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Epidemiology of Injuries in National Collegiate Athletic Association Women's Softball: 2014–2015 Through 2018–2019

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Context: Women's softball athletes account for approximately 9% of all female athletes competing within the National Collegiate Athletic Association (NCAA).

Background: Routine surveillance of NCAA women's softball injuries is important for identifying the emerging injury patterns in this sport.

Methods: Exposure and injury data collected during competitive seasons in the NCAA Injury Surveillance Program during 2014–2015 through 2018–2019 (5 years) academic years were analyzed. Injury counts, rates, and proportions were used to describe injury characteristics; injury rate ratios (IRRs) were used to examine differential injury rates.

Results: The overall injury rate was 3.92 per 1000 athlete exposures. Practice and preseason injury rates increased during 2015/16 through 2018/19. Most injuries were shoulder (15.2%), hand/wrist (11.8%), knee (11.2%), and head/face injuries (11.2%) and were classified as contusions (14.2%), sprains (14.1%), and inflammatory conditions (14.1%). Concussion (6.8%) was the most commonly reported injury, and concussion incidence fluctuated during 2014–2015 through 2018–2019.

Summary: Results indicate an increasing trend in practice and preseason injury incidence. Findings also suggest that workload accumulation in the shoulder and the mechanisms of concussion warrant further attention in this population.

Key Words: collegiate, epidemiology, injury surveillance

Key Points

- Competition injury rates were higher than practice injury rates during the early years of the study period, though the practice injury rate in 2018/19 was notably higher than the corresponding competition injury rate.
- Preseason injury rates were observed to have increased during 2015–16 through 2018/19, while regular season injury rates remained relatively stable during much of the study period.
- Concussions were the most commonly reported specific injury and were predominantly attributed to equipment contact.

The National Collegiate Athletic Association (NCAA) champions high-level competitive softball in the United States, and the first NCAA Women's College World Series was held in 1982.[1] Women's softball is widely participated in at the NCAA level, accounting for approximately 9% of all female NCAA student-athletes.[2] In the 2018/19 academic year alone, more than 1000 member institutions and more than 20 000 NCAA women's softball athletes competed across all divisions.[2] Given the large number of participants and the widespread interest in softball, it is important to examine the burden of injury among NCAA women's softball athletes.

Sport-specific injury surveillance has proven to be an effective mechanism to monitor injury-related trends that allows for athletic performance advancements and evidence-based research targeting improvements in athlete health and safety.[3,4] The NCAA established an injury surveillance system (in its current form, the Injury Surveillance Program [ISP]) in 1982, and injury surveillance among NCAA women's softball athletes has been ongoing for more than 2 decades.[5–8] Previous work in this population has shown that the overall injury rate in women's softball is approximately 3 injuries per 1000 athlete exposures (AEs).[7] It has also been previously reported that overall injury rates vary across divisions; in particular, the Division I rate is higher than the Division III rate.[7,8] Previous findings have also indicated that injuries in collegiate women's softball are most often reported during fielding,[7] with ankle sprains, knee derangements, and concussions being the most commonly reported injuries.[8]

As the most recent study of NCAA women's softball injuries included the 2003–2004 through 2013–2014 academic years, there is a need to identify emerging

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patterns in injury incidence in this population.[7] For instance, it is important to evaluate the evolving burden of injury across event types or during various segments of the competitive season. This information can serve as a foundational platform for targeted research and development of evidence-based policy and injury prevention protocols that mitigate the risk of injury in this population.[3,4] Accordingly, in this report we aim to describe the epidemiology of NCAA women's softball-related injuries reported to the NCAA ISP from 2014–2015 through 2018–2019, with specific aims to evaluate injury characteristics by such factors as event type, competition level, season segment, and player position.

METHODS

Study Data

Women's softball exposure and injury data collected in the NCAA ISP during the 2014–2015 through 2018–2019 competitive seasons were analyzed in this study. The methods of the NCAA ISP have been reviewed and approved as an exempt study by the NCAA Research Review Board. Briefly, athletic trainers at participating institutions contributed exposure and injury data using their clinical electronic medical record systems. A reportable injury was one that occurred due to participation in an organized intercollegiate practice or competition, and required medical attention by a team certified athletic trainer or physician (regardless of time loss). Scheduled team practices and competitions were considered reportable exposures for this analysis. Data from 24 (2% of membership) participating programs in 2014–2015, 18 (2% of membership) in 2015–2016, 24 (2% of membership) in 2016–2017, 28 (3% of membership) in 2017–2018, and 101 (10% of membership) in 2018–2019 qualified for inclusion in analyses. Qualification criteria are detailed further in the methods article within this special issue.[9]

