



# Descriptive Epidemiology of Injuries Sustained in National Collegiate Athletic Association Men's and Women's Volleyball, 2013-2014 to 2014-2015

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**Background:** There were 18,844 volleyball players in the National Collegiate Athletic Association (NCAA) in the 2014-2015 academic year. Little research has examined sex-based differences among these athletes.

**Purpose:** To examine injury epidemiology in NCAA men's and women's volleyball athletes.

**Study Design:** Descriptive epidemiology study.

**Level of Evidence:** Level 3.

**Methods:** Injury surveillance data from the 2013-2014 through 2014-2015 academic years were obtained from the NCAA Injury Surveillance Program for 6 men's and 33 women's collegiate volleyball teams. Injury rates per 1000 athlete-exposures (AEs) and injury rate ratios (IRRs) with 95% CIs were calculated. Time-loss (TL) injuries resulted in participation restriction for at least 24 hours, and non-time-loss (NTL) injuries resulted in participation restriction of less than 24 hours.

**Results:** Overall, 83 and 510 injuries were reported in men and women, respectively, leading to injury rates of 4.69 and 7.07 per 1000 AEs. The injury rate was greater in women than men (IRR, 1.51; 95% CI, 1.19-1.90). TL injury rates were 1.75 and 2.62 per 1000 AEs for men and women, respectively. The ankle was the most commonly injured body part among TL injuries (men, 25.8%; women, 24.3%); the knee was the most commonly injured body part among NTL injuries (men, 25.5%; women, 16.3%). Among TL injuries, common diagnoses included sprains (men, 25.8%; women, 31.2%) and concussions (men, 19.4%; women, 14.8%). Most TL concussions were due to ball contact (men, 83.3%; women, 53.6%). Compared with men, women had a greater NTL overuse injury rate (IRR, 3.47; 95% CI, 1.61-7.46). Compared with women, men had a greater TL injury rate associated with ball contact (IRR, 2.24; 95% CI, 1.07-4.68).

**Conclusion:** There are differences in injury patterns and rates between male and female intercollegiate volleyball players. Although a limited-contact sport, a notable number of concussions were sustained, mostly from ball contact.

**Clinical Relevance:** Understanding injury patterns may aid clinicians in injury diagnosis, management, and prevention.

**Keywords:** volleyball; injury epidemiology; college; concussion

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Volleyball is a popular sport internationally, with participation ranging from youth club teams to professional leagues. The first National Collegiate Athletic Association (NCAA)-sanctioned indoor volleyball championship (indoor volleyball will hereafter be known as volleyball) was held in 1970 and 1981 for men and women, respectively. In the 2014-2015 season, there were 113 NCAA men's teams with 1818 athletes and 1071 NCAA women's teams with 17,026 athletes participating in volleyball.<sup>12</sup> While volleyball is considered a "noncontact" sport and players are separated by a net, participants who compete at high levels have been found to be at risk for traumatic and overuse injuries, although rates of injury are relatively low.<sup>3,8</sup>

Existing research on volleyball-related injuries leaves gaps in knowledge, including very limited data on men's volleyball injuries and comparing rates of injury between male and female volleyball athletes. Research on college volleyball athletes has generally focused only on females.<sup>1</sup> In addition, older data from the NCAA Injury Surveillance Program (NCAA-ISP) only included time-loss (TL) injuries, or injuries resulting in participation restriction of at least 24 hours. Thus, data on non-time-loss (NTL) injuries, or injuries resulting in participation restriction of less than 24 hours, were not collected.<sup>7</sup> To date, injuries in NCAA men's volleyball have yet to be described. Thus, current research comparing men and women is restricted to national Dutch players or elite international competition.<sup>3,14</sup>

Given the lack of injury data for men's and women's collegiate volleyball, this current study utilizes the NCAA-ISP to describe the epidemiology of volleyball-related injuries during the 2013-2014 and 2014-2015 seasons. Injury rates and patterns are presented for both men's and women's volleyball, and sex-based differences are examined. The inclusion of both TL and NTL injuries also allows for a better understanding of the breadth of injuries managed by team medical staff.

## METHODS

Data originated from the NCAA-ISP, which is managed by the Datalys Center for Sports Injury Research and Prevention (hereafter known as the *Datalys Center*), an independent, nonprofit research organization. Data on men's and women's volleyball injuries are from the 2013-2014 and 2014-2015 academic years. This time frame is used as it demarks the only 2 academic years, to date, in which the number of men's volleyball teams included in data collection were sufficient to make comparisons. The methodology of the NCAA-ISP has been previously described<sup>7</sup> and is summarized below.

