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

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

Design: Descriptive epidemiology study.

Setting: Online injury surveillance from softball teams in high school girls (annual average = 100) and collegiate women (annual average = 41).

Patients or Other Participants: Girls' or women's softball 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.

Main Outcome Measure(s): Athletic trainers collected time-loss injury and exposure data. Injury rates per 1000 athlete-exposures (AEs) were calculated. Injury rate ratios (IRRs) with 95% confidence intervals (CIs) compared injury rates by competition level, school size or division, event type, and time in season.

Results: The High School Reporting Information Online system documented 1357 time-loss injuries during 1 173 722 AEs; the National Collegiate Athletic Association Injury Surveillance Program documented 1848 time-loss injuries during 579 553 AEs. The injury rate was higher in college than in high school (3.19 versus 1.16/1000 AEs; IRR = 2.76; 95% CI = 2.57, 2.96). The competition injury rate was higher than the practice injury rate in high school (IRR = 2.02; 95% CI = 1.82, 2.25) and in college (IRR = 1.39; 95% CI = 1.27, 1.52). Softball players at both levels sustained a variety of injuries, with the most common being ankle sprains and concussions. Many injuries also occurred while fielding or running bases.

Conclusions: Injury rates were greater in collegiate versus high school softball and in competitions versus practices. These findings highlight the need for injury-prevention interventions, including strength-training and prevention programs to reduce ankle sprains and provide protection for batters from pitches and fielders from batted balls.

Key Words: concussions, ankle sprains, musculoskeletal injuries, overuse injuries, injury prevention

Key Points

- The injury rate was higher in collegiate women's softball than in high school girls' softball.
- Competition injury rates exceeded practice injury rates in both high school girls' and collegiate women's softball.
- Ankle sprains and concussions were common injuries during competitions.

Softball is played by a large proportion of female student-athletes at the high school and collegiate levels. In the 2013–2014 academic year, softball was the fifth most common sport played by high school females, played by 11% of female high school athletic participants.[1] Similarly, in the National Collegiate Athletic Association (NCAA), softball was the sport with the fourth-most female student-athletes participating; softball players comprised 9% of all NCAA female student-athletes.[2]

Given the large proportion of female student-athletes participating in softball, it is important to examine injury incidences in high school girls' and collegiate women's softball. Although baseball injuries have been examined extensively, few authors have described the epidemiology of injuries in softball, especially at the high school level. Presently, the most extensive study of collegiate women's softball injury epidemiology is the 2007 study of NCAA data from 1988–1989 through 2003–2004.[3] However, those data, which were limited to collegiate women's softball, are now more than 10 years old, and much has changed in the sport since that report.

As denoted in the van Mechelen et al[4] framework, injury prevention benefits from ongoing monitoring of injury incidence, and updated descriptive epidemiology is needed. Findings from these analyses can inform resource-allocation efforts and help drive the development of future injury-prevention interventions specific to softball. 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).[5] A year later, High School Reporting Information Online (HS RIO), a similar Web-based high school sports injury-surveillance system, was launched.[6] The purpose of this article is to summarize the descriptive epidemiology of injuries sustained in high school girls' and collegiate women's softball during the first decade of Web-based sports injury surveillance (2004–2005 through 2013–2014 academic years).

METHODS

Data Sources and Study Period

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

An average of 100 high schools sponsoring girls' softball 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 = 9, Division III = 17) sponsoring women's softball participated in the NCAA-ISP during the 2004–2005 through 2013–2014 academic years. The methods of HS RIO and the NCAA-ISP are summarized in the following sections. In-depth information on the methods and analyses for this special series of articles on Web-based sports injury surveillance can be found in the previously published methodologic article.[7] In addition, previous publications have described the sampling and data collection of HS RIO[6,8] and the NCAA-ISP[5] 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 athlete-exposure (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 $\leq$1000 or $>$1000) and US Census geographic region.[9] The ATs from these schools reported data for the 9 sports of interest (boys' baseball, basketball, football, soccer, and wrestling; girls' basketball, soccer, softball, and volleyball). At the beginning of the next academic year, 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.[5] 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 provide the number of student-athletes participating in each practice and competition.

For data collection 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.[5] 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

standard to improve process flow. The common data element 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 common data element 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 participating 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, poststratification sample weights, based on sport, division, and academic year, were applied to each reported injury and AE. Poststratification sample weights were calculated using the following formula:

$$\text{Weight}_{ijk} = \left(\frac{\text{Number of teams participating in ISP}_{ijk}}{\text{Number of teams in NCAA}_{ijk}}\right)^{-1}$$

where $weight_{ijk}$ is the weight for the ith sport of the jth division in the kth year. Weights for all data were further adjusted to correct for underreporting, according to the findings of Kucera et al,[10] 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}).

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) were included.

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

Statistical Analysis

Data were analyzed using SAS-Enterprise Guide software (version 5.4; SAS Institute Inc, Cary, NC). Because the data collected from HS RIO and the NCAA-ISP are similar, we opted to recode data when necessary to increase the comparability between high school and collegiate student-athletes. We also opted to ensure that categorizations were consistent among all sport-specific articles within this special series. Because methodologic variations may lead to small differences in injury reporting among 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, >21 days, including injuries resulting in a premature end to the season), body part injured, diagnosis, mechanism of injury, activity during injury, and position. We also calculated injury rates per 1000 AEs and injury rate ratios (IRRs). The IRRs focused on comparisons by level of play (high school and college), event type (practice and competition), school size in high school ($\leq$1000 and >1000 students), division in college (Division I, II, and III), and time in season (preseason, regular season, and postseason). The following is an example of an IRR comparing competition and practice injury rates:

$$\text{IRR} = \frac{\left(\frac{\sum \text{Competition injuries}}{\sum \text{Competition AEs}}\right)}{\left(\frac{\sum \text{Practice injuries}}{\sum \text{Practice AEs}}\right)}$$

All IRRs with 95% confidence intervals (CIs) not containing 1.0 were considered statistically significant.

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

Between 2004–2005 and 2013–2014, ATs reported a total of 3205 time-loss injuries in high school girls' and collegiate women's softball (high school = 1357, college = 1848; Table 1). This equated to a national estimate of 563 821 high school injuries (annual average of 62 647) and 41 661 collegiate injuries (annual average of 4166). The total injury rate for high school girls' softball was 1.16/1000 AEs (95% CI = 1.09, 1.22). The total injury rate for collegiate women's softball was 3.19/1000 AEs (95% CI = 3.04, 3.33). The total injury rate was higher in college than in high school (IRR = 2.76; 95% CI = 2.57, 2.96).