Statistical Analysis

Injury counts and rates (per 1000 AEs, where 1 AE was defined as 1 athlete participating in 1 exposure event) were analyzed across event type (practice, competition), competition level (Division I, Division II, Division III), season segment (preseason, regular season, postseason), and time loss (time loss, non–time loss). Poststratification sample weights by sport, year, and division are established within the surveillance system to compute national estimates of injury events based on the sampled teams. Weighted and unweighted rates were estimated, and all results were presented in terms of unweighted rates (due to low frequencies of injury observations across levels of certain covariates) unless otherwise specified. Temporal trends in injury rates across the study period were evaluated using rate profile plots stratified by the aforementioned variables. Similarly, temporal trends in rates of most commonly reported injuries were also examined across the study period. Injury counts and proportions were examined by time loss (time loss, non–time loss), body part injured, injury mechanism, injury diagnosis, player position, and activity at the time of injury. Injury rate ratios (IRRs) were used to examine differential injury rates across event types, competition levels, and season segments. For instance, the IRR to compare competition- and practice-related injury rates was computed as follows:

$$\mathrm{IRR} = \frac{\left(\frac{\text{Total Number of Competition Injuries}}{\sum_{i=1}^{j} \text{Number of Participating Athletes}}\right)}{\left(\frac{\text{Total Number of Practice Injuries}}{\sum_{i=1}^{k} \text{Number of Participating Athletes}}\right)}$$

where j denotes all reported competition exposure events, and k denotes all reported practice exposure events. IRRs with associated 95% CIs excluding 1.00 were considered statistically significant, and all analyses were conducted using SAS version 9.4 (SAS Institute).

RESULTS

A total of 1511 women's softball injuries from 385 922 AEs were reported to the NCAA ISP during the 2014–2015 through 2018–2019 athletic seasons (3.92 per 1000 AEs). This equated to a national estimate of 40 433 injuries overall (Table 1). The competition and practice injury rates were comparable across the study period (Table 1). Competition injury rates remained relatively stable between 2014–2015 and 2016–2017 before decreasing sharply between 2016–2017 and 2017–2018 (Figure A). In comparison, practice injury rates increased moderately between 2015–2016 and 2017–2018, before sharply increasing during the final year of the study period (Figure A). The overall Division I injury rate (3.48 per 1000 AEs) was lower than Division II (3.85 per 1000 AEs) and Division III (4.61 per 1000 AEs) injury rates. The Division III injury rate was significantly higher than the Division I (IRR = 1.33; 95% CI = 1.17, 1.50) and Division II (IRR = 1.20; 95% CI = 1.06, 1.36) injury rates.

Injuries by Season Segment

A total of 529 preseason injuries (national estimate = 14 078), 945 regular season injuries (national estimate = 25 217), and 37 postseason injuries (national estimate = 1138) were reported from 2014–2015 through 2018–2019 (Table 2). The preseason injury rate (5.23 per 1000 AEs) was higher than the regular season (3.49 per 1000 AEs) and postseason (2.58 per 1000 AEs) rates; statistically significant differences were observed when comparing preseason rates with regular season rates (IRR = 1.50; 95% CI = 1.35, 1.67) and when comparing preseason rates with postseason rates (IRR = 2.03; 95% CI = 1.45, 2.83). Preseason injury rates decreased between 2014–2015 and 2015–2016, then increased steadily thereafter (Figure B). In comparison, regular season injury rates remained stable during the early years of the study before decreasing between 2016–2017 and 2017–2018 and then increasing sharply during the final year of the study (Figure B). Temporal patterns in postseason injury incidence were not examined due to low frequencies of postseason injuries observed during certain years of the study period.

Time Loss

Approximately one-third (31.9%) of all reported injuries during the study period resulted in time loss (time loss was not recorded in 31.0% of all reported injuries). Time-loss injuries accounted for comparable proportions of reported competition (34.2%) and practice (30.2%) injuries. Rates of

Table 1. Reported and National Estimates of Injuries, Athlete Exposures (AEs), and Rates per 1000 AEs by Event Type Across Divisions[a]

	Number AEs Rate per 1000 AEs (95% CI)					
	Overall		Practices		Competitions	
Division	Reported	National Estimate	Reported	National Estimate	Reported	National Estimate
I	489	11712	248	5943	241	5,769
	140531	3553131	79377	2057291	61154	1495840
	3.48 (3.17, 3.79)	3.30 (2.99, 3.60)	3.12 (2.74, 3.51)	2.89 (2.50, 3.28)	3.94 (3.44, 4.44)	3.86 (3.36, 4.35)
II	551	11550	324	6217	227	5,333
	143,274	3070442	81235	1801206	62039	1269236
	3.85 (3.52, 4.17)	3.76 (3.44, 4.08)	3.99 (3.55, 4.42)	3.45 (3.02, 3.89)	3.66 (3.18, 4.13)	4.20 (3.73, 4.68)
III	471	17171	302	10293	169	6879
	102118	4456933	63,034	2861926	39084	1595007
	4.61 (4.20, 5.03)	3.85 (3.44, 4.27)	4.79 (4.25, 5.33)	3.60 (3.06, 4.14)	4.32 (3.67, 4.98)	4.31 (3.66, 4.96)
Overall	1511	40433	874	22452	637	17981
	385922	11080507	223646	6720423	162276	4360083
	3.92 (3.72, 4.11)	3.65 (3.45, 3.85)	3.91 (3.65, 4.17)	3.34 (3.08, 3.60)	3.93 (3.62, 4.23)	4.12 (3.82, 4.43)

[a] Data presented in the order of reported number, followed by athlete exposures (AEs), estimated injury rates, and associated 95% Confidence Intervals (CIs) for each cross-tabulation of division and event types. Data pooled association-wide are presented overall, and separately for practices and competitions. National estimates were produced using sampling weights estimated on the basis of sport, division, and year. All CIs were constructed using variance estimates calculated on the basis of reported data. A reportable injury was one that occurred due to participation in an organized intercollegiate practice or competition, and required medical attention by a team Certified Athletic Trainer or physician (regardless of time loss). Only scheduled team practices and competitions were retained in this analysis.

competition-related time-loss injuries followed an increasing trajectory between 2014–2015 and 2016–2017 before fluctuating drastically during the final years of the study (Figure C). In contrast, rates of practice-related time-loss injuries followed a decreasing trajectory between 2014–2015 and 2016–2017 and steadily increased thereafter (Figure C).

