Journal of Athletic Training 2021;56(7):750–757
doi: 10.4085/1062-6050-613-20

www.natajournals.org

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

Abigail C. Bretzin, PhD, ATC*; Bernadette A. D'Alonzo, MPH*; Avinash Chandran, PhD, MS†; Adrian J. Boltz, MSH†; Hannah J. Robison, MS, LAT, ATC†; Christy L. Collins, PhD†; Sarah N. Morris, PhD†

*Department of Biostatistics, Epidemiology and Informatics, Penn Injury Science Center, University of Pennsylvania, Philadelphia; †Datalys Center for Sports Injury Research and Prevention, Indianapolis, IN

Context: Lacrosse is an increasingly popular sport; the number of teams participating in collegiate women's lacrosse has increased by 21.4% in the past 5 years.

Background: The growth of National Collegiate Athletic Association women's lacrosse, coupled with the ongoing discussions surrounding protective equipment, necessitates further epidemiologic studies in this population.

Methods: Exposure and injury data collected in the National Collegiate Athletic Association Injury Surveillance Program during 2014–2015 through 2018–2019 were analyzed. Injury counts, rates, and proportions were used to describe injury characteristics, and injury rate ratios with 95% CIs were used to examine differential injury rates.

Results: The overall injury rate was 4.99 per 1000 athlete exposures. Less than 30% of injuries were time-loss injuries; injuries were most commonly attributed to noncontact (26.6%) and overuse (25.2%) mechanisms. The most commonly reported specific injuries were lateral ligament complex tears (ankle sprains; 9.1%), concussions (7.2%), and hamstring tears (3.8%).

Summary: Findings from this study were consistent with the existing epidemiologic evidence in previous studies. Injury incidence in practices, in preseason, and as a result of player contact warrant further attention in this population.

Key Words: collegiate sports, descriptive epidemiology, injury surveillance

Key Points

- The overall competition injury rate was higher than the practice injury rate; competition and practice injury rates remained relatively stable across the study period.
- Most injuries were attributed to non-contact and overuse mechanisms.
- The most common specific injuries reported were ankle sprains, concussions, and hamstring tears; rates of hamstring tears initially increased and then followed a decreasing trajectory during 2015-16 through 2017–18, while rates of ankle sprains increased for the majority of the study period before decreasing during the final year.

Lacrosse is an increasingly popular sport, and it is suggested to be the fastest-growing team sport in the United States since 2001 across all levels of participation.[1,2] Collegiate lacrosse participation in particular has grown in recent years, as the number of National Collegiate Athletic Association (NCAA) schools sponsoring women's lacrosse increased from 416 (14 767 players) in 2013 to 505 (17 640 players) in 2018.[2] Parallel to the increase in popularity and participation, epidemiologic studies of injuries related to women's lacrosse athletes have emerged and identified the burden of injury in this sport.[1,3–6] The sustained rise in women's collegiate lacrosse sponsorship and participation necessitates routine epidemiologic investigation into the nature and incidence of injuries in this population.

Since the 1980s, the NCAA has acquired injury data related to participation in collegiate athletics through sports injury surveillance.[7] Continued monitoring of athletic injury is currently accomplished electronically via the NCAA Injury Surveillance Program (ISP).[7,8] Prior researchers using data from the NCAA ISP have identified the overall injury rate in women's lacrosse as approximately 4 injuries per 1000 athlete exposures (AEs)[3,5]; however, until recently, nontime loss (NTL) injuries were not included in the analyses. In addition, the Division III injury rate has been noted to be higher than the Division I injury rate, and the rate of injury during competitions has been reported as more than twice as high as the practice injury rate.[5] Prior investigators have also indicated that the hip/thigh/upper leg, ankle, and knee were among the most commonly injured body parts, and ligament sprains, muscle/tendon strains, and concussions were among the most common diagnoses in NCAA women's lacrosse.[5]

The articles in this issue are published as accepted and have not been edited.

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	495	7778	332	5216	163	2562
	110 230	1 770 060	90 351	454 241	19 879	315 819
	4.49 (4.10, 4.89)	4.39 (4.00, 4.79)	3.67 (3.28, 4.07)	3.59 (3.19, 3.98)	8.20 (6.94, 9.46)	8.11 (6.85, 9.37)
II	354	3802	227	2381	127	1421
	96 744	1 429 844	77 999	1 165 096	18 745	264 748
	3.66 (3.28, 4.04)	2.66 (2.28, 3.04)	2.91 (2.53, 3.29)	2.04 (1.67, 2.42)	6.78 (5.60, 7.95)	5.37 (4.19, 6.55)
III	586	14 044	389	9225	197	4819
	80 648	2 093 497	64 360	1 691 751	16 288	401 747
	7.27 (6.68, 7.85)	6.71 (6.12, 7.30)	6.04 (5.44, 6.64)	5.45 (4.85, 6.05)	12.09 (10.41, 13.78)	12.00 (10.31, 13.68)
Overall	1435	25 624	948	16 822	487	8802
	287 622	5 293 401	232 710	4 311 ,087	54 912	982 314
	4.99 (4.73, 5.25)	4.84 (4.58, 5.10)	4.07 (3.81, 4.33)	3.90 (3.64, 4.16)	8.87 (8.08, 9.66)	8.96 (8.17, 9.75)

[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.

