

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

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**Context:** Women's volleyball is a globally popular sport with widespread participation at the National Collegiate Athletic Association (NCAA) level.

**Background:** Routine examinations of NCAA women's volleyball injuries are important for recognizing emerging injury-related patterns in this population.

**Methods:** Exposure and injury data collected in the NCAA Injury Surveillance Program during the 2014–2015 through 2018–2019 athletic years were analyzed. Injury counts, rates, and proportions were used to describe injury characteristics, and injury rate ratios were used to examine differences in injury rates.

**Results:** The overall injury rate was 6.73 per 1000 athlete-exposures. Knee (14.6%) and ankle (13.8%) injuries accounted

for the largest proportion of all reported injuries, and most injuries were attributed to overuse (26.1%) or noncontact (22.7%) mechanisms. Lateral ankle ligament complex tears (11.1%) and concussions (7.3%) were the most commonly reported specific injury.

**Summary:** Results indicate an increasing burden of practice-related injuries and the need to further examine overuse injuries. Lower-extremity injury prevention strategies and mechanisms of concussion also warrant further attention.

**Key Words:** collegiate sports, descriptive epidemiology, injury surveillance

## Key Points

- Overall, competition and practice injury rates were similar, though competition injury rates fluctuated across the study period while practice injury rates increased during 2015-2016 through 2018-2019.
- Knee and ankle injuries accounted for the largest proportion of all reported injuries, and most injuries were classified as sprains, strains, and inflammatory conditions.
- Concussion was among the most prevalently reported injuries during the study period, and concussion incidence increased steadily during 2015-2016 through 2018-2019.

Volleyball is a widely popular sport throughout the world and across all demographics.<sup>1–3</sup> Women's volleyball in the National Collegiate Athletic Association (NCAA) has continued to gain traction in recent years as well, with a record high of 17 780 student-athletes across 1069 membership teams participating in the 2018–2019 academic year.<sup>1</sup> As the sport has continued to gather momentum at the collegiate level, the dynamics of NCAA women's volleyball have evolved in recent years. For instance, notable playing rule changes such as the elimination of the “pursuit rule” (intended to reduce player collisions on the court) in 2016–2017 may have affected game play and positively affected athlete safety.<sup>4</sup> Given the continued participation growth in NCAA women's volleyball, coupled with recent playing rule changes and ever-changing sport culture, it is important to monitor injury

incidence and outcomes in this population to appraise the burden of injury.

The NCAA Injury Surveillance Program (ISP) is a foundational prospective sports injury surveillance system for monitoring injuries and exposures in NCAA sports.<sup>5,6</sup> The NCAA ISP has served a vital role in monitoring NCAA women's volleyball-related injuries throughout its existence.<sup>7,8</sup> Prior researchers have indicated that injury rates in practices and competitions are similar in women's volleyball.<sup>7,8</sup> Previous reports have also consistently identified that most injuries in this population are classified as ligament sprains and muscle/tendon strains, and have indicated that concussions are a prevalently reported injury in this group.<sup>7,8</sup> Furthermore, injuries in NCAA women's volleyball are most often attributed to non-contact mechanisms, while player contact injuries account for nearly a one-fourth of all competition injuries.<sup>8</sup> After recently implemented rule changes in NCAA women's volleyball and advancements in injury prevention practices,<sup>9</sup> it is

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**Table 1. Reported and National Estimates of Injuries, Athlete-Exposures (AEs), and Rates per 1000 AEs by Event Type Across Divisions<sup>a</sup>**