Injury Characteristics

Shoulder (15.2%), hand/wrist (11.8%), knee (11.2%), and head/face (11.2%) injuries accounted for the largest proportions of all injuries reported during the study. Knee injuries accounted for comparable proportions of practice- and competition-related injuries (Table 3). Conversely, shoulder injuries (61% of which were attributed to throwing or pitching activities) accounted for a larger proportion of practice injuries (17.3%) than competition injuries (12.2%), and head/face injuries accounted for a larger proportion of competition injuries (14.3%) than practice injuries (8.9%). About one-quarter of all reported injuries were accredited to noncontact mechanisms (25.0%), and noncontact injuries accounted for compara-

Table 2. Reported and National Estimates of Injuries, Athlete Exposures (AEs), and Rates per 1000 AEs by Season Segment Across Divisions[a]

	Number AEs Rate per 1000 AEs (95% CI)					
	Preseason		Regular Season		Postseason	
Division	Reported	National Estimate	Reported	National Estimate	Reported	National Estimate
I	142	3595	343	8033	4	84
	37971	1016166	98657	2439472	3902	97493
	3.74 (3.12, 4.35)	3.54 (2.92, 4.15)	3.48 (3.11, 3.84)	3.29 (2.92, 3.66)	1.03 (0.02, 2.03)	0.86 (0.00, 1.87)
II	191	4010	345	7265	15	274
	33051	772562	105173	2211035	5049	86846
	5.78 (4.96, 6.60)	5.19 (4.37, 6.01)	3.28 (2.93, 3.63)	3.29 (2.94, 3.63)	2.97 (1.47, 4.47)	3.16 (1.65, 4.66)
III	196	6,473	257	9919	18	780
	30108	1147252	66623	3131799	5387	177882
	6.51 (5.60, 7.42)	5.64 (4.73, 6.55)	3.86 (3.39, 4.33)	3.17 (2.70, 3.64)	3.34 (1.80, 4.89)	4.38 (2.84, 5.93)
Overall	529	14078	945	25217	37	1138
	101131	2935980	270453	7782306	14338	362222
	5.23 (4.79, 5.68)	4.79 (4.35, 5.24)	3.49 (3.27, 3.72)	3.24 (3.02, 3.46)	2.58 (1.75, 3.41)	3.14 (2.31, 3.97)

[a] Data presented in the order of reported number, followed by athlete exposures (AEs), estimated injury rates, and associated 95% Confidence Intervals (CIs) for each cross-tabulation of division and season segments. Data pooled association-wide are presented overall, and separately for preseason, regular season, and post season. National estimates were produced using sampling weights estimated on the basis of sport, division, and year. All CIs were constructed using variance estimates calculated on the basis of reported data. A reportable injury was one that occurred due to participation in an organized intercollegiate practice or competition and required medical attention by a team certified athletic trainer or physician (regardless of time loss). Only scheduled team practices and competitions were retained in this analysis.