Table 1. Injury Rates by School Size or Division and Type of Athlete-Exposure in High School Girls' and Collegiate Women's Softball[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	247 (46.3)	172 586 (46.7)	289 563	0.85 (0.75, 0.96)
	Competition	287 (53.7)	197 117 (53.3)	146 055	1.97 (1.74, 2.19)
	Total	534 (100.0)	369 703 (100.0)	435 618	1.23 (1.12, 1.33)
>1000 students	Practice	411 (49.9)	100 200 (51.6)	479 675	0.86 (0.77, 0.94)
	Competition	412 (50.1)	93 917 (48.4)	258 429	1.59 (1.44, 1.75)
	Total	823 (100.0)	194 117 (100.0)	738 104	1.12 (1.04, 1.19)
Total	Practice	658 (48.5)	272 786 (48.4)	769 238	0.86 (0.79, 0.92)
	Competition	699 (51.5)	291 035 (51.6)	404 484	1.73 (1.60, 1.86)
	Total	1357 (100.0)	563 821 (100.0)	1 173 722	1.16 (1.09, 1.22)
NCAA-ISP (2004–2005 through 2013–2014)					
Division I	Practice	416 (49.1)	7399 (48.6)	141 117	2.95 (2.66, 3.23)
	Competition	432 (50.9)	7830 (51.4)	110 578	3.91 (3.54, 4.28)
	Total	848 (100.0)	15 228 (100.0)	251 695	3.37 (3.14, 3.60)
Division II	Practice	205 (48.8)	5637 (48.1)	74 692	2.74 (2.37, 3.12)
	Competition	215 (51.2)	6086 (51.9)	54 185	3.97 (3.44, 4.50)
	Total	420 (100.0)	11 723 (100.0)	128 877	3.26 (2.95, 3.57)
Division III	Practice	316 (54.5)	7793 (53.0)	125 040	2.53 (2.25, 2.81)
	Competition	264 (45.5)	6917 (47.0)	73 941	3.57 (3.14, 4.00)
	Total	580 (100.0)	14 709 (100.0)	198 981	2.91 (2.68, 3.15)
Total	Practice	937 (50.7)	20 829 (50.0)	340 849	2.75 (2.57, 2.93)
	Competition	911 (49.3)	20 832 (50.0)	238 704	3.82 (3.57, 4.06)
	Total	1848 (100.0)	41 661 (100.0)	579 553	3.19 (3.04, 3.33)

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 add up to totals due to rounding error.

School Size and Division

In high school, total injury rates did not differ between schools with ≤1000 students and schools with >1000 students (IRR = 1.10; 95% CI = 0.99, 1.23; Table 1). In college, Division I had a higher total injury rate than Division III (IRR = 1.16; 95% CI = 1.04, 1.28) but not Division II (IRR = 1.03; 95% CI = 0.92, 1.16). Total injury rates in Division II and Division III did not differ (IRR = 1.12; 95% CI = 0.99, 1.27).

Event Type

Slightly more than half of all injuries occurred during competitions in high school (51.5%), whereas slightly over half of all injuries occurred during practices in college (50.7%; Table 1). The competition injury rate was higher than the practice injury rate in both high school (IRR = 2.02; 95% CI = 1.82, 2.25) and college (IRR = 1.39; 95% CI = 1.27, 1.52).

No yearly linear trends were found in high school injury rates for practices (annual average change of 0.03/1000 AEs; 95% CI = –0.01, 0.06) or competitions (annual average change of –0.04/1000 AEs; 95% CI = –0.11, 0.03; Figure). Similarly, no yearly linear trends were found in college for the 2004–2005 through 2008–2009 academic years for practices (annual average change of –0.48/1000 AEs; 95% CI = –1.01, 0.04) or competitions (annual average change of –0.20/1000 AEs; 95% CI = –0.73, 0.32). However, yearly linear trends were present in college for the 2009–2010 through 2013–2014 academic years, with evidence that practice injury rates were increasing (annual average change of 0.09/1000 AEs; 95% CI = 0.05, 0.14), whereas competition injury rates were decreasing (annual average change of –0.36/1000 AEs; 95% CI = –0.54, –0.17).

Time in Season

For both high school and collegiate players, the majority of injuries occurred during the regular season (high school = 72.8%, college = 65.3%; Table 2). In college, the preseason had a higher injury rate than the regular season (IRR = 1.17; 95% CI = 1.06, 1.29) and the postseason (IRR = 2.33; 95% CI = 1.70, 3.21). Also, the regular season had a higher injury rate than the postseason (IRR = 1.99; 95% CI = 1.45, 2.73). 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

In both high school and college, the largest proportion of injuries resulted in time loss of less than 1 week, ranging

Table 2. Injury Rates by Time in Season and Type of Athlete-Exposure in High School Girls' and Collegiate Women's Softball[a]

		HS RIO (2005–2006 Through 2013–2014)		NCAA-ISP (2004–2005 Through 2013–2014)			
Time in Season	Event 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	280 (87.0)	120 395 (89.0)	596 (99.0)	13 322 (98.9)	162 819	3.66 (3.37, 3.95)
	Competition	42 (13.0)	14 858 (11.0)	6 (1.0)	144 (1.1)	2563	2.34 (0.47, 4.21)
	Total	322 (100.0)	135 253 (100.0)	602 (100.0)	13 466 (100.0)	165 381	3.64 (3.35, 3.93)
Regular season	Practice	360 (36.7)	142 350 (35.7)	336 (27.9)	7393 (27.0)	164 550	2.04 (1.82, 2.26)
	Competition	622 (63.3)	256 797 (64.3)	870 (72.1)	20 029 (73.0)	223 968	3.88 (3.63, 4.14)
	Total	982 (100.0)	399 148 (100.0)	1206 (100.0)	27 422 (100.0)	388 518	3.10 (2.93, 3.28)
Postseason	Practice	13 (29.6)	5166 (24.1)	5 (12.5)	113 (14.6)	13 480	0.37 (0.05, 0.70)
	Competition	31 (70.4)	16 234 (75.9)	35 (87.5)	659 (85.4)	12 173	2.88 (1.92, 3.83)
	Total	44 (100.0)	21 401 (100.0)	40 (100.0)	772 (100.0)	25 653	1.56 (1.08, 2.04)

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

[a] Excluded 6 injuries reported in HS RIO due to missing data for time in season. Injury rates by time in season could not be calculated for high school as athlete-exposures were not stratified by time in season. National estimates and athlete-exposures may not add up to totals due to rounding error. High school data originated from HS RIO surveillance data, 2005–2006 through 2013–2014; collegiate data originated from NCAA-ISP surveillance data, 2004–2005 through 2013–2014. Injuries included in the analysis were those that (1) occurred during a sanctioned practice or competition; (2) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; and (3) restricted the student-athlete from participation for at least 24 hours past the day of injury. All concussions, fractures, and dental injuries were included in the analysis, regardless of time loss. Data may include multiple injuries that occurred at 1 injury event.

from 42.6% of injuries in high school competitions to 51.4% of injuries in collegiate competitions (Table 3). At both the high school and collegiate levels, injuries resulting in more than 3 weeks of time loss had the greatest proportion that required surgery.

Body Parts Injured and Diagnoses

High School. The most commonly injured body parts during practices and competitions were the head/face (practices = 20.3%, competitions = 20.5%), hand/wrist (practices = 15.2%, competitions = 16.6%), and ankle (practices = 13.7%, competitions = 17.6%; Table 4). Frequent injury diagnoses in practices and competitions were muscle/tendon strains (practices = 20.2%, competitions = 14.0%) and ligament sprains (practices = 19.2%, competitions = 28.7%; Table 5). Also, 17.6% of injuries during competitions were contusions.