Further, the notable burden of head/face injuries has sparked discussion surrounding the role of protective equipment in the sport.[5,9] Given the continued increase in NCAA women's lacrosse participation, and the emerging interest in the topic of protective equipment in women's lacrosse (eg, addition of a helmet),[9] it is critical to update the epidemiologic evidence surrounding injury incidence in this population. Therefore, the purpose of this study was to summarize the descriptive epidemiology of women's lacrosse injuries in a sample of NCAA teams recorded in the NCAA ISP during the 2014–2015 through 2018–2019 athletic seasons.

METHODS

Study Data

In this study we analyzed women's lacrosse exposure and injury data collected in the NCAA ISP during the 2014–2015 through 2018–2019 athletic seasons. The methods of the NCAA ISP have been reviewed and approved as an exempt study by the NCAA Research Review Board. Athletic trainers (ATs) 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 an AT or physician regardless of time loss. Reportable exposures included scheduled team practices and competitions for this analysis. Data from 18 (4% of membership) participating programs in 2014–2015, 12 (3% of membership) in 2015–2016, 17 (3% of membership) in 2016–2017, 23 (5% of membership) in 2017–2018, and 69 (13% of membership) in 2018–2019 qualified for inclusion in analyses. The methods manuscript in this special issue further details the surveillance program and qualification criteria for participating programs.[10]

Statistical Analysis

Injury counts and rates per 1000 AEs were examined overall and by event type (practice, competition), competition level (Division I, Division II, Division III), season segment (preseason, regular season, postseason), and time loss (time loss [TL], NTL). An AE was defined as 1 athlete participating in 1 exposure event (practice or competition). Weighted and unweighted rates were estimated; however, results were presented in terms of unweighted rates due to low frequencies of injury observations across levels of certain covariates unless otherwise specified. Rate profile plots displayed temporal trends in injury rates across the study period stratified by levels of exposure characteristics, and time trends in rates of most commonly reported injuries were examined across the study period. Stratified injury counts and proportions were presented by TL, 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. IRRs with associated 95% CIs excluding 1.00 were considered statistically significant. All analyses were conducted using SAS version 9.4 (SAS Institute).

RESULTS

A total of 1435 women's lacrosse injuries from 287 622 AEs were reported to the NCAA ISP during the 2014–2015 through 2018–2019 athletic seasons, yielding an overall injury rate of 4.99 per 1000 AEs (95% CI = 4.33, 5.25). This equated to a national estimate of 25 624 injuries overall (Table 1). Across the study period, the competition injury rate was higher than the practice injury rate (IRR = 2.18; 95% CI = 1.95, 2.43). Competition injury rates remained relatively stable throughout the study period, with the exception of an increase during the 2017–2018 season (Figure A). Practice injury rates also remained stable

