity, mechanism, etc). 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 ≤1000 or >1000) and US Census geographic region.15 Athletic trainers from these schools reported data for the 9 sports of interest (boys’ football, soccer, basketball, wrestling, and baseball and girls’ soccer, volleyball, basketball, and softball). If a school dropped out of the system, a replacement from the same stratum was selected.

In HS RIO, national injury estimates were calculated from injury counts obtained from the sample. A weighting algorithm based on the inverse probability of participant schools’ selection into the study (based on geographic location and high school size) was applied to individual case counts to calculate the national injury estimates.

The NCAA-ISP

The NCAA-ISP depends on a convenience sample of teams with ATs voluntarily reporting injury and exposure data.4 Participation in the NCAA-ISP, although 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 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 or injury-documentation applications, including the Athletic Trainer System (Kefferr Development, Grove City, PA), the Injury Surveillance Tool (Datalys Center), and the 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.

To calculate national estimates of the number of injuries and AEs, we applied poststratification sample weights, based upon sport, division, and academic year, to each reported injury and AE. Weights for all data were further adjusted to correct for underreporting, consistent with Kucera et al., who estimated that the ISP captured 88.3% of all time-loss medical-care injury events. Weighted injuries, as noted earlier (with the exception of concussions, fractures, and dental ATs), for this series of publications, only time-loss injuries (to reduce the time burden on 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 and competition), time in season (preseason, regular season, postseason), time loss (1–6 days; 7–21 days; 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) with 95% confidence intervals (CIs). The IRRs focused on comparisons by level of play (high school and college), event type (practice and competition), school size in high school (≤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% CIs not containing 1.0 were considered statistically significant.

Last, we used linear regression to analyze linear trends across time of injury rates and compute average annual changes (ie, mean differences). Because of 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.

RESULTS

Total Injury Frequency, National Estimates, and Injury Rates

During the 2005–2006 through 2013–2014 academic years, ATs reported a total of 2912 time-loss injuries in high school boys’ soccer (Table 1). During the 2004–2005 through 2013–2014 academic years, ATs reported a total of 4765 injuries in collegiate men’s soccer. These raw data counts represent overall national estimates of 1507166 high school injuries (annual average of 167463) and 93507 collegiate injuries (annual average of 9351). The total injury rate for high school boys’ soccer was 1.83/1000 AEs (95% CI = 1.76, 1.90). The total injury rate for collegiate men’s soccer was 6.94/1000 AEs (95% CI = 6.74, 7.13). The total injury rate was higher in college than in high school (IRR = 3.79; 95% CI = 3.62, 3.97).

School Size and Division

In high school boys’ soccer, the total injury rate was higher in high schools with ≤1000 students than in those with >1000 students (IRR = 1.61; 95% CI = 1.50, 1.73; Table 1). In collegiate men’s soccer, Division I had a higher total injury rate than Division II (IRR = 1.27; 95% CI = 1.16, 1.39) and Division III (IRR = 1.11; 95% CI = 1.04, 1.18). Also, Division III had a higher total injury rate than Division II (IRR = 1.14; 95% CI = 1.04, 1.25).

Table 1. Total Injury Rates per 1000 AEs and IRRs of Injury Rates by School Size and Division for High School and College Boys’ Soccer: 2005–2014

| School Size | Division | Injury Rate per 1000 AEs | IRR (95% CI) |
|-------------|----------|--------------------------|-----------|
| ≤1000       | I        | 1.83 (1.76, 1.90)        |          |
| >1000       | I        | 1.61 (1.50, 1.73)        |          |

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 the 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 in order 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.
Table 1. Injury Rates by School Size or Division and Type of Athlete-Exposure in High School Boys’ and Collegiate Men’s Soccera