College. The most often injured body parts were the hip/thigh/upper leg (15.7%), shoulder/clavicle (15.3%), and

Table 3. Number of Injuries and Injury Rates by Time Loss and Type of Athlete-Exposure in High School Girls' and Collegiate Women's Softball[a]

	Practices			Competitions		
Surveillance System and Time-Loss Category	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	285 (45.0)	119 850 (45.6)	0.37 (0.33, 0.41)	294 (42.6)	129 174 (44.8)	0.73 (0.64, 0.81)
1 to 3 wk	215 (33.9)	89 574 (34.1)	0.28 (0.24, 0.32)	231 (33.5)	92 066 (31.9)	0.57 (0.50, 0.64)
>3 wk[b]	134 (21.1)	53 402 (20.3)	0.17 (0.14, 0.20)	165 (23.9)	66 983 (23.2)	0.41 (0.35, 0.47)
NCAA-ISP (2004–2005 through 2013–2014)						
1 d to <1 wk	456 (50.3)	10 351 (51.6)	1.34 (1.22, 1.46)	454 (51.4)	10 558 (52.4)	1.90 (1.73, 2.08)
1 to 3 wk	269 (29.7)	6094 (30.4)	0.79 (0.69, 0.88)	237 (26.8)	5397 (26.8)	0.99 (0.87, 1.12)
>3 wk[b]	182 (20.1)	3610 (18.0)	0.53 (0.46, 0.61)	193 (21.8)	4197 (20.8)	0.81 (0.69, 0.92)

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

[a] Excluded 33 injuries reported in HS RIO and 57 injuries reported in the NCAA-ISP due to missing data for time loss. Percentages may not add up to 100.0 due to rounding error. High school data originated from HS RIO surveillance data, 2005–2006 through 2013–2014; collegiate data originated from NCAA-ISP surveillance data, 2004–2005 through 2013–2014. Injuries included in the analysis were those that (1) occurred during a sanctioned practice or competition; (2) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; and (3) restricted the student-athlete from participation for at least 24 hours past the day of injury. All concussions, fractures, and dental injuries were included in the analysis, regardless of time loss. Data may include multiple injuries that occurred at 1 injury event.

[b] Included 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.

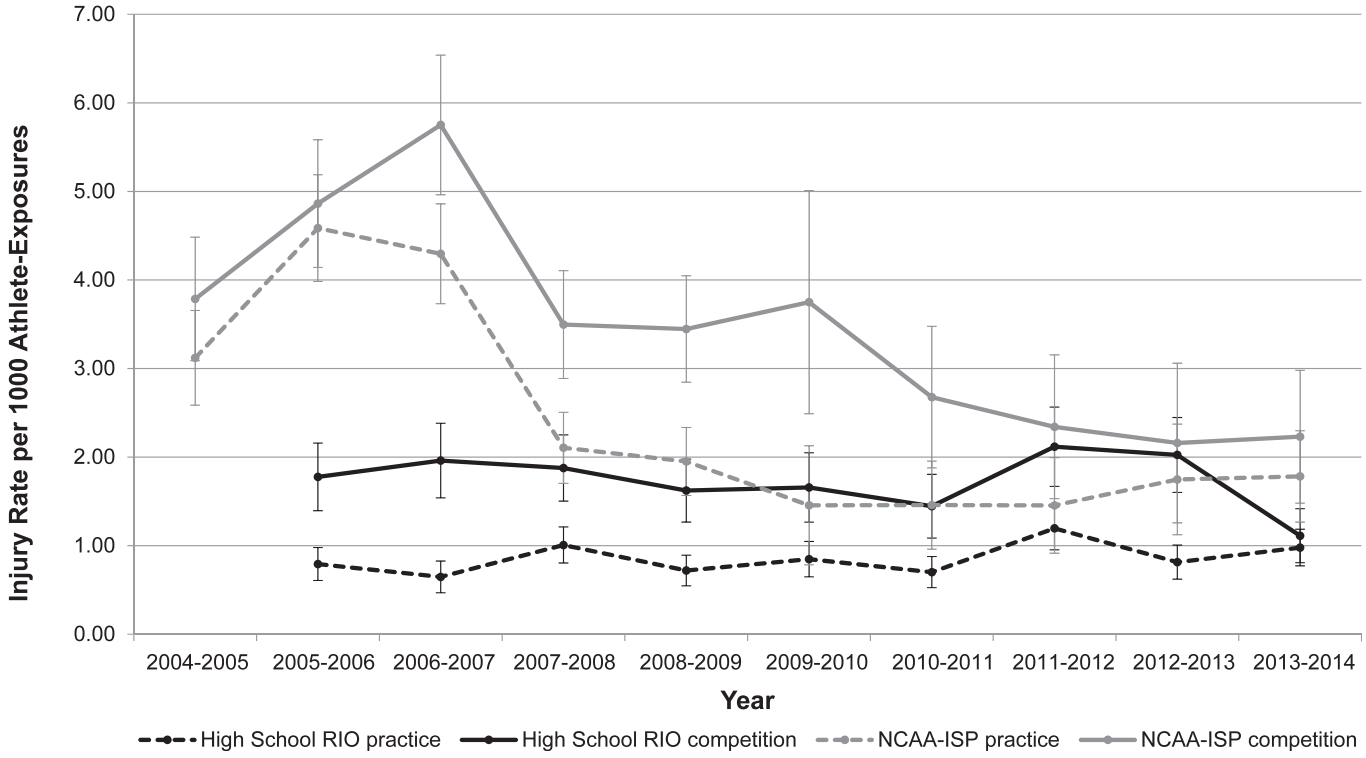

Figure. Injury rates by year and type of athlete-exposure (AE) in high school girls' and collegiate women's softball. Note: Annual average changes for the linear trend test for injury rates are as follows: High School Reporting Information Online (RIO; practices = 0.03/1000 AEs, 95% confidence interval [CI] = –0.01, 0.06; competitions = –0.04/1000 AEs, 95% CI = –0.11, 0.03); National Collegiate Athletic Association Injury Surveillance Program (NCAA-ISP) 2004–2005 through 2008–2009 (practices = –0.48/1000 AEs, 95% CI = –1.01, 0.04; competitions = –0.20/1000 AEs, 95% CI = –0.73, 0.32); NCAA-ISP 2009–2010 through 2013–2014 academic years (practices = 0.09/1000 AEs, 95% CI = 0.05, 0.14; competitions = –0.36/1000 AEs, 95% CI = –0.54, –0.17). A negative rate indicates a decrease in the annual average change between years and a positive rate indicates an increase in the annual average change; 95% CIs that include 0.00 are not significant.

head/face (11.3%) during practices and the head/face (19.1%) and hand/wrist (16.8%) during competitions (Table 4). The most common injury diagnoses during practices and competitions were muscle/tendon strains (practices = 23.5%, competitions = 12.9%), ligament sprains (practices = 14.5%, competitions = 18.4%), and contusions (practices = 13.2%, competitions = 23.3%; Table 5).