Division	Number AEs Rate per 1000 AEs (95% CI)					
	Overall		Practices		Competitions	
	Reported	National Estimate	Reported	National Estimate	Reported	National Estimate
I	1029	19 022	723	13 622	306	5400
	158 181	3 049 924	116 272	2 265 915	41 909	784 009
	6.51 (6.11, 6.90)	6.24 (5.84, 6.63)	6.22 (5.76, 6.67)	6.01 (5.56, 6.46)	7.30 (6.48, 8.12)	6.89 (6.07, 7.71)
II	626	12 698	414	8242	212	4456
	92 254	2 188 689	60 504	1 503 481	31 750	685 208
	6.79 (6.25, 7.32)	5.80 (5.27, 6.33)	6.84 (6.18, 7.50)	5.48 (4.82, 6.14)	6.68 (5.78, 7.58)	6.50 (5.60, 7.40)
III	692	22 587	503	16 215	189	6372
	98 544	3 056 532	64 778	2 038 579	33 767	1 017 953
	7.02 (6.50, 7.55)	7.39 (6.87, 7.91)	7.76 (7.09, 8.44)	7.95 (7.28, 8.63)	5.60 (4.80, 6.40)	6.26 (5.46, 7.06)
Overall	2347	54 308	1640	38 079	707	16 228
	348 979	8 295 145	241 554	5 807 975	107 425	2 487 170
	6.73 (6.45, 7.00)	6.55 (6.27, 6.82)	6.79 (6.46, 7.12)	6.56 (6.23, 6.88)	6.58 (6.10, 7.07)	6.52 (6.04, 7.01)

<sup>a</sup> 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.

important to continue evaluating injury surveillance data to identify emerging injury incidence patterns as the most recent similar investigation of this population covered data captured through the 2013–2014 academic year.<sup>8</sup> Therefore, the purpose of this study was to describe the epidemiology of sport-related injuries among NCAA women’s volleyball student-athletes during the 2014–2015 through 2018–2019 academic years.

**METHODS**

**Study Data**

Women’s volleyball exposure and injury data collected in the NCAA ISP during the 2014–2015 through 2018–2019 athletic years 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 (RRB). The NCAA ISP methods are detailed in a separate manuscript within this special issue.<sup>10</sup> Briefly, athletic trainers (ATs) at participating NCAA institutions contributed exposure and injury data by using their clinical electronic medical record systems. A reportable injury was one that occurred from participation in an organized intercollegiate practice or competition and required medical attention by a team AT or physician, regardless of time loss (TL). Scheduled team practices and competitions were considered reportable exposures for this analysis. Data from 31 (3% of membership) participating programs in 2014–2015, 25 (2% of membership) in 2015–2016, 35 (3% of membership) in 2016–2017, 41 (4% of membership) in 2017–2018, and 115 (11% of membership) in 2018–2019 qualified for inclusion in our analyses. Qualification criteria are detailed further in the methods manuscript within this special issue.<sup>10</sup>