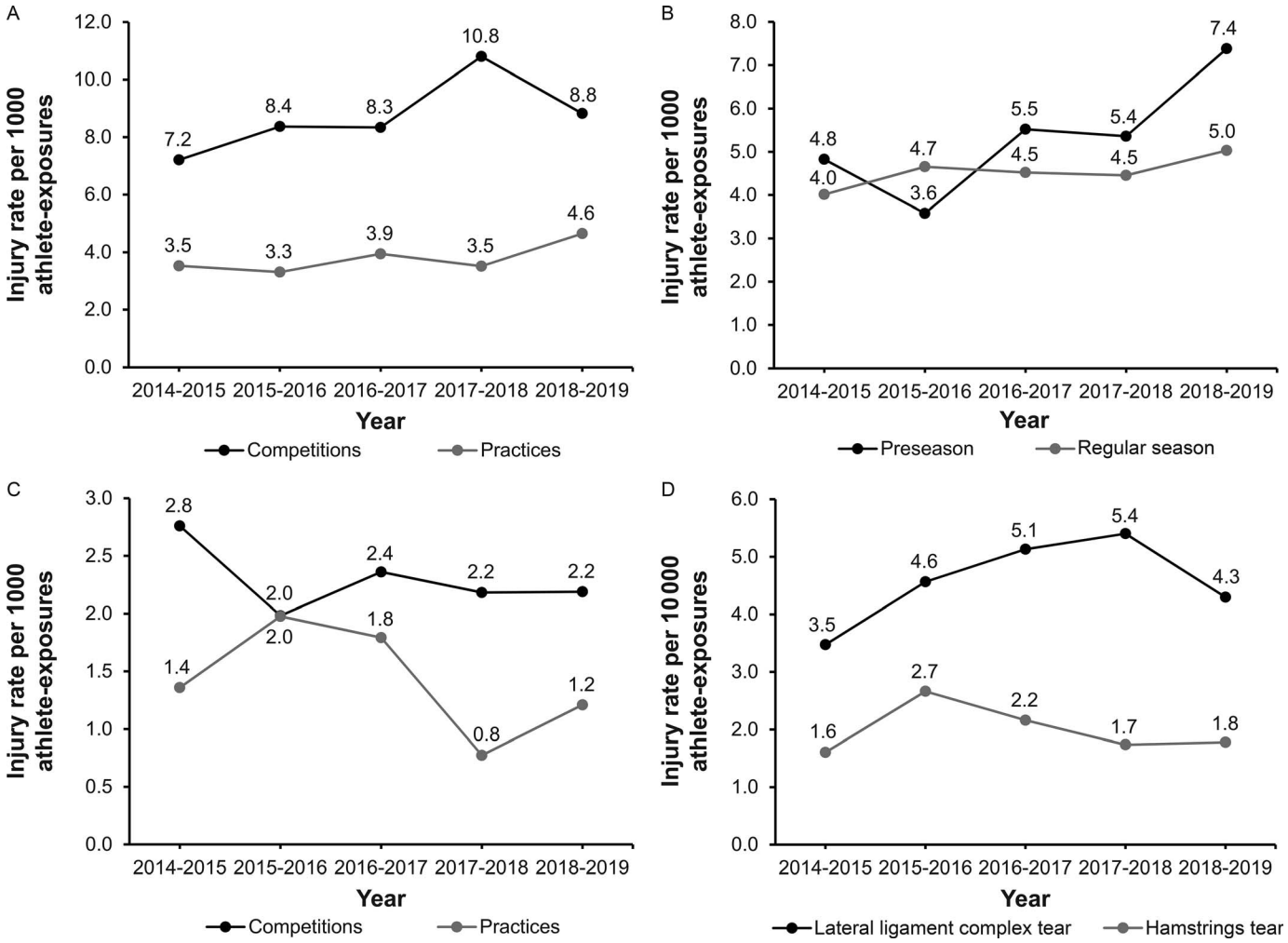

Figure. Temporal patterns in injury rates between 2014–2015 and 2018–2019. A, Overall injury rates (per 1000 athlete exposures [AEs]) stratified by event type (practices, competitions). B, Injury rates (per 1000 AEs) stratified by season segment. C, Rates of time-loss injuries (per 1000 AEs) stratified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

between 2014–2015 and 2017–2018, with a slight increase during the final year of the study (Figure A). Injury rates were highest in Division III, and statistically significant differences were observed when comparing the overall Division I (IRR = 0.62; 95% CI = 0.55, 0.70) and Division II (IRR = 0.50; 95% CI = 0.44, 0.57) injury rates to the overall Division III injury rate (Table 1).

Injuries by Season Segment

A total of 528 preseason injuries (national estimate = 8797), 852 regular season injuries (national estimate = 15 990), and 55 postseason injuries (national estimate = 837) were reported between 2014–2015 and 2018–2019 (Table 2). The overall preseason injury rates were higher than regular season (IRR = 1.29; 95% CI = 1.16, 1.44) and postseason (IRR = 2.11; 95% CI = 1.60, 2.79) injury rates. While regular season injury rates remained stable, preseason injury rates fluctuated across the study period (Figure B). Increases in preseason injury rates were seen between 2015–2016 and 2016–2017 and again between 2017–2018 and 2018–2019 (Figure B). Temporal trends in postseason rates were not examined due to the low counts of reported postseason injuries in certain years of the study period.

Time Loss

Approximately 40.1% of all reported injuries were NTL, less than a third (29.7%) resulted in TL ≥1 day, and ~30% had missing/unknown TL. The prevalence of TL injuries was higher among practice-related (31.9%) than competition-related (25.5%) injuries. The prevalence of TL injuries varied across the study period (2014–2015 = 38.5%; 2015–2016 = 47.3%; 2016–2017 = 40.2%; 2017–2018 = 21.3%; 2018–2019 = 25.6%), as did the prevalence of injuries with missing TL data (2014–2015 = 14.7%; 2015–2016 = 8.2%; 2016–2017 = 20.7%; 2017–2018 = 43.8%; 2018–2019 = 34.5%). Over one-third of all TL injuries (35.0%) resulted in TL of 10 or more days. The prevalence of TL injuries were higher among practice-related (31.9%) than competition-related (25.5%) injuries. Rates of competition-related TL injuries decreased notably between 2014–2015 and 2015–2016 and remained stable throughout the remainder of the study period (Figure C). Rates of practice-related TL injuries fluctuated throughout the study period, decreasing consis-

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	171	2661	303	4783	21	333
	29 112	474 954	72 006	1 150 793	9113	144 313
	5.87 (4.99, 6.75)	5.60 (4.72, 6.48)	4.21 (3.73, 4.68)	4.16 (3.68, 4.63)	2.30 (1.32, 3.29)	2.31 (1.32, 3.29)
II	139	1479	195	2071	20	252
	33 404	539 753	57 654	806 816	5686	83 275
	4.16 (3.47, 4.85)	2.74 (2.05, 3.43)	3.38 (2.91, 3.86)	2.57 (2.09, 3.04)	3.52 (1.98, 5.06)	3.03 (1.48, 4.57)
III	218	4656	354	9136	14	252
	24 637	651 477	51 626	1 366 347	4385	75 674
	8.85 (7.67, 10.02)	7.15 (5.97, 8.32)	6.86 (6.14, 7.57)	6.69 (5.97, 7.40)	3.19 (1.52, 4.87)	3.33 (1.66, 5.00)
Overall	528	8797	852	15 990	55	837
	87 153	1 666 184	181 285	3 323 955	19 184	303 262
	6.06 (5.54, 6.58)	5.28 (4.76, 5.80)	4.70 (4.38, 5.02)	4.81 (4.49, 5.13)	2.87 (2.11, 3.62)	2.76 (2.00, 3.52)

[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.

tently between 2015–2016 and 2017–2018 before increasing sharply during the final year of the study (Figure C).