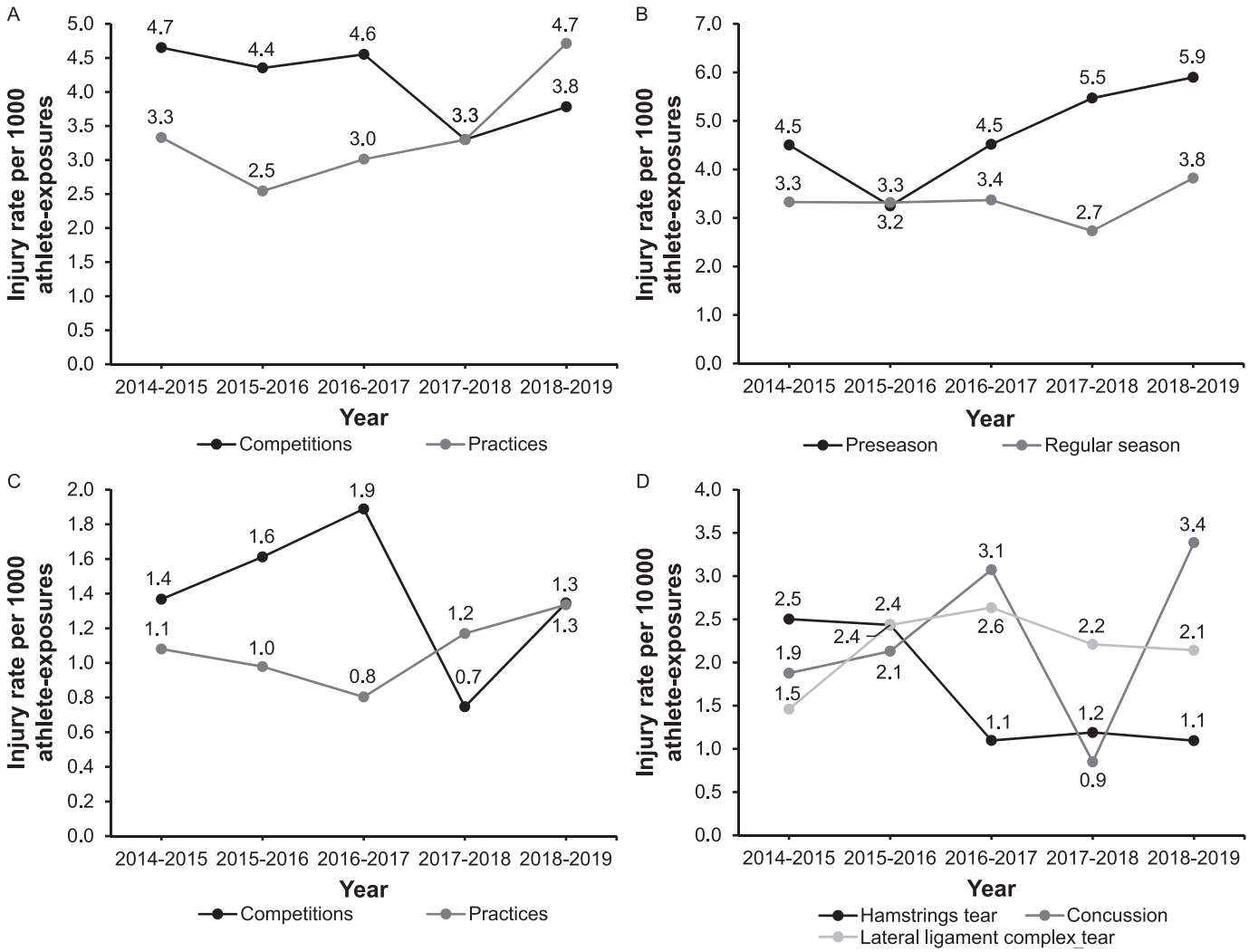

Figure. Temporal patterns in injury rates between 2014–2015 and 2018–2019. A, Overall injury rates (per 1000 athlete exposures [AEs]) stratified by event type (practices, competitions). B) Injury rates (per 1000 AEs) stratified by season segment. C, Rates (per 1000 AEs) of time-loss injuries stratified by event type (practices, competitions). D) Rates (per 10 000 AEs) of most commonly reported injuries. "Hamstring tear" and "Lateral Ligament Complex tear" includes complete and partial tears. Rates presented in all figures are unweighted and based on reported data.

ble proportions of practice (26.7%) and competition (22.6%) injuries (Table 3). Overuse mechanism injuries also accounted for a notable proportion (21.4%) of all reported injuries. Overuse injuries accounted for a larger proportion of reported practice injuries (29.4%) than competition injuries (10.4%).

Overall, women's softball injuries reported between 2014–2015 and 2018–2019 were most commonly classified as strains (19.3%). Contusions (14.2%), sprains (14.1%), and inflammatory conditions (14.1%) also accounted for considerable proportions of all reported injuries. Strains accounted for comparable proportions of competition (18.5%) and practice (19.9%) injuries. Contusions and sprains accounted for larger proportions of competition injuries than practice injuries, while inflammatory conditions were more prevalent among reported practice injuries than competition injuries (Table 3). The most commonly reported specific injuries during the study period were concussion (6.8%), lateral ligament complex tears (ankle sprains; 5.5%), and hamstring tears (3.6%). Concussions were most often attributed to equipment contact (59.2%) and player contact (20.4%). Rates of lateral ligament complex tears were stable for most of the study period (Figure D). Rates of hamstring tears followed a decreasing trajectory between 2014–2015 and 2016–2017 and remained stable thereafter, while concussion rates fluctuated across the study period (Figure D).

Injuries by Women's Softball-Specific Activities and Playing Positions

Women's softball injuries reported during the study period were comparably distributed among several activities, including throwing, fielding, batting, general play, and pitching (Table 4). Throwing and general play accounted for larger proportions of practice injuries than competition injuries, while batting and pitching injuries accounted for larger proportions of competition injuries than practice injuries (Table 4). Most women's softball injuries during the study period were reported among outfielders (Table 4).

Table 3. Distribution of Injuries by Body Part, Mechanism, and Injury Diagnosis Stratified by Event Type

