

The First Decade of Web-Based Sports Injury Surveillance: Descriptive Epidemiology of Injuries in US High School Girls' Basketball (2005–2006 Through 2013–2014) and National Collegiate Athletic Association Women's Basketball (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 girls' and women's basketball injury data.

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

Design: Descriptive epidemiology study.

Setting: Online injury surveillance from basketball teams in high school girls (annual average = 100) and collegiate women (annual average = 57).

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

Main Outcome Measure(s): Certified athletic trainers collected time-loss (≥ 24 hours) injury and exposure data. Injury rates per 1000 athlete-exposures (AEs) were calculated. Injury rate ratios (IRRs) with 95% confidence intervals (CIs) were used

to compare injury rates by school size or division, time in season, event type, and competition level.

Results: The High School Reporting Information Online system documented 2930 time-loss injuries during 1 609 733 AEs; the National Collegiate Athletic Association Injury Surveillance Program documented 3887 time-loss injuries during 783 600 AEs. The injury rate was higher in college than in high school (4.96 versus 1.82/1000 AEs; IRR = 2.73; 95% CI = 2.60, 2.86). The injury rate was higher in competitions than in practices for both high school (IRR = 3.03; 95% CI = 2.82, 3.26) and collegiate (IRR = 1.99; 95% CI = 1.86, 2.12) players. The most common injuries at both levels were ligament sprains, concussions, and muscle/tendon strains; the majority of injuries affected the ankle, knee, and head/face. These injuries were often caused by contact with another player or a noncontact mechanism.

Conclusions: Injury rates were higher in collegiate than in high school athletes and in competitions than in practices. Similarities in distributions of injuries by body parts, specific diagnoses, and mechanisms of injury suggest that both levels may benefit from similar injury-prevention strategies.

Key Words: injury rates, females, student-athletes

Key Points

- The rate of injury in collegiate women's basketball exceeded that of high school girls' basketball.
- Competition injury rates were higher than practice injury rates.
- Common injuries during competitions were ankle sprains, concussions, and knee sprains.

Involvement in high school girls' and collegiate women's basketball, measured by team and individual participation, has changed over time.^{1,2} Compared with the 2004–2005 academic year, the number of high school teams in 2013–2014 increased by 3.4% (2004–2005 = 17 175; 2013–2014 = 17 754) while the number of student-athletes decreased by 5.1% (2004–2005 = 456 543; 2013–2014 = 433 344).¹ The number of collegiate women's basketball teams and student-athletes in 2013–2014 increased by 7.4% (2004–2005 = 1025; 2013–2014 = 1101) and 11.1% (2004–2005 = 14 686; 2013–2014 = 16 319), respectively, since 2004–2005.²

Since the 1980s, the National Collegiate Athletic Association (NCAA) has used injury surveillance to acquire collegiate sports injury data. 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).³ A year later, the High School Reporting Information Online (HS RIO) system, a similar Web-based high school sports injury-surveillance system, was launched.⁴

As denoted in the Van Mechelen et al⁵ framework, injury-prevention efforts benefit from ongoing monitoring of injury incidence, and updated descriptive epidemiology is needed. A previous NCAA-ISP report for the 1988–1989 through 2003–2004 academic years documented women's basketball competition and practice injury rates of 7.68/1000 and 3.99/1000 athlete-exposures (AEs), respectively.⁶ However, over the past decade, rule changes related to rough play have helped to reduce the incidence of injury⁷; a heightened awareness of injury-prevention efforts, particularly with respect to concussion, has also been important.^{8,9} Because less research has been conducted at the high school level, documenting injuries through high school sports injury surveillance is important to establish injury incidence estimates and compare 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 girls' and collegiate women's basketball during the first decade of Web-based sports injury surveillance (2004–2005 through 2013–2014 academic years).

METHODS

Data Sources and Study Period

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

An average of 100 high schools sponsoring girls' basketball 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 57 NCAA member institutions (Division I = 21, Division II = 11, Division III = 25) sponsoring women's basketball participated in the NCAA-ISP during the 2004–2005 through 2013–2014 academic years. The methods of HS RIO and NCAA-ISP are summarized in the sections that follow. 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.¹⁰ In addition, previous publications have described in depth the sampling and data collection of HS RIO^{4,11} and the NCAA-ISP.³

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 (eg, age, height, weight), the injury (eg, site, diagnosis, severity), and the injury event (eg, activity, mechanism). Throughout each academic year, participating ATs were able to view and update previously submitted reports as needed with new information (eg, time loss).

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 per stratum) based on school population (enrollment ≤ 1000 or > 1000) and US Census geographic region.¹² The ATs from these schools reported data for the 9 sports of interest (boys' basketball, football, soccer, wrestling, and baseball and girls' basketball, soccer, softball, and volleyball). If a school dropped out of the system, a replacement from the same stratum was selected.

National Estimates. 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 for the study (based on geographic location and high school size) was applied to individual case counts in order 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.³ Participation in the NCAA-ISP, while voluntary, is available to all NCAA institutions. For each injury event, the AT completes a detailed 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. A description of data collection for the 2004–2005 through 2013–2014 academic years follows.

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.³ This platform integrated some of the functional components of an electronic medical record, such as athlete demographic information and preseason injury information. During the 2009–2010 through 2013–2014 academic years, the Datalys Center for Sports Injury Research and Prevention, Inc (Datalys Center, Indianapolis, IN) introduced a common data element (CDE) standard to improve process flow. The CDE standard allowed data to be gathered from different electronic medical record and injury-documentation applications, including the Athletic Trainer System (Keffer Development, Grove City, PA), Injury Surveillance Tool (Datalys Center), and the Sports Injury Monitoring System (FlanTech, Iowa City, IA). The CDE export standard allowed ATs to document injuries as they normally would during their daily clinical practice, as opposed to asking them to report injuries solely for purposes of participating in an injury-surveillance program. Data were deidentified and sent to the Datalys Center to be examined by data quality-control staff and a verification engine.

National Estimates. To calculate national estimates of the number of injuries and AEs, poststratification sample weights, based on sport, division, and academic year, were applied to each reported injury and AE. Weights for all data were further adjusted to correct for underreporting, according to the findings of Kucera et al,¹³ 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.¹⁰

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, physician, or other health care professional; 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 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 previously) were included.

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

We examined injury counts, national estimates, and distributions by event type (practice and competition), time in season (preseason, regular season, postseason), time loss (1 to 6 days; 7 to 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). 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 (Divisions I, II, and III), and time in season (preseason, regular season, and postseason). All IRRs with 95% confidence intervals (CIs) not containing 1.0 were considered statistically significant.