**Statistical Analysis**

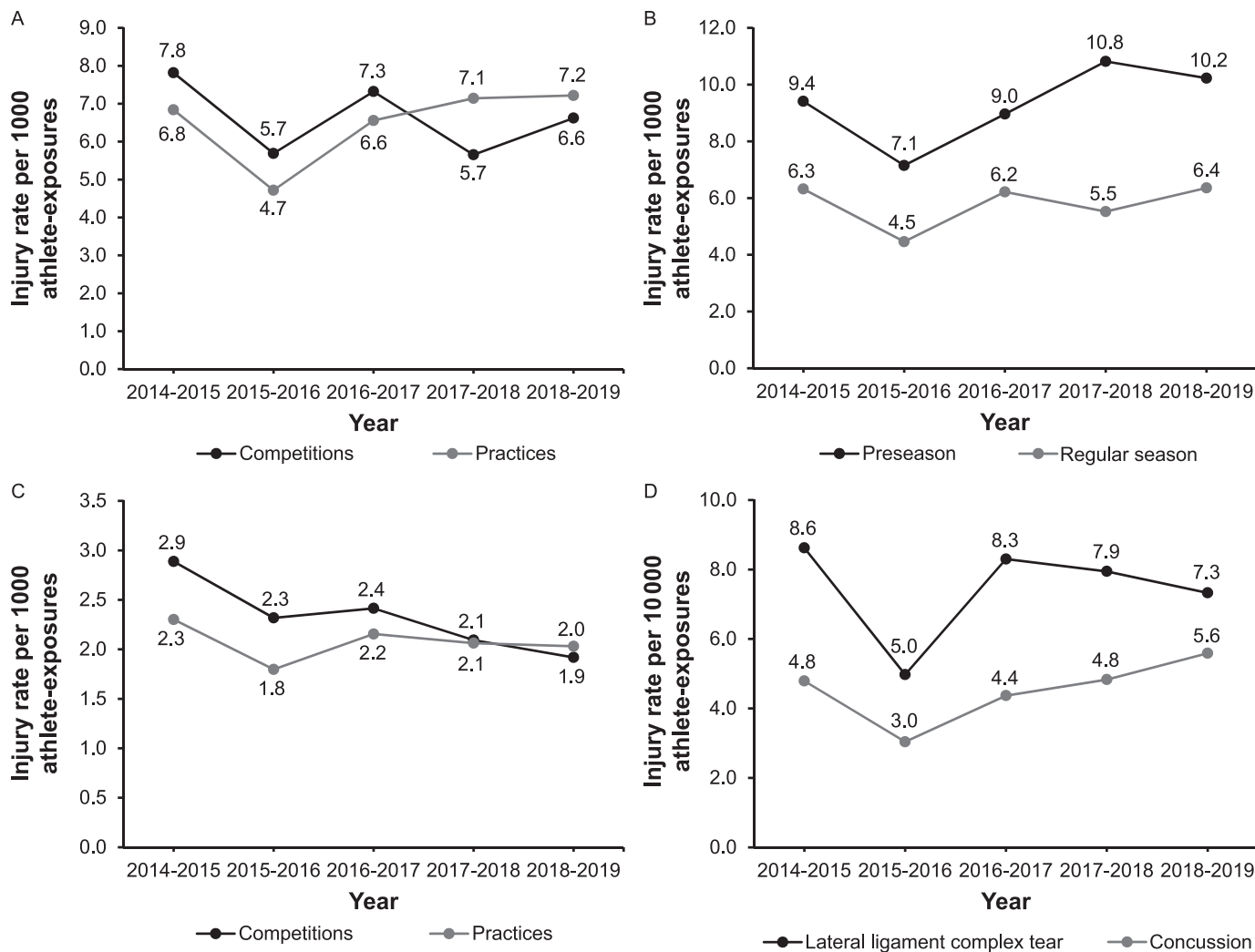
Injury counts and rates per 1000 AEs were examined by event type (practice or competition), competition level

(Division I, Division II, or Division III), season segment (preseason, regular season, or postseason), and TL (TL or non-TL [NTL]). An AE was defined as 1 athlete participating in 1 exposure event. A TL injury was one in which an athlete returned the day after or beyond with respect to the date of injury, and TL due to an injury was determined on the basis of the injury and return dates reported by ATs. Weighted and unweighted rates were estimated; however, results were presented in terms of unweighted rates (unless otherwise specified) due to low frequencies of injury observations across levels of certain explanatory variables. Temporal trends in injury rates across the study period were described using rate profile plots stratified by levels of exposure characteristics. Similarly, temporal trends in rates of the most commonly reported injuries were also examined across the study period. Injury counts and distributions were examined by TL, body part injured, mechanism of injury, 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% confidence intervals (CIs) excluding 1.00 were considered statistically significant. All analyses were conducted using SAS 9.4 (SAS Institute).

**RESULTS**

A total of 2347 women’s volleyball injuries from 348 979 AEs were reported to the NCAA ISP during the 2014–2015 through 2018–2019 academic years (rate = 6.73 per 1,000 AEs; Table 1). This equated to a national estimate of 54 308 injuries overall. Across the study period, the competition injury rate (rate = 6.58 per 1000 AEs) was comparable to the practice injury rate (rate = 6.79 per 1000 AEs). Competition injury rates fluctuated across the study period and were highest in 2014–2015 (Figure A). Conversely, practice injury rates decreased between 2014–2015 and 2015–2016

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

and then followed an increasing trajectory thereafter, with the highest rate in 2018–2019 (Figure A). Across the study period, overall injury rates did not vary between Division I (rate = 6.51 per 1000 AEs), Division II (rate = 6.79 per 1000 AEs), and Division III (rate = 7.02 per 1000 AEs).

