Journal of Athletic Training 2018;53(9):893–905
doi: 10.4085/1062-6050-166-17

www.natajournals.org

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.[1] 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[6] framework, injury prevention benefits from ongoing monitoring of injury incidence, and updated descriptive epidemiology is needed. A previous NCAA-ISP report[7] 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 soccer[8–10] as well as across all sports (eg, concussion legislation).[11,12] 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 RIO[5,14] 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–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 $\leq$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 (Keffer 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,[16] who estimated that the ISP captured 88.3% of all time-loss medical-care injury events. Weighted counts were scaled up by a factor of (0.883^{-1}). In-depth information on the formula used to calculate national estimates can be found in the previously published methodologic article.[13]

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 beween 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 ($\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% 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 1 507 166 high school injuries (annual average of 167 463) and 93 507 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 $\leq$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. Injury Rates by School Size or Division and Type of Athlete-Exposure in High School Boys' and Collegiate Men's Soccer[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	611 (42.5)	491 381 (43.9)	420 650	1.45 (1.34, 1.57)
	Competition	825 (57.5)	628 576 (56.1)	179 001	4.61 (4.29, 4.92)
	Total	1436 (100.0)	1 119 957 (100.0)	599 651	2.39 (2.27, 2.52)
>1000 students	Practice	546 (37.0)	142 370 (36.8)	695 327	0.79 (0.72, 0.85)
	Competition	930 (63.0)	244 839 (63.2)	297 260	3.13 (2.93, 3.33)
	Total	1476 (100.0)	387 209 (100.0)	992 587	1.49 (1.41, 1.56)
Total	Practice	1157 (39.7)	633 751 (42.0)	1 115 977	1.04 (0.98, 1.10)
	Competition	1755 (60.3)	873 415 (58.0)	476 260	3.68 (3.51, 3.86)
	Total	2912 (100.0)	1 507 166 (100.0)	1 592 238	1.83 (1.76, 1.90)
NCAA-ISP (2004–2005 through 2013–2014)					
Division I	Practice	1061 (51.2)	13 949 (49.8)	222 056	4.78 (4.49, 5.07)
	Competition	1012 (48.8)	14 067 (50.2)	54 552	18.55 (17.41, 19.69)
	Total	2073 (100.0)	28 016 (100.0)	276 607	7.49 (7.17, 7.82)
Division II	Practice	303 (52.0)	9 909 (51.5)	77 432	3.91 (3.47, 4.35)
	Competition	280 (48.0)	9345 (48.5)	21 131	13.25 (11.70, 14.80)
	Total	583 (100.0)	19 254 (100.0)	98 563	5.91 (5.43, 6.40)
Division III	Practice	1083 (51.4)	23 388 (50.6)	239 352	4.52 (4.26, 4.79)
	Competition	1026 (48.6)	22 849 (49.4)	72 395	14.17 (13.31, 15.04)
	Total	2109 (100.0)	46 237 (100.0)	311 747	6.77 (6.48, 7.05)
Total	Practice	2447 (51.4)	47 247 (50.5)	538 840	4.54 (4.36, 4.72)
	Competition	2318 (48.6)	46 260 (49.5)	148 078	15.65 (15.02, 16.29)
	Total	4765 (100.0)	93 507 (100.0)	686 918	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 strains (31.9%), ligament sprains (22.5%),