### Data Collection

The NCAA-ISP relies on a convenience sample of NCAA varsity sport teams with athletic trainers (ATs) reporting injury data. For men's volleyball, 6 programs provided 9 team-seasons of data. For women's volleyball, 33 programs provided 55 team-seasons of data.

ATs from participating programs reported injuries in real time through their electronic health record application throughout

the academic year. Common data elements, including injury and exposure information, are deidentified, recoded, and exported to an aggregate database. In addition, the NCAA-ISP captured other sports-related adverse health events such as heat-related conditions, general medical illness/conditions, and skin infections, all of which are included in the analyses. Only varsity-level practice and competition events were included in the NCAA-ISP data sets. Junior varsity programs, as well as any individual weight lifting and conditioning sessions, were excluded.

For each event, the AT completed a detailed event report on the injury or condition (eg, body part, diagnosis) and the circumstances (eg, activity, mechanism, event type [ie, competition or practice]). ATs were able to view and update previously submitted information as needed over the course of a season. Additionally, ATs provided the number of student-athletes participating in each practice and competition.

Prior to arriving to the Datalys Center, data were stripped of any identifiers and personally identifiable information (eg, name, date of birth, insurance information), retaining only relevant variables and values.<sup>7</sup> Exported data passed through an automated verification process, during which a series of consistency checks was conducted. Data were reviewed and flagged for invalid values. In such instances, the automated verification process would notify the AT and data quality assurance staff, who would assist the AT in resolution of the issue.

### Definitions

Definitions of injury used in this study correspond to the standardized definitions applied across NCAA-ISP publications.<sup>7</sup> A reportable injury in the NCAA-ISP was defined as an injury that (1) occurred as a result of participation in an organized intercollegiate practice or competition and (2) required attention from an AT or physician. Multiple injuries occurring from 1 event could be included. TL injuries were those that resulted in participation restriction for at least 24 hours. Among TL injuries, we were also particularly interested in those resulting in participation restriction over 3 weeks (which includes those student-athletes prematurely ending their season). Compared with previous NCAA data that only reported TL injuries, NTL injuries resulting in participation restriction for less than 24 hours were also included.

A reportable athlete-exposure (AE) was defined as 1 student-athlete participating in 1 NCAA-sanctioned practice or competition in which he or she was exposed to the possibility of athletic injury, regardless of the time associated with that participation. Only athletes with actual playing time in a competition, including warm-up, were included in competition exposures.

Body parts injured were categorized as head/face, neck, shoulder, arm/elbow, hand/wrist, trunk (including chest, abdomen, upper back, and lower back), hip/groin, upper leg, knee, lower leg, ankle, foot, and other. Diagnoses were categorized as sprain, strain, contusion, concussion, fracture, dislocation/subluxation, inflammatory conditions (including

bursitis, inflammation, tendinitis, etc), laceration, spasm, and other. Injury mechanisms were categorized as player contact, surface contact, ball contact, other contact (including contact with out-of-bounds object), noncontact, overuse, illness/infection, and other/unknown.

### Statistical Analysis

Data were analyzed using SAS-Enterprise Guide software (version 4.3; SAS Institute) to assess rates and patterns of college men's and women's volleyball injuries. The injury rate was calculated as the number of injuries per 1000 AEs. Statistical analyses included calculation of injury rate ratios (IRRs).<sup>10</sup> All 95% CIs not containing 1.0 were considered statistically significant. Because of low cell counts, IRRs were only calculated when both comparison groups had counts less than 10. This study was approved by the Research Review Board at the NCAA.

## RESULTS

### Overall Incidence and Rates

#### Men's Volleyball

ATs reported 83 injuries (Table 1) during 19,913 AEs, for an injury rate of 4.69 per 1000 AEs (95% CI, 3.68-5.70); the TL injury rate was 1.75 per 1000 AEs (95% CI, 1.14-2.37). The competition injury rate was greater than the practice injury rate among all injuries (7.28 vs 4.16 per 1000 AEs; IRR, 1.75; 95% CI, 1.08-2.85) and TL injuries (3.31 vs 1.43 per 1000 AEs; IRR, 2.31; 95% CI, 1.09-4.91). Competition rates did not differ from practice rates among NTL injuries (3.97 vs 2.66 per 1000 AEs; IRR, 1.49; 95% CI, 0.78-2.85). Preseason and in-season injury rates did not differ (4.88 vs 4.76 per 1000 AEs; IRR, 1.02; 95% CI, 0.62-1.70).