### Injuries by Season Segment

A total of 745 preseason injuries (national estimate: 17968), 1546 regular season injuries (national estimate: 35186), and 56 postseason injuries (national estimate: 1154) were reported between 2014–2015 and 2018–2019 (Table 2). The rate of preseason injuries was higher than regular season (IRR = 1.62; 95% CI = 1.49, 1.77) and postseason injuries (IRR = 2.45; 95% CI = 1.86, 3.21). Although preseason and regular season injury rates decreased between 2014–2015 and 2015–2016, incidence trajectories by season segment varied for the remainder of the study period (Figure B). Preseason injury rates decreased between 2014–2015 and 2015–2016, steadily increased between 2015–2016 and 2017–2018, and slightly decreased during the final year of the study (Figure B).

Conversely, regular season injury rates fluctuated between 2015–2016 and 2018–2019 (Figure B). Temporal patterns in postseason injury rates were not examined due to low frequencies ( $n < 5$ ) of postseason injuries observed during certain years of the study period.

### Time Loss

Approximately one-third (31.1%) of all reported injuries resulted in TL of >1 day (TL was not recorded in ~21% of all reported injuries). TL injuries accounted for comparable proportions of reported practice (30.4%) and competition injuries (32.7%). Rates of competition-related TL injuries followed a generally decreasing trajectory across the study period (Figure C). Rates of practice-related TL injuries fluctuated between 2014–2015 and 2016–2017 and then remained relatively stable for the remainder of the study period (Figure C).

### Injury Characteristics

Knee (14.6%) and ankle injuries (13.8%) accounted for the largest proportions of all injuries reported during the

**Table 2. Reported and National Estimates of Injuries, Athlete-Exposures (AEs), and Rates per 1000 AEs by Season Segment Across Divisions<sup>a</sup>**

Division	Number AEs Rate per 1000 AEs (95% CI)					
	Preseason		Regular Season		Postseason	
	Reported	National Estimate	Reported	National Estimate	Reported	National Estimate
I	311	5857	694	12 727	24	438
	35 846	713 450	115 096	2 214 934	7239	121 540
	8.68 (7.71, 9.64)	8.21 (7.25, 9.17)	6.03 (5.58, 6.48)	5.75 (5.30, 6.19)	3.32 (1.99, 4.64)	3.60 (2.28, 4.93)
II	182	4262	429	8157	15	280
	18 401	493 864	70 487	1 607 610	3366	87 215
	9.89 (8.45, 11.33)	8.63 (7.19, 10.07)	6.09 (5.51, 6.66)	5.07 (4.50, 5.65)	4.46 (2.20, 6.71)	3.21 (0.96, 5.47)
III	252	7849	423	14 302	17	437
	22 457	707 748	72 589	2 249 275	3499	99 508
	11.22 (9.84, 12.61)	11.09 (9.70, 12.48)	5.83 (5.27, 6.38)	6.36 (5.80, 6.91)	4.86 (2.55, 7.17)	4.39 (2.08, 6.70)
Overall	745	17 968	1546	35 186	56	1154
	76 704	1 915 063	258 171	6 071 819	14 104	308 264
	9.71 (9.02, 10.41)	9.38 (8.69, 10.08)	5.99 (5.69, 6.29)	5.79 (5.50, 6.09)	3.97 (2.93, 5.01)	3.74 (2.70, 4.78)

<sup>a</sup> 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.

study period. Trunk (10.7%), shoulder (10.4%; notably, of which 50.9% were classified as inflammatory conditions or as impingement or entrapment), and head/face (9.4%) injuries were also prevalent among all reported injuries (Table 3). Knee injuries accounted for comparable proportions of reported practice (13.8%) and competition injuries (16.4%), whereas ankle injuries accounted for a larger proportion of competition injuries (18.7%) than practice injuries (11.7%). Nearly one-half of all reported injuries were overuse (26.1%, of which 25.9% were upper extremity injuries and 58.7% were lower extremity injuries) or noncontact (22.7%) injuries (compared with player contact or contact with equipment or apparatus such as the ball or surface; Table 3). Noncontact injuries accounted for comparable proportions of reported practice (22.4%) and competition (23.3%) injuries. Conversely, injuries attributed to overuse mechanisms accounted for a considerably larger proportion of practice-related injuries (32.2%) than competition-related injuries (12.0%).