Injury Characteristics

Knee injuries (17.4%) and ankle injuries (13.2%) accounted for the largest proportions of all women's lacrosse injuries reported during the study period. Also commonly reported were lower leg injuries (11.7%) and injuries to the head/face (11.6%). Knee injuries and ankle injuries accounted for comparable proportions of reported practice and competition injuries (Table 3). In contrast, lower leg injuries were more prevalent among reported practice injuries (14.4%) than competition injuries (6.6%), while head/face injuries accounted for a larger proportion of competition injuries (15.2%) than practice injuries (9.7%). Most reported injuries were attributed to noncontact (26.6%) and overuse (25.2%) mechanisms. Comparable proportions of practice and competition injuries were attributed to noncontact mechanisms (Table 3), while a larger proportion of practice injuries (34.0%) than competition injuries (8.0%) were attributed to overuse mechanisms. Player contact, surface contact, and apparatus (other than ball) contact injuries were more prevalent among competition injuries than practice injuries (Table 3).

Overall, most women's lacrosse injuries reported between 2014–2015 and 2018–2019 were sprains (19.9%), strains (19.2%), and inflammatory conditions (15.3%). Contusions (12.8%) were also commonly reported during the study period. While strains accounted for comparable proportions of reported practice and competition injuries (Table 3), sprains accounted for a larger proportion of competition injuries (25.9%) than practice injuries (16.8%), and inflammatory conditions accounted for a larger proportion of practice injuries (19.7%) than competition injuries (6.8%). The most commonly reported specific injuries during the study period were partial or complete lateral ligament complex tears (ankle sprains; 9.1%), concussions (7.2%; overall rate = 3.58 per 10 000 AEs; 95% CI = 2.89, 4.27), and partial or complete hamstring tears (3.8%). Rates of lateral ligament complex tears steadily increased between 2014–2015 and 2017–2018 before decreasing during the final year of the study (Figure D). Rates of hamstring tears increased between 2014–2015 and 2015–2016 before decreasing steadily until 2017-2018 (Figure D). Temporal patterns in concussion rates were not described due to low counts of concussions observed during certain years of the study period.

Injuries by Lacrosse-Specific Activities and Playing Positions

Most injuries in women's lacrosse between 2014–2015 and 2018–2019 occurred during general play (35.3%) and then during running (18.5%) and defending (10.9%). While comparable proportions of competition (33.5%) and practice (36.2%) injuries occurred during general play, the proportion of injuries attributed to running was larger among practice injuries (21.3%) than competition injuries (12.9%). In contrast, defending accounted for a slightly larger proportion of competition injuries (14.4%) than practice injuries (9.2%). Forwards/attackers and midfielders accounted for the largest proportions of injured women's lacrosse players reported in this study period (Table 4).

SUMMARY

In this study we describe the epidemiology of injuries in NCAA women's lacrosse during the 2014–2015 through 2018–2019 athletic seasons. The overall injury rate was ~5 injuries per 1,000 AEs, and the rate of injury was twice as high in competitions as in practices. The injury rate in Division III was higher than those in Divisions I and II,