Mechanisms of Injury and Activities

High School. The most frequent mechanisms of injury during practices were no contact (22.9%) and overuse/chronic (20.4%) and during competitions were contact with another person (21.4%), contact with the playing surface (17.5%), and overuse/chronic (16.8%; Table 6). Common injury-causing activities during practices and competitions were fielding (practices = 25.3%, competitions = 26.8%) and running bases (practices = 13.8%, competitions = 18.2%; Table 7). Also, 14.8% of injuries during practices occurred while throwing the ball, and 16.9% of injuries during competitions occurred while sliding.

College. The most often reported mechanism of injury during practices and competitions was no contact (practices = 38.1%, competitions = 22.4%; Table 6). Other common mechanisms of injury were overuse/chronic (21.7%) during practices and contact with another person (20.4%) during competitions. The most frequent activity during injury during practices and competitions was fielding (practices = 22.4%, competitions = 23.5%; Table 7). Also, 19.2% and 16.7% of all injuries during competitions occurred while batting and running bases, respectively.

Position-Specific Injuries During Competitions

In competitions, the most frequent injury varied depending on position (Table 8). For example, ankle sprains were the most common injury for high school base runners (34.1%), outfielders (14.2%), and pitchers (14.1%) as well as for collegiate base runners (21.6%). Concussions were the most often reported injury for high school catchers (15.2%) and infielders (15.2%) and for collegiate catchers (21.2%), infielders (11.8%), and outfielders (11.5%).

DISCUSSION

The findings from these analyses can be used to inform resource-allocation efforts and determine possible directions of softball-specific injury-prevention interventions. Reported injury rates were higher in college than in high school, but a larger proportion of collegiate injuries occurred from overuse or contact with a batted ball or while batting. Large proportions of injuries at both levels were concussions and ankle sprains. Our results also highlight the need for level-specific interventions for high school and collegiate players, as well as further in-depth research into softball injuries.

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 Softball[a]

	Practices			Competitions		
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	133 (20.3)	53 782 (19.8)	0.17 (0.14, 0.20)	143 (20.5)	65 583 (22.6)	0.35 (0.30, 0.41)
Neck	1 (0.2)	485 (0.2)	<0.01 (0.00, <0.01)	7 (1.0)	1744 (0.6)	0.02 (0.00, 0.03)
Shoulder/clavicle	66 (10.1)	27 527 (10.1)	0.09 (0.07, 0.11)	50 (7.2)	18 864 (6.5)	0.12 (0.09, 0.16)
Arm/elbow	49 (7.5)	19 393 (7.1)	0.06 (0.05, 0.08)	34 (4.9)	16 176 (5.6)	0.08 (0.06, 0.11)
Hand/wrist	100 (15.2)	41 033 (15.1)	0.13 (0.10, 0.16)	116 (16.6)	46 390 (16.0)	0.29 (0.23, 0.34)
Trunk	28 (4.3)	13 758 (5.1)	0.04 (0.02, 0.05)	17 (2.4)	7429 (2.6)	0.04 (0.02, 0.06)
Hip/thigh/upper leg	64 (9.8)	27 711 (10.2)	0.08 (0.06, 0.10)	51 (7.3)	24 604 (8.5)	0.13 (0.09, 0.16)
Knee	68 (10.4)	25 765 (9.5)	0.09 (0.07, 0.11)	97 (13.9)	39 315 (13.5)	0.24 (0.19, 0.29)
Lower leg	34 (5.2)	13 635 (5.0)	0.04 (0.03, 0.06)	44 (6.3)	17 275 (5.9)	0.11 (0.08, 0.14)
Ankle	90 (13.7)	40 625 (15.0)	0.12 (0.09, 0.14)	123 (17.6)	48 516 (16.7)	0.30 (0.25, 0.36)
Foot	18 (2.7)	6159 (2.3)	0.02 (0.01, 0.03)	14 (2.0)	4398 (1.5)	0.03 (0.02, 0.05)
Other	5 (0.8)	1804 (0.7)	0.01 (0.00, 0.01)	1 (0.1)	437 (0.2)	<0.01 (0.00, 0.01)
NCAA-ISP (2004–2005 through 2013–2014)						
Head/face	106 (11.3)	2809 (13.5)	0.31 (0.25, 0.37)	174 (19.1)	4688 (22.5)	0.73 (0.62, 0.84)
Neck	10 (1.1)	236 (1.1)	0.03 (0.01, 0.05)	13 (1.4)	256 (1.2)	0.05 (0.02, 0.08)
Shoulder/clavicle	143 (15.3)	2929 (14.1)	0.42 (0.35, 0.49)	75 (8.2)	1524 (7.3)	0.31 (0.24, 0.39)
Arm/elbow	67 (7.2)	1377 (6.6)	0.20 (0.15, 0.24)	69 (7.6)	1408 (6.8)	0.29 (0.22, 0.36)
Hand/wrist	93 (9.9)	1919 (9.2)	0.27 (0.22, 0.33)	153 (16.8)	3486 (16.7)	0.64 (0.54, 0.74)
Trunk	88 (9.4)	1980 (9.5)	0.26 (0.20, 0.31)	45 (4.9)	1074 (5.2)	0.19 (0.13, 0.24)
Hip/thigh/upper leg	147 (15.7)	3318 (15.9)	0.43 (0.36, 0.50)	66 (7.2)	1499 (7.2)	0.28 (0.21, 0.34)
Knee	95 (10.1)	2164 (10.4)	0.28 (0.22, 0.33)	121 (13.3)	2468 (11.9)	0.51 (0.42, 0.60)
Lower leg	59 (6.3)	1191 (5.7)	0.17 (0.13, 0.22)	56 (6.2)	1133 (5.4)	0.23 (0.17, 0.30)
Ankle	86 (9.2)	1962 (9.4)	0.25 (0.20, 0.31)	104 (11.4)	2383 (11.4)	0.44 (0.35, 0.52)
Foot	22 (2.4)	448 (2.2)	0.06 (0.04, 0.09)	26 (2.9)	712 (3.4)	0.11 (0.07, 0.15)
Other	21 (2.2)	495 (2.4)	0.06 (0.04, 0.09)	9 (1.0)	201 (1.0)	0.04 (0.01, 0.06)

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

[a] Excluded 4 injuries reported in HS RIO due to missing data for body part. Percentages may not add up to 100.0 due to rounding error. High school data originates 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.

Comparison of Injury Rates With Previous Research

The high school injury rates we observed varied from those reported by Powell and Barber-Foss[11] for the 1995–1997 seasons. Their overall injury rate in high school softball was 3.5/1000 AEs, compared with 1.16/1000 AEs in our study. Additionally, the rates reported here for HS RIO were lower in both competitions (1.7 versus 5.9/1000 AEs) and practices (0.86 versus 2.7/1000 AEs) compared with those reported by Powell and Barber-Foss.[11] In a separate study, Shanley et al[12] documented a high school softball injury incidence rate of 5.6/1000 AEs during a single (2009) season, which was higher than both the HS RIO rate and that reported by Powell and Barber-Foss.[11] However, a key difference is that Shanley et al[12] included both time-loss and non–time-loss injuries, whereas we included only time-loss injuries. Previous research[13] on high school athletes showed that the majority (82.5%) of sport-related injuries were non–time-loss injuries.