| Surveillance System and School Size or Division | Injuries in Exposure Type | National Estimates, No. (%) | Athlete-Exposures | Injury Rate/1000 Athlete-Exposures (95% Confidence Interval) |
|------------------------------------------------|---------------------------|-----------------------------|------------------|----------------------------------------------------------|
| HS RIO (2005–2006 through 2013–2014)           |                           |                             |                  |                                                         |
| ≤1000 students                                  | Practice 611 (42.5)       | 491381 (43.9)               | 420650           | 1.45 (1.34, 1.57)                                        |
|                                                | Competition 825 (57.5)    | 628576 (56.1)               | 179001           | 4.61 (4.29, 4.92)                                        |
|                                                | Total 1436 (100.0)        | 1119957 (100.0)             | 599651           | 2.39 (2.27, 2.52)                                        |
| >1000 students                                  | Practice 546 (37.0)       | 142370 (38.6)               | 695327           | 0.79 (0.72, 0.85)                                        |
|                                                | Competition 930 (63.0)    | 244839 (62.3)               | 297260           | 3.13 (2.93, 3.33)                                        |
|                                                | Total 1476 (100.0)        | 387209 (100.0)              | 992587           | 1.49 (1.41, 1.56)                                        |
| Total                                          | Practice 1157 (39.7)      | 633751 (42.0)               | 111577           | 1.04 (0.98, 1.10)                                        |
|                                                | Competition 1755 (60.3)   | 873415 (58.0)               | 476260           | 3.68 (3.51, 3.86)                                        |
|                                                | Total 2912 (100.0)        | 1507166 (100.0)             | 1592238          | 1.83 (1.76, 1.90)                                        |
| NCAA-ISP (2004–2005 through 2013–2014)        |                           |                             |                  |                                                         |
| Division I                                      | Practice 1061 (51.2)      | 13949 (49.8)                | 220056           | 4.78 (4.49, 5.07)                                        |
|                                                | Competition 1012 (48.8)   | 14067 (50.2)                | 54552            | 18.55 (17.41, 19.69)                                     |
|                                                | Total 2073 (100.0)        | 28016 (100.0)               | 276607           | 7.49 (7.17, 7.82)                                        |
| Division II                                     | Practice 303 (52.0)       | 9909 (51.5)                 | 77432            | 3.91 (3.47, 4.35)                                        |
|                                                | Competition 280 (48.0)    | 9345 (48.5)                 | 21131            | 13.25 (11.70, 14.80)                                     |
|                                                | Total 583 (100.0)         | 19254 (100.0)               | 98563            | 5.91 (5.43, 6.40)                                        |
| Division III                                    | Practice 1083 (51.4)      | 23388 (50.6)                | 239352           | 4.52 (4.26, 4.79)                                        |
|                                                | Competition 1026 (48.6)   | 22849 (49.4)                | 72395            | 14.17 (13.13, 15.04)                                     |
|                                                | Total 2109 (100.0)        | 46237 (100.0)               | 311747           | 6.77 (6.48, 7.05)                                        |
| Total                                          | Practice 2447 (51.4)      | 47247 (50.5)                | 53840            | 4.54 (4.36, 4.72)                                        |
|                                                | Competition 2318 (48.6)   | 46260 (49.5)                | 14078            | 15.65 (15.02, 16.29)                                     |
|                                                | Total 4765 (100.0)        | 93507 (100.0)               | 686918           | 6.94 (6.74, 7.13)                                        |

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. National estimates and athlete-exposures may not sum to totals because of rounding error.

Event Type

The majority of high school injuries occurred during competitions (60.3%), whereas the majority of collegiate injuries occurred during practices (51.4%; Table 1). The competition injury rate was higher than the practice injury rate in high school (IRR = 3.55; 95% CI = 3.30, 3.83) and in college (IRR = 3.45; 95% CI = 3.26, 3.65).

In high school, decreases were found in the annual injury rates for practices (annual average change of −0.08/1000 AEs; 95% CI = −0.12, −0.04) and competitions (annual average change of −0.08/1000 AEs; 95% CI = −0.15, −0.01; Figure). Decreases occurred in collegiate practice injury rates during the 2004–2005 through 2008–2009 (annual average change of −0.40/1000 AEs; 95% CI = −0.73, −0.06) and 2009–2010 through 2013–2014 (annual average change of −0.17/1000 AEs; 95% CI = −0.33, −0.01) academic years. No linear trends were seen for collegiate competition injury rates during the 2004–2005 through 2008–2009 (annual average change of −1.42/1000 AEs; 95% CI = −3.13, 0.29) or 2009–2010 through 2013–2014 (annual average change of 0.60/1000 AEs; 95% CI = −0.65, 1.85) academic years.

Time in Season

For both high school and college, the majority of injuries occurred during the regular season (high school = 72.0%; college = 64.6%; Table 2). In college, the preseason had a higher injury rate than the regular season (IRR = 1.15; 95% CI = 1.08, 1.23) and postseason (IRR = 1.78; 95% CI = 1.55, 2.06). In addition, the injury rate was higher during the regular season than during the postseason (IRR = 1.55; 95% CI = 1.35, 1.78). Injury rates by time in season could not be calculated for high school as AEs were not stratified by time in season.

