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

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Context: The National Collegiate Athletic Association (NCAA) has sponsored women's tennis programs since 1966. Women's tennis has risen in global prominence and popularity within the NCAA.

Background: Continued surveillance of athletic injuries in the NCAA is critical for identifying emerging injury trends and assessing injury prevention strategies.

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

Results: The overall injury rate was 4.16 per 1000 athlete exposures. Injury to the shoulder, foot, and trunk were the most prevalent throughout the study period. Approximately 30% of all injury diagnoses were related to inflammatory conditions. Also, 32.1% of all injuries were time-loss injuries, and 45.0% of all injuries were non–time-loss injuries.

Conclusions: The findings of this study differed slightly from those of previous investigations, most notably with regard to injury rate by season segment and commonly injured body parts. Future surveillance efforts should attempt to capture the nuances of tennis competitions.

Key Words: collegiate, sport-related, surveillance

Key Points

- The Division I injury rate was greater than the Division II and Division III injury rates among women's tennis players.
- Injury to the shoulder comprised the largest proportion of all injuries and similar proportions were observed across competition and practice related injuries.
- One-third of all reported injuries were classified as time loss (> 1 day), the most prevalent mechanisms of injury were overuse and non-contact.

Tennis is an international sport with 87 million players worldwide, nearly half of whom are women,[1] that play across various (recreational to professional) competitive and lucrative levels. The United States has the highest percentage of ranking women's junior tennis players in the world, many of whom may go on to participate in intercollegiate athletics.[1] The widespread popularity and scope of women's tennis results in injuries among women's tennis athletes that differ between novice and experienced players.[2] Women's tennis has been included in the National Collegiate Athletic Association (NCAA) since 1966, and participation among NCAA member schools has continued to grow. As of 2018–2019, 904 women's tennis programs competed in NCAA championships.[3] Elite women's tennis players competing at the NCAA level are a unique and substantial population that warrants specific attention for injury surveillance. Additionally, to excel in this sport, these elite athletes perform highly technical actions that impose shear biomechanical stress on their musculoskeletal system; therefore, regularly describing the nature of and outcomes (including time loss [TL]) after injuries in this population is also critical.[4]

Injury surveillance in collegiate athletics provides team medical staff with injury-level data that can inform the development and implementation of injury prevention programs.[5] The NCAA maintains an injury surveillance system (currently known as the NCAA Injury Surveillance Program [ISP]) that has evolved considerably since its inception in 1982. In 2005, the NCAA ISP began including surveillance of women's tennis injuries.[6] The injury rate in women's tennis is approximately 5 injuries per 1000 athlete exposures (AEs).[