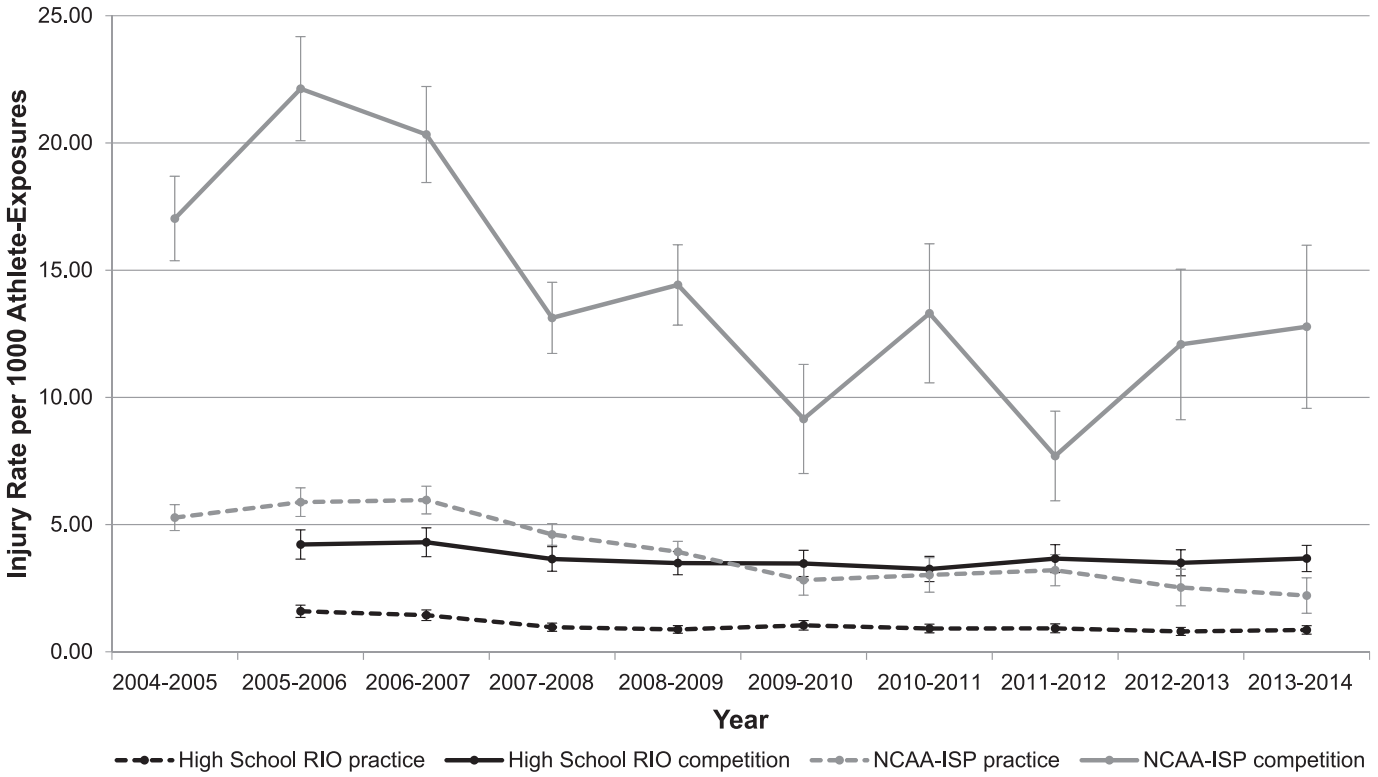

Figure. Injury rates by year and type of athlete-exposure (AE) in high school boys' and collegiate men's soccer. Note: Annual average changes for linear trend test for injury rates are as follows: High School Reporting Information Online (RIO; practices = –0.08/1000 AEs, 95% confidence interval [CI] = –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 = –0.17/1000 AEs, 95% CI = –0.33, –0.01; competitions = 0.60/1000 AEs, 95% CI = –0.65, 1.85). 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.

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

Table 2. Injury Rates by Time in Season and Type of Athlete-Exposure in High School Boys' and Collegiate Men's Soccer[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	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)	2538 (9.2)	6852	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	87 (82.1)	48 116 (83.2)	131 (61.5)	2426 (63.0)	9742	13.45 (11.14, 15.75)
	Total	106 (100.0)	57 842 (100.0)	213 (100.0)	3851 (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.

[a] 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.

Table 3. Number of Injuries and Injury Rates by Time Loss and Type of Athlete-Exposure in High School Boys' and Collegiate Men's Soccer[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	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[b]	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[b]	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.

[a] Excludes 87 injuries reported in HS RIO and 159 injuries reported in the NCAA-ISP because of missing data for time loss. 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.

[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.

(practices = 31.3%, competitions = 25.2%; Table 4). Other frequently injured body parts were the ankle (19.0%) and knee (12.0%) during practices and the ankle (18.9%) and head/face (13.3%) during competitions. The most often cited injury diagnoses during practices and competitions were muscle/tendon strains (practices = 31.4%, competitions = 20.9%), ligament sprains (practices = 23.6%, competitions = 26.5%), and contusions (practices = 14.3%, competitions = 25.2%; Table 5).