Last, we used linear regression to analyze linear trends of injury rates across time 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 the 2009–2010 through 2013–2014 academic years, linear trends were assessed 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 study period, ATs reported a total of 6817 injuries in girls' and women's basketball (high school = 2930, college = 3887; Table 1). This equated to a national estimate of 775 942 high school injuries (annual average of 86 216) and 72 264 collegiate injuries (annual average of 7226). The total injury rate for high school girls' basketball was 1.82/1000 AEs (95% CI = 1.75, 1.89). The total injury rate for collegiate women's basketball was 4.96/1000 AEs (95% CI = 4.80, 5.12). The total injury rate was higher for

Table 1. Injury Rates by School Size or Division and Type of Athlete-Exposure in High School Girls' and Collegiate Women's Basketball^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 system (2005–2006 through 2013–2014) | | | | | |
| ≤1000 students | Practice | 531 (42.5) | 214 261 (42.5) | 433 878 | 1.22 (1.12, 1.33) |
| | Competition | 720 (57.6) | 289 682 (57.5) | 186 357 | 3.86 (3.58, 4.15) |
| | Total | 1251 (100.0) | 503 943 (100.0) | 620 235 | 2.02 (1.91, 2.13) |
| >1000 students | Practice | 742 (44.2) | 122 945 (45.2) | 692 550 | 1.07 (0.99, 1.15) |
| | Competition | 937 (55.8) | 149 055 (54.8) | 296 948 | 3.16 (2.95, 3.36) |
| | Total | 1679 (100.0) | 272 000 (100.0) | 989 498 | 1.70 (1.62, 1.78) |
| Total | Practice | 1273 (43.5) | 337 206 (43.5) | 1 126 428 | 1.13 (1.07, 1.19) |
| | Competition | 1657 (56.6) | 438 737 (56.5) | 483 305 | 3.43 (3.26, 3.59) |
| | Total | 2930 (100.0) | 775 942 (100.0) | 1 609 733 | 1.82 (1.75, 1.89) |
| NCAA-ISP (2004–2005 through 2013–2014) | | | | | |
| Division I | Practice | 988 (61.7) | 15 104 (61.9) | 263 802 | 3.75 (3.51, 3.98) |
| | Competition | 613 (38.3) | 9289 (38.1) | 70 551 | 8.69 (8.00, 9.38) |
| | Total | 1601 (100.0) | 24 393 (100.0) | 334 353 | 4.79 (4.55, 5.02) |
| Division II | Practice | 428 (66.3) | 11 133 (67.3) | 115 608 | 3.70 (3.35, 4.05) |
| | Competition | 218 (33.7) | 5408 (32.7) | 33 522 | 6.50 (5.64, 7.37) |
| | Total | 646 (100.0) | 16 541 (100.0) | 149 131 | 4.33 (4.00, 4.67) |
| Division III | Practice | 1050 (64.0) | 20 107 (64.2) | 228 001 | 4.61 (4.33, 4.88) |
| | Competition | 590 (36.0) | 11 223 (35.8) | 72 116 | 8.18 (7.52, 8.84) |
| | Total | 1640 (100.0) | 31 330 (100.0) | 300 117 | 5.46 (5.20, 5.73) |
| Total | Practice | 2466 (63.4) | 46 343 (64.1) | 607 411 | 4.06 (3.90, 4.22) |
| | Competition | 1421 (36.6) | 25 921 (35.9) | 176 189 | 8.07 (7.65, 8.48) |
| | Total | 3887 (100.0) | 72 264 (100.0) | 783 600 | 4.96 (4.80, 5.12) |

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 system 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 due to rounding errors.

collegiate than high school (IRR = 2.73; 95% CI = 2.60, 2.86) athletes.

School Size and Division

In high school, the total injury rate was higher in high schools with ≤1000 students than in high schools with >1000 students (IRR = 1.19; 95% CI = 1.10, 1.28; Table 1). In college, Division I had a higher total injury rate than Division II (IRR = 1.11; 95% CI = 1.01, 1.21). Also, Division III had a higher total injury rate than Division I (IRR = 1.14; 95% CI = 1.07, 1.22) and Division II (IRR = 1.26; 95% CI = 1.15, 1.38).

Event Type

The majority of injuries occurred during competitions in high school (56.6%) and practices in college (63.4%; Table 1). The competition injury rate was higher than the practice injury rate at the high school (IRR = 3.03; 95% CI = 2.82, 3.26) and collegiate (IRR = 1.99; 95% CI = 1.86, 2.12) levels.

No linear trends were found for the annual injury rates for high school practices (annual average change of −0.02/1000 AEs; 95% CI = −0.07, 0.04) and competitions (annual average change of 0.02/1000 AEs; 95% CI = −0.06, 0.09; Figure). Decreases occurred in the 2004–2005 through 2008–2009 academic years for practices (annual average

change of −0.61/1000 AEs; 95% CI = −0.89, −0.33) and competitions (annual average change of −0.80/1000 AEs; 95% CI = −1.26, −0.33). However, no linear trends were evident in the 2009–2010 through 2013–2014 academic years for practices (annual average change of −0.16/1000 AEs; 95% CI = −0.36, 0.04) and competitions (annual average change of 0.08/1000 AEs; 95% CI = −0.45, 0.62).

Time in Season

For both high school and collegiate athletes, most injuries occurred during the regular season (high school = 78.4%, college = 65.5%; Table 2). At the collegiate level, the injury rate was higher in the preseason than in the regular season (IRR = 1.50; 95% CI = 1.40, 1.60) and the postseason (IRR = 2.62; 95% CI = 2.13, 3.21). In addition, the injury rate was higher in the regular season than the postseason (IRR = 1.75; 95% CI = 1.43, 2.14). We could not calculate injury rates by time in season as AEs were not stratified by time in season.

Time Loss From Participation

For both high school and collegiate players, the largest proportion of injuries resulted in time loss of less than 1 week, ranging from 40.6% of injuries in high school competitions to 53.9% of injuries in collegiate practices (Table 3).