#### Women's Volleyball

ATs reported 510 injuries (Table 1) during 72,180 AEs, for an injury rate of 7.07 per 1000 AEs (95% CI, 6.45-7.68); the TL injury rate was 2.62 per 1000 AEs (95% CI, 2.25-2.99). Competition rates did not differ from practice rates among all injuries (7.48 vs 6.91 per 1000 AEs; IRR, 1.08; 95% CI, 0.90-1.31), NTL injuries (4.12 vs 4.29 per 1000 AEs; IRR, 0.96; 95% CI, 0.75-1.24), and TL injuries (3.16 vs 2.41 per 1000 AEs; IRR, 1.31; 95% CI, 0.97-1.78). The injury rate was higher in the preseason than in-season injury rates (10.43 vs 5.99 per 1000 AEs; IRR, 1.74; 95% CI, 1.45-2.09).

#### Sex-Based Differences

The injury rate was higher in women than men overall (IRR, 1.51; 95% CI, 1.19-1.90) and in practices (IRR, 1.66; 95% CI, 1.27-2.18), but not in competitions (IRR, 1.03; 95% CI, 0.66-1.61) (Table 1). Findings were similar when restricted to NTL injuries (IRR, 1.47; 95% CI, 1.09-2.27) and TL injuries (IRR, 1.49; 95% CI, 1.02-2.19). Injury rates were higher among women than men in the preseason (IRR, 2.14; 95% CI, 1.35-3.39).

### Body Site Injured and Diagnoses

The lower extremity comprised the largest proportion of injuries among TL (men, 45.2% [n = 14]; women, 58.7% [n = 111]) and NTL injuries (men, 47.1% [n = 24]; women, 57.5% [n = 176]) (Table 2). Whereas the ankle was the most commonly injured body part among TL injuries (men, 25.8% [n = 8]; women, 24.3% [n = 46]), the knee was the most commonly injured body part among NTL injuries (men, 25.5% [n = 13]; women, 16.3% [n = 50]). Various diagnoses were reported among TL and NTL injuries in both men's and women's volleyball (Table 3). No site-specific or diagnosis-specific injury rate differences were found between men and women.

### Injury Mechanisms and Activities

Various injury mechanisms were reported among TL and NTL injuries in both men's and women's volleyball (Table 4). Also, although general play was associated with many NTL injuries (men, 23.5% [n = 12]; women, 47.1% [n = 144]), a large proportion of TL injuries were associated with blocking (men, 41.9% [n = 13]; women, 19.1% [n = 36]). Compared with men, women had a higher NTL overuse injury rate (1.37 vs 0.40 per 1000 AEs; IRR, 3.47; 95% CI, 1.61-7.46). Compared with women, men had a higher TL injury rate associated with ball contact (0.62 vs 0.28 per 1000 AEs; IRR, 2.24; 95% CI, 1.07-4.68).

### Common Injuries

Common TL injuries included concussions and sprains to the hand/wrist for men and ankle and knee for women (Table 5). Most TL concussions were due to ball contact (men, 83.3% [n = 5]; women, 53.6% [n = 15]), particularly while blocking (men, n = 3; women, n = 4) and digging (men, n = 2; women, n = 5).

### Injuries With Over 3 Weeks of Participation Restriction Time

The 1 injury with over 3 weeks of participation restriction time in men's volleyball was an ankle sprain while serving. The majority of the 31 injuries with longer than 3 weeks of participation restriction time in women's volleyball were knee sprains (n = 11), particularly ACL tears (n = 8); other common injuries with longer than 3 weeks of participation restriction time were ankle sprains (n = 6) and concussion (n = 4). Most of these injuries in women's volleyball occurred while spiking (n = 10) or blocking (n = 6).

## DISCUSSION

Compared with men, women sustained a higher injury rate, which contrasts with previous research among elite international athletes that found no differences.<sup>3,14</sup> This finding was attributable to females sustaining greater rates of injury in practices and in the preseason than males. Although the current body of literature is limited, the mixed findings highlight the need for further research on injury incidence and severity between males and females in volleyball.