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 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.[2,3] 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[17] from the 1995–1997 seasons (competitions = 3.68 versus 10.2/1000 AEs, practices = 1.04 versus 2.5/1000 AEs). 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 Dompier[18] (Division I = 7.49 versus 8.2/1000 AEs; Division II = 5.91 versus 7.7/1000 AEs; Division III = 6.77 versus 8.5/1000 AEs). In an earlier iteration of the NCAA-ISP during the 1988–1989 through 2003–2004 academic years, competition and practice injury rates were

Table 4. Number of Injuries, National Estimates, and Injury Rates by Body Part Injured and Type of Athlete-Exposure in High School Boys' and Collegiate Men's Soccer[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	104 (9.0)	57 395 (9.1)	0.09 (0.08, 0.11)	464 (26.5)	254 034 (29.1)	0.97 (0.89, 1.06)
Neck	9 (0.8)	6342 (1.0)	0.01 (0.00, 0.01)	8 (0.5)	2783 (0.3)	0.02 (0.01, 0.03)
Shoulder/clavicle	28 (2.4)	12 340 (2.0)	0.03 (0.02, 0.03)	70 (4.0)	29 317 (3.4)	0.15 (0.11, 0.18)
Arm/elbow	15 (1.3)	7926 (1.3)	0.01 (0.01, 0.02)	27 (1.5)	12 571 (1.4)	0.06 (0.04, 0.08)
Hand/wrist	63 (5.5)	36 919 (5.8)	0.06 (0.04, 0.07)	83 (4.7)	37 415 (4.3)	0.17 (0.14, 0.21)
Trunk	62 (5.4)	30 035 (4.7)	0.06 (0.04, 0.07)	78 (4.5)	39 772 (4.6)	0.16 (0.13, 0.20)
Hip/thigh/upper leg	296 (25.6)	160 196 (25.3)	0.27 (0.24, 0.30)	215 (12.3)	107 346 (12.3)	0.45 (0.39, 0.51)
Knee	167 (14.5)	90 715 (14.3)	0.15 (0.13, 0.17)	242 (13.8)	114 384 (13.1)	0.51 (0.44, 0.57)
Lower leg	100 (8.7)	58 376 (9.2)	0.09 (0.07, 0.11)	129 (7.4)	59 667 (6.8)	0.27 (0.22, 0.32)
Ankle	200 (17.3)	108 059 (17.1)	0.18 (0.15, 0.20)	321 (18.3)	158 645 (18.2)	0.67 (0.60, 0.75)
Foot	99 (8.6)	56 177 (8.9)	0.09 (0.07, 0.11)	103 (5.9)	50 029 (5.7)	0.22 (0.17, 0.26)
Other	12 (1.0)	7887 (1.3)	0.01 (0.00, 0.02)	12 (0.7)	5998 (0.7)	0.03 (0.01, 0.04)
NCAA-ISP (2004–2005 through 2013–2014)						
Head/face	159 (6.5)	3731 (7.9)	0.30 (0.25, 0.34)	308 (13.3)	6385 (13.8)	2.08 (1.85, 2.31)
Neck	11 (0.5)	127 (0.3)	0.02 (0.01, 0.03)	10 (0.4)	194 (0.4)	0.07 (0.03, 0.11)
Shoulder/clavicle	51 (2.1)	892 (1.9)	0.09 (0.07, 0.12)	93 (4.0)	1759 (3.8)	0.63 (0.50, 0.76)
Arm/elbow	10 (0.4)	187 (0.4)	0.02 (0.01, 0.03)	15 (0.7)	256 (0.6)	0.10 (0.05, 0.15)
Hand/wrist	63 (2.6)	1100 (2.3)	0.12 (0.09, 0.15)	52 (2.2)	981 (2.1)	0.35 (0.26, 0.45)
Trunk	124 (5.1)	2590 (5.5)	0.23 (0.19, 0.27)	110 (4.8)	1705 (3.7)	0.74 (0.60, 0.88)
Hip/thigh/upper leg	766 (31.3)	15 222 (32.2)	1.42 (1.32, 1.52)	584 (25.2)	11 841 (25.6)	3.94 (3.62, 4.26)
Knee	294 (12.0)	6132 (13.0)	0.55 (0.48, 0.61)	274 (11.8)	5611 (12.1)	1.85 (1.63, 2.07)
Lower leg	192 (7.9)	3274 (6.9)	0.36 (0.31, 0.41)	204 (8.8)	4016 (8.7)	1.38 (1.19, 1.57)
Ankle	465 (19.0)	8466 (17.9)	0.86 (0.78, 0.94)	439 (18.9)	9179 (19.8)	2.96 (2.69, 3.24)
Foot	206 (8.4)	3821 (8.1)	0.38 (0.33, 0.43)	211 (9.1)	4032 (8.7)	1.42 (1.23, 1.62)
Other	106 (4.3)	1704 (3.6)	0.20 (0.16, 0.23)	18 (0.8)	301 (0.7)	0.12 (0.07, 0.18)

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

[a] 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.[7] 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.