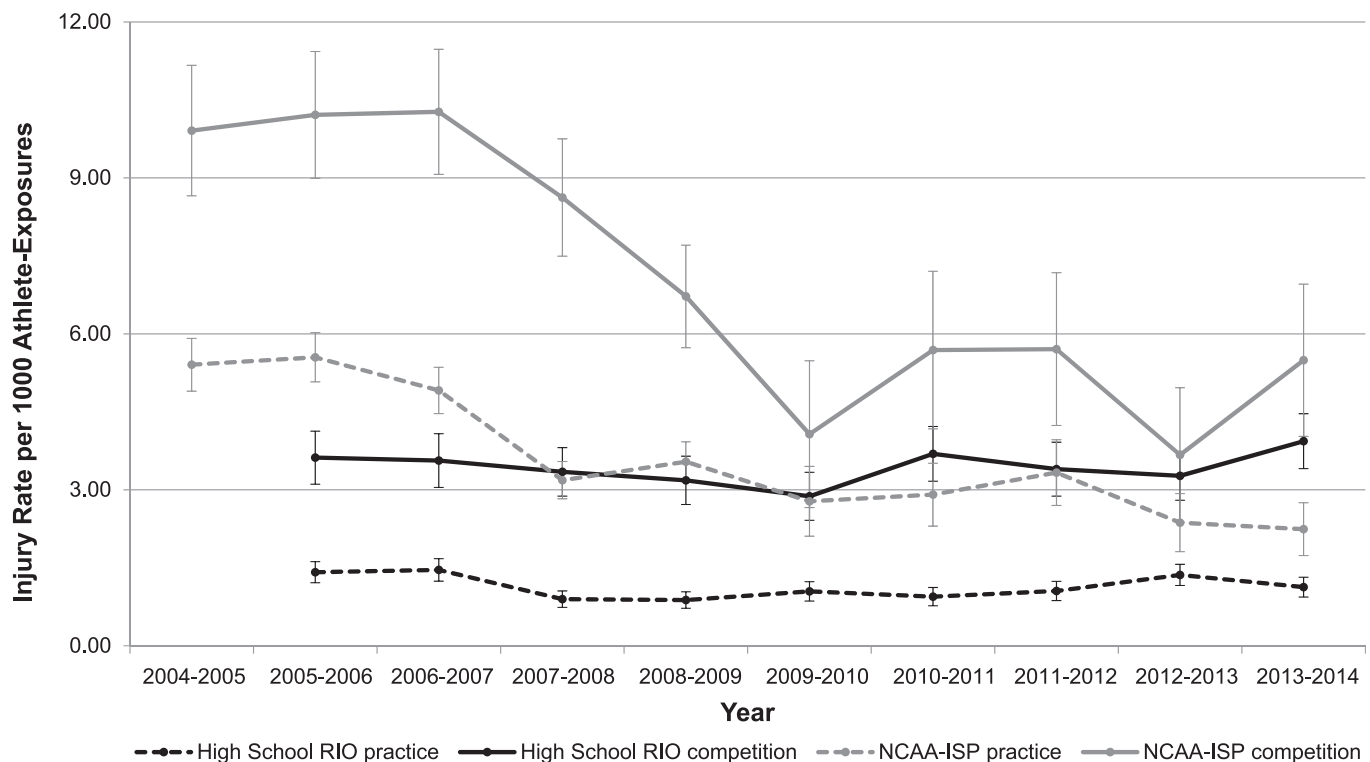


Figure. Injury rates by year and type of athlete-exposure (AE) in high school girls' and collegiate women's basketball. **Note:** Annual average changes for linear trend test for injury rates were as follows: High School Reporting Information Online system (RIO; practices = $-0.02/1000$ AEs, 95% confidence interval [CI] = $-0.07, 0.04$; competitions = $0.02/1000$ AEs, 95% CI = $-0.06, 0.09$); National Collegiate Athletic Association Injury Surveillance Program (NCAA-ISP) 2004–2005 through 2008–2009 (practices = $-0.61/1000$ AEs, 95% CI = $-0.89, -0.33$; competitions = $-0.80/1000$ AEs, 95% CI = $-1.26, -0.33$); NCAA-ISP 2009–2010 through 2013–2014 academic years (practices = $0.16/1000$ AEs, 95% CI = $-0.36, 0.04$; competitions = $0.08/1000$ AEs, 95% CI = $-0.45, 0.62$). A negative rate indicates a decrease in the annual average change between years, and a positive rate indicates an increase in the annual average change. Any 95% CI that includes 0.00 is not significant.

Table 2. Injury Rates by Time in Season and Type of Athlete-Exposure in High School Girls' and Collegiate Women's Basketball^{a,b}

| Time in Season | Exposure Type | HS RIO System (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. (%) | Athlete-Exposures | Injury Rate/1000 Athlete-Exposures (95% Confidence Interval) |
| Preseason | Practice | 449 (81.5) | 117 563 (83.7) | 1216 (97.8) | 22 785 (98.3) | 179 729 | 6.77 (6.39, 7.15) |
| | Competition | 102 (18.5) | 22 848 (16.3) | 27 (2.2) | 389 (1.7) | 3520 | 7.67 (4.78, 10.56) |
| | Total | 551 (100.0) | 140 411 (100.0) | 1243 (100.0) | 23 175 (100.0) | 183 249 | 6.78 (6.41, 7.16) |
| Regular season | Practice | 784 (34.4) | 205 604 (34.2) | 1193 (46.9) | 22 535 (47.6) | 399 887 | 2.98 (2.81, 3.15) |
| | Competition | 1495 (65.6) | 396 258 (65.8) | 1353 (53.1) | 24 820 (52.4) | 162 676 | 8.32 (7.87, 8.76) |
| | Total | 2279 (100.0) | 601 861 (100.0) | 2546 (100.0) | 47 355 (100.0) | 562 563 | 4.53 (4.35, 4.70) |
| Postseason | Practice | 27 (34.6) | 7519 (33.5) | 57 (58.2) | 1023 (59.0) | 27 796 | 2.05 (1.52, 2.58) |
| | Competition | 51 (65.4) | 14 948 (66.5) | 41 (41.8) | 711 (41.0) | 9993 | 4.10 (2.85, 5.36) |
| | Total | 78 (100.0) | 22 467 (100.0) | 98 (100.0) | 1734 (100.0) | 37 789 | 2.59 (2.08, 3.11) |

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

^a Excluded 22 injuries reported in HS RIO system due to missing data for time in season. Injury rates by time in season could not be calculated for high school as athlete-exposures were not stratified by time in season. National estimates and athlete-exposures may not sum to totals due to rounding errors.