Overall, most women's volleyball injuries reported between 2014–2015 and 2018–2019 were sprains (22.8%), strains (17.1%), and inflammatory conditions (17.1%). Strains accounted for comparable proportions of reported practice (17.1%) and competition (17.0%) injuries. Conversely, sprains accounted for a larger proportion of competition injuries (31.1%) than practice injuries (19.2%), and inflammatory conditions accounted for a larger proportion of practice injuries (20.1%) than competition injuries (10.2%). The most commonly reported specific injuries were partial or complete lateral ankle ligament complex tear (ankle sprains; 11.1%) and concussion (7.3%, of which 60.5% were attributed to ball contact). These specific injury rates followed comparable trajectories between 2014–2015 and 2016–2017 by initially decreasing and then increasing (Figure D). Although concussion injury

rates continued on an upward trajectory for the remainder of the study period, rates of lateral ankle ligament complex tears (ankle sprains) steadily decreased between 2016–2017 and 2018–2019 (Figure D).

### Injuries by Volleyball-Specific Activities and Playing Positions

Most injuries in women's volleyball between 2014–2015 and 2018–2019 occurred during general play (34.3%), digging (13.9%), and blocking (13.8%). Spiking also accounted for a notable proportion (11.2%) of all reported injuries. Although general play (37.0% versus 28.3%, respectively) and spiking (12.1% versus 9.1%, respectively) accounted for larger proportions of practice injuries than competition injuries, digging (20.2% versus 11.2%, respectively) and blocking (18.1% versus 11.9%, respectively) accounted for larger proportions of competition injuries than practice injuries (Table 4). Most injuries in women's volleyball were reported among outside hitters (27.5%) and middle blockers (21.8%).

### SUMMARY

Here, we described the epidemiology of injuries among NCAA women's volleyball athletes during the 2014–2015 through 2018–2019 academic years. Across the study period, the competition and practice injury rates were comparable, aligning with the existing literature in this population.<sup>7,8</sup> It may be noted that practice injury rates followed an upward trajectory for most of the study period and were higher than competition injury rates during the final 2 years of the study period. Further examination of practice routines (particularly during 2015–2016 through 2018–2019 and across divisions) is warranted to better elucidate factors contributing to the increasing burden of



**Table 3. Distribution of Injuries by Body Part, Mechanism, and Injury Diagnosis; Stratified by Event Type<sup>a</sup>**