Table 1. Injury rates and 95% CI by type of athlete-exposure (AE) in NCAA men's and women's volleyball, 2013-2014 to 2014-2015<sup>a,b</sup>

	Competition		Practice		Overall	
	No. of Injuries in Sample	Rate and 95% CI (per 1000 AEs)	No. of Injuries in Sample	Rate and 95% CI (per 1000 AEs)	No. of Injuries in Sample	Rate and 95% CI (per 1000 AEs)
<b>Men's volleyball</b>						
Type of injury						
All injuries	22	7.28 (4.24-10.32)	61	4.16 (3.11-5.20)	83	4.69 (3.68-5.70)
All time-loss injuries <sup>c</sup>	10	3.31 (1.26-5.36)	21	1.43 (0.82-2.04)	31	1.75 (1.14-2.37)
All non-time-loss injuries <sup>d</sup>	12	3.97 (1.72-6.22)	39	2.66 (1.82-3.49)	51	2.88 (2.09-3.67)
Time in season						
Preseason	0	0.00	20	5.04 (2.83-7.24)	20	4.88 (2.74-7.02)
In-season	20	7.18 (4.04-10.33)	41	4.09 (2.84-5.34)	61	4.76 (3.57-5.96)
Postseason	2	18.05 (0.00-43.06)	0	0.00	2	2.54 (0.00-6.05)
<b>Women's volleyball</b>						
Type of injury						
All injuries	149	7.48 (6.28-8.68)	361	6.91 (6.19-7.62)	510	7.07 (6.45-7.68)
All time-loss injuries <sup>c</sup>	63	3.16 (2.38-3.95)	126	2.41 (1.99-2.83)	189	2.62 (2.25-2.99)
All non-time-loss injuries <sup>d</sup>	82	4.12 (3.23-5.01)	224	4.29 (3.72-4.85)	306	4.24 (3.76-4.71)
Time in season						
Preseason	3	10.25 (0.00-21.84)	186	10.44 (8.94-11.94)	189	10.43 (8.95-11.92)
In-season	141	7.36 (6.15-8.58)	171	5.19 (4.41-5.97)	312	5.99 (5.32-6.65)
Postseason	5	10.6 (1.31-19.89)	4	2.66 (0.05-5.27)	9	4.56 (1.58-7.54)

NCAA, National Collegiate Athletic Association.

<sup>a</sup>Sum of numbers of non-time-loss and time-loss injuries does not equal number of all injuries due to 1 men's volleyball and 15 women's volleyball injuries lacking participation restriction time information.

<sup>b</sup>Data originate from the DataLys Center for Sports Injury Research and Prevention Injury Surveillance Program, 2013-2014 to 2014-2015.

<sup>c</sup>Includes injuries that resulted in participation restriction  $\geq 24$  hours.

<sup>d</sup>Includes injuries that resulted in participation restriction  $< 24$  hours.

Table 2. Injury counts and percentages per 1000 athlete-exposures (AEs) by body part in NCAA men's and women's volleyball, 2013-2014 to 2014-2015<sup>a</sup>

Body Part	Men			Women		
	Time-Loss Injuries <sup>b</sup>		Non-Time-Loss Injuries <sup>c</sup>	Time-Loss Injuries <sup>b</sup>		Non-Time-Loss Injuries <sup>c</sup>
	Injury Count (%)	Rate and 95% CI (per 1000 AEs)	Injury Count (%)	Injury Count (%)	Rate and 95% CI (per 1000 AEs)	Injury Count (%)
Head/Face	7 (22.6)	0.40 (0.10-0.69)	2 (3.9)	33 (17.5)	0.46 (0.30-0.61)	7 (2.3)
Neck	0	0.00	0	1 (0.5)	0.01 (0.00-0.04)	5 (1.6)
Shoulder	2 (6.5)	0.11 (0.00-0.27)	10 (19.6)	8 (4.2)	0.11 (0.03-0.19)	32 (10.5)
Arm/Elbow	0	0.00	0	3 (1.6)	0.04 (0.00-0.09)	12 (3.9)
Hand/Wrist	4 (12.9)	0.23 (0.00-0.45)	9 (17.6)	7 (3.7)	0.10 (0.03-0.17)	33 (10.8)
Trunk	4 (12.9)	0.23 (0.00-0.45)	6 (11.8)	16 (8.5)	0.22 (0.11, 0.33)	36 (11.8)
Hip/Groin	0	0.00	2 (3.9)	14 (7.4)	0.19 (0.09-0.30)	20 (6.5)
Upper leg	0	0.00	3 (5.9)	7 (3.7)	0.10 (0.03-0.17)	17 (5.6)
Knee	2 (6.5)	0.11 (0.00-0.27)	13 (25.5)	30 (15.9)	0.42 (0.27-0.56)	50 (16.3)
Lower leg	3 (9.7)	0.17 (0.00-0.36)	3 (5.9)	6 (3.2)	0.08 (0.02-0.15)	33 (10.8)
Ankle	8 (25.8)	0.45 (0.14-0.77)	3 (5.9)	46 (24.3)	0.64 (0.45-0.82)	25 (8.2)
Foot	1 (3.2)	0.06 (0.00-0.17)	0	8 (4.2)	0.11 (0.03-0.19)	31 (10.1)
Other	0	0.00	0	10 (5.3)	0.14 (0.05-0.22)	5 (1.6)
Total	31 (100.0)	1.75 (1.14-2.37)	51 (100.0)	189 (100.0)	2.62 (2.25-2.99)	306 (100.0)
						4.24 (3.76-4.71)