In the collegiate setting, an earlier examination[3] of the NCAA-ISP during the 1988–1989 through 2003–2004 academic years indicated that competition and practice injury rates were 4.30 and 2.67/1000 AEs, respectively. The competition injury rate was higher than we report (3.82/1000 AEs), but the practice rate was similar (2.75/1000 AEs). Also, the overall injury rates observed from 2004–2005 through 2013–2014 were lower than those reported by Powell and Dompier[14] for the 2000–2001 through 2001–2002 academic years in Division I (3.4 versus 5.3/1000 AEs) but similar in Division II (3.3 versus 3.5/1000 AEs) and Division III (2.9 versus 3.2/1000 AEs).

Comparisons with previous research should be cautious as the composition of the samples may vary by school size and division. Additionally, injury definitions and reporting methods varied across these studies. At the same time, the linear trend analyses we performed demonstrated minimal changes in injury rates across time, although later collegiate data displayed evidence of changes, particularly increases in practice injury rates. Thus, although softball injury prevention has made many strides through rules changes, which may be evidenced by lower injury rates in our study compared with previously reported rates, continued development and implementation of injury-prevention interven-

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 Softball[a]

	Practices			Competitions		
Surveillance System and Diagnosis	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	75 (11.5)	30 553 (11.3)	0.10 (0.08, 0.12)	89 (12.8)	39 375 (13.5)	0.22 (0.17, 0.27)
Contusion	78 (11.9)	33 497 (12.4)	0.10 (0.08, 0.12)	123 (17.6)	48 662 (16.7)	0.30 (0.25, 0.36)
Dislocation[b]	15 (2.3)	7145 (2.6)	0.02 (0.01, 0.03)	19 (2.7)	7598 (2.6)	0.05 (0.03, 0.07)
Fracture/avulsion	88 (13.4)	35 813 (13.2)	0.11 (0.09, 0.14)	85 (12.2)	35 586 (12.2)	0.21 (0.17, 0.25)
Laceration	10 (1.5)	3792 (1.4)	0.01 (0.00, 0.02)	20 (2.9)	8735 (3.0)	0.05 (0.03, 0.07)
Ligament sprain	126 (19.2)	57 284 (21.1)	0.16 (0.14, 0.19)	200 (28.7)	77 875 (26.8)	0.49 (0.43, 0.56)
Muscle/tendon strain	132 (20.2)	57 989 (21.4)	0.17 (0.14, 0.20)	98 (14.0)	43 594 (15.0)	0.24 (0.19, 0.29)
Other	131 (20.0)	44 914 (16.6)	0.17 (0.14, 0.20)	64 (9.2)	29 411 (10.1)	0.16 (0.12, 0.20)
NCAA-ISP (2004–2005 through 2013–2014)						
Concussion	51 (5.4)	1469 (7.1)	0.15 (0.11, 0.19)	100 (11.0)	2927 (14.1)	0.42 (0.34, 0.50)
Contusion	124 (13.2)	2667 (12.8)	0.36 (0.30, 0.43)	212 (23.3)	4536 (21.8)	0.89 (0.77, 1.01)
Dislocation[b]	8 (0.9)	291 (1.4)	0.02 (0.01, 0.04)	11 (1.2)	246 (1.2)	0.05 (0.02, 0.07)
Fracture/avulsion	50 (5.3)	1034 (5.0)	0.15 (0.11, 0.19)	94 (10.3)	2163 (10.4)	0.39 (0.31, 0.47)
Laceration	6 (0.6)	109 (0.5)	0.02 (0.00, 0.03)	35 (3.9)	743 (3.6)	0.15 (0.10, 0.20)
Ligament sprain	136 (14.5)	3186 (15.3)	0.40 (0.33, 0.47)	167 (18.4)	3815 (18.3)	0.70 (0.59, 0.81)
Muscle/tendon strain	220 (23.5)	4889 (23.5)	0.65 (0.56, 0.73)	117 (12.9)	2664 (12.8)	0.49 (0.40, 0.58)
Other	342 (36.5)	7184 (34.5)	1.00 (0.90, 1.11)	174 (19.1)	3717 (17.9)	0.73 (0.62, 0.84)

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

[a] Excluded 4 injuries reported in HS RIO and 1 injury reported in the NCAA-ISP due to missing data for diagnosis. Percentages may not add up to 100.0 due to rounding error. High school data originated from HS RIO surveillance data, 2005–2006 through 2013–2014; collegiate data originated from NCAA-ISP surveillance data, 2004–2005 through 2013–2014. Injuries included in the analysis were those that (1) occurred during a sanctioned practice or competition; (2) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; and (3) restricted the student-athlete from participation for at least 24 hours past the day of injury. All concussions, fractures, and dental injuries were included in the analysis, regardless of time loss. Data may include multiple injuries that occurred at 1 injury event.

[b] Included separations.

tions with the aim of reducing the incidence of injury are still needed.

Comparisons Between and Within High School Girls' and Collegiate Women's Softball

Injury Rates. The injury rates observed in the collegiate setting were nearly 3 times those observed in the high school setting. This was the case for both practice and competition injuries and may reflect a higher intensity of play at the collegiate level compared with the high school level. It could also be due to the differential availability of athletic training resources at the high school and collegiate levels. In college, student-athletes are much more likely to have regular and consistent access to an AT, which may increase the reporting of injuries.[15–17] For example, at the majority of high schools, a single AT reports data for all sports. In contrast, at many colleges, an AT is dedicated primarily to softball. This additional AT resourcing at the collegiate level could lead to more injury reporting due to their greater familiarity with, and access to, the athletes. Additionally, at the collegiate level, practice and training are more likely to occur year-round, though specialization is increasing at the high school level.[18,19] With this year-round practice and training schedule, the overall work load is greater, possibly increasing the risk of overuse injuries and injuries due to fatigue.[20] The proportion of injuries that were due to no contact was larger in college than in high school, though the proportion due to an overuse mechanism was similar in high school and college.

Event Type. In both high school and college, approximately half of the injuries occurred during practices; however, the injury rate was higher during competitions for both high school and collegiate players. This information is important for resource-allocation and injury-prevention measures. Athletic trainers should be prepared for more injuries and recognize the greater number of high-risk activities during games. Therefore, in an environment with limited resources for providing on-site health care services, such as a small rural high school, priority should be given to the AT being present at games over practices. However, changes in the practice setting that possibly prevent injuries, such as limiting repetitions[21] and increasing rest when athletes feel fatigue or pain,[22] may help to reduce injuries. Further research is needed to measure and analyze the workload experienced during practices and how modifying the workload might prevent injury.