	Overall		Competitions		Practices	
	Injuries Reported (%)	National Est. (%)	Injuries Reported (%)	National Est. (%)	Injuries Reported (%)	National Est. (%)
<b>Body part</b>						
Head/face	221 (9.42)	4647 (8.56)	84 (11.88)	2017 (12.43)	137 (8.35)	2630 (6.91)
Neck	21 (0.89)	538 (0.99)	6 (0.85)	109 (0.67)	15 (0.91)	429 (1.13)
Shoulder	244 (10.40)	5553 (10.23)	51 (7.21)	1252 (7.72)	193 (11.77)	4302 (11.30)
Arm/elbow	61 (2.60)	1298 (2.39)	22 (3.11)	450 (2.77)	39 (2.38)	848 (2.23)
Hand/wrist	224 (9.54)	4543 (8.37)	76 (10.75)	1369 (8.44)	148 (9.02)	3173 (8.33)
Trunk	252 (10.74)	6046 (11.13)	58 (8.20)	1437 (8.86)	194 (11.83)	4610 (12.11)
Hip/groin	131 (5.58)	3294 (6.07)	43 (6.08)	1183 (7.29)	88 (5.37)	2111 (5.54)
Thigh	110 (4.69)	2322 (4.28)	27 (3.82)	468 (2.88)	83 (5.06)	1854 (4.87)
Knee	342 (14.57)	8124 (14.96)	116 (16.41)	2926 (18.03)	226 (13.78)	5198 (13.65)
Lower leg	220 (9.37)	5369 (9.89)	47 (6.65)	1119 (6.90)	173 (10.55)	4250 (11.16)
Ankle	323 (13.76)	7785 (14.33)	132 (18.67)	2915 (17.96)	191 (11.65)	4870 (12.79)
Foot	132 (5.62)	3282 (6.04)	32 (4.53)	733 (4.52)	100 (6.10)	2549 (6.69)
Other	66 (2.81)	1506 (2.77)	13 (1.84)	250 (1.54)	53 (3.23)	1257 (3.30)
<b>Mechanism</b>						
Player contact	271 (11.55)	6224 (11.46)	123 (17.40)	2802 (17.27)	148 (9.02)	3422 (8.99)
Surface contact	336 (14.32)	7489 (13.79)	151 (21.36)	3209 (19.77)	185 (11.28)	4280 (11.24)
Ball contact	311 (13.25)	6282 (11.57)	105 (14.85)	2317 (14.28)	206 (12.56)	3964 (10.41)
Other apparatus contact	10 (0.43)	237 (0.44)	2 (0.28)	30 (0.18)	8 (0.49)	207 (0.54)
Out of bounds contact	18 (0.77)	415 (0.76)	13 (1.84)	310 (1.91)	5 (0.30)	105 (0.28)
Noncontact	533 (22.71)	13283 (24.46)	165 (23.34)	4035 (24.86)	368 (22.44)	9248 (24.29)
Overuse	613 (26.12)	14398 (26.51)	85 (12.02)	2035 (12.54)	528 (32.20)	12364 (32.47)
Other/unknown	255 (10.86)	5981 (11.01)	63 (8.91)	1491 (9.19)	192 (11.71)	4489 (11.79)
<b>Diagnosis</b>						
Abrasion/laceration	9 (0.38)	165 (0.30)	6 (0.85)	112 (0.69)	3 (0.18)	53 (0.14)
Concussion	172 (7.33)	3585 (6.60)	65 (9.19)	1555 (9.58)	107 (6.52)	2030 (5.33)
Contusion	148 (6.31)	3500 (6.44)	67 (9.48)	1633 (10.06)	81 (4.94)	1868 (4.91)
Dislocation/subluxation	45 (1.92)	883 (1.63)	12 (1.70)	235 (1.45)	33 (2.01)	648 (1.70)
Fracture	73 (3.11)	1556 (2.87)	22 (3.11)	383 (2.36)	51 (3.11)	1173 (3.08)
Illness/infection	16 (0.68)	469 (0.86)	4 (0.57)	109 (0.67)	12 (0.73)	360 (0.95)
Inflammatory condition	401 (17.09)	9308 (17.14)	72 (10.18)	1502 (9.26)	329 (20.06)	7806 (20.50)
Spasm	86 (3.66)	1875 (3.45)	13 (1.84)	194 (1.20)	73 (4.45)	1681 (4.41)
Sprain	535 (22.80)	12423 (22.88)	220 (31.12)	4964 (30.59)	315 (19.21)	7459 (19.59)
Strain	401 (17.09)	10022 (18.45)	120 (16.97)	3158 (19.46)	281 (17.13)	6864 (18.03)
Other	461 (19.64)	10523 (19.38)	106 (14.99)	2384 (14.69)	355 (21.65)	8138 (21.37)

<sup>a</sup> 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.

practice-related injuries. Nearly one-third of all practice-related injuries reported during the study period were overuse injuries, potentially indicating that practice-related injuries in this population may be related to chronic accumulation of concentrated workload.<sup>11</sup> Notably, practice-related TL injury rates remained relatively stable during the study period and overall practice injury rates increased, which implies that practice-related NTL injury rates have increased across the study period. The observed distribution of practice injuries by injury mechanism, coupled with the increasing rate of practice-related NTL injuries, are consistent with the notion that chronic injuries attributed to overuse mechanisms often manifest as NTL injuries.<sup>12</sup> Continued monitoring of the rates of practice-related TL injuries is needed to determine whether this pattern is maintained. Importantly, approximately one-fifth of all reported injuries were classified neither as TL nor NTL due to missing (TL) data. The observed level of missing TL data may reflect an inherent limitation of the NCAA ISP data collection methods and restricts the

inferential capacity of the estimates presented here. In future small-sample studies, researchers should examine recovery after practice-related injuries and target capturing comprehensive TL data in this population. Based on the results of the present study, such examinations may also particularly focus on practice-related overuse injuries.