Time Loss From Participation

For both high school and collegiate athletes, the largest proportion of injuries resulted in time loss of less than 1 week, ranging from 44.3% of injuries in high school competitions to 62.4% of injuries in collegiate practices (Table 3). The proportion of injuries resulting in more than 3 weeks’ time loss from participation was higher in high school (competitions = 21.0%, practices = 14.5%) than in college (competitions = 11.1%, practices = 9.8%).

Body Parts Injured and Diagnoses

High School. The most commonly injured body parts during practices and competitions were the hip/thigh/upper leg (25.6%) and the head/face (26.5%), respectively (Table 4). Other frequently injured body parts were the ankle (practices = 17.3%, competitions = 18.3%) and knee (practices = 14.5%, competitions = 13.8%). The injury diagnoses most often associated with practices were muscle/tendon strain (31.9%), ligament sprains (22.5%),
and contusions (10.1%); for competitions, they were ligament sprains (26.0%), concussions (20.9%), and contusions (18.7%; Table 5). Although concussions accounted for a very high proportion of injuries during competitions, they were responsible for only 6.6% of injuries during high school practices.

**College.** The most commonly injured body part during practices and competitions was the hip/thigh/upper leg

![Figure. Injury rates by year and type of athlete-exposure (AE) in high school boys’ and collegiate men’s soccer. Note: Annual average changes for linear trend test for injury rates are as follows: High School Reporting Information Online (RIO; practices = 0.08/1000 AEs, 95% confidence interval [CI] = −0.12, −0.04; competitions = 0.08/1000 AEs, 95% CI = −0.15, −0.01); National Collegiate Athletic Association Injury Surveillance Program (NCAA-ISP) 2004–2005 through 2008–2009 (practices = 0.40/1000 AEs, 95% CI = −0.73, −0.06; competitions = 1.42/1000 AEs, 95% CI = −3.13, 0.29); NCAA-ISP 2009–2010 through 2013–2014 (practices = 0.60/1000 AEs, 95% CI = −0.17, 0.01; competitions = 1.42/1000 AEs, 95% CI = −3.13, 0.29). A negative rate indicates a decrease in annual average change between years, and a positive rate indicates an increase in annual average change; 95% CIs including 0.00 are not significant.**

### Table 2. Injury Rates by Time in Season and Type of Athlete-Exposure in High School Boys’ and Collegiate Men’s Soccer

| Time in Season | Exposure Type | HS RIO (2005–2006 Through 2013–2014) | NCAA-ISP (2004–2005 Through 2013–2014) |
|----------------|---------------|-------------------------------------|----------------------------------------|
|                | Injuries in Sample, No. (%) | National Estimates, No. (%) | Injuries in Sample, No. (%) | National Estimates, No. (%) | Injury Rate/1000 Athlete-Exposures (95% Confidence Interval) |
| Preseason      | Practice      | 589 (83.5) | 310,517 (85.2) | 1330 (90.1) | 25,146 (90.8) | 180,792 | 7.36 (6.96, 7.75) |
|                | Competition   | 116 (16.5) | 53,995 (14.8) | 146 (9.9)   | 25,383 (9.2)  | 6,852  | 21.31 (17.85, 24.76) |
|                | Total         | 705 (100.0) | 364,512 (100.0) | 1476 (100.0) | 27,684 (100.0) | 187,645 | 7.87 (7.46, 8.27) |
| Regular season | Practice      | 545 (26.2) | 309,637 (28.9) | 1035 (33.6) | 20,675 (33.4) | 319,467 | 3.24 (3.04, 3.44) |
|                | Competition   | 1538 (73.8) | 763,059 (71.1) | 2041 (66.4) | 41,295 (66.6) | 131,484 | 15.52 (14.85, 16.20) |
|                | Total         | 2083 (100.0) | 1,072,696 (100.0) | 3076 (100.0) | 61,971 (100.0) | 450,951 | 6.82 (6.58, 7.06) |
| Postseason     | Practice      | 19 (17.9)  | 9726 (16.8)   | 82 (38.5)   | 1425 (37.0)   | 38,581 | 2.13 (1.67, 2.59) |
|                | Competition   | 67 (82.1)  | 48,116 (83.2) | 131 (61.5)  | 2426 (63.0)   | 97,424 | 13.45 (11.14, 15.75) |
|                | Total         | 106 (100.0) | 57,842 (100.0) | 213 (100.0) | 38,515 (100.0) | 48,323 | 4.41 (3.82, 5.00) |