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[20–22] 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.[17] 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

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[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	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)
Dislocation[b]	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)
Dislocation[b]	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)	487 (1.0)	0.05 (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.

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,[10] neuromuscular training to prevent noncontact lower extremity injuries,[9] and training-load monitoring to help prevent overuse and volume-related injuries.[23,24] We also encourage further research on other training priorities, such as the effect of neck strength on reducing concussion risk or severity,[25] which may be beneficial during contact mechanisms. In addition, preventing injuries due to player-to-player contact may require reexaminations of the rules that aim to limit contact and the effectiveness of protective equipment in reducing injury incidence.[7]

Our findings also suggest differences in injury rates based on school size for high schools and division for colleges. Smaller high schools had higher injury rates than larger high schools. Collegiate injury rates were the highest in Division I, which is similar to previous research.[7] Such differences may also be attributable to other factors, including variations in team composition, skill level, 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.

Authors[26–29] 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 all member institutions to provide appropriate AT coverage across all sports,[12] 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,[27–29] 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 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[a]

	Practice			Competition		
Surveillance System and Mechanism of Injury	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)						
Contact with another person	264 (23.4)	137 807 (22.3)	0.24 (0.21, 0.27)	1032 (60.0)	517 513 (60.9)	2.17 (2.03, 2.30)
Contact with playing surface	179 (15.8)	93 943 (15.2)	0.16 (0.14, 0.18)	297 (17.3)	133 308 (15.7)	0.62 (0.55, 0.69)
Contact with soccer ball	108 (9.6)	57 391 (9.3)	0.10 (0.08, 0.12)	99 (5.8)	51 406 (6.1)	0.21 (0.17, 0.25)
Contact with goal	5 (0.4)	2912 (0.5)	<0.01 (0.00, 0.01)	5 (0.3)	2322 (0.3)	0.01 (0.00, 0.02)
Contact with other playing equipment	6 (0.5)	4565 (0.7)	0.01 (0.00, 0.01)	8 (0.5)	5037 (0.6)	0.02 (0.01, 0.03)
Contact with out-of-bounds object	1 (0.1)	365 (0.1)	<0.01 (0.00, <0.01)	0	0	0.00
No contact	400 (35.4)	222 798 (36.0)	0.36 (0.32, 0.39)	242 (14.1)	124 161 (14.6)	0.51 (0.44, 0.57)
Overuse/chronic	159 (14.1)	94 473 (15.3)	0.14 (0.12, 0.16)	33 (1.9)	12 047 (1.4)	0.07 (0.05, 0.09)
Illness/infection	8 (0.7)	4704 (0.8)	0.01 (0.00, 0.01)	5 (0.3)	3289 (0.4)	0.01 (0.00, 0.02)
NCAA-ISP (2004–2005 through 2013–2014)						
Contact with another person	680 (28.2)	13 270 (28.8)	1.26 (1.17, 1.36)	1339 (58.2)	25 974 (57.2)	9.04 (8.56, 9.53)
Contact with playing surface	208 (8.6)	3962 (8.6)	0.39 (0.33, 0.44)	204 (8.9)	4931 (10.9)	1.38 (1.19, 1.57)
Contact with soccer ball	189 (7.8)	3896 (8.5)	0.35 (0.30, 0.40)	108 (4.7)	2267 (5.0)	0.73 (0.59, 0.87)
Contact with goal	7 (0.3)	118 (0.3)	0.01 (0.00, 0.02)	7 (0.3)	188 (0.4)	0.05 (0.01, 0.08)
Contact with other playing equipment	4 (0.2)	49 (0.1)	0.01 (0.00, 0.01)	3 (0.1)	45 (0.1)	0.02 (0.00, 0.04)
Contact with out-of-bounds object	9 (0.4)	167 (0.4)	0.02 (0.01, 0.03)	2 (0.1)	31 (<0.1)	0.01 (0.00, 0.03)
No contact	944 (39.1)	17 552 (38.1)	1.75 (1.64, 1.86)	539 (23.4)	9495 (20.9)	3.64 (3.33, 3.95)
Overuse/chronic	258 (10.7)	5273 (11.5)	0.48 (0.42, 0.54)	82 (3.6)	2181 (4.8)	0.55 (0.43, 0.67)
Illness/infection	115 (4.8)	1747 (3.8)	0.21 (0.17, 0.25)	18 (0.8)	263 (0.6)	0.12 (0.07, 0.18)