Knee and ankle injuries accounted for the largest proportion of all reported injuries during the study period, and injuries were most often classified as sprains, strains, and inflammatory conditions. Unsurprisingly for the nature of the sport, trunk and shoulder injuries were also commonly reported during the study period. These findings are consistent with previous reports in this population.<sup>7,8</sup> The biomechanics of the overhead swing require complex neuromuscular control, particularly between the shoulder and trunk.<sup>13</sup> Shoulder and trunk injuries accounted for greater proportions of practice than competition injuries, and as noted above, nearly one-third of all practice injuries were attributed to overuse mechanisms. Furthermore, one-half of all reported shoulder injuries were inflammatory

**Table 4. Distribution of Injuries by Injury Activity and Playing Position; Stratified by Event Type<sup>a</sup>**

	Overall		Competitions		Practices	
	Injuries Reported (%)	National Est. (%)	Injuries Reported (%)	National Est. (%)	Injuries Reported (%)	National Est. (%)
<b>Activity</b>						
Blocking	323 (13.76)	7041 (12.96)	128 (18.10)	2774 (17.09)	195 (11.89)	4267 (11.21)
Conditioning	48 (2.05)	1515 (2.79)	3 (0.42)	50 (0.31)	45 (2.74)	1465 (3.85)
Digging	326 (13.89)	7141 (13.15)	143 (20.23)	3098 (19.09)	183 (11.16)	4042 (10.61)
General play	806 (34.34)	18 893 (34.79)	200 (28.29)	4845 (29.86)	606 (36.95)	14 048 (36.89)
Passing	112 (4.77)	2537 (4.67)	43 (6.08)	1009 (6.22)	69 (4.21)	1528 (4.01)
Serving	52 (2.22)	1090 (2.01)	10 (1.41)	196 (1.21)	42 (2.56)	894 (2.35)
Setting	57 (2.43)	1358 (2.50)	21 (2.97)	507 (3.12)	36 (2.20)	851 (2.23)
Spiking	262 (11.16)	6291 (11.58)	64 (9.05)	1505 (9.27)	198 (12.07)	4787 (12.57)
Other/unknown	361 (15.38)	8441 (15.54)	95 (13.44)	2245 (13.83)	266 (16.22)	6196 (16.27)
<b>Position</b>						
Libero	372 (15.85)	8174 (15.05)	128 (18.10)	2773 (17.09)	244 (14.88)	5401 (14.18)
Middle blocker	512 (21.82)	11 420 (21.03)	139 (19.66)	3130 (19.29)	373 (22.74)	8290 (21.77)
Outside hitter	645 (27.48)	15 089 (27.78)	204 (28.85)	4743 (29.23)	441 (26.89)	10 346 (27.17)
Setter	333 (14.19)	8213 (15.12)	116 (16.41)	2799 (17.25)	217 (13.23)	5414 (14.22)
Opposite/right-side hitter	243 (10.35)	5509 (10.14)	64 (9.05)	1480 (9.12)	179 (10.91)	4029 (10.58)
Other/unknown	242 (10.31)	5902 (10.87)	56 (7.92)	1303 (8.03)	186 (11.34)	4599 (12.08)

<sup>a</sup> 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.

conditions or impingement or entrapment. With these results, we indicate that chronic overuse mechanisms, likely exacerbated by muscular imbalances and repetitive-high velocity movements,<sup>14–16</sup> may offer insight into the pathoetiology of the shoulder and trunk. Greater overhead swing volumes and workloads examined among volleyball players have been related to heightened injury risk<sup>17,18</sup> and further indicate that workload frequency and intensity are critical considerations for practice injury prevention. Similarly, given that noncontact injuries were prevalent in this study, and that nearly 60% of all overuse injuries occurred in the lower extremities, further attention to the etiology of lower-extremity overuse injuries in this population is also warranted, and the need to potentially intervene with injury prevention programs or prophylactic taping or bracing may be indicated. More specifically, lateral ligament complex tears (ankle sprains) were among the most commonly observed specific injuries during the study period, and the benefits of preventative exercises and prophylactic taping or bracing with regard to ankle sprain injury risk have been previously demonstrated.<sup>19</sup> Indeed, prior researchers have particularly shown prophylactic support-based and exercise-based intervention programs to be effective in the primary prevention of ankle sprains in various athlete samples,<sup>19–23</sup> and these approaches may be considered for women’s volleyball athletes as well. Furthermore, dynamic neuromuscular warm up programs have also demonstrated effectiveness in reducing injury rates in volleyball athletes and may hold clinical utility.<sup>9</sup> The nature and prevalence of both lower extremity overuse injuries and ankle sprains suggest that injury prevention programs or prophylactic taping or bracing may have a positive effect on the reduction of injury in women’s volleyball.