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

Excludes 6 injuries reported in HS RIO because of 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. National estimates and athlete-exposures may not sum to totals because of 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.
14.4% of injuries occurred during defending.

| Surveillance System and Time-Loss Category | Practice | | | | | Competition | | | |
|------------------------------------------|----------|-----------------|-----------------|-----------------|
|                                           | Injuries in Sample, No. (%) | Estimates, No. (%) | Injury Rate/1000 Athlete-Exposures (95% Confidence Interval) | Injuries in Sample, No. (%) | Estimates, No. (%) | Injury Rate/1000 Athlete-Exposures (95% Confidence Interval) |
| HS RIO (2005–2006 through 2013–2014)    | 1 d to < 1 wk | 604 (53.5) | 328,662 (53.0) | 0.54 (0.50, 0.58) | 752 (44.3) | 381,040 (45.2) | 1.58 (1.47, 1.69) |
|                                           | 1 to 3 wk | 361 (32.0) | 193,136 (31.1) | 0.32 (0.29, 0.36) | 588 (34.7) | 288,295 (34.2) | 1.23 (1.13, 1.33) |
|                                           | >3 wk | 164 (14.5) | 98,926 (15.9) | 0.15 (0.12, 0.17) | 356 (21.0) | 173,820 (20.6) | 0.75 (0.67, 0.83) |
| NCAA-ISP (2004–2005 through 2013–2014) | 1 d to < 1 wk | 1473 (62.4) | 28,222 (61.9) | 2.73 (2.59, 2.87) | 1302 (58.0) | 24,732 (56.2) | 8.79 (8.32, 9.27) |
|                                           | 1 to 3 wk | 657 (27.8) | 12,868 (28.2) | 1.22 (1.13, 1.31) | 694 (30.9) | 13,160 (29.9) | 4.69 (4.34, 5.04) |
|                                           | >3 wk | 232 (9.8) | 4488 (9.9) | 0.43 (0.38, 0.49) | 248 (11.1) | 6134 (13.9) | 1.67 (1.47, 1.88) |

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

| No. (%) | |
|--------|--------|--------|--------|--------|
| 1 d to < 1 wk | 604 (53.5) | 328,662 (53.0) | 0.54 (0.50, 0.58) | |
| 1 to 3 wk | 361 (32.0) | 193,136 (31.1) | 0.32 (0.29, 0.36) | |
| >3 wk | 164 (14.5) | 98,926 (15.9) | 0.15 (0.12, 0.17) | |
| 1 d to < 1 wk | 1473 (62.4) | 28,222 (61.9) | 2.73 (2.59, 2.87) | |
| 1 to 3 wk | 657 (27.8) | 12,868 (28.2) | 1.22 (1.13, 1.31) | |
| >3 wk | 232 (9.8) | 4488 (9.9) | 0.43 (0.38, 0.49) | |

The most common mechanisms of injury during practices were no contact (35.4%) and contact with another person (23.4%); during competitions, they were contact with another person (60.0%) and contact with the playing surface (17.3%). The most frequent activity during injury in practices and competitions was general play (practices = 31.4%, competitions = 28.2%). Other typical activities during injury in practices and competitions were no contact (35.4%), contact with another person (23.4%), and contact with the playing surface (17.3%). During competitions, the most frequent activity during injury in practices and competitions was general play (practices = 29.6%, competitions = 16.7%). Other typical activities during injury in practices were conditioning (12.0%) in practices and defending (13.7%), chasing a loose ball (13.3%), and ball handling (13.3%) in competitions.

Mechanisms of Injury and Activities

High School. The most common mechanisms of injury during practices were no contact (35.4%) and contact with another person (23.4%); during competitions, they were contact with another person (60.0%) and contact with the playing surface (17.3%); Table 6). The most frequent activity during injury in practices and competitions was general play (practices = 29.6%, competitions = 16.7%; Table 7). Other typical activities during injury in practices were conditioning (12.0%) in practices and defending (13.7%), chasing a loose ball (13.3%), and ball handling (13.3%) in competitions.

College. The most common mechanisms of injury during practices and competitions were no contact (practices = 39.1%, competitions = 23.4%) and contact with another person (practices = 28.2%, competitions = 58.2%; Table 6). The most frequent activity during injury in practices and competitions was general play (practices = 43.1%, competitions = 32.4%; Table 7). Also, in competitions, 14.4% of injuries occurred during defending.