^b High school data originated from HS RIO system 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 Girls' and Collegiate Women's Basketball^{a,b}

| 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 system (2005–2006 through 2013–2014) | | | | | | |
| 1 d to <1 wk | 567 (46.6) | 149 395 (46.5) | 0.50 (0.46, 0.54) | 617 (38.9) | 170 135 (40.6) | 1.28 (1.18, 1.38) |
| 1 to 3 wk | 443 (36.4) | 113 553 (35.3) | 0.39 (0.36, 0.43) | 598 (37.7) | 150 101 (35.8) | 1.24 (1.14, 1.34) |
| >3 wk ^c | 206 (16.9) | 58 531 (18.2) | 0.18 (0.16, 0.21) | 373 (23.5) | 98 628 (23.6) | 0.77 (0.69, 0.85) |
| NCAA-ISP (2004–2005 through 2013–2014) | | | | | | |
| 1 d to <1 wk | 1295 (54.0) | 23 846 (53.9) | 2.13 (2.02, 2.25) | 712 (51.9) | 13 004 (52.6) | 4.04 (3.74, 4.34) |
| 1 to 3 wk | 605 (25.2) | 11 285 (25.5) | 1.00 (0.92, 1.08) | 319 (23.3) | 5832 (23.6) | 1.81 (1.61, 2.01) |
| >3 wk ^c | 499 (20.8) | 9109 (20.6) | 0.82 (0.75, 0.89) | 341 (24.9) | 5876 (23.8) | 1.94 (1.73, 2.14) |

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

^a Excluded 126 injuries reported in HS RIO system and 116 injuries reported in the NCAA-ISP due to missing data for time loss. Percentages may not sum to 100.0 due to rounding errors.

^b High school data originated from HS RIO system 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.

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

Body Parts Injured and Diagnoses

High School. Commonly injured body parts were the ankle (practices = 29.3%, competitions = 28.9%), knee (practices = 16.6%, competitions = 19.2%), and head/face (practices = 11.3%, competitions = 27.5%; Table 4). The injury diagnosis cited most often was ligament sprain (practices = 39.8%, competitions = 42.3%; Table 5). Other typical injury diagnoses were muscle/tendon strains (16.4%) in practices and concussions (21.7%) in competitions.

College. Frequently injured body parts were the ankle (practices = 21.7%, competitions = 21.2%), knee (practices = 17.8%, competitions = 22.1%), and head/face (practices = 14.2%, competitions = 19.2%; Table 4). The most common injury diagnosis was ligament sprain (practices = 30.2%, competitions = 39.3%; Table 5). Other typical injury diagnoses were muscle/tendon strains (15.1%) in practices and concussions (12.4%) in competitions.

Mechanisms of Injury and Activities

High School. The most often cited mechanisms of injury were contact with another person (practices = 28.9%, competitions = 47.0%), no contact (practices = 28.4%, competitions = 19.5%), and contact with the playing surface (practices = 17.5%, competitions = 26.5%; Table 6). The most frequent activities during which injuries occurred were general play (29.5%) and rebounding (17.4%) in practices and rebounding (22.6%) and defending (20.1%) in competitions (Table 7).

College. The most common mechanisms of injury were contact with another person (practices = 36.3%, competitions = 47.9%) and no contact (practices = 33.8%, competitions = 27.4%; Table 6). In competitions, 15.8% of injuries were also due to contact with the playing surface. The activities cited most often during which

injuries occurred were general play (practices = 44.2%, competitions = 26.0%), rebounding (practices = 15.0%, competitions = 22.2%), and defending (practices = 13.7%, competitions = 18.2%; Table 7).

Position-Specific Injuries in Competitions

During both practices and competitions at both levels, the most frequent injuries among all positions were ankle sprains due to contact with another person (Table 8). At both levels, knee sprains due to no contact represented the third most common injury among guards.

DISCUSSION

This study provides the most detailed comparison of the epidemiology of injury in high school girls' and collegiate women's basketball players to date. It is important to acknowledge that despite the inherent risk of injury during basketball, the sport is still relatively safe. Placing high school and collegiate basketball injury rates in the context of roster sizes suggests that a small number of time-loss injuries would be expected to occur on a team during any 1 season. Still, our national annual estimates of approximately 86 000 and 7200 injuries occurring among girls' high school and women's collegiate basketball players, respectively, highlight the importance of injury-prevention efforts. Establishing epidemiologic trends in injuries among high school and collegiate basketball players may help guide targeted injury-prevention efforts. Broad similarities in distributions of injuries by body parts, specific diagnoses, and mechanisms of injury in high school and collegiate basketball indicate that both levels may benefit from similar injury-prevention strategies: specifically, programs designed to prevent ankle and knee injuries resulting from player contact and noncontact mechanisms. Variations in injury rates by time in season and school size or division

Table 4. Number of Injuries, National Estimates, and Injury Rates by Body Part Injured and Type of Athlete-Exposure in High School Girls' and Collegiate Women's Basketball^{a,b}