	Overall		Competitions		Practices	
	Injuries Reported (%)	National Estimate (%)	Injuries Reported (%)	National Estimate (%)	Injuries Reported (%)	National Estimate (%)
Injury site						
Head/face	169 (11.18)	3852 (9.53)	91 (14.29)	2097 (11.66)	78 (8.92)	1755 (7.82)
Neck	20 (1.32)	531 (1.31)	8 (1.26)	96 (0.53)	12 (1.37)	434 (1.93)
Shoulder	229 (15.16)	5556 (13.74)	78 (12.24)	2032 (11.30)	151 (17.28)	3524 (15.70)
Arm/elbow	131 (8.67)	3722 (9.21)	45 (7.06)	1357 (7.55)	86 (9.84)	2365 (10.53)
Hand/wrist	178 (11.78)	4469 (11.05)	96 (15.07)	2547 (14.16)	82 (9.38)	1922 (8.56)
Trunk	113 (7.48)	3132 (7.75)	38 (5.97)	1075 (5.98)	75 (8.58)	2057 (9.16)
Hip/groin	76 (5.03)	1880 (4.65)	24 (3.77)	555 (3.09)	52 (5.95)	1325 (5.90)
Thigh	133 (8.80)	4929 (12.19)	52 (8.16)	1990 (11.07)	81 (9.27)	2939 (13.09)
Knee	169 (11.18)	4748 (11.74)	74 (11.62)	2242 (12.47)	95 (10.87)	2506 (11.16)
Lower leg	95 (6.29)	2127 (5.26)	42 (6.59)	900 (5.01)	53 (6.06)	1227 (5.46)
Ankle	123 (8.14)	3359 (8.31)	61 (9.58)	2100 (11.68)	62 (7.09)	1258 (5.60)
Foot	55 (3.64)	1588 (3.93)	20 (3.14)	753 (4.19)	35 (4.00)	834 (3.71)
Other	20 (1.32)	543 (1.34)	8 (1.26)	237 (1.32)	12 (1.37)	306 (1.36)
Mechanism						
Player contact	109 (7.21)	3255 (8.05)	82 (12.87)	2437 (13.55)	27 (3.09)	819 (3.65)
Surface contact	199 (13.17)	5546 (13.72)	98 (15.38)	3068 (17.06)	101 (11.56)	2478 (11.04)
Equipment Contact	357 (23.63)	9076 (22.45)	199 (31.24)	5188 (28.85)	158 (18.08)	3888 (17.32)
Other contact	14 (0.93)	334 (0.83)	6 (0.94)	105 (0.58)	8 (0.92)	229 (1.02)
Noncontact	377 (24.95)	10 946 (27.07)	144 (22.61)	4042 (22.48)	233 (26.66)	6904 (30.75)
Overuse	323 (21.38)	8256 (20.42)	66 (10.36)	1941 (10.79)	257 (29.41)	6315 (28.13)
Illness/infection	9 (0.60)	293 (0.72)	2 (0.31)	66 (0.37)	7 (0.80)	228 (1.02)
Other/unknown	123 (8.14)	2726 (6.74)	40 (6.28)	1134 (6.31)	83 (9.50)	1592 (7.09)
Diagnosis						
Abrasion/laceration	34 (2.25)	895 (2.21)	21 (3.30)	629 (3.50)	13 (1.49)	266 (1.18)
Concussion	103 (6.82)	2223 (5.50)	57 (8.95)	1332 (7.41)	46 (5.26)	891 (3.97)
Contusion	215 (14.23)	5528 (13.67)	128 (20.09)	3335 (18.55)	87 (9.95)	2193 (9.77)
Dislocation/subluxation.	41 (2.71)	1067 (2.64)	23 (3.61)	512 (2.85)	18 (2.06)	554 (2.47)
Entrapment/impingement	42 (2.78)	1053 (2.60)	12 (1.88)	235 (1.31)	30 (3.43)	818 (3.64)
Fracture	64 (4.24)	1569 (3.88)	37 (5.81)	792 (4.40)	27 (3.09)	777 (3.46)
Illness/infection/derm.	4 (0.26)	148 (0.37)	0 (0.0)	0 (0.0)	4 (0.46)	148 (0.66)
Inflammatory condition	213 (14.10)	5379 (13.30)	43 (6.75)	1167 (6.49)	170 (19.45)	4213 (18.76)
Spasm	62 (4.10)	1218 (3.01)	16 (2.51)	424 (2.36)	46 (5.26)	794 (3.54)
Sprain	213 (14.10)	6271 (15.51)	109 (17.11)	3859 (21.46)	104 (11.90)	2412 (10.74)
Strain	292 (19.32)	8854 (21.90)	118 (18.52)	3559 (19.79)	174 (19.91)	5295 (23.58)
Other	228 (15.09)	6229 (15.41)	73 (11.46)	2138 (11.89)	155 (17.73)	4091 (18.22)

[a] Data presented in the order of reported number, followed by the proportion of all injuries attributable to a given category. Data pooled across event types are presented overall, and separately for practices and competitions. National estimates were produced using sampling weights estimated on the basis of sport, division, and year. A reportable injury was one that occurred due to participation in an organized intercollegiate practice or competition, and required medical attention by a team Certified Athletic Trainer or physician (regardless of time loss). Only scheduled team practices and competitions were retained in this analysis.