Position-Specific Injuries in Competitions

During high school competitions, concussion was the most common injury among defenders, forwards, midfielders, and goalkeepers (22.5%, 18.7%, 19.8%, and 28.7%, respectively), with the mechanism of injury primarily being contact with another person (Table 8). This was in contrast to competitions at the collegiate level, during which hip/thigh/upper leg sprains were the most frequent injuries to defenders (25.4%) as were ankle sprains to forwards (19.2%) and midfielders (18.4%). Among collegiate goalkeepers, concussion and hip/thigh/upper leg strains were the most typical injuries (13.9% each).

DISCUSSION

We examined time-loss injuries sustained during the past decade among a sample of high school boys’ and collegiate men’s soccer players and found variations in the incidence of injury. However, these injury estimates emphasize the relative safety of the sport in relation to other sports, particularly those with contact integrated into game play. Nevertheless, both high school boys’ and collegiate men’s soccer had large populations of 417,419 and 23,602 student-athletes, respectively. Thus, epidemiologic examinations of injury in soccer can help drive the development of data-driven injury-prevention interventions specific to the sport.

Comparison of Injury Rates With Previous Research

Our high school injury rates were lower than those previously reported from the 1995–1997 seasons (competitions = 3.68 versus 10.2/1000 AEIs, practices = 1.04 versus 2.5/1000 AEIs). At the collegiate level, overall injury rates within Divisions I through III were lower than the time-loss injury rates demonstrated for the 2000–2001 through 2001–2002 academic years by Powell and Dompi18 (Division I = 7.49 versus 8.2/1000 AEIs; Division II = 5.91 versus 7.7/1000 AEIs; Division III = 6.77 versus 8.5/1000 AEIs). In an earlier iteration of the NCAA-ISP during the 1988–1989 through 2003–2004 academic years, competition and practice injury rates were...
resulted in time loss of less than 1 week (range 44.3%– 62.4%). Comparisons with earlier studies should be made with caution as the composition of the samples may vary by practice level and rule changes that could help to reduce those rates, it is important to note that practices compose a larger proportion of at-risk exposure time than competitions. The ratios of

Comparisons Between and Within High School Boys’ and Collegiate Men’s Soccer

Collegiate injury rates were higher than high school injury rates among male soccer players. Although varying levels of intensity or skill level may explain the difference between playing levels, other factors may contribute as well. For example, previous researchers hypothesized that a history of injury may place athletes at greater risk for reinjury. It is likely that collegiate soccer players also played at the high school level. Thus, the higher injury rates in college may be due to a greater likelihood of previous injury due to more exposure time in the sport. In many cases, injury surveillance does not collect in-depth data on individual-level characteristics such as exertion or intensity, skill level, and injury history. Methods to integrate such data with current surveillance efforts may help us to better understand the factors associated with injury risk in large datasets. However, longitudinal analyses are needed to monitor trends in injury incidence at both levels, particularly for high school, where players may be multisport athletes and also playing soccer in club leagues.

In both high school and college, competition injury rates were higher than practice injury rates, which is consistent with previous findings. Although the higher injury rates during competitions merit further examinations of policy and rule changes that could help to reduce those rates, it is important to note that practices compose a larger proportion of at-risk exposure time than competitions. The ratios of

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

Excludes 5 injuries reported in HS RIO because of missing data for body part. Percentages may not add up to 100.0 because of 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.

18.75 and 4.34/1000 AEs, respectively. Whereas our competition injury rate was lower (15.65/1000 AEs), our practice injury rate was slightly higher (4.54/1000 AEs). The previously reported higher injury rates, particularly during competitions, may suggest an overall decrease in injury incidence across time. This finding may be further validated given that the largest proportion of injuries resulted in time loss of less than 1 week (range = 44.3%–62.4%). Comparisons with earlier studies should be made with caution as the composition of the samples may vary by division, school size, and resources such as team medical staff size or staff-to-athlete ratio, and consequently, be associated with injury rates.19 As a result, we recommend research that continues to monitor trends in injury incidence while testing hypotheses that address why reductions in injury incidence and severity may occur.
practice to competition AEs in high school and college were 2.34:1 and 3.64:1, respectively. In addition, 39.7% of high school and 51.4% of collegiate injuries were reported to have occurred during practices. With the most common injury mechanisms differing between competitions (increased potential contact with opposing player) and practices (no contact or potential contact with teammate), we advocate the use of injury-prevention strategies that comprehensively address risk factors for both contact and noncontact injury mechanisms across both competitions and practices. These can include eccentric strengthening to reduce the risk of muscle strains, neuromuscular training to prevent noncontact lower extremity injuries, and training-load monitoring to help prevent overuse and volume-related injuries. We also encourage further research on other training priorities, such as the effect of neck strength on reducing concussion risk or severity, and research on other training priorities, such as the effect of coaching pedagogy, availability of resources (eg, strength and conditioning programming, staffing), and the use of injury-prevention programs. Future investigators should seek to fully examine the factors associated with injury incidence and reporting in the high school and collegiate sport settings.