Time Loss From Participation. The largest proportion of injuries resulted in time loss of less than 1 week in both high school and collegiate players. The distributions of time-loss injuries between high school and college were similar, and the distributions were also similar between practices and games. This finding is noteworthy, as even though the rate of injuries was higher in college than in

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 Softball[a]

Surveillance System and Mechanism of Injury	Practices			Competitions		
	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	19 (3.0)	7685 (3.0)	0.02 (0.01, 0.04)	144 (21.4)	64 299 (23.1)	0.36 (0.30, 0.41)
Contact with playing surface	90 (14.2)	42 297 (16.4)	0.12 (0.09, 0.14)	118 (17.5)	42 109 (15.2)	0.29 (0.24, 0.34)
Contact with bases	28 (4.4)	14 068 (5.5)	0.04 (0.02, 0.05)	59 (8.8)	23 123 (8.3)	0.15 (0.11, 0.18)
Contact with bat	7 (1.1)	2999 (1.2)	0.01 (0.00, 0.02)	9 (1.3)	4141 (1.5)	0.02 (0.01, 0.04)
Contact with outfield wall/dugout/foul fence	0	0	0.00	27 (4.0)	8850 (3.2)	0.07 (0.04, 0.09)
Contact with batted ball	70 (11.1)	26 418 (10.3)	0.09 (0.07, 0.11)	4 (0.6)	2055 (0.7)	0.01 (0.00, 0.02)
Contact with pitch	26 (4.1)	10 817 (4.2)	0.03 (0.02, 0.05)	75 (11.1)	34 354 (12.4)	0.19 (0.14, 0.23)
Contact with thrown ball (not pitch)	81 (12.8)	32 201 (12.5)	0.11 (0.08, 0.13)	42 (6.2)	18 734 (6.8)	0.10 (0.07, 0.14)
Contact with other playing equipment	32 (5.1)	14 366 (5.6)	0.04 (0.03, 0.06)	49 (7.3)	18 572 (6.7)	0.12 (0.09, 0.16)
No contact	145 (22.9)	53 098 (20.6)	0.19 (0.16, 0.22)	5 (0.7)	1076 (0.4)	0.01 (0.00, 0.02)
Overuse/chronic	129 (20.4)	51 072 (19.8)	0.17 (0.14, 0.20)	113 (16.8)	47 472 (17.1)	0.28 (0.23, 0.33)
Illness/infection	6 (0.9)	2488 (1.0)	0.01 (0.00, 0.01)	28 (4.2)	12 957 (4.7)	0.07 (0.04, 0.09)
NCAA-ISP (2004–2005 through 2013–2014)						
Contact with another person	35 (3.8)	730 (3.6)	0.10 (0.07, 0.14)	184 (20.4)	3922 (19.1)	0.77 (0.66, 0.88)
Contact with playing surface	90 (9.8)	2018 (9.9)	0.26 (0.21, 0.32)	76 (8.4)	1748 (8.5)	0.32 (0.25, 0.39)
Contact with bases	21 (2.3)	417 (2.1)	0.06 (0.04, 0.09)	53 (5.9)	1286 (6.3)	0.22 (0.16, 0.28)
Contact with bat	9 (1.0)	173 (0.9)	0.03 (0.01, 0.04)	9 (1.0)	168 (0.8)	0.04 (0.01, 0.06)
Contact with outfield wall/dugout/foul fence	3 (0.3)	53 (0.3)	0.01 (0.00, 0.02)	16 (1.8)	460 (2.2)	0.07 (0.03, 0.10)
Contact with batted ball	91 (9.9)	2197 (10.8)	0.27 (0.21, 0.32)	134 (14.9)	3314 (16.2)	0.56 (0.47, 0.66)
Contact with pitch	37 (4.0)	812 (4.0)	0.11 (0.07, 0.14)	106 (11.8)	2223 (10.8)	0.44 (0.36, 0.53)
Contact with thrown ball (not pitch)	39 (4.2)	973 (4.8)	0.11 (0.08, 0.15)	33 (3.7)	812 (4.0)	0.14 (0.09, 0.19)
Contact with other playing equipment	26 (2.8)	685 (3.4)	0.08 (0.05, 0.11)	17 (1.9)	578 (2.8)	0.07 (0.04, 0.11)
No contact	351 (38.1)	7949 (39.1)	1.03 (0.92, 1.14)	202 (22.4)	4331 (21.1)	0.85 (0.73, 0.96)
Overuse/chronic	200 (21.7)	3904 (19.2)	0.59 (0.51, 0.67)	60 (6.7)	1411 (6.9)	0.25 (0.19, 0.31)
Illness/infection	19 (2.1)	413 (2.0)	0.06 (0.03, 0.08)	12 (1.3)	255 (1.3)	0.05 (0.02, 0.08)

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

[a] Mechanism of injury excluded 51 injuries reported in HS RIO and 25 injuries reported in the NCAA-ISP due to missing data or athletic trainer reporting *Other* or *Unknown*. Percentages may not add up to 100.0 due to rounding error. High school data originated from HS RIO surveillance data, 2005–2006 through 2013–2014; collegiate data originated from NCAA-ISP surveillance data, 2004–2005 through 2013–2014. Injuries included in the analysis were those that (1) occurred during a sanctioned practice or competition; (2) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; and (3) restricted the student-athlete from participation for at least 24 hours past the day of injury. All concussions, fractures, and dental injuries were included in the analysis, regardless of time loss. Data may include multiple injuries that occurred at 1 injury event.

high school, the severity of injuries was not different between the levels. Therefore, the increase in injuries may not simply indicate increases in work load and overuse because overuse injuries may have a different distribution of severity.[23] Although the proportions of severe injuries were similar between the 2 levels, the proportion of practice injuries that resulted in time loss of more than 3 weeks in college was twice the proportion in high school. Further research is needed to determine why time loss varied between the levels of play. For example, time loss associated with injury may be due to both injury severity and injury management.

Common Injuries and Injury Prevention

Body Parts Injured and Diagnoses. The largest proportion of reported injuries in high school was to the head/face (approximately 20% in both practices and competitions). This was also true for collegiate competitions (19%) but not collegiate practices (11%). Similarly, although the proportions of injuries that were concussions were similar between high school and college in competitions, the proportion in high school practices was double that in collegiate practices (11.5% versus 5.4%). Future researchers should examine practice drills and activities in the collegiate softball setting to determine if the student-athletes are engaged in activities with a lower concussion risk.