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

[a] Mechanism of injury excludes 61 injuries reported in HS RIO and 49 injuries reported in the NCAA-ISP because of missing data or athletic trainer reporting "Other" or "Unknown." 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 and/or treated 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.

reporting of injuries in both settings will help to further validate the value of AT coverage.

Common Injuries and Injury Prevention

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 researchers[30] 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 7. Number of Injuries, National Estimates, and Injury Rates by Activity During Injury and Type of Athlete-Exposure in High School Boys' and Collegiate Men's Soccer[a]

	Practice			Competition		
Surveillance System and Activity During Injury	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)						
Attempting a slide tackle	15 (1.4)	9491 (1.6)	0.01 (0.01, 0.02)	33 (2.0)	15 133 (1.8)	0.07 (0.05, 0.09)
Ball handling	109 (9.9)	53 150 (8.8)	0.10 (0.08, 0.12)	221 (13.3)	102 125 (12.3)	0.46 (0.40, 0.53)
Blocking shot	28 (2.6)	11 272 (1.9)	0.03 (0.02, 0.03)	39 (2.3)	18 474 (2.2)	0.08 (0.06, 0.11)
Chasing loose ball	105 (9.6)	54 956 (9.1)	0.09 (0.08, 0.11)	221 (13.3)	100 602 (12.1)	0.46 (0.40, 0.53)
Conditioning	132 (12.0)	66 940 (11.1)	0.12 (0.10, 0.14)	2 (0.1)	1301 (0.2)	<0.01 (0.00, 0.01)
Defending	67 (6.1)	37 845 (6.3)	0.06 (0.05, 0.07)	228 (13.7)	106 230 (12.8)	0.48 (0.42, 0.54)
General play	326 (29.6)	197 457 (32.8)	0.29 (0.26, 0.32)	279 (16.7)	148 679 (17.9)	0.59 (0.52, 0.65)
Goaltending	80 (7.3)	41 034 (6.8)	0.07 (0.06, 0.09)	125 (7.5)	72 879 (8.8)	0.26 (0.22, 0.31)
Heading ball	49 (4.4)	27 785 (4.6)	0.04 (0.03, 0.06)	197 (11.8)	105 865 (12.7)	0.41 (0.36, 0.47)
Passing	57 (5.2)	34 414 (5.7)	0.05 (0.04, 0.06)	102 (6.1)	45 875 (5.5)	0.21 (0.17, 0.26)
Receiving a slide tackle	12 (1.1)	6438 (1.1)	0.01 (0.00, 0.02)	47 (2.8)	27 793 (3.3)	0.10 (0.07, 0.13)
Receiving pass	41 (3.7)	26 507 (4.4)	0.04 (0.03, 0.05)	94 (5.6)	48 342 (5.8)	0.20 (0.16, 0.24)
Shooting	79 (7.2)	34 789 (5.8)	0.07 (0.06, 0.09)	80 (4.8)	37 711 (4.5)	0.17 (0.13, 0.20)
NCAA-ISP (2004–2005 through 2013–2014)						
Attempting a slide tackle	27 (1.1)	558 (1.2)	0.05 (0.03, 0.07)	68 (3.0)	1228 (2.7)	0.46 (0.35, 0.57)
Ball handling	161 (6.7)	2494 (5.5)	0.30 (0.25, 0.34)	208 (9.1)	3915 (8.7)	1.40 (1.21, 1.60)
Blocking shot	46 (1.9)	814 (1.8)	0.09 (0.06, 0.11)	45 (2.0)	836 (1.9)	0.30 (0.22, 0.39)
Chasing loose ball	103 (4.3)	1942 (4.3)	0.19 (0.15, 0.23)	171 (7.5)	3317 (7.4)	1.15 (0.98, 1.33)
Conditioning	196 (8.2)	3305 (7.3)	0.36 (0.31, 0.41)	13 (0.6)	187 (0.4)	0.09 (0.04, 0.14)
Defending	191 (8.0)	3917 (8.7)	0.35 (0.30, 0.40)	330 (14.4)	6931 (15.5)	2.23 (1.99, 2.47)
General play	1032 (43.1)	19 723 (43.6)	1.92 (1.80, 2.03)	743 (32.4)	15 166 (33.8)	5.02 (4.66, 5.38)
Goaltending	170 (7.1)	3163 (7.0)	0.32 (0.27, 0.36)	132 (5.8)	2260 (5.0)	0.89 (0.74, 1.04)
Heading ball	100 (4.2)	2062 (4.6)	0.19 (0.15, 0.22)	206 (9.0)	4089 (9.1)	1.39 (1.20, 1.58)
Passing	98 (4.1)	1588 (3.5)	0.18 (0.15, 0.22)	115 (5.0)	1871 (4.2)	0.78 (0.63, 0.92)
Receiving a slide tackle	38 (1.6)	900 (2.0)	0.07 (0.05, 0.09)	107 (4.7)	2287 (5.1)	0.72 (0.59, 0.86)
Receiving pass	53 (2.2)	1089 (2.4)	0.10 (0.07, 0.12)	56 (2.4)	960 (2.1)	0.38 (0.28, 0.48)
Shooting	177 (7.4)	3724 (8.2)	0.33 (0.28, 0.38)	96 (4.2)	1813 (4.0)	0.65 (0.52, 0.78)