SUMMARY

This study aimed to describe the epidemiology of NCAA women's softball-related injuries during the 2014–2015 through 2018–2019 athletic seasons. Across the study period, the overall practice and competition injury rates were comparable, although a larger proportion of all reported injuries were practice related (~58%). In the present study, we did not observe a difference between competition and practice injury rates. Conversely, previous studies (albeit including only TL injuries in analyses) have reported higher competition injury rates than practice injury rates in this population (1988–1989 through 2003–2004: IRR = 1.60; 95% CI = 1.50, 1.70; 2004–2005 through 2013–2014: IRR = 1.39; 95% CI = 1.27, 1.52).[7,8] Notably, the competition injury rate decreased sharply between 2016–2017 and 2017–2018, and although it increased thereafter during the final year of the study, the practice injury rate also rose considerably during the same time period. Consequently, the practice injury rate was markedly higher than the competition injury rate during the final year of the study, and it is reasonable to suggest that the overall comparability of practice- and competition-related injury rates is attributable to the aforementioned changes observed between 2016–2017 and 2018–2019. Further, preseason injury rates steadily increased during the majority of the study period. Given this result, it may be important to assess preseason training routines, particularly the abrupt change in workload between offseason and preseason, to better understand preseason injury risk in this population. The NCAA ISP does not collect detailed information on training activities (specific drills or exercises) and is therefore unable to support such assessments. Future studies should specifically target preseason training routines, including the rapid return to play and high repetitions of throwing in softball (which may be activity with the greatest change in frequency/repetition between offseason and preseason). Given that athletes are at greater risk of injury after rapid return to activity without adequate

Table 4. Distribution of Injuries by Women's Softball-Specific Activities and Player Position[a]

	Overall		Competitions		Practices	
	Injuries Reported (%)	National Estimate (%)	Injuries Reported (%)	National Estimate (%)	Injuries Reported (%)	National Estimate (%)
Activity						
Base Running	141 (9.33)	3873 (9.58)	86 (13.50)	2698 (15.00)	55 (6.29)	1175 (5.23)
Batting	165 (10.92)	3660 (9.05)	91 (14.29)	2035 (11.32)	74 (8.47)	1625 (7.24)
Conditioning	51 (3.38)	1832 (4.53)	3 (0.47)	102 (0.57)	48 (5.49)	1730 (7.71)
Fielding	172 (11.38)	4452 (11.01)	76 (11.93)	1814 (10.09)	96 (10.98)	2638 (11.75)
General Play	165 (10.92)	3970 (9.82)	38 (5.97)	1110 (6.17)	127 (14.53)	2860 (12.74)
Chasing/diving	97 (6.42)	3254 (8.05)	57 (8.95)	2202 (12.25)	40 (4.58)	1053 (4.69)
Pitching	148 (9.79)	3921 (9.70)	74 (11.62)	2022 (11.25)	74 (8.47)	1899 (8.46)
Catching	103 (6.82)	2307 (5.71)	51 (8.01)	1166 (6.48)	52 (5.95)	1141 (5.08)
Running	85 (5.63)	2646 (6.54)	27 (4.24)	995 (5.53)	58 (6.64)	1652 (7.36)
Sliding	49 (3.24)	1490 (3.69)	32 (5.02)	1123 (6.25)	17 (1.95)	367 (1.63)
Throwing	173 (11.45)	4436 (10.97)	40 (6.28)	1054 (5.86)	133 (15.22)	3382 (15.06)
Other/unknown	162 (10.72)	4591 (11.35)	62 (9.73)	1660 (9.23)	100 (11.44)	2931 (13.05)
Position						
Base runner	92 (6.09)	2890 (7.15)	59 (9.26)	2072 (11.52)	33 (3.78)	819 (3.65)
Batter	88 (5.82)	1960 (4.85)	49 (7.69)	899 (5.00)	39 (4.46)	1062 (4.73)
Catcher	182 (12.05)	4595 (11.36)	75 (11.77)	2060 (11.46)	107 (12.24)	2535 (11.29)
Corner Infielder	211 (13.96)	5617 (13.89)	80 (12.56)	2493 (13.86)	131 (14.99)	3124 (13.91)
Middle Infielder	261 (17.27)	7216 (17.85)	110 (17.27)	3504 (19.49)	151 (17.28)	3712 (16.53)
Outfielder	359 (23.76)	9654 (23.88)	136 (21.35)	3673 (20.43)	223 (25.51)	5982 (26.64)
Pitcher	235 (15.55)	6142 (15.19)	101 (15.86)	2719 (15.12)	134 (15.33)	3423 (15.25)
Other/unknown	83 (5.49)	2358 (5.83)	27 (4.24)	562 (3.13)	56 (6.41)	1796 (8.00)

[a] Data presented in the order of reported number, followed by the proportion of all injuries attributable to a given category. Data pooled across event types are presented overall, and separately for practices and competitions. National estimates were produced using sampling weights estimated on the basis of sport, division, and year. A reportable injury was one that occurred due to participation in an organized intercollegiate practice or competition, and required medical attention by a team Certified Athletic Trainer or physician (regardless of time loss). Only scheduled team practices and competitions were retained in this analysis.

rest,[10,11] implementing workload monitoring and subsequent workload management may form parts of effective injury prevention programs throughout the softball season.[12] Nonetheless, based on the results observed in this study, it remains vital to continue monitoring practice-related and preseason injury incidence beyond 2018–2019. This may be particularly important considering the marked increase in NCAA ISP participation among women's softball programs during the final year of the study, which is largely attributable to revised recruitment strategies (eg, support and communication from the NCAA Sport Science Institute). Although the external validity of the findings presented here may be limited by low ISP participation during the earlier years of the study period, it is reasonable to suggest that the estimates associated with 2018–2019 are a more appropriate representation of the injury burden in this population compared with the earlier years. Close monitoring of the incidence trajectories of practice-related and preseason injuries will elucidate whether the patterns observed here are maintained, and will inform the direction of specific injury prevention efforts.