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

	Overall		Competitions		Practices	
	Injuries Reported (%)	National Estimate (%)	Injuries Reported (%)	National Estimate (%)	Injuries Reported (%)	National Estimate (%)
Body part						
Head/face	166 (11.57)	2871 (11.20)	74 (15.20)	1291 (14.67)	92 (9.70)	1580 (9.39)
Neck	13 (0.91)	164 (0.64)	5 (1.03)	53 (0.60)	8 (0.84)	111 (0.66)
Shoulder	48 (3.34)	772 (3.01)	22 (4.52)	326 (3.70)	26 (2.74)	446 (2.65)
Arm/elbow	23 (1.60)	427 (1.67)	13 (2.67)	285 (3.24)	10 (1.05)	143 (0.85)
Hand/wrist	75 (5.23)	1427 (5.57)	49 (10.06)	959 (10.90)	26 (2.74)	468 (2.78)
Trunk	101 (7.04)	1609 (6.28)	31 (6.37)	443 (5.03)	70 (7.38)	1166 (6.93)
Hip/groin	137 (9.55)	2689 (10.49)	29 (5.95)	595 (6.76)	108 (11.39)	2095 (12.45)
Thigh	141 (9.83)	2711 (10.58)	42 (8.62)	935 (10.62)	99 (10.44)	1776 (10.56)
Knee	250 (17.42)	4422 (17.26)	93 (19.10)	1577 (17.92)	157 (16.56)	2845 (16.91)
Lower leg	168 (11.71)	2981 (11.63)	32 (6.57)	688 (7.82)	136 (14.35)	2293 (13.63)
Ankle	189 (13.17)	3512 (13.71)	74 (15.20)	1337 (15.19)	115 (12.13)	2176 (12.94)
Foot	107 (7.46)	1852 (7.23)	20 (4.11)	293 (3.33)	87 (9.18)	1559 (9.27)
Other	17 (1.18)	186 (0.73)	3 (0.62)	21 (0.24)	14 (1.48)	165 (0.98)
Mechanism						
Player contact	201 (14.01)	3700 (14.44)	115 (23.61)	2022 (22.97)	86 (9.07)	1679 (9.98)
Surface contact	160 (11.15)	2927 (11.42)	74 (15.20)	1420 (16.13)	86 (9.07)	1507 (8.96)
Ball contact	101 (7.04)	1885 (7.36)	27 (5.54)	349 (3.97)	74 (7.81)	1535 (9.12)
Other apparatus contact	115 (8.01)	2038 (7.95)	73 (14.99)	1398 (15.88)	42 (4.43)	639 (3.80)
Out of bounds contact	1 (0.07)	11 (0.04)	0 (0.0)	0 (0.0)	1 (0.11)	11 (0.07)
Noncontact	382 (26.62)	7022 (27.40)	123 (25.26)	2340 (26.58)	259 (27.32)	4682 (27.83)
Overuse	361 (25.16)	6400 (24.98)	39 (8.01)	697 (7.92)	322 (33.97)	5702 (33.90)
Illness/infection	12 (0.84)	152 (0.59)	2 (0.41)	16 (0.18)	10 (1.05)	136 (0.81)
Other/unknown	102 (7.11)	1489 (5.81)	34 (6.98)	559 (6.35)	68 (7.17)	930 (5.53)
Diagnosis						
Abrasion/laceration	14 (0.98)	181 (0.71)	7 (1.44)	72 (0.82)	7 (0.74)	109 (0.65)
Concussion	103 (7.18)	1909 (7.45)	51 (10.47)	979 (11.12)	52 (5.49)	930 (5.53)
Contusion	183 (12.75)	3371 (13.16)	96 (19.71)	1687 (19.17)	87 (9.18)	1684 (10.01)
Dislocation/subluxation	24 (1.67)	377 (1.47)	9 (1.85)	136 (1.55)	15 (1.58)	241 (1.43)
Fracture	47 (3.28)	843 (3.29)	19 (3.90)	322 (3.66)	28 (2.95)	521 (3.10)
Illness/infection	1 (0.07)	25 (0.10)	0 (0.0)	0 (0.0)	1 (0.11)	25 (0.15)
Inflammatory condition	220 (15.33)	3848 (15.02)	33 (6.78)	651 (7.40)	187 (19.73)	3197 (19.00)
Spasm	56 (3.90)	937 (3.66)	5 (1.03)	157 (1.78)	51 (5.38)	780 (4.64)
Sprain	285 (19.86)	5327 (20.79)	126 (25.87)	2253 (25.60)	159 (16.77)	3075 (18.28)
Strain	275 (19.16)	5437 (21.22)	83 (17.04)	1674 (19.02)	192 (20.25)	3763 (22.37)
Other	227 (15.82)	3370 (13.15)	58 (11.91)	871 (9.90)	169 (17.83)	2498 (14.85)

[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.

which is similar to findings previously reported by Pierpoint et al.[5] Recent research indicated that ATs at Division III programs typically incurred a greater patient load than their Division I and II counterparts.[11] Further, schools with a greater number of clinicians per student-athletes have also been shown to have lower injury rates than schools in which ATs have higher patient loads,[12] which has been hypothesized to be related to clinicians' involvement in injury prevention programs, attitudes toward athlete health and well-being, and documentation practices. The injury rates observed in this study were comparable to previous findings, albeit marginally higher than select previous reports within this population.[3,5] Practice injury rates were relatively stable during this 5-year study period; however, a notable increase was observed during the final year of the study. In comparison, the competition injury rate increased between 2014–2015 and 2017–2018 (most sharply between 2016–2017 and 2017–2018) and decreased notably during the final year of the study. Importantly, the current study included TL and NTL injuries, which is not the case in previous reports and therefore may influence the practice and competition injury rates.[5] Further, given that participation in the NCAA ISP among women's lacrosse programs increased dramatically during the final year of the study, it is reasonable to suggest that the higher practice injury rates observed in 2018–2019 are a more stable representation of the injury burden in this population compared with those from previous years. It is therefore important to examine the contrasting trajectories of practice and competition injury rates observed between 2017–2018 and 2018–2019 more closely and to identify potential contributing factors. We note that increases in participation across the study period are due to new recruitment strategies (in particular, the NCAA Sport Science Institute's role in association-wide communication). With that said, limitations to the external validity of the present study should be considered as the ISP uses a convenience sampling scheme, and participation in the ISP

Table 4. Distribution of Injuries by Injury Activity and Playing Position Stratified by Event Type[a]