| Surveillance System and Body Part Injured | 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 system (2005–2006 through 2013–2014) | | | | | | |
| Head/face | 143 (11.3) | 38 730 (11.5) | 0.13 (0.11, 0.15) | 454 (27.5) | 118 064 (27.0) | 0.94 (0.85, 1.03) |
| Neck | 9 (0.7) | 2320 (0.7) | 0.01 (0.00, 0.01) | 7 (0.4) | 1367 (0.3) | 0.01 (0.00, 0.03) |
| Shoulder/clavicle | 42 (3.3) | 11 640 (3.5) | 0.04 (0.03, 0.05) | 57 (3.5) | 15 526 (3.6) | 0.12 (0.09, 0.15) |
| Arm/elbow | 12 (1.0) | 2995 (0.9) | 0.01 (0.00, 0.02) | 31 (1.9) | 7979 (1.8) | 0.06 (0.04, 0.09) |
| Hand/wrist | 122 (9.6) | 34 884 (10.4) | 0.11 (0.09, 0.13) | 124 (7.5) | 32 775 (7.5) | 0.26 (0.21, 0.30) |
| Trunk | 62 (4.9) | 16 961 (5.1) | 0.06 (0.04, 0.07) | 55 (3.3) | 14 881 (3.4) | 0.11 (0.08, 0.14) |
| Hip/thigh/upper leg | 124 (9.8) | 32 983 (9.8) | 0.11 (0.09, 0.13) | 53 (3.2) | 13 345 (3.1) | 0.11 (0.08, 0.14) |
| Knee | 211 (16.6) | 58 555 (17.4) | 0.19 (0.16, 0.21) | 317 (19.2) | 83 226 (19.1) | 0.66 (0.58, 0.73) |
| Lower leg | 86 (6.8) | 20 247 (6.0) | 0.08 (0.06, 0.09) | 37 (2.2) | 10 809 (2.5) | 0.08 (0.05, 0.10) |
| Ankle | 372 (29.3) | 94 850 (28.2) | 0.33 (0.30, 0.36) | 476 (28.9) | 129 694 (29.7) | 0.98 (0.90, 1.07) |
| Foot | 68 (5.4) | 17 281 (5.1) | 0.06 (0.05, 0.07) | 36 (2.2) | 8133 (1.9) | 0.07 (0.05, 0.10) |
| Other | 17 (1.3) | 4748 (1.4) | 0.02 (0.01, 0.02) | 3 (0.2) | 1093 (0.3) | 0.01 (0.00, 0.01) |
| NCAA-ISP (2004–2005 through 2013–2014) | | | | | | |
| Head/face | 351 (14.2) | 7624 (16.5) | 0.58 (0.52, 0.64) | 273 (19.2) | 5494 (21.2) | 1.55 (1.37, 1.73) |
| Neck | 12 (0.5) | 323 (0.7) | 0.02 (0.01, 0.03) | 17 (1.2) | 343 (1.3) | 0.10 (0.05, 0.14) |
| Shoulder/clavicle | 93 (3.8) | 1670 (3.6) | 0.15 (0.12, 0.18) | 85 (6.0) | 1441 (5.6) | 0.48 (0.38, 0.58) |
| Arm/elbow | 22 (0.9) | 425 (0.9) | 0.04 (0.02, 0.05) | 28 (2.0) | 433 (1.7) | 0.16 (0.10, 0.22) |
| Hand/wrist | 134 (5.4) | 2301 (5.0) | 0.22 (0.18, 0.26) | 90 (6.3) | 1608 (6.2) | 0.51 (0.41, 0.62) |
| Trunk | 142 (5.8) | 2610 (5.6) | 0.23 (0.20, 0.27) | 82 (5.8) | 1385 (5.3) | 0.47 (0.36, 0.57) |
| Hip/thigh/upper leg | 296 (12.0) | 5511 (11.9) | 0.49 (0.43, 0.54) | 77 (5.4) | 1437 (5.6) | 0.44 (0.34, 0.53) |
| Knee | 438 (17.8) | 8335 (18.0) | 0.72 (0.65, 0.79) | 314 (22.1) | 5591 (21.6) | 1.78 (1.59, 1.98) |
| Lower leg | 191 (7.8) | 3550 (7.7) | 0.31 (0.27, 0.36) | 46 (3.2) | 770 (3.0) | 0.26 (0.19, 0.34) |
| Ankle | 536 (21.7) | 9688 (20.9) | 0.88 (0.81, 0.96) | 301 (21.2) | 5452 (21.0) | 1.71 (1.52, 1.90) |
| Foot | 169 (6.9) | 2957 (6.4) | 0.28 (0.24, 0.32) | 97 (6.8) | 1807 (7.0) | 0.55 (0.44, 0.66) |
| Other | 82 (3.3) | 1349 (2.9) | 0.13 (0.11, 0.16) | 11 (0.8) | 160 (0.6) | 0.06 (0.03, 0.10) |

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

^a Excluded 12 injuries reported in HS RIO system due to missing data for body part. Percentages may not sum to 100.0 due to rounding errors.

^b High school data originated from HS RIO system 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.

suggest that some interventions more targeted to playing level may also be warranted.

Comparisons With Previous Research

Our reported injury rate in girls' high school basketball (1.82/1000 AEs) was similar to that demonstrated by Borowski et al¹⁴ in a subset of data from this study examining solely the 2005–2006 through 2006–2007 academic years (2.08/1000 AEs). Our practice (4.06/1000 AEs) and competition (8.07/1000 AEs) rates in women's collegiate basketball were also consistent with those derived from the 1988–1989 through 2003–2004 academic years.⁶ Agel et al⁶ noted practice and competition injury rates of 3.99/1000 AEs and 7.68/1000 AEs, respectively. Rates by year demonstrated a general decline in both practice and competition injury rates over time in the first half of the study period for women's collegiate basketball. These reductions may be due to changes in rules and points of emphasis over the past decade that have resulted in less player contact. Greater emphasis has been placed on calling fouls related to rough offensive and defensive post play and

during loose-ball situations in an attempt to improve player safety.⁷ Additionally, extending the distance of the 3-point line has created more space for players by the basket, potentially resulting in less player-to-player contact during games and practices.⁷ However, no linear trends were seen across the study period for high school injury rates. Also, no decreases were seen in more recent years for collegiate injury rates. Thus, our findings still highlight the need for the continued development of injury-prevention interventions to help decrease the incidence and severity of basketball injuries.

Injury Rates Between and Within High School and Collegiate Basketball Players

Injury rates were 2.73 times higher in collegiate (4.96/1000 AEs) than in high school (1.82/1000 AEs) basketball, but the estimated national number of high school basketball injuries was higher (high school = 775 942, college = 72 264). Injury rates by body part and diagnosis were also generally higher in collegiate than in high school athletes, which may be due to a greater intensity of play in the

Table 5. Number of Injuries, National Estimates, and Injury Rates by Diagnosis and Type of Athlete Exposure in High School Girls' and Collegiate Women's Basketball^{a,b}