Most women's softball injuries reported were attributed to the shoulder, hand/wrist, knee, and head/face. Most shoulder injuries occurred during pitching or throwing activities. Similar distributions of injuries by body part have also been previously reported in men's baseball.[13] It has been previously suggested that softball (windmill) and baseball (overhead) pitching create a similar joint distraction moment in the shoulder,[12,14,15] and it is further estimated that the maximum weight force produced on the shoulder, during windmill pitching motion in particular, is ~70% to 80% of the pitcher's body weight.[14] Despite these biomechanical similarities, our results, coupled with findings from previous studies of NCAA baseball and softball, highlight differences in the prevalence of injury associated with the pitching activity, with much higher proportions of practice and competition pitching injuries being sustained by baseball pitchers than softball pitchers.[7,13] An additional point to consider when comparing the injury epidemiology across NCAA baseball and softball is the difference in proportion of pitchers within a softball or baseball roster (ie, softball teams on average may carry comparatively fewer pitchers, subsequently resulting in a greater volume of exposures among softball pitchers). It may therefore be important to particularly assess the accumulation of concentrated workload (in the shoulder) among pitchers to better reconcile the observed findings and inform future injury prevention efforts. That said, workload monitoring (ie, pitch count, pitch type, pitch speed),[10,16,17] which has been used across overhead-throwing–dominant sports, may also be effectively leveraged to better assess injury risk and prevent injuries in women's softball.[18] Such investigations may be used to better understand the etiology of shoulder injuries in this population and prompt interventions aimed at managing training workloads during practice and pitcher recovery status. The NCAA ISP in its current form is not equipped to accommodate workload monitoring. As such, targeted studies may be needed to better understand the relationship between workload accumulation and overuse injury risk among NCAA women's softball athletes. Further, the overhead throw, which is a common activity among infield players and an activity in which injuries were prevalent, is biomechanically distinct from windmill pitching. There-

fore, injuries attributed to throwing and pitching should be examined separately. There is a paucity of data examining the overhead throw among softball players. However, the relationship between hip, trunk, shoulder, and elbow muscle activation has been identified to be critical for a biomechanically efficient throw.[19] Softball players use a larger and heavier ball than baseball players, potentially influencing the nature and etiology of (overhead) throwing injuries. In its current form, the NCAA ISP does not collect nuanced athlete-level information that could identify a connection between the injuries observed in the present study and biomechanical differences that may result from a larger and heavier ball (compared with baseball). As such, future research efforts should also be directed toward investigating the complex neuromusculoskeletal movements associated with the overhead throw in softball by specifically capturing and analyzing biomechanical (throwing) information, including athlete-specific workload metrics/indices. Together with sports injury surveillance, these efforts are likely to better characterize the scientific understanding of overhead movements and risk of injury.

The most commonly reported specific injuries were concussions, lateral ligament complex (partial or complete) tears of the ankle, and hamstring tears (partial or complete). The incidence of lateral ligament complex tears and hamstring tears remained relatively stable during much of the study period. Conversely, concussion rates fluctuated throughout the study period and increased drastically between 2017–2018 and 2018–2019. In juxtaposition to the stability in rates of lateral ligament complex tears and hamstring tears, the marked increase in concussion rates that accompanied improved participation in the ISP is noteworthy. While it is reasonable to suggest that the observed concussion rate in 2018–2019 may be attributable to greater awareness and diagnostic sensitivity, it is likely that there are also other contributing factors.[20,21] Given the limited contact nature of the sport,[22] it may be particularly important for future studies to specifically examine the dynamics of equipment/apparatus contact-resultant concussions in this population while continuing to monitor concussion incidence after 2018–2019. This is particularly salient given that concussions were most prevalently attributed to equipment contact mechanisms in the present study. Further investigation of inciting mechanisms and antecedent events surrounding concussions in women's softball is needed to truly appraise the burden of concussions to NCAA women's softball athletes.

The results of this study were in alignment with existing research in this population, though the observed trajectories of practice injury rates and preseason injury rates are noteworthy and warrant further attention. Future research may also target concussion incidence, overuse injury etiology, and the relationship between workload accumulation and shoulder injury risk in this population. While surveillance-based studies are important in identifying salient patterns in injury incidence, small-scale studies are needed to expand on the observed results to better understand the underlying etiologic frameworks.