NCAA, National Collegiate Athletic Association.

<sup>a</sup>Data originate from the Datalys Center for Sports Injury Research and Prevention Injury Surveillance Program, 2013-2014 to 2014-2015.<sup>b</sup>Includes injuries that resulted in participation restriction  $\geq 24$  hours.<sup>c</sup>Includes injuries that resulted in participation restriction  $< 24$  hours.

Table 3. Injury counts and percentages per 1000 athlete-exposures (AEs) by diagnosis in NCAA men's and women's volleyball, 2013-2014-2014-2015<sup>a</sup>

Body Part	Men						Women					
	Time-Loss Injuries <sup>b</sup>			Non-Time-Loss Injuries <sup>c</sup>			Time-Loss Injuries <sup>b</sup>			Non-Time-Loss Injuries <sup>c</sup>		
	Injury Count (%)	Rate and 95% CI (per 1000 AEs)	Injury Count (%)	Rate and 95% CI (per 1000 AEs)	Injury Count (%)	Rate and 95% CI (per 1000 AEs)	Injury Count (%)	Rate and 95% CI (per 1000 AEs)	Injury Count (%)	Rate and 95% CI (per 1000 AEs)	Injury Count (%)	Rate and 95% CI (per 1000 AEs)
Concussion	6 (19.4)	0.34 (0.07-0.61)	1 (2.0)	0.06 (0.00-0.17)	28 (14.8)	0.39 (0.24-0.53)	1 (0.3)	0.01 (0.00-0.04)				
Contusion	2 (6.5)	0.11 (0.00-0.27)	3 (5.9)	0.17 (0.00-0.36)	11 (5.8)	0.15 (0.06-0.24)	17 (5.6)	0.24 (0.12-0.35)				
Dislocation/Subluxation	1 (3.2)	0.06 (0.00-0.17)	1 (2.0)	0.06 (0.00-0.17)	2 (1.1)	0.03 (0.00-0.07)	3 (1.0)	0.04 (0.00-0.09)				
Entrapment/Impingement	0	0.00	2 (3.9)	0.11 (0.00-0.27)	2 (1.1)	0.03 (0.00-0.07)	8 (2.6)	0.11 (0.03-0.19)				
Fracture	2 (6.5)	0.11 (0.00-0.27)	1 (2.0)	0.06 (0.00-0.17)	2 (1.1)	0.03 (0.00-0.07)	8 (2.6)	0.11 (0.03-0.19)				
Inflammatory conditions	2 (6.5)	0.11 (0.00-0.27)	14 (27.5)	0.79 (0.38-1.21)	11 (5.8)	0.15 (0.06-0.24)	62 (20.3)	0.86 (0.65-1.07)				
Sacroiliac dysfunction	0	0.00	1 (2.0)	0.06 (0.00-0.17)	1 (0.5)	0.01 (0.00-0.04)	6 (2.0)	0.08 (0.02-0.15)				
Patella femoral pain syndrome	0	0.00	0	0.00	4 (2.1)	0.06 (0.00-0.11)	5 (1.6)	0.07 (0.01-0.13)				
Spasm	1 (3.2)	0.06 (0.00-0.17)	0	0.00	3 (1.6)	0.04 (0.00-0.09)	9 (2.9)	0.12 (0.04-0.21)				
Sprain	8 (25.8)	0.45 (0.14-0.77)	10 (19.6)	0.57 (0.21-0.92)	59 (31.2)	0.82 (0.61-1.03)	59 (19.3)	0.82 (0.61-1.03)				
Strain	3 (9.7)	0.17 (0.00-0.36)	13 (25.5)	0.73 (0.34-1.13)	29 (15.3)	0.40 (0.26-0.55)	77 (25.2)	1.07 (0.83-1.31)				
Stress fracture	2 (6.5)	0.11 (0.00-0.27)	0	0.00	2 (1.1)	0.03 (0.00-0.07)	2 (0.7)	0.03 (0.00-0.07)				
Other	4 (12.9)	0.23 (0.00-0.45)	5 (9.8)	0.28 (0.03-0.53)	35 (18.5)	0.48 (0.32-0.65)	49 (16.0)	0.68 (0.49-0.87)				
Total	31 (100.0)	1.75 (1.14-2.37)	51 (100.0)	2.88 (2.09-3.67)	189 (100.0)	2.62 (2.25-2.99)	306 (100.0)	4.24 (3.76-4.71)				