Authors26–29 have examined AT coverage in amateur sport settings and how variations in coverage may affect the documentation and management of injuries. Smaller high schools may have less access to ATs, which may contribute to less care and more injuries. However, the athlete-to-AT ratio may also be smaller at smaller high schools, resulting in athletes having more access to care, which could lead to the ATs reporting more injuries to injury-surveillance programs. Such dynamics may be similar at the collegiate level, in which staffing resources may vary by division. At the same time, it is important to note that whereas the NCAA advocates for member institutions to provide appropriate AT coverage across all sports, 30% of US public high schools do not have at least 1 AT on site.26 State-specific analyses of associations between high school size and medical staff coverage have shown mixed findings but these analyses were specific to American football. Although findings supporting the value of ATs are promising, additional research is needed to strengthen the linkage between AT coverage and lower injury incidences. Comparing injury incidences in settings with and without medical coverage while ensuring complete and accurate

Table 5. Number of Injuries, National Estimates, and Injury Rates by Diagnosis and Type of Athlete-Exposure in High School Boys’ and Collegiate Men’s Soccer

| 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 | 76 (6.6) | 42 536 (6.7) | 0.07 (0.05, 0.08) | 366 (20.9) | 206 324 (23.6) | 0.77 (0.69, 0.85) |
| Contusion | 116 (10.1) | 56 577 (9.0) | 0.10 (0.09, 0.12) | 327 (18.7) | 157 805 (18.1) | 0.69 (0.61, 0.76) |
| Dislocationb | 25 (2.2) | 13 027 (2.1) | 0.02 (0.01, 0.03) | 29 (1.7) | 15 548 (1.8) | 0.06 (0.04, 0.08) |
| Fracture/avulsion | 86 (7.5) | 47 814 (7.6) | 0.08 (0.06, 0.09) | 218 (12.4) | 92 149 (10.6) | 0.46 (0.40, 0.52) |
| Laceration | 13 (1.1) | 7020 (1.1) | 0.01 (0.01, 0.02) | 51 (2.9) | 22 902 (2.6) | 0.11 (0.08, 0.14) |
| Ligament sprain | 259 (22.5) | 136 490 (21.6) | 0.23 (0.20, 0.26) | 456 (26.0) | 222 500 (25.5) | 0.96 (0.87, 1.05) |
| Muscle/tendon strain | 368 (31.9) | 205 690 (32.6) | 0.33 (0.30, 0.36) | 202 (11.5) | 103 729 (11.9) | 0.42 (0.37, 0.48) |
| Other | 210 (18.2) | 121 531 (20.4) | 0.19 (0.16, 0.21) | 103 (5.9) | 51 519 (5.9) | 0.22 (0.17, 0.26) |
| NCAA-ISP (2004–2005 through 2013–2014) | | | | | |
| Concussion | 93 (3.8) | 2267 (4.8) | 0.17 (0.14, 0.21) | 183 (7.9) | 3652 (7.9) | 1.24 (1.06, 1.41) |
| Contusion | 351 (14.3) | 6353 (13.5) | 0.65 (0.58, 0.72) | 585 (25.2) | 10 068 (21.8) | 3.95 (3.63, 4.27) |
| Dislocationb | 21 (0.9) | 338 (0.7) | 0.04 (0.02, 0.06) | 22 (1.0) | 419 (0.9) | 0.15 (0.09, 0.21) |
| Fracture/avulsion | 54 (2.2) | 1074 (2.3) | 0.10 (0.07, 0.13) | 100 (4.3) | 2403 (5.2) | 0.68 (0.54, 0.81) |
| Laceration | 28 (1.1) | 467 (1.0) | 0.06 (0.03, 0.07) | 63 (2.7) | 1305 (2.8) | 0.43 (0.32, 0.53) |
| Ligament sprain | 577 (23.6) | 11 149 (23.6) | 1.07 (0.98, 1.16) | 613 (26.5) | 12 701 (27.5) | 4.14 (3.81, 4.47) |
| Muscle/tendon strain | 768 (31.4) | 15 146 (32.1) | 1.43 (1.32, 1.53) | 484 (20.9) | 9896 (21.4) | 3.27 (2.98, 3.56) |
| Other | 555 (22.7) | 10 434 (22.1) | 1.03 (0.94, 1.12) | 268 (11.6) | 5817 (12.6) | 1.81 (1.59, 2.03) |