In both high school and college, concussion accounted for a large proportion of the reported injuries. This is contrary to a previous study[24] of softball players presenting to the emergency department between 1994 and 2010, in which the most commonly injured body regions were the hand/wrist and face. However, the athletes with injuries presenting to the emergency department are likely different than those seen by an AT. Marshall et al[3] noted that concussions accounted for only 6% of competition injuries and 3% of practice injuries in collegiate softball from 1988–1989 through 2003–2004, compared with our study's 11% and 5%, respectively. It is unclear whether the incidence of concussion truly increased in softball during this time

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 Softball[a]

	Practices			Competitions		
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 to 2013–2014)						
Batting	42 (7.0)	19 577 (8.0)	0.05 (0.04, 0.07)	69 (10.5)	33 684 (12.2)	0.17 (0.13. 0.21)
Catching	52 (8.6)	21 661 (8.9)	0.07 (0.05, 0.09)	69 (10.5)	29 227 (10.6)	0.17 (0.13, 0.21)
Conditioning	57 (9.5)	20 935 (8.6)	0.07 (0.05, 0.09)	0	0	0.00
Fielding	152 (25.3)	60 966 (24.9)	0.20 (0.17, 0.23)	176 (26.8)	71 860 (26.1)	0.44 (0.37, 0.50)
General play	51 (8.5)	19 342 (7.9)	0.07 (0.05, 0.08)	20 (3.0)	10 393 (3.8)	0.05 (0.03, 0.07)
Pitching	32 (5.3)	11 338 (4.6)	0.04 (0.03, 0.06)	62 (9.4)	23 190 (8.4)	0.15 (0.12, 0.19)
Running bases	83 (13.8)	34 493 (14.1)	0.11 (0.08, 0.13)	120 (18.2)	51 119 (18.6)	0.30 (0.24, 0.35)
Sliding	44 (7.3)	21 306 (8.7)	0.06 (0.04, 0.07)	111 (16.9)	42 967 (15.6)	0.27 (0.22, 0.33)
Throwing ball	89 (14.8)	34 995 (14.3)	0.12 (0.09, 0.14)	31 (4.7)	13 158 (4.8)	0.08 (0.05, 0.10)
NCAA-ISP (2004–2005 to 2013–2014)						
Batting	86 (9.6)	1727 (8.8)	0.25 (0.20, 0.31)	168 (19.2)	3502 (17.7)	0.70 (0.60, 0.81)
Catching	44 (4.9)	918 (4.7)	0.13 (0.09, 0.17)	76 (8.7)	1578 (8.0)	0.32 (0.25, 0.39)
Conditioning	115 (12.8)	2502 (12.7)	0.34 (0.28, 0.40)	5 (0.6)	108 (0.6)	0.02 (0.00, 0.04)
Fielding	201 (22.4)	4621 (23.4)	0.59 (0.51, 0.67)	206 (23.5)	4810 (24.3)	0.86 (0.75, 0.98)
General play	108 (12.0)	2555 (13.0)	0.32 (0.26, 0.38)	47 (5.4)	1157 (5.8)	0.20 (0.14, 0.25)
Pitching	99 (11.0)	2107 (10.7)	0.29 (0.23, 0.35)	83 (9.5)	2112 (10.7)	0.35 (0.27, 0.42)
Running bases	91 (10.1)	1913 (9.7)	0.27 (0.21, 0.32)	146 (16.7)	3326 (16.8)	0.61 (0.51, 0.71)
Sliding	31 (3.5)	695 (3.5)	0.09 (0.06, 0.12)	107 (12.2)	2378 (12.0)	0.45 (0.36, 0.53)
Throwing ball	124 (13.8)	2690 (13.6)	0.36 (0.30, 0.43)	37 (4.2)	831 (4.2)	0.16 (0.11, 0.20)

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

[a] Activity excluded 97 injuries reported in HS RIO and 74 injuries reported in the NCAA-ISP due to missing data or athletic trainer reporting *Other* or *Unknown*. Percentages may not add up to 100.0 due to rounding error. High school data originated from HS RIO surveillance data, 2005–2006 through 2013–2014; collegiate data originated from NCAA-ISP surveillance data, 2004–2005 through 2013–2014. Injuries included in the analysis were those that (1) occurred during a sanctioned practice or competition; (2) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; and (3) restricted the student-athlete from participation for at least 24 hours past the day of injury. All concussions, fractures, and dental injuries were included in the analysis, regardless of time loss. Data may include multiple injuries that occurred at 1 injury event.

frame or if the increase was instead due to more awareness and reporting. Currently, all 50 US states and the District of Columbia have passed laws to increase concussion education and improve management and reporting.[25] Additionally, many groups, including the NCAA, have established guidelines with best practices for identifying and managing concussion.[26] Recent evidence[27] suggested that these changes in legislation and specific concussion guidelines may be responsible, at least in part, for the increased number of identified concussions.

During both high school and collegiate practices and competitions, a larger proportion of injuries was to the lower extremity than the upper extremity. The distribution of injuries to the upper versus lower extremities was similar between high school and college, though the proportion of injuries to the lower extremity (41%) was lower during collegiate than high school competitions (47%). In high school, the most commonly injured upper extremity body part was the hand/wrist during both practices and competitions, whereas in college, it was the shoulder/clavicle during practices but the hand/wrist during competitions. Although our results did not specify the mechanism of injury by body part injured, within specific player positions, hand/wrist injuries were more often due to ball contact or player contact and shoulder injuries to overuse or noncontact mechanisms (Table 8). These findings are consistent with the pattern of injury mechanisms described earlier. Future investigators should examine whether protective equipment, such as wrist guards, could prevent hand and wrist injuries due to contact with the ball or bases and whether changes in training load may be effective in preventing shoulder injuries in collegiate softball players.

Mechanisms of Injury and Activities. In college, a larger proportion of competition injuries was due to contact with a batted ball than in high school. Currently, the NCAA has an approved list of bats that result in a batted-ball exit speed of less than 98 mph (158 kph).[28] This was implemented with the 2011 season. Before this, the NCAA only banned bats on the American Softball Association Non-Approved Bat List, which is the current standard for high school softball.[29] This limit on the exit speed of a batted ball may reduce the number of injuries to fielders from batted balls. Further research is needed to determine if implementing this standard was effective.

In addition to changing the speed of exited balls from bats, the distance from the pitcher's mound to home plate can influence the speed of the ball coming to the plate and the reaction time available to a batter, thereby possibly reducing contact with a pitch. This in turn can also reduce the exit speed of the batted ball and the reaction time

Table 8. Most Common Injuries Associated With Position in Competitions in High School Girls' and Collegiate Women's Softball[a]

	HS RIO (2005–2006 Through 2013–2014)			NCAA-ISP (2004–2005 Through 2013–2014)		
Position	Most Common Injuries	% of Injuries Within Position	Most Frequent Mechanism of Injury for This Injury Within Position	Most Common Injuries	% of Injuries Within Position	Most Frequent Mechanism of Injury for This Injury Within Position
Base runner	Ankle sprain	34.1	Contact with bases	Ankle sprain	21.6	Contact with bases
	Concussion	12.5	Contact with another person	Concussion	9.4	Contact with another person
	Knee sprain	11.4	Contact with playing surface			
Batter	Hand/wrist contusion	14.0	Hit by pitch	Arm/elbow contusion	16.1	Hit by pitch
	Hand/wrist sprain	10.5	Hit by pitch	Hand/wrist contusion	12.1	Hit by pitch
				Hand/wrist fracture	11.3	Hit by pitch
Catcher	Concussion	15.2	Contact with another person	Concussion	21.2	Contact with another person
	Hand/wrist contusion	8.9	Contact with another person	Hand/wrist sprain	7.1	Contact with other playing equipment
				Hand/wrist contusion	7.1	Hit by pitch
Infielder	Concussion	15.2	Hit by thrown ball	Concussion	11.8	Contact with another person
	Ankle sprain	12.9	Contact with playing surface	Ankle sprain	10.1	No contact
Outfielder	Ankle sprain	14.2	Contact with playing surface	Concussion	11.5	Contact with another person
	Concussion	12.1	Contact with another person	Hip/thigh/upper leg strain	9.0	No contact
	Knee sprain	12.1	Contact with playing surface	Ankle sprain	9.0	Contact with bases
Pitcher	Ankle sprain	14.1	Contact with bases	Trunk strain	6.4	No contact
	Hip/thigh/upper leg strain	12.9	No contact	Concussion	5.5	Hit by batted ball
				Shoulder strain	5.5	No contact