NCAA, National Collegiate Athletic Association.

<sup>a</sup>Data originate from the DataLys Center for Sports Injury Research and Prevention Injury Surveillance Program, 2013-2014 to 2014-2015.<sup>b</sup>Includes injuries that resulted in participation restriction  $\geq 24$  hours.<sup>c</sup>Includes injuries that resulted in participation restriction  $< 24$  hours.

Table 4. Injury counts and percentages per 1000 athlete-exposures (AEs) by injury mechanism in NCAA men's and women's volleyball, 2013-2014 to 2014-2015<sup>a</sup>

Injury Mechanism	Men						Women					
	Time-Loss Injuries <sup>b</sup>			Non-Time-Loss Injuries <sup>c</sup>			Time-Loss Injuries <sup>b</sup>			Non-Time-Loss Injuries <sup>c</sup>		
	Injury Count (%)	Rate and 95% CI (per 1000 AEs)	Injury Count (%)	Rate and 95% CI (per 1000 AEs)	Injury Count (%)	Rate and 95% CI (per 1000 AEs)	Injury Count (%)	Rate and 95% CI (per 1000 AEs)	Injury Count (%)	Rate and 95% CI (per 1000 AEs)	Injury Count (%)	Rate and 95% CI (per 1000 AEs)
Player contact	7 (22.6)	0.40 (0.10-0.69)	5 (9.8)	0.28 (0.03-0.53)	47 (24.9)	0.65 (0.46-0.84)	18 (5.9)	0.25 (0.13-0.36)				
Surface contact	2 (6.5)	0.11 (0.00-0.27)	5 (9.8)	0.28 (0.03-0.53)	23 (12.2)	0.32 (0.19-0.45)	40 (13.1)	0.55 (0.38-0.73)				
Ball contact	11 (35.5)	0.62 (0.25-0.99)	7 (13.7)	0.40 (0.10-0.69)	20 (10.6)	0.28 (0.16-0.40)	27 (8.8)	0.37 (0.23-0.52)				
Other contact	0	0.00	0	0.00	7 (3.7)	0.10 (0.03-0.17)	0	0.00				
Noncontact	7 (22.6)	0.40 (0.10-0.69)	21 (41.2)	1.19 (0.68-1.69)	44 (23.3)	0.61 (0.43-0.79)	82 (26.8)	1.14 (0.89-1.38)				
Overuse	2 (6.5)	0.11 (0.00-0.27)	7 (13.7)	0.40 (0.10-0.69)	25 (13.2)	0.35 (0.21-0.48)	99 (32.4)	1.37 (1.10-1.64)				
Illness/Infection	0	0.00	0	0.00	11 (5.8)	0.15 (0.06-0.24)	5 (1.6)	0.07 (0.01-0.13)				
Other/Unknown	2 (6.5)	0.11 (0.00-0.27)	6 (11.8)	0.34 (0.07-0.61)	12 (6.3)	0.17 (0.07-0.26)	35 (11.4)	0.48 (0.32-0.65)				
Total	31 (100.0)	1.75 (1.14-2.37)	51 (100.0)	2.88 (2.09-3.67)	189 (100.0)	2.62 (2.25-2.99)	306 (100.0)	4.24 (3.76-4.71)				

NCAA, National Collegiate Athletic Association.

<sup>a</sup>Data originate from the DataLys Center for Sports Injury Research and Prevention Injury Surveillance Program, 2013-2014 to 2014-2015.<sup>b</sup>Includes injuries that resulted in participation restriction  $\geq 24$  hours.<sup>c</sup>Includes injuries that resulted in participation restriction  $< 24$  hours.