	Overall		Competitions		Practices	
	Injuries Reported (%)	National Estimate (%)	Injuries Reported (%)	National Estimate (%)	Injuries Reported (%)	National Estimate (%)
Activity						
Ball handling	58 (4.04)	1396 (5.45)	33 (6.78)	766 (8.70)	25 (2.64)	630 (3.75)
Blocking shot	22 (1.53)	361 (1.41)	12 (2.46)	207 (2.35)	10 (1.05)	154 (0.92)
Checking	16 (1.11)	372 (1.45)	13 (2.67)	310 (3.52)	3 (0.32)	62 (0.37)
Conditioning	43 (3.00)	790 (3.08)	0 (0.0)	0 (0.0)	43 (4.54)	790 (4.70)
Defending	157 (10.94)	2601 (10.15)	70 (14.37)	1166 (13.25)	87 (9.18)	1435 (8.53)
Face off	10 (0.70)	103 (0.40)	6 (1.23)	62 (0.70)	4 (0.42)	41 (0.24)
General Play	506 (35.26)	9951 (38.83)	163 (33.47)	2924 (33.22)	343 (36.18)	7027 (41.77)
Goaltending	43 (3.00)	1001 (3.91)	15 (3.08)	282 (3.20)	28 (2.95)	718 (4.27)
Loose ball	52 (3.62)	858 (3.35)	30 (6.16)	553 (6.28)	22 (2.32)	306 (1.82)
Passing	9 (0.63)	91 (0.36)	3 (0.62)	37 (0.42)	6 (0.63)	54 (0.32)
Receiving	37 (2.58)	661 (2.58)	10 (2.05)	179 (2.03)	27 (2.85)	483 (2.87)
Running	265 (18.47)	4226 (16.49)	63 (12.94)	1154 (13.11)	202 (21.31)	3072 (18.26)
Shooting	69 (4.81)	1022 (3.99)	31 (6.37)	506 (5.75)	38 (4.01)	516 (3.07)
Weights	2 (0.14)	33 (0.13)	0 (0.0)	0 (0.0)	2 (0.21)	33 (0.20)
Other/unknown	146 (10.17)	2157 (8.42)	38 (7.80)	657 (7.46)	108 (11.39)	1501 (8.92)
Position						
Defensive back	357 (24.88)	6645 (25.93)	122 (25.05)	2172 (24.68)	235 (24.79)	4473 (26.59)
Forward/attack	444 (30.94)	8130 (31.73)	156 (32.03)	2854 (32.42)	288 (30.38)	5276 (31.36)
Goalkeeper	84 (5.85)	1663 (6.49)	28 (5.75)	467 (5.31)	56 (5.91)	1196 (7.11)
Midfielder	405 (28.22)	6958 (27.15)	151 (31.01)	2802 (31.83)	254 (26.79)	4156 (24.71)
Other/unknown	145 (10.10)	2229 (8.70)	30 (6.16)	507 (5.76)	115 (12.13)	1722 (10.24)

[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.

is therefore not compulsory for ATs at NCAA-sponsored institutions. Therefore, given the findings of this study it is important to continue monitoring practice-related injury incidence in this population after 2018–2019 to determine whether the increasing trajectory is maintained. Furthermore, the marked increase in competition injury rates between 2016–2017 and 2017–2018 is noteworthy and warrants juxtaposition with competition rule changes and policy updates from the same time period. Important playing rule changes with regards to free movement, self-starting after minor fouls, and permission to kick the ball (to move away from congested spaces) were implemented in NCAA women's lacrosse during the study period.[13–15] The observed trajectories indicate that these changes may have required a familiarization period for athletes to adapt to gameplay, during which competition injury risk may have been higher than previously recorded. Future researchers may wish to measure features (eg, penalty event) and phases (eg, pace of play after the penalty) of gameplay to appraise how rule additions, amendments, or both affect gameplay and injury incidence. In examining competition-related injury incidence more closely, it is also salient to consider the dynamic nature of NCAA women's lacrosse sponsorship over time.[2] Indeed, the rise in the total number of women's lacrosse teams sponsored by the NCAA may change the nature of competition within the sport, consequently yielding fluctuating competition injury rates.

We identified that the preseason injury rate was higher than the regular season and postseason injury rates. This may be attributed to a sudden increase in training workload that most athletes encounter while transitioning from the offseason to preseason as well as a rapid reintroduction to dynamic team play in an intense and competitive atmosphere.[16] Interestingly, these findings contrast with those of previous reports indicating no differences between preseason and regular season injury rates in this setting.[5] In comparing the results observed here with previously reported surveillance-based findings within this population, it is important to consider that the present study leveraged a larger volume of data given the improved participation in the NCAA ISP over time. In addition, potential differences in findings between studies may be due to the inclusion of both TL and NTL injuries in the current study; previous studies only included TL injury events.[5] Further, it is important to note that the preseason injury rates followed an increasing trajectory for most of the study period (between 2015–2016 and 2018–2019), suggesting that the preseason injury incidence has been increasing in recent years. It is important to further examine recent changes in preseason training practices and workload accumulation during preseason to better understand preseason injury risk in this population. In its current form, the NCAA ISP is not positioned to capture information on training details or workload. Given the inherent limitations of sports injury surveillance systems, these investigations may be better carried out using small-sample, targeted examinations.[17]