Noncontact and overuse injuries together accounted for nearly one-half of all reported injuries during the study period, and this may be explained by a multitude of factors.

First, playing rule changes directed toward reducing opposing player collisions on the court have been implemented in NCAA women’s volleyball in recent years (during the study period).<sup>4</sup> In particular, the pursuit rule was eliminated in 2016–2017 with the intention of reducing player collisions on the court.<sup>4</sup> Although the implemented changes may have subsequently reduced the incidence of player contact injuries as intended, the observed noncontact and overuse injury prevalence may be a natural function of fewer player contact injuries occurring during game play (that is, fewer player contact injuries resulting in noncontact and overuse injuries accounting for a larger fraction of all reported injuries). Furthermore, a high prevalence of early sport specialization has been observed in women’s volleyball over the past 2 decades.<sup>25</sup> Early sport specialization has been associated with a higher risk of overuse injuries in particular,<sup>26</sup> and the observed results may also be indicative of this association. The NCAA ISP in its current form does not collect information on sport experience or sport history and is therefore not well positioned to examine this relationship. Future researchers may need conduct longitudinal studies to better study this paradigm.

Aside from lateral ligament complex tears (ankle sprains), concussion was the most commonly observed injury during the study period. Concussion incidence followed an upward trajectory for most of the study period, particularly during the latter years of the study. This finding is striking given that participation in the ISP among women’s volleyball programs improved considerably between 2015–2016 and 2018–2019. NCAA ISP recruitment strategies have evolved over time, and improved participation during these years reflects the success of recently used recruitment strategies (for instance, support and communication from the NCAA Sport Science Institute). As such, estimates from the latter part of the study period may be considered a more valid representation of injury incidence in this population than those from the

earlier years of the study period. With that said, it is important to acknowledge that the observed concussion incidence patterns may be attributable to several factors. Much attention has been directed in recent years toward improving concussion knowledge, awareness, and reporting behaviors among athletes.<sup>26</sup> Clinical practice in sports medicine has also grown to implement multifaceted assessment batteries (ie, symptom, balance, and neurocognitive testing) more frequently than ever before, resulting in improved diagnostic sensitivity.<sup>27</sup> Together, these factors may have reasonably contributed to the observed patterns. However, it remains important for researchers to conduct nuanced examinations of the dynamics of women's volleyball to appraise concussion risk in this sport. Given the limited contact nature of the sport,<sup>28</sup> further attention may be directed towards the frequency and nature (including the impact biomechanics) of particularly ball contact-resultant concussions (which accounted for ~61% of all concussions reported), in order to better understand concussion incidence in women's volleyball. The NCAA ISP is not equipped to capture detailed concussion characteristics, and researchers may need to conduct small-sample, targeted studies to study this further. Such future studies notwithstanding, continued monitoring of concussion incidence in this population beyond 2018–2019 is needed to determine whether or not the upward trajectory is maintained.

The findings of this study highlight the need for large-sample examinations of injury incidence and patterns in this population and offer insight into avenues for further exploration. The results observed here indicate the need to closely monitor practice-related injury incidence, evaluate the etiology of overuse injuries, and probe mechanisms of concussion incidence among NCAA women's volleyball athletes. Routine injury surveillance in this population should continue monitoring injury trajectories of specific injuries that are most commonly reported in this context. Surveillance-based descriptive epidemiological studies are important for identifying emerging temporal patterns, although targeted studies are needed to further expand upon observed results.

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