Table 5. Common time-loss injuries and non-time-loss injuries in NCAA men's and women's volleyball, 2013-2014 to 2014-2015<sup>a</sup>

Injury	Injury Count (%)	Rate and 95% CI (per 1000 AEs)	Most Common Injury Mechanism, n (% Within Injury)
Time-loss injuries <sup>b</sup>			
Men's volleyball			
Concussion	6 (19.4)	0.34 (0.07-0.61)	Ball contact, 5 (83.3)
Hand/Wrist sprain	5 (16.1)	0.28 (0.03-0.53)	Noncontact, 2 (40.0)
Women's volleyball			
Ankle sprain	41 (21.7)	0.57 (0.39-0.74)	Player contact, 24 (58.5)
Concussion	28 (14.8)	0.39 (0.24-0.53)	Ball contact, 15 (53.6)
Knee sprain	13 (6.9)	0.18 (0.08-0.28)	Noncontact, 8 (61.5)
Non-time-loss injuries <sup>c</sup>			
Men's volleyball			
Knee inflammatory condition	11 (21.6)	0.62 (0.25-0.99)	Noncontact, 6 (54.6)
Hand/Wrist sprain	7 (13.7)	0.40 (0.10-0.69)	Ball contact, 6 (85.7)
Shoulder strain	6 (11.8)	0.34 (0.07-0.61)	Noncontact, 4 (66.7)
Women's volleyball			
Hand/Wrist sprain	21 (6.9)	0.29 (0.17-0.42)	Ball contact, 16 (76.2)
Knee inflammatory condition	20 (6.5)	0.28 (0.16-0.40)	Overuse, 15 (75.0)
Ankle sprain	19 (6.2)	0.26 (0.14-0.38)	Player contact, 9 (47.4)

NCAA, National Collegiate Athletic Association.

<sup>a</sup>Data originate from the Datalys Center for Sports Injury Research and Prevention Injury Surveillance Program, 2013-2014 to 2014-2015.

<sup>b</sup>Includes injuries that resulted in participation restriction  $\geq 24$  hours.

<sup>c</sup>Includes injuries that resulted in participation restriction  $< 24$  hours.

## Previous Volleyball Injury Rates

Previous research using the NCAA-ISP examined women's volleyball from 1988-1989 to 2003-2004,<sup>1</sup> finding competition and practice injury rates of 4.58 and 4.10 per 1000 AEs, respectively. In more recent NCAA-ISP data (2005-2006 to 2008-2009),<sup>13</sup> competition and practice injury rates were 3.93 and 4.12 per 1000 AEs, respectively. Although the current study's injury rates appear higher (competition and practice injury rates of 7.48 and 6.91 per 1000 AEs, respectively), previous research only reported TL injuries resulting in participation restriction time of at least 24 hours. Our data also included NTL injuries resulting in participation restriction time of less than 24 hours; such injuries accounted for over half of all injuries reported in men's and women's volleyball. Because of the varying injury

definitions from previous research, we caution comparisons to previous research that only included TL injuries. Nevertheless, the inclusion of NTL injury data may provide a more accurate understanding of the breadth of injuries identified and managed by clinicians in the collegiate sport setting. With the immediate provision of on-site management of injuries by clinicians, the severity of these injuries could have been mitigated.

When comparing estimates from previous research, our reported TL injury rates in women's volleyball from 2013-2014 to 2014-2015 (3.16 and 2.41 per 1000 AEs for competitions and practices, respectively) were lower. This may suggest a longitudinal decrease in injury rates or changes in the manner in which ATs classify injuries when given the option. For men, because data at the collegiate level had not been previously available, the injury rate trend is unknown. Furthermore,



because other research<sup>3</sup> has used different metrics for at-risk exposure time (eg, player-hours vs AEs), it is difficult to make comparisons. Although a baseline has been established for men's volleyball, additional surveillance will help track injury incidence longitudinally.

### Competition and Practice Rates in Women's Volleyball

Across sports, injury rates are generally higher in competitions than practices<sup>8</sup>; however, this was not the case for women's volleyball injury rates in the present study. This is consistent with several recent studies of women's volleyball injuries at the high school and college level.<sup>1,8,13,14</sup> The intensity and composition of activities and specific drills that occur within practices may vary in women's volleyball as compared with men's volleyball or other sports.<sup>8</sup> Future research is warranted to better understand the unique lack of association between event type and injury rates only present in women's volleyball and whether this contributes to the high rates of overuse injury.