In the current study, we also found that the knee, ankle, lower leg, and head/face were the most commonly injured body parts among NCAA women's lacrosse athletes, and this is generally consistent with previously reported findings in this population.[3] Overuse mechanisms contributed a large proportion of reported injuries during 2014–2015 through 2018–2019 seasons. Overuse mechanisms

were largely attributed to the lower extremity, were most often reported from practice-related exposures, and were predominantly NTL injuries. The observed prevalence of overuse injuries mirror previous studies of this population, and the findings of the present study may be even be more reflective of the distribution of injuries incurred by women's lacrosse athletes given the additional capture of NTL injuries in the present study in contrast to previous studies.[5] In this regard, it is important to acknowledge that the prevalence of injuries missing TL data was relatively high across the study period, and the TL distribution of overuse injuries therefore may not be entirely reflected in these results. Missing outcome information is an inherent limitation of sports injury surveillance, and future studies should aim to more comprehensively capture outcome data to better examine overuse injuries in this population. Given that it has been previously reported that lower extremity injuries accounted for approximately 70% of overuse injuries in NCAA athletes (albeit not specifically in women's lacrosse athletes),[18] the distributions of injuries by body part and injury mechanism observed in this study are unsurprising. Close monitoring of workload accumulation and acute to chronic workload ratio may be needed to facilitate detection of these injuries and better identify effective preventive strategies.[19,20] In particular, lateral ligament complex tear (ankle sprain) and hamstring tear (partial or complete) were the most common diagnoses in this sample, which may be due to demands within lacrosse, including quick or unanticipated changes of direction[20] and acceleration/deceleration during play.[22] Therefore, ATs should aim to include primary and secondary areas of prevention for these specific injury diagnoses. Further, with regard to injury mechanism, despite restrictions for player-to-player contact in women's lacrosse, player contact accounted for 14% of reported injuries during the study period. While this is also consistent with previously reported findings,[3,8] the inciting mechanisms are modifiable risk factors influenced by rules, officiating, and protective equipment and suggest an area for future injury prevention study. It is also important to consider that head/face injuries accounted for ~12% of all reported injuries and that concussion was one of the most common specific injuries reported during the time period. The topic of protective headgear in women's lacrosse has gathered much academic and media attention in recent years.[9,23–25] While evidence indicates a reduction of eye and head/face injuries after institution of protective eyewear requirements in youth girls' lacrosse,[6] the efficacy of helmets in reducing concussion risk has not been robustly demonstrated using empirical evidence. Given that helmets are used in boys' and men's lacrosse, previous researchers have compared injury incidence in boys' and girls' lacrosse to determine the protective effect of helmet use in lacrosse.[9,23–25] Subsequently, it was observed that in high school girl's lacrosse, concussions were most often attributed to ball or stick contact.[9,23–25] These mechanisms, and their resulting effect on head movements, may be abated by requiring a hard-shelled helmet in women's lacrosse. However, due to the inherent differences between the sports, targeted studies in women's lacrosse are needed to better determine the protective effect of helmets in this population.

Routine monitoring of NCAA women's lacrosse injuries will provide valuable insight into injury incidence and outcomes in this population. The results of this study indicate that injury incidence in practices and during preseason warrant further attention in this population. The prevalence of player-contact resultant injuries is also noteworthy given the playing rules and regulations of the sport. In the interest of obtaining a robust and stable representation of the injury burden in women's lacrosse, it is important for surveillance participation to align with the increasing popularity of the sport at the collegiate level. A stable representation of emerging patterns in women's lacrosse will offer the platform upon which to build targeted studies that reconcile etiologic determinants of injury risk in this group.

ACKNOWLEDGMENTS

The NCAA Injury Surveillance Program was funded by the NCAA. The Datalys Center is an independent nonprofit organization that manages the operations of the NCAA ISP. The content of this report is solely the responsibility of the authors and does not necessarily represent the official views of the funding organization. We thank the many ATs who have volunteered their time and efforts to submit data to the NCAA-ISP. Their efforts are greatly appreciated and have had a tremendously positive effect on the safety of collegiate student-athletes.

REFERENCES

1. Barber Foss KD, Le Cara E, McCambridge T, Hinton RY, Kushner A, Myer GD. Epidemiology of Injuries in women's lacrosse: implications for sport-, level-, and sex-specific injury prevention strategies. *Clin J Sport Med*. 2018;28(4):406–413. doi: 10.1097/JSM.0000000000000458
2. US Lacrosse participation report 2018. US Lacrosse. Published 2018. Accessed September 2, 2020. https://www.uslacrosse.org/sites/default/files/public/documents/about-us-lacrosse/2018-participation-report.pdf
3. Kerr ZY, Lincoln AE, Caswell SV, Klossner DA, Walker N, Dompier TP. Epidemiology of National Collegiate Athletic Association women's lacrosse injuries, 2009–10 through 2014–15. *J Sport Rehabil*. 2018;27(2):118–125. doi: 10.1123/jsr. 2016-0124
4. Kerr ZY, Lincoln AE, Dodge T, et al. Epidemiology of youth boys' and girls' lacrosse injuries in the 2015 to 2016 seasons. *Med Sci Sports Exerc*. 2018;50(2):284–291. doi: 10.1249/MSS.0000000000001422
5. Pierpoint LA, Caswell SV, Walker N, et al. The first decade of web-based sports injury surveillance: descriptive epidemiology of injuries in US high school girls' lacrosse (2008–2009 through 2013–2014) and National Collegiate Athletic Association women's lacrosse (2004–2005 through 2013–2014). *J Athl Train*. 2019;54(1):42–54. doi: 10.4085/1062-6050-201-17
6. Lincoln AE, Caswell SV, Almquist JL, et al. Effectiveness of the women's lacrosse protective eyewear mandate in the reduction of eye injuries. *Am J Sports Med*. 2012;40(3):611–614. doi: 10.1177/0363546511428873
7. 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.
8. Kerr ZY, Dompier TP, Snook EM, et al. National Collegiate Athletic Association Injury Surveillance System: review of methods for 2004–2005 through 2013–2014 data collection. *J Athl Train*. 2014;49(4):552–560. doi: 10.4085/1062-6050-49.3.58
9. Comstock RD, Arakkal AT, Pierpoint LA, Fields SK. Are high school girls' lacrosse players at increased risk of concussion because they are not allowed to wear the same helmet boys' lacrosse