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

[a] Excluded 18 competition injuries reported in HS RIO and 92 competition injuries reported in the NCAA-ISP due to position not being indicated. The table reads as follows: for the base runner position in high school, ankle sprains accounted for 34.1% of all competition injuries to that position. The most common mechanism of injury for this specific injury for this specific position was contact with the bases. 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.

available to a pitcher once she becomes a fielder. In 2009, the National Federation of State High School Associations (NFHS) passed a rule that moved the pitching rubber from 40 to 43 ft (12 to 13 m), which became mandatory for the 2010–2011 academic year.[30] This rule had been in place in the NCAA since 1988.[31] The change in the high school setting should be further examined to determine if it affected contact-with-pitch and contact-with-batted-ball injuries.

Current NCAA and NFHS rules allow a defensive player to wear a helmet or a face mask, whether attached to a helmet or not. Additionally, defensive players may wear other protective equipment, such as elbow, knee, and shin pads.[31] The number of participants who use this equipment, as well as its actual protective ability, remains unknown and should be studied further.

Compared with high school players, a larger proportion of injuries to collegiate players occurred while batting, especially during competitions. The most common mechanism of injury among batters at both competition levels was being hit by a pitch. In college, the speed of pitches is generally faster than in high school, which may result in a greater proportion of hit-by-pitches injuries. Similarly, a larger proportion of injuries in college was due to contact with a batted ball than in high school. This may also be due to greater exit speed of the ball off the bat, as collegiate hitters may be more skilled and generate more power with their swings. Future researchers should examine whether additional protective gear for batters and fielders may help to prevent these injuries. In addition, further studies are needed to determine the appropriate distance from the pitching mound to home plate and acceptable bats in college (discussed earlier). Additionally, "slapping," a style of hitting in which a hitter runs toward the field while making contact with the ball to better control where the batted ball is placed, may increase the batter's risk of injury. Batters who use this technique may be at greater risk of getting hit by a pitch, and a batted ball from this style of hit may hit a fielder with greater speed due to the shorter distance to the fielder. However, it is important to note that

this possibility is speculative, as we did not evaluate this specific mechanism of injury; more work is needed to assess how this style of hitting affects injury risks for both batters and fielders.

A larger proportion of practice injuries in college was reported while pitching than in high school. This indicates a larger proportion of overuse injuries in collegiate than in high school athletes, as overuse injuries are more likely to be reported in practices.[23] Most injuries in softball pitchers are due to overuse,[32] and collegiate softball players are more likely to participate in pitching activities year-round. Furthermore, collegiate pitchers, due to increased age and often more years pitching, may have greater lifetime pitching exposure. Among high school and collegiate softball pitchers, 64% had a history of arm injury, 31% missed activity for more than 10 days, and the most common site of time-loss injury was the shoulder (81%).[33] Currently, no pitching limits in softball or pitch-count guidelines have been specified by any medical or governing body. Unlike the literature regarding pitching load in baseball and the injury-prevention benefits of limiting pitch counts,[34–37] biomechanics, softball pitchers' workloads, and their association with injury have not been investigated in depth.[32] Researchers should examine whether limiting pitch counts is an effective injury-prevention strategy in softball. Additionally, pitching injuries are more frequent in the beginning of the season.[38] Further evaluation of strength and conditioning programs in the off-season and strategies for scaling up pitching at the beginning of a season that can reduce the risk of pitching injuries early in the season is needed.

A large proportion of injuries in both high school and college occurred while running bases, especially during competitions. The most often reported injuries among base runners during competitions were ankle sprains and concussions. Most ankle sprains were due to contact with bases. This is an area for injury prevention and should include determining whether these injuries are occurring while stepping on the base or while sliding into the base and instituting the appropriate prevention measures. Student-athletes could participate in drills during practice to better anticipate contact with the base and to learn better landing techniques to mitigate the risk of ankle sprain.

Most concussions among base runners were due to contact with another person. Additionally, the most common competition injuries among catchers were concussions, and most were due to contact with another person. The NCAA has modified its rules regarding defensive team members and obstruction such that, beginning with the 2016 season, a catcher is only allowed to impede the progress of the runner if "*in the act of catching* a thrown ball" rather than when she is "*about to receive* a thrown ball."[17] The NCAA noted that "'about to receive' is a longer time frame than being 'in the act of catching' a thrown ball," thereby reducing the amount of time for a potential collision between the defensive team member and the base runner. Further study is needed to determine whether injuries due to contact with another person decreased after this rule change.

Limitations

Our findings may not be generalizable to other playing levels, such as youth, middle school, and professional programs or to collegiate programs at non-NCAA institutions or high schools without ATs. Furthermore, we were unable to account for factors potentially associated with injury occurrence, such as AT coverage (eg, numbers and frequency), 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 between the systems; this is most evident in the fact that HS RIO uses a random sample, whereas the NCAA-ISP uses a convenience sample. In addition, differences may exist between high school and college in regard to the length of the season in total, as well as the preseason, regular season, and postseason; the potentially longer collegiate season may increase the injury risk. We calculated injury rates using AEs, which may not be as precise an at-risk exposure measure as minutes, hours, or the 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 participating in both HS RIO and the NCAA-ISP.

Although our study is one of the 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 due to differences in maturation status. Playing positions may vary in physical demands and resulting injury risk. The AEs were not collected by position, preventing us from calculating position-specific injury rates. Also, the data regarding injuries at specific positions and activities should be interpreted cautiously, as the AT reported the position the athlete was playing at the time of injury, which may be difficult to interpret in some cases: "running bases" versus "sliding" or "pitcher" versus "fielder" when a pitcher is fielding a batted ball.

CONCLUSIONS

The injury rate in collegiate women's softball was higher than that in high school girls' softball, but the patterns of injuries were largely the same across the 2 levels of play. Clinically, ATs in a collegiate setting should expect to see more softball injuries than in the high school setting. Furthermore, ATs should anticipate that half of injuries will be reported during practices but a higher volume of injuries will occur during games than practices. Resources should be allocated for treating upper extremity injuries more often than lower extremity injuries. Our findings highlight the need for injury-prevention interventions specific to the level of competition and the position. For example, further examination of ways to protect batters from pitches and fielders from batted balls is needed. Additionally, strength-training and injury-prevention programs that focus on awareness while base running may reduce the incidence of ankle sprains. Such interventions should ensure that female softball players continue to participate in their sport while mitigating their risk of injury.

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