| 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 system (2005–2006 through 2013–2014) | | | | | | |
| Concussion | 122 (9.6) | 31 963 (9.6) | 0.11 (0.09, 0.13) | 357 (21.7) | 92 876 (21.3) | 0.74 (0.66, 0.82) |
| Contusion | 70 (5.5) | 20 409 (6.1) | 0.06 (0.05, 0.08) | 126 (7.7) | 31 209 (7.2) | 0.26 (0.22, 0.31) |
| Dislocation ^c | 26 (2.1) | 7 124 (2.1) | 0.02 (0.01, 0.03) | 34 (2.1) | 9 242 (2.1) | 0.07 (0.05, 0.09) |
| Fracture/avulsion | 82 (6.5) | 21 592 (6.5) | 0.07 (0.06, 0.09) | 122 (7.4) | 30 619 (7.0) | 0.25 (0.21, 0.30) |
| Laceration | 5 (0.4) | 1 305 (0.4) | <0.01 (0.00, 0.01) | 25 (1.5) | 7 624 (1.8) | 0.05 (0.03, 0.07) |
| Ligament sprain | 504 (39.8) | 130 577 (39.0) | 0.45 (0.41, 0.49) | 697 (42.3) | 186 591 (42.8) | 1.44 (1.34, 1.55) |
| Muscle/tendon strain | 208 (16.4) | 57 372 (17.2) | 0.18 (0.16, 0.21) | 123 (7.5) | 31 412 (7.2) | 0.25 (0.21, 0.30) |
| Other | 248 (19.6) | 64 205 (19.2) | 0.22 (0.19, 0.25) | 164 (10.0) | 46 279 (10.6) | 0.34 (0.29, 0.39) |
| NCAA-ISP (2004–2005 through 2013–2014) | | | | | | |
| Concussion | 215 (8.7) | 51 28 (11.1) | 0.35 (0.31, 0.40) | 176 (12.4) | 3800 (14.7) | 1.00 (0.85, 1.15) |
| Contusion | 176 (7.2) | 31 27 (6.8) | 0.29 (0.25, 0.33) | 138 (9.7) | 2475 (9.6) | 0.78 (0.65, 0.91) |
| Dislocation ^c | 31 (1.3) | 642 (1.4) | 0.05 (0.03, 0.07) | 28 (2.0) | 501 (1.9) | 0.16 (0.10, 0.22) |
| Fracture/avulsion | 102 (4.2) | 2038 (4.4) | 0.17 (0.14, 0.20) | 81 (5.7) | 1653 (6.4) | 0.46 (0.36, 0.56) |
| Laceration | 33 (1.3) | 509 (1.1) | 0.05 (0.04, 0.07) | 25 (1.8) | 431 (1.7) | 0.14 (0.09, 0.20) |
| Ligament sprain | 743 (30.2) | 13 676 (29.6) | 1.22 (1.14, 1.31) | 558 (39.3) | 9968 (38.5) | 3.17 (2.90, 3.43) |
| Muscle/tendon strain | 372 (15.1) | 7709 (16.7) | 0.61 (0.55, 0.67) | 121 (8.5) | 2322 (9.0) | 0.69 (0.56, 0.81) |
| Other | 788 (32.0) | 13 425 (29.0) | 1.30 (1.21, 1.39) | 294 (20.7) | 4771 (18.4) | 1.67 (1.48, 1.86) |

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

^a Excluded 17 injuries reported in HS RIO system and 6 injuries reported in the NCAA-ISP due to missing data for diagnosis. Percentages may not sum to 100.0 due to rounding errors.

^b High school data originated from HS RIO system 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.

^c Includes separations.

collegiate sport. Taller and stronger players at the collegiate level may generate greater forces during play, potentially increasing the risk of injury. Previous researchers^{15–18} have reported increased injury rates among more skilled athletes. However, the relationship between skill level and injury remains unclear. Chomiak et al¹⁸ observed that the risk of injury in football may be twice as large for less skilled groups compared with highly skilled groups within a single competition level. Similarly, Harmon and Dick¹⁹ did not identify a relationship between the risk of anterior cruciate ligament injury and NCAA women's basketball division level. In this study, we did not examine variations in injury rates by skill level within each competition level. Thus, the role of skill level at each competition level may be an influencing factor and warrants further examination.

When examining injury rates within competition levels, we found that rates were higher for small high schools than for large high schools. Additionally, Division III collegiate basketball had higher rates than Division I and Division II programs. The increased injury rates in small high schools and Division III programs may be related to fewer health care resources. Smaller schools and athletic programs may have fewer ATs available to provide medical coverage compared with larger schools and athletic programs, which may result in fewer injury-prevention programs being implemented. Smaller schools may also have less skilled athletes, potentially placing them at greater risk for injury. As discussed previously, though, the true relationship between skill level and injury risk remains unclear.

Event Type

Injury rates, overall as well as by body part and specific diagnosis, were greater during competitions than during practices for both high school (overall IRR = 3.03, 95% CI = 2.82, 3.26) and collegiate (overall IRR = 1.99, 95% CI = 1.86, 2.12) basketball. This finding is similar to previous results^{6,11,20–29} that showed increased rates in competitions compared with practices across various competition levels and sports. Earlier investigators¹¹ who used a subset of data included in this study also reported that competition injury rates were higher than practice injury rates in high school girls' basketball (IRR = 2.63; 95% CI = 2.15, 3.22). Hootman et al²¹ identified competition injury rates in collegiate athletics as approximately 3.5 times larger than practice injury rates. These findings indicate that gameplay intensity appears to be greater during competitions compared with practices. Willingness to take risks may be 1 explanation for this increased intensity. Individuals may be more willing to take risks if they feel the potential gain is meaningful enough,³⁰ and athletes may perceive winning a game as meaningful enough to take greater chances.

Common Injuries and Mechanisms

The most often injured body parts in high school girls' and collegiate women's basketball were the ankle, knee, and head/face, and the most frequently injured body parts did not differ by player position. These findings are similar

Table 6. Number of Injuries, National Estimates, and Injury Rates by Mechanism of Injury and Type of Athlete Exposure in High School Girls' and Collegiate Women's Basketball^{a,b}