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

[a] Activity excludes 144 injuries reported in HS RIO and 83 injuries reported in the NCAA-ISP because of missing data or athletic trainer reporting "Other" or "Unknown." 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.

movement-control instruction.[9] When implemented with high compliance, the FIFA 11+ was effective in reducing the incidence of ankle injuries among various male soccer populations, including collegiate athletes.[9,38] Silvers-Granelli et al[9] reported that the FIFA 11+ 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.[39] 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.[40] Eccentric strengthening exercises, such as the Nordic hamstrings exercise, in conjunction with other preventive training programs, can reduce up to 51% of hamstrings injuries in men's soccer.[10] A player's age and prior injuries are also considered strong risk factors for muscle strain injuries,[41] 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.[23,24] Further work is needed in this area, especially in the

Table 8. Most Common Injuries Associated With Position in Competitions in High School Boys' and Collegiate Men's Soccer[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
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
				Concussion	7.7	Contact with another person
Forward	Concussion	18.7	Contact with another person	Ankle sprain	19.2	Contact with another person
	Ankle sprain	17.3	Contact with another person	Hip/thigh/upper leg strain	16.6	No contact
				Concussion	7.9	Contact with another person
Goalkeeper	Concussion	28.7	Contact with another person	Concussion	13.9	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.

[a] Excludes 53 competition injuries reported in HS RIO and 89 competition injuries reported in the NCAA-ISP because of position not being indicated. The table reads as follows: for the defense position in high school, concussions composed 22.5% of all competition injuries to that position. The most common mechanism of injury for this specific injury for this specific position was contact with another person. 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.

availability of low-cost options at the high school level. Our results highlight the importance of preventing these injuries, as well as managing them properly before return to play.

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 injury-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.

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

CONCLUSIONS

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

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 rule changes and policies focused on injury prevention has yet to be assessed but evaluation is warranted.

ACKNOWLEDGMENTS

The NCAA-ISP data were provided by the Datalys Center for Sports Injury Research and Prevention, Inc. The ISP was funded by the NCAA. The HS RIO was funded in part by the Centers for Disease Control and Prevention grants R49/CE000674-01 and R49/CE001172-01 and the National Center for Research Resources award KL2 RR025754. The authors also acknowledge the research funding contributions of the National Federation of State High School Associations (Indianapolis, IN), National Operating Committee on Standards for Athletic Equipment (Overland Park, KS), DonJoy Orthotics (Vista, CA), and EyeBlack (Potomac, MD). The content of this report is solely the responsibility of the authors and does not necessarily represent the official views of the funding organizations. We thank the many ATs who have volunteered their time and efforts to submit data to HS RIO and the NCAA-ISP. Their efforts are greatly appreciated and have had a tremendously positive effect on the safety of high school and collegiate student-athletes.