players are required to wear? *Inj Epidemiol*. 2020;7(1):18. doi: 10.1186/s40621-020-00242-5
10. 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.
11. Baugh CM, Kroshus E, Lanser BL, Lindley TR, Meehan WP. Sports medicine staffing across National Collegiate Athletic Association Division I, II, and III schools: evidence for the medical model. *J Athl Train*. 2020;55(6):573–579. doi: 10.4085/1062-6050-0463-19
12. Baugh CM, Meehan WP, McGuire TG, Hatfield LA. Staffing, financial, and administrative oversight models and rates of injury in collegiate athletes. *J Athl Train*. 2020;55(6):580–586. doi: 10.4085/1062-6050-0517.19
13. 2018 and 2019 NCAA Women's lacrosse rules. National Collegiate Athletic Association. Accessed October 9, 2020. http://www.ncaapublications.com/p-4522-2018-and-2019-ncaa-womens-lacrosse-rules.aspx
14. 2016 and 2017 NCAA Women's lacrosse rules. National Collegiate Athletic Association. Accessed October 9, 2020. https://www.ncaapublications.com/p-4408-2016-and-2017-ncaa-womens-lacrosse-rules.aspx
15. 2014 and 2015 NCAA Women's lacrosse rules changes. National Collegiate Athletic Association. Accessed October 9, 2020. http://www.ncaa.org/sites/default/files/2014 and 2015 Rules Changes %28Updated 09%3A03%3A2013%29.pdf
16. Zabriskie HA, Currier BS, Harty PS, Stecker RA, Jagim AR, Kerksick CM. Energy status and body composition across a collegiate women's lacrosse season. *Nutrients*. 2019;11(2):470. doi: 10.3390/nu11020470
17. 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." *Sports Med*. 2019;49(10):1621–1623. doi: 10.1007/s40279-019-01154-1
18. Roos KG, Marshall SW, Kerr ZY, et al. Epidemiology of overuse injuries in collegiate and high school athletics in the United States. *Am J Sports Med*. 2015;43(7):1790–1797. doi: 10.1177/0363546515580790
19. Windt J, Gabbett TJ. How do training and competition workloads relate to injury? The workload-injury aetiology model. *Br J Sports Med*. 2017;51(5):428–435. doi: 10.1136/bjsports-2016-096040
20. Drew MK, Purdam C. Time to bin the term 'overuse' injury: is 'training load error' a more accurate term? *Br J Sports Med*. 2016;50(22):1423–1424. doi: 10.1136/bjsports-2015-095543
21. van der Merwe C, Shultz SP, Colborne GR, Hebert-Losier K, Fink PW. The coordination patterns of the foot segments in relation to lateral ankle sprain injury mechanism during unanticipated changes of direction. *Foot (Edinb)*. 2020;45:101745. doi: 10.1016/j.foot.2020.101745
22. Danielsson A, Horvath A, Senorski C, et al. The mechanism of hamstring injuries: a systematic review. *BMC Musculoskelet Disord*. 2020;21(1):641. doi: 10.1186/s12891-020-03658-8
23. Rodowicz KA, Olberding JE, Rau AC. Head injury potential and the effectiveness of headgear in women's lacrosse. *Ann Biomed Eng*. 2015;43(4):949–957. doi: 10.1007/s10439-014-1154-x
24. Clark JM, Hoshizaki TB, Gilchrist MD. Assessing women's lacrosse head impacts using finite element modelling. *J Mech Behav Biomed Mater*. 2018;80:20–26. doi: 10.1016/j.jmbbm.2018.01.020
25. Clark JM, Hoshizaki TB. The ability of men's lacrosse helmets to reduce the dynamic impact response for different striking techniques in women's field lacrosse. *Am J Sports Med*. 2016;44(4):1047–1055. doi: 10.1177/0363546515623272

Address correspondence to Avinash Chandran, PhD, MS, Datalys Center for Sports Injury Research and Prevention, 6151 Central Avenue, Suite 117, Indianapolis, IN 46202. Address email to avinashc@datalyscenter.org.