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REFERENCES

1. Wright K. A brief history of grand slams at the Women's College World Series. National Collegiate Athletic Association. Accessed March 13, 2021. https://www.ncaa.com/news/softball/article/2020-06-16/brief-history-grand-slams-womens-college-world-series
2. NCAA sports sponsorship and participation rates database. National Collegeiate Athletic Association. Published 2020. Accessed July 3, 2020. http://www.ncaa.org/about/resources/research/ncaa-sports-sponsorship-and-participation-rates-database
3. van Mechelen W, Hlobil H, Kemper HCG. Incidence, severity, aetiology and prevention of sports injuries: a review of concepts. *Sports Med*. 1992;14(2):82–99. doi:10.2165/00007256-199214020-00002
4. Chandran A, Nedimyer AK, Register-Mihalik JK, DiPietro L, Kerr ZY. Comment on: "Incidence, severity, aetiology and prevention of sports injuries: a review of concepts." *Sport Med*. 2019;49(10):1621–1623. doi:10.1007/s40279-019-01154-1
5. Kerr ZY, Comstock RD, Dompier TP, Marshall SW. The first decade of web-based sports injury surveillance (2004-2005 through 2013-2014): methods of the National Collegiate Athletic Association Injury Surveillance Program and High School Reporting Information Online. *J Athl Train*. 2018;53(8):729–737. doi:10.4085/1062-6050-143-17
6. Dick R, Agel J, Marshall SW. National Collegiate Athletic Association Injury Surveillance System commentaries : introduction and methods. *J Athl Train*. 2007;42(2):173–182.
7. Wasserman EB, Register-Mihalik JK, Sauers EL, et al. 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). *J Athl Train*. 2019;54(2):212–225. doi:10.4085/1062-6050-206-17
8. Marshall SW, Hamstra-Wright KL, Dick R, Grove KA, Agel J. Descriptive epidemiology of collegiate women's softball injuries: National Collegiate Athletic Association Injury Surveillance System, 1988–1989 through 2003–2004. *J Athl Train*. 2007;42(2):286–294. doi:10.1016/s0276-1092(08)79204-6
9. Chandran A, Morris SN, Wasserman EB, Boltz A, Collins CL. Methods of the National Collegiate Athletic Association Injury Surveillance Program, 2014–2015 Through 2018–2019. *J Athl Train*. 2021;56(7):616–621.
10. Black GM, Gabbett TJ, Cole MH, Naughton G. Monitoring workload in throwing-dominant sports: a systematic review. *Sports Med*. 2016;46(10):1503–1516. doi:10.1007/s40279-016-0529-6
11. Vetter RE, Symonds ML. Correlations between injury, training intensity, and physical and mental exhaustion among college athletes. *J Strength Cond Res*. 2010;24(3):587–596. doi: 10.1519/JSC.0b013e3181c7c2eb
12. Fry KE, Wittman K, Gerke D, Parr A. Clinical and biomechanical evaluation of the softball pitcher: a review of current concepts and clinical commentary. *Clin J Sport Med*. 2019;29(5):406–412. doi:10.1097/JSM.0000000000000692
13. Wasserman EB, Sauers EL, Register-Mihalik JK, et al. The first decade of web-based sports injury surveillance: descriptive epidemiology of injuries in US high school boys' baseball (2005–2006 through 2013–2014) and National Collegiate Athletic Association men's baseball (2004–2005 through 2013–2014). *J Athl Train*. 2019;54(2):198–211. doi:10.4085/1062-6050-239-17

14. Barrentine SW, Fleisig GS, Whiteside JA, Escamilla RF, Andrews JR. Biomechanics of windmill softball pitching with implications about injury mechanisms at the shoulder and elbow. *J Orthop Sports Phys Ther*. 1998;28(6):405–415. doi:10.1111/j.2042-3306.1986.tb04621.x
15. Rojas IL, Provencher MT, Bhatia S, et al. Biceps activity during windmill softball pitching: injury implications and comparison with overhand throwing. *Am J Sports Med*. 2009;37(3):558–565. doi:10.1177/0363546508328105
16. Yang JS, Stepan JG, Dvoracek L, Wright RW, Brophy RH, Smith MV. Fast-pitch softball pitchers experience a significant increase in pain and fatigue during a single high school season. *HSS J*. 2016;12(2):111–118. doi:10.1007/s11420-016-9499-3
17. Shanley E, Michener LA, Ellenbecker TS, Rauh MJ. Shoulder range of motion, pitch count, and injuries among interscholastic female softball pitchers: a descriptive study. *Int J Sports Phys Ther*. 2012;7(5):548–557. http://www.ncbi.nlm.nih.gov/pubmed/23091788
18. Shanley E, Rauh MJ, Michener LA, Ellenbecker TS. Incidence of injuries in high school softball and baseball players. *J Athl Train*. 2011;46(6):648–654. doi:10.4085/1062-6050-46.6.648
19. Gilmer GG, Washington JK, Dugas JR, Andrews JR, Oliver GD. The role of lumbopelvic-hip complex stability in softball throwing mechanics. *J Sport Rehabil*. 2019;28(2):196–204. doi: 10.1123/jsr.2017-0276
20. Register-Mihalik JK, Guskiewicz KM, Valovich McLeod TC, Linnan LA, Mueller FO, Marshall SW. Knowledge, attitude, and concussion-reporting behaviors among high school athletes: a preliminary study. *J Athl Train*. 2013;48(5):645–653. doi:10.4085/1062-6050-48.3.20
21. McGuine TA, Pfaller AY, Post EG, Hetzel SJ, Brooks A, Broglio SP. The influence of athletic trainers on the incidence and management of concussions in high school athletes. *J Athl Train*. 2018;53(11):1017–1024. doi:10.4085/1062-6050-209-18
22. Rice SG, American Academy of Pediatrics Council on Sports Medicine and Fitness. Medical conditions affecting sports participation. *Pediatrics*. 2008;121(4):841–848. doi:10.1542/peds.2008-0080

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