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

a Excludes 7 injuries reported in HS RIO because of missing data for diagnosis. Percentages may not add up to 100.0 because of 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 analysis regardless of time loss. Data may include multiple injuries that occurred at 1 injury event.

b Includes separations.
Columbia have enacted concussion-related legislation. At the high school level, all 50 states and the District of Columbia have enacted concussion-related legislation.11

Across all positions at the high school level, concussion was the most common injury in competitions; concussion was also the most frequent injury for goalkeepers in collegiate competitions. Most of these concussions were due to contact with another player. The reason for the increased proportion of concussions during high school relative to collegiate competitions is unclear and demands further attention. Additionally, the elevated incidence of concussion during high school competitions highlights the need to ensure that appropriate medical coverage is available during soccer competitions to detect, diagnose, and manage the concussions that occur. At the high school level, all 50 states and the District of Columbia have enacted concussion-related legislation.11

In April 2010, the NCAA Executive Committee adopted a new policy that focused on proper identification and management of concussions.12 Still, the development of interventions focused on reducing their occurrence is lacking. Because most concussions during competitions occur from contact with another person, prevention can focus on strategies such as emphasizing “heads-up, eyes-up play” that may allow players to better anticipate open-field collisions. Such anticipation may also reduce injuries associated with ball contact, as previous researchers30 suggested that errant and unintentional deflected balls, not purposeful heading, may be more likely to produce injurious head impacts.

In addition to concussion, lower extremity injuries, such as knee and ankle sprains and hip/thigh/groin/upper leg strains, were among the most common injuries sustained in high school and collegiate soccer. Fortunately, the incidence of lower extremity injuries, such as knee and ankle injuries, may be lowered through prophylactic bracing, balance training, and conditioning and drills.31–36 Ankle-sprain prevention has been examined in particular, with prevention recommendations focused on multi-intervention programs that incorporate balance and neuromuscular control, as well as increasing leg-muscle strength and range of motion.37 One of the most well-known injury-prevention interventions is the Fédération Internationale de Football Association (FIFA) 11+, which involves multiple types of exercises, including balance, plyometric, flexibility, agility, and resistance exercises in combination with

Table 6. Number of Injuries, National Estimates, and Injury Rates by Mechanism of Injury and Type of Athlete-Exposure in High School Boys’ and Collegiate Men’s Soccer*
movement-control instruction. When implemented with high compliance, the FIFA 11þ was effective in reducing the incidence of ankle injuries among various male soccer populations, including collegiate athletes. Silvers-Graselli et al reported that the FIFA 11þ program performed as a 20-minute dynamic warm-up reduced knee (including 74% of anterior cruciate ligament injuries), ankle, and muscle strain injuries and decreased the total time lost because of injury in collegiate men’s soccer. These types of warm-up programs may be a cost-effective and efficient method for preventing many injuries sustained in men’s soccer. Despite the evidence at other levels, no authors have specifically evaluated the effect of this program or others among high school male soccer athletes. Alongside recommending the use of such soccer injury-prevention programs, clinicians should emphasize the need to ensure proper implementation and compliance. Because research is typically performed in controlled and monitored environments, the findings may not be replicable in real-life settings unless the factors that aid and hinder implementation and compliance are identified and resolved.