REFERENCES

1. 265 million playing football. FIFA Web site. http://www.fifa.com/mm/document/fifafacts/bcoffsurv/emaga_9384_10704.pdf. Accessed August 1, 2017.
2. Participation statistics. National Federation of State High Schools Association Web site. http://www.nfhs.org/ParticipationStatics/ParticipationStatics.aspx/. Accessed April 9, 2017.
3. Student-athlete participation: 1981–82—2014–15. National Collegiate Athletic Association Web site. http://www.ncaa.org/sites/default/files/Participation%20Rates%20Final.pdf. Accessed April 9, 2017.
4. Kerr ZY, Dompier TP, Snook EM, et al. National Collegiate Athletic Association Injury Surveillance System: review of methods for 2004–2005 through 2013–2014 data collection. *J Athl Train*. 2014;49(4):552–560.
5. Centers for Disease Control and Prevention. Sports-related injuries among high school athletes—United States, 2005–06 school year. *MMWR Morb Mortal Wkly Rep*. 2006;55(38):1037–1040.
6. Van Mechelen W, Hlobil H, Kemper HC. Incidence, severity, aetiology and prevention of sports injuries: a review of concepts. *Sports Med*. 1992;14(2):82–99.
7. Agel J, Evans TA, Dick R, Putukian M, Marshall SW. Descriptive epidemiology of collegiate men's soccer injuries: National Collegiate Athletic Association Injury Surveillance System, 1988–1989 through 2002–2003. *J Athl Train*. 2007;42(2):270–277.
8. Grooms DR, Palmer T, Onate JA, Myer GD, Grindstaff T. Soccer-specific warm-up and lower extremity injury rates in collegiate male soccer players. *J Athl Train*. 2013;48(6):782–789.
9. Silvers-Granelli H, Mandelbaum B, Adeniji O, et al. Efficacy of the FIFA 11+ Injury Prevention Program in the collegiate male soccer player. *Am J Sports Med*. 2015;43(11):2628–2637.
10. Al Attar WSA, Soomro N, Sinclair PJ, Pappas E, Sanders RH. Effect of injury prevention programs that include the Nordic hamstring exercise on hamstring injury rates in soccer players: a systematic review and meta-analysis. *Sports Med*. 2017;47(5):907–916.
11. States address concerns about concussions in youth sports. Education Commission of the States Web site. https://www.ecs.org/clearinghouse/01/11/61/11161.pdf. Accessed February 17, 2018.
12. *2014–15 Sports Medicine Handbook*. National Collegiate Athletic Association Web site. http://www.ncaapublications.com/DownloadPublication.aspx?download=MD15.pdf. Accessed March 16, 2017.
13. Kerr ZY, Comstock RD, Dompier TP, Marshall SW. The first decade of Web-based sports injury surveillance (2004–2005 through 2013–2014): methods of the National Collegiate Athletic Association Injury Surveillance Program and High School Reporting Information Online. *J Athl Train*. 2018;53(8):729–737.
14. Rechel JA, Yard EE, Comstock RD. An epidemiologic comparison of high school sports injuries sustained in practice and competition. *J Athl Train*. 2008;43(2):197–204.
15. Census regions of the United States. US Census Bureau Web site. http://www.census.gov/const/regionmap.pdf. Accessed April 14, 2017.
16. Kucera KL, Marshall SW, Bell DR, DiStefano MJ, Goerger CP, Oyama S. Validity of soccer injury data from the National Collegiate Athletic Association's Injury Surveillance System. *J Athl Train*. 2011;46(5):489–499.
17. Powell JW, Barber-Foss KD. Injury patterns in selected high school sports: a review of the 1995-1997 seasons. *J Athl Train*. 1999;34(3):277–284.
18. Powell JW, Dompier TP. Analysis of injury rates and treatment patterns for time-loss and non–time-loss injuries among collegiate student-athletes. *J Athl Train*. 2004;39(1):56–70.
19. Kerr ZY, Lynall RC, Mauntel TC, Dompier TP. High school football injury rates and services by athletic trainer employment status. *J Athl Train*. 2016;51(1):70–73.
20. Petersen J, Thorborg K, Nielsen MB, Budtz-Jørgensen E, Hölmich P. Preventive effect of eccentric training on acute hamstring injuries in men's soccer a cluster-randomized controlled trial. *Am J Sports Med*. 2011;39(11):2296–2303.
21. Arnason A, Sigurdsson SB, Gudmundsson A, Holme I, Engebretsen L, Bahr R. Risk factors for injuries in football. *Am J Sports Med*. 2004;32(suppl 1):5S–16S.
22. Hägglund M, Waldén M, Ekstrand J. Previous injury as a risk factor for injury in elite football: a prospective study over two consecutive seasons. *Br J Sports Med*. 2006;40(9):767–772.
23. Brink MS, Visscher C, Arends S, Zwerver J, Post WJ, Lemmink KA. Monitoring stress and recovery: new insights for the prevention of injuries and illnesses in elite youth soccer players. *Br J Sports Med*. 2010;44(11):809–815.
24. Halson SL. Monitoring training load to understand fatigue in athletes. *Sports Med*. 2014;44(2):139–147.
25. Collins CL, Fletcher EN, Fields SK, et al. Neck strength: a protective factor reducing risk for concussion in high school sports. *J Prim Prev*. 2014;35(5):309–319.
26. Pryor RR, Casa DJ, Vandermark LW, et al. Athletic training services in public secondary schools: a benchmark study. *J Athl Train*. 2015;50(2):156–162.