| Surveillance System and Mechanism of Injury | Practice | | | Competition | | |
|---|-----------------------------|-----------------------------|--|-----------------------------|-----------------------------|--|
| | Injuries in Sample, No. (%) | National Estimates, No. (%) | Injury Rate/1000 Athlete-Exposures (95% Confidence Interval) | Injuries in Sample, No. (%) | National Estimates, No. (%) | Injury Rate/1000 Athlete-Exposures (95% Confidence Interval) |
| HS RIO system (2005–2006 through 2013–2014) | | | | | | |
| Contact with another person | 353 (28.9) | 89 608 (27.9) | 0.31 (0.28, 0.35) | 749 (47.0) | 190 828 (45.6) | 1.55 (1.44, 1.66) |
| Contact with playing surface | 214 (17.5) | 63 102 (19.7) | 0.19 (0.16, 0.22) | 422 (26.5) | 116 152 (27.8) | 0.87 (0.79, 0.96) |
| Contact with ball | 101 (8.3) | 27 467 (8.6) | 0.09 (0.07, 0.11) | 64 (4.0) | 16 706 (4.0) | 0.13 (0.10, 0.16) |
| Contact with other playing equipment | 11 (0.9) | 265 6 (0.8) | 0.01 (0.00, 0.02) | 4 (0.3) | 564 (0.1) | 0.01 (0.00, 0.02) |
| Contact with out of bounds object | 2 (0.2) | 1260 (0.4) | <0.01 (0.00, <0.01) | 5 (0.3) | 644 (0.2) | 0.01 (0.00, 0.02) |
| No contact | 347 (28.4) | 86 930 (27.1) | 0.31 (0.28, 0.34) | 310 (19.5) | 83 028 (19.8) | 0.64 (0.57, 0.71) |
| Overuse/chronic | 172 (14.1) | 43 888 (13.7) | 0.15 (0.13, 0.18) | 31 (1.9) | 8455 (2.0) | 0.06 (0.04, 0.09) |
| Illness/infection | 21 (1.7) | 5882 (1.8) | 0.02 (0.01, 0.03) | 9 (0.6) | 2006 (0.5) | 0.02 (0.01, 0.03) |
| NCAA-ISP (2004–2005 through 2013–2014) | | | | | | |
| Contact with another person | 876 (36.3) | 17 269 (38.7) | 1.44 (1.35, 1.54) | 675 (47.9) | 12 521 (49.1) | 3.83 (3.54, 4.12) |
| Contact with playing surface | 215 (8.9) | 4295 (9.6) | 0.35 (0.31, 0.40) | 222 (15.8) | 4304 (16.9) | 1.26 (1.09, 1.43) |
| Contact with ball | 69 (2.9) | 1288 (2.9) | 0.11 (0.09, 0.14) | 42 (3.0) | 803 (3.2) | 0.24 (0.17, 0.31) |
| Contact with other playing equipment | 3 (0.1) | 74 (0.2) | <0.01 (0.00, <0.01) | 3 (0.2) | 64 (0.3) | 0.02 (0.00, 0.04) |
| Contact with out of bounds object | 2 (0.1) | 30 (0.1) | <0.01 (0.00, <0.01) | 13 (0.9) | 246 (1.0) | 0.07 (0.03, 0.11) |
| No contact | 817 (33.8) | 14 490 (32.5) | 1.35 (1.25, 1.44) | 386 (27.4) | 6497 (25.5) | 2.19 (1.97, 2.41) |
| Overuse/chronic | 344 (14.2) | 5802 (13.0) | 0.57 (0.51, 0.63) | 59 (4.2) | 978 (3.8) | 0.33 (0.25, 0.42) |
| Illness/infection | 89 (3.7) | 1350 (3.0) | 0.15 (0.12, 0.18) | 8 (0.6) | 103 (0.4) | 0.05 (0.01, 0.08) |

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

^a Mechanism of injury excluded 115 injuries reported in HS RIO system and 64 injuries reported in the NCAA-ISP due to missing data or athletic trainer reporting *Other* or *Unknown*. Percentages may not sum to 100.0 due to rounding errors.

^b High school data originated from HS RIO system 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.

to those of previous researchers^{6,14,20–22} who observed that the ankle and knee were regularly injured in basketball. Borowski et al¹⁴ showed that 35.9%, 18.2%, and 14.2% of all high school girls' basketball injuries from 2005–2007 affected the ankle/foot, knee, and head/face, respectively. Similarly, Agel et al⁶ identified the body parts injured the most among college basketball players from 1988–1989 through 2003–2004 as the ankle and knee. Practice and competition ankle-injury rates were 0.95/1000 AEs and 1.89/1000 AEs, respectively. Practice and competition knee-injury rates were 0.37/1000 AEs and 1.22/1000 AEs, respectively.⁶

The most frequent injury diagnoses among high school girls' and collegiate women's basketball athletes were ligament sprains, muscle/tendon strains, and concussions, and diagnoses were similar across levels and by player position. These results are consistent with those of previous researchers,^{6,11,14} highlighting the importance of injury-prevention programs designed to reduce injuries at multiple joints. Additionally, the concussion injury rate we demonstrated emphasizes the continued importance of appropriate concussion recognition and management in basketball players. This is especially important in high schools because approximately two thirds of schools do not employ an AT full time.³¹ The difference between high school basketball practices and competitions for the proportion of

injuries affecting the head/face is concerning. The proportion of injuries affecting this region was approximately 2.5 times larger during competitions (27.5%) than during practices (11.3%). The reason for the elevated proportion of injuries affecting the head/face during competitions is unclear, but it may be due to a greater intensity of play during these events. Therefore, it is especially important for officials to enforce rules that discourage contact to the head/face.

Typical injury mechanisms were similar between high school and collegiate basketball, as well as among player positions. Despite the rules designed to minimize bodily contact,⁷ contact with another person was the most common mechanism of injury. This finding supported previous research.^{6,22} Hootman et al²¹ reported that player contact accounted for 41.6% and 58.0% of injuries occurring during collegiate practices and competitions, respectively. Agel et al⁶ described 27.0% of competition injuries from 1988–1989 through 2003–2004 as resulting from contact with another player. Noncontact and contact with the playing surface were the second and third most often cited injury mechanisms, respectively. These results are consistent with a previous report⁶ indicating that 19.2% and 26.5% of collegiate women's basketball injuries occurring during competition were due to contact with the playing surface and noncontact mechanisms, respectively. The

Table 7. Number of Injuries, National Estimates, and Injury Rates by Activity During Injury and Type of Athlete Exposure in High School Girls' and Collegiate Women's Basketball^{a,b}