However, it is also important to note that in previous research,<sup>1</sup> the women's volleyball injury rate was greater in competitions than practices by approximately 12% (4.58 vs 4.10 per 1000 AEs), yet statistically significant. In the current study, when considering only TL injuries (ie, an injury definition similar to that of previous research),<sup>1</sup> the TL injury rate was greater in competitions than practices by 31%, yet not statistically significant. This finding may be driven by only examining 2 academic years of data compared with the 16 years of data from Agel et al.<sup>1</sup> Nevertheless, when also considering the NTL injury data that the NCAA-ISP now collects, the inclusion of such injuries causes the difference to drop to 7%. Continued prospective research regarding injury rates in competition and practice will help better determine injury incidence in both settings.

Because previous research has also found that injury rates are higher in competitions than practices,<sup>13</sup> it is important to identify prevention strategies that will help reduce the incidence of injury in competitions. This could include the use of protective equipment as well as rule changes that aim to increase athlete safety. However, because more than 70% of all injuries occurred in practice, prevention efforts should also include practice sessions. Patient care in volleyball needs to focus on both event types. Although not examined in the current study, future research should examine factors related to neuromuscular fatigue in practice scheduling that may contribute to increased injury risk.

### Body Parts Injured and Diagnoses

Similar to those reported in previous research,<sup>1,3,14</sup> most volleyball injuries were sustained to the lower extremity. The ankle was the most frequently injured body part in both men's and women's volleyball. This aligns with previous research that found that the ankle, particularly ankle sprains, was the most frequently injured body part and injury.<sup>1,3,14</sup> In contrast, the most common body part injured among NTL injuries was the knee.

Bere et al<sup>13</sup> likewise found that in elite volleyball athletes, the knee comprised the largest proportion of NTL injuries. The use of preventative strategies such as bracing may help to reduce the incidence of lower extremity injuries.<sup>2,4</sup> However, research that examines the barriers and facilitators of their use, as well as the differences in the incidence and etiology of lower extremity injuries, is warranted.

Concussions comprised 19.4% and 14.8% of men's and women's volleyball TL injuries, respectively. Because volleyball includes rules to limit the amount of contact, such a finding may be unexpected.<sup>13</sup> However, the most common mechanism of concussion was not due to player contact, as in many contact and collision sports as well as volleyball at the high school level,<sup>11,15</sup> but rather ball contact, particularly during blocking and digging. To date, a large focus of concussion research has been on contact and collision sports. Thus, it is important to emphasize the potential incidence of concussion in volleyball to sports medicine providers, athletes, and coaches, as well as the importance of education, particularly around disclosure of symptomatology.<sup>9</sup>

### Injury Mechanisms

We found sex-based differences both in the distribution of diagnoses and injury mechanisms. Where women had a higher rate of overuse injuries, men had a higher rate of ball contact-related injuries. The latter finding may be due to greater physicality at the net among men (eg, jumping higher, higher velocity spikes, more triple blocks or jousts), which may increase the risk for incidental contact. The former may be related to earlier volleyball participation and specialization among women than men. Preventing injuries from ball contact may be difficult without imposing rule changes. However, overuse injuries among females may be prevented by monitoring training load and using appropriate strength and conditioning techniques, including increasing flexibility, which have been successful in reducing overuse injuries in other sports.<sup>5,6</sup>

### Limitations

This study examined 2 seasons of volleyball from a convenience sample of NCAA men's and women's programs. Findings may not be representative of nonparticipating programs as well as programs from other competition levels (eg, high school, youth), collegiate organizations (eg, junior colleges), or other eras of play. Also, using AE for at-risk exposure time may make it difficult to interpret findings in comparison with previous research using playing-hours for injury rate denominators. There were fewer team-seasons among men's volleyball, which may be a function of the larger number of NCAA member institutions sponsoring women's vs men's volleyball (10:1).<sup>12</sup> Last, our analyses excluded conditions such as "low back pain" and "shoulder instability" that are not diagnoses; however, we note that 3 of these cases (2 low back pain, 1 shoulder instability) resulted in over 3 weeks of participation restriction time.

## CONCLUSION

Overall, injury rates in NCAA women's volleyball exceeded those of men's volleyball. The injury rate was higher in competitions than practices for men; women had similar competition and practice injury rates. Most injuries in both sports were to the lower extremity and non-time-loss. A significant number of the injuries were from overuse, which are potentially preventable. Ball contact is a common injury mechanism in men and should be further evaluated for rule changes and protection that might prevent injury. Although concussions comprised a small proportion of injuries in both sports, their presence in a limited-contact sport highlights the need for continued targeted concussion research and prevention efforts.

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