27. Rutherford DS, Niedfeldt MW, Young CC. Medical coverage of high school football in Wisconsin in 1997. *Clin J Sport Med*. 1999;9(4):209–215.
28. Aukerman DF, Aukerman MM, Browning D. Medical coverage of high school athletics in North Carolina. *South Med J*. 2006;99(2):132–136.
29. Carek PJ, Dunn J, Hawkins A. Health care coverage of high school athletics in South Carolina: does school size make a difference? *J S C Med Assoc*. 1999;95(11):420–425.
30. Caccese JB, Kaminski TW. Minimizing head acceleration in soccer: a review of the literature. *Sports Med*. 2016;46(11):1591–1604.
31. McCriskin BJ, Cameron KL, Orr JD, Waterman BR. Management and prevention of acute and chronic lateral ankle instability in athletic patient populations. *World J Orthop*. 2015;6(2):161–171.
32. McGuine TA, Brooks A, Hetzel S. The effect of lace-up ankle braces on injury rates in high school basketball players. *Am J Sports Med*. 2011;39(9):1840–1848.
33. Van Reijen M, Vriend I, Zuidema V, van Mechelen W, Verhagen EA. The "strengthen your ankle" program to prevent recurrent injuries: a randomized controlled trial aimed at long-term effectiveness. *J Sci Med Sport*. 2017;20(6):549–554.
34. Pedowitz DI, Reddy S, Parekh SG, Huffman GR, Sennett BJ. Prophylactic bracing decreases ankle injuries in collegiate female volleyball players. *Am J Sports Med*. 2008;36(2):324–327.
35. Stasinopoulos D. Comparison of three preventive methods in order to reduce the incidence of ankle inversion sprains among female volleyball players. *Br J Sports Med*. 2004;38(2):182–185.
36. Bahr R, Lian Ø, Bahr IA. A twofold reduction in the incidence of acute ankle sprains in volleyball after the introduction of an injury prevention program: a prospective cohort study. *Scand J Med Sci Sports*. 1997;7(3):172–177.
37. Kaminski TW, Hertel J, Amendola N, et al. National Athletic Trainers' Association position statement: conservative management and prevention of ankle sprains in athletes. *J Athl Train*. 2013;48(4):528–545.
38. Bizzini M, Dvorak J. FIFA 11+: an effective programme to prevent football injuries in various player groups worldwide—a narrative review. *Br J Sports Med*. 2015;49(9):577–579.
39. Finch C. A new framework for research leading to sports injury prevention. *J Sci Med Sport*. 2006;9(1):3–9.
40. Askling C, Karlsson J, Thorstensson A. Hamstring injury occurrence in elite soccer players after preseason strength training with eccentric overload. *Scand J Med Sci Sports*. 2003;13(4):244–250.
41. Freckleton G, Pizzari T. Risk factors for hamstring muscle strain injury in sport: a systematic review and meta-analysis. *Br J Sports Med*. 2013;47(6):351–358.

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