Muscle strains, especially those involving the hamstrings, are well documented in men’s soccer athletes. Strains were the most common injury sustained during soccer practices, regardless of level. A lack of muscle strength, especially eccentric strength, has been discussed as a modifiable risk factor for soccer athletes. Eccentric strengthening exercises, such as the Nordic hamstrings exercise, in conjunction with other preventive training programs, can reduce up to 51% of hamstring injuries in men’s soccer. A player’s age and prior injuries are also considered strong risk factors for muscle strain injuries, and the current findings support this: collegiate men’s soccer players demonstrated a higher rate of strain injuries compared with high school boys’ soccer players across practices and competitions. Advances in monitoring player workload through training loads and physiological responses may reduce the rate and severity of many injuries, as well as assist in returning the athlete to play. Further work is needed in this area, especially in the...
In that HS RIO used a random sample, whereas the NCAA-variations that do exist between them; this is most evident surveillance systems, it is important to consider the although HS RIO and the NCAA-ISP are similar injury-istics (eg, previous injury, functional capabilities). Also, injury-prevention programs, and athlete-specific character-

Our results further highlight the risks of slide tackling. Nearly a third of injuries sustained when a player received a Mechanism of injury. Slide tackling is one aspect of soccer that has garnered attention for its associated risk of injury. Our findings may not be generalizable to other playing

Table 8. Most Common Injuries Associated With Position in Competitions in High School Boys' and Collegiate Men's Soccer*

| Position  | Most Common Injuries | Within Position, % | Most Frequent Mechanism of Injury for This Injury | Within Position |
|-----------|----------------------|--------------------|-----------------------------------------------|----------------|
| Defense   | Concussion 22.5       | Contact with another person | Hip/thigh/upper leg strain 25.4 | No contact |
|           | Ankle sprain 16.1    | Contact with another person | Ankle sprain 16.1 | Contact with another person |
| Forward   | Concussion 18.7       | Contact with another person | Concussion 7.7 | Contact with another person |
|           | Ankle sprain 17.3     | Contact with another person | Ankle sprain 19.2 | Contact with another person |
| Goalkeeper| Concussion 28.7       | Contact with another person | Concussion 7.9 | Contact with another person |
|           |                      |            | Hip/thigh/upper leg strain 13.9 | No contact |
|           |                      |            | Hip/thigh/upper leg contusion 11.1 | Contact with another person |
| Midfielder| Concussion 19.8       | Contact with another person | Ankle sprain 18.4 | Contact with another person |
|           | Ankle sprain 16.3     | Contact with another person | Hip/thigh/upper leg strain 16.0 | No contact |
|           |                      |            | Concussion 7.2 | Contact with another person |

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

Concussion 7.7 Contact with another person

Ankle sprain 16.0 No contact

Our findings may not be generalizable to other playing levels, such as youth, middle school, and professional programs, nor to collegiate programs at non-NCAA institutions or high schools without National Athletic Trainers’ Association–affiliated ATs. 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 surveillance systems, it is important to consider the variations that do exist between them; this is most evident in that HS RIO used a random sample, whereas the NCAA-

CONCLUSIONS

Although soccer injury rates are relatively low in comparison with other sports, differences were seen between and within our study populations. Injury rates

Lower extremity injuries can also be the result of contact with another player. Rules and policies during competitions may help to decrease the incidence of contact-related lower extremity injuries. Slide tackling is one aspect of soccer that has garnered attention for its associated risk of injury. Our results further highlight the risks of slide tackling. Nearly a third of injuries sustained when a player received a slide tackle during a competition led to more than 3 weeks lost from soccer participation, regardless of the level of competition. Further evaluation of the rules governing legal slide tackling may be warranted.

Limitations

Our findings may not be generalizable to other playing levels, such as youth, middle school, and professional programs, nor to collegiate programs at non-NCAA institutions or high schools without National Athletic Trainers’ Association–affiliated ATs. 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 surveillance systems, it is important to consider the variations that do exist between them; this is most evident in 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 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. However, collecting such exposure data is more laborious than collecting AE data and may be too burdensome for ATs collecting data for HS RIO and the NCAA-ISP.
were higher in collegiate men’s soccer than in high school boys’ soccer. In addition, injury rates were higher during competitions than during practices at both levels and varied by school size in high school and by division in college. Although most injuries affected the lower extremity, concussions were also common, particularly among collegiate goalkeepers and among high school players at all positions.

Clinically, ATs working with high school boys’ and collegiate men’s soccer players should advocate for the incorporation of injury-prevention interventions focused on reducing lower extremity injuries, as recent results appear promising.9,10 However, it is important to consider how variations across and within both of these settings may affect the implementation and resulting efficacy. From a research standpoint, examinations of intervention efficacy need to account for these factors, which were not assessed in our study. In addition, the effectiveness of rules changes and policies focused on injury prevention has yet to be assessed but evaluation is warranted.

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