| Surveillance System and Activity During Injury | Practice | | | Competition | | |
|--|-----------------------------|-----------------------------|---|-----------------------------|-----------------------------|---|
| | Injuries in Sample, No. (%) | National Estimates, No. (%) | Injury Rate/ 1000 Athlete-Exposures (95% Confidence Interval) | Injuries in Sample, No. (%) | National Estimates, No. (%) | Injury Rate/ 1000 Athlete-Exposures (95% Confidence Interval) |
| HS RIO system (2005–2006 through 2013–2014) | | | | | | |
| Ball handling | 67 (5.6) | 21 183 (6.8) | 0.06 (0.05, 0.07) | 138 (8.9) | 36 035 (8.9) | 0.29 (0.24, 0.33) |
| Conditioning | 150 (12.6) | 37 877 (12.1) | 0.13 (0.11, 0.15) | 3 (0.2) | 232 (0.1) | 0.01 (0.00, 0.01) |
| Defending | 136 (11.5) | 35 201 (11.2) | 0.12 (0.10, 0.14) | 311 (20.1) | 83 628 (20.6) | 0.64 (0.57, 0.72) |
| General play | 350 (29.5) | 87 536 (27.9) | 0.31 (0.28, 0.34) | 293 (18.9) | 81 628 (20.1) | 0.61 (0.54, 0.68) |
| Loose ball | 90 (7.6) | 24 149 (7.7) | 0.08 (0.06, 0.10) | 237 (15.3) | 55 276 (13.6) | 0.49 (0.43, 0.55) |
| Passing | 24 (2.0) | 5563 (1.8) | 0.02 (0.01, 0.03) | 27 (1.7) | 7450 (1.8) | 0.06 (0.03, 0.08) |
| Rebounding | 207 (17.4) | 57 484 (18.3) | 0.18 (0.16, 0.21) | 350 (22.6) | 87 225 (21.5) | 0.72 (0.65, 0.80) |
| Receiving pass | 89 (7.5) | 23 584 (7.5) | 0.08 (0.06, 0.10) | 67 (4.3) | 16 486 (4.1) | 0.14 (0.11, 0.17) |
| Screening | 2 (0.2) | 942 (0.3) | <0.01 (0.00, <0.01) | 7 (0.5) | 1453 (0.4) | 0.01 (0.00, 0.03) |
| Shooting | 73 (6.1) | 20 273 (6.5) | 0.06 (0.05, 0.08) | 117 (7.6) | 36 461 (9.0) | 0.24 (0.20, 0.29) |
| NCAA-ISP (2004–2005 through 2013–2014) | | | | | | |
| Ball handling | 108 (4.5) | 1686 (3.8) | 0.18 (0.14, 0.21) | 98 (7.0) | 1486 (5.9) | 0.56 (0.45, 0.67) |
| Conditioning | 167 (7.0) | 2630 (6.0) | 0.27 (0.23, 0.32) | 0 | 0 | 0.00 |
| Defending | 328 (13.7) | 6073 (13.7) | 0.54 (0.48, 0.60) | 255 (18.2) | 4758 (18.9) | 1.45 (1.27, 1.62) |
| General play | 1056 (44.2) | 20 341 (46.0) | 1.74 (1.63, 1.84) | 365 (26.0) | 6977 (27.7) | 2.07 (1.86, 2.28) |
| Loose ball | 118 (4.9) | 2326 (5.3) | 0.19 (0.16, 0.23) | 177 (12.6) | 3108 (12.3) | 1.00 (0.86, 1.15) |
| Passing | 22 (0.9) | 306 (0.7) | 0.04 (0.02, 0.05) | 18 (1.3) | 283 (1.1) | 0.10 (0.05, 0.15) |
| Rebounding | 358 (15.0) | 6720 (15.2) | 0.59 (0.53, 0.65) | 311 (22.2) | 5231 (20.8) | 1.77 (1.57, 1.96) |
| Receiving pass | 64 (2.7) | 1028 (2.3) | 0.11 (0.08, 0.13) | 39 (2.8) | 620 (2.5) | 0.22 (0.15, 0.29) |
| Screening | 25 (1.1) | 425 (1.0) | 0.04 (0.03, 0.06) | 15 (1.1) | 286 (1.1) | 0.09 (0.04, 0.13) |
| Shooting | 146 (6.1) | 2658 (6.0) | 0.24 (0.20, 0.28) | 124 (8.8) | 2442 (9.7) | 0.70 (0.58, 0.83) |

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

^a Activity excluded 192 injuries reported in HS RIO system and 93 injuries reported in the NCAA-ISP due to missing data or athletic trainer reporting *Other* or *Unknown*. Percentages may not sum to 100.0 due to rounding errors.

^b High school data originated from HS RIO system 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 8. Most Common Injuries Associated With Position in Competitions in High School Girls' and Collegiate Women's Basketball^{a,b}

| Position | HS RIO System (2005–2006 Through 2013–2014) | | | NCAA-ISP (2004–2005 Through 2013–2014) | | |
|----------|---|-----------------------------|---|--|-----------------------------|---|
| | 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 |
| Center | Ankle sprain | 25.1 | Contact with another person | Ankle sprain | 20.3 | Contact with another person |
| | Concussion | 17.4 | Contact with another person | Knee sprain | 14.2 | No contact |
| | Knee sprain | 10.1 | Contact with another person | | | |
| Forward | Ankle sprain | 29.6 | Contact with another person | Ankle sprain | 22.9 | Contact with another person |
| | Concussion | 22.2 | Contact with another person | Concussion | 12.9 | Contact with another person |
| Guard | Ankle sprain | 25.9 | Contact with another person | Ankle sprain | 20.0 | Contact with another person |
| | Concussion | 21.9 | Contact with another person | Concussion | 12.7 | Contact with another person |
| | Knee sprain | 10.1 | No contact | Knee sprain | 12.6 | No contact |

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

^a Excluded 63 competition injuries reported in HS RIO system and 115 competition injuries reported in the NCAA-ISP due to position not being indicated. The table reads as follows: for the center position in high school, ankle sprains accounted for 25.1% 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.

^b High school data originated from HS RIO system 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.

distribution of injuries by mechanism highlights the need for injury-prevention strategies that target a variety of injury mechanisms.^{32–37} For example, basketball players may benefit from injury-prevention programs that simulate player contact in a safe manner.^{32,33}

LIMITATIONS

Our results 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 the fact that HS RIO used a random sample, whereas the NCAA-ISP used a convenience sample. In addition, differences may exist between high school and college for the length of the season in total, as well as the preseason, regular season, and postseason; the potentially longer collegiate season may increase the injury risk. We calculated injury rates using AEs, which may not be as precise an at-risk exposure measure as minutes/hours or total number of game plays across a season. 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.

CONCLUSIONS

Injury-surveillance data were used to describe injury rates and patterns among high school girls' and collegiate women's basketball from 2004–2005 through 2013–2014. We identified differences in injury rates by competition level and event type. Injury rates were greater in collegiate basketball and were greater during competitions than during practices at both levels. Comparable distributions of injuries by body part, specific diagnosis, and mechanism of injury suggest that both competition levels may benefit from similar injury-prevention strategies: specifically, programs designed to prevent ankle and knee injuries resulting from player contact and noncontact mechanisms. However, variations in injury rates by school size and division indicate that some interventions more targeted to playing level may also be warranted. Given the small roster sizes within basketball, the individual risk of time-loss injury was rather low; however, our findings nonetheless highlight the continued need to inform future injury-prevention strategies to improve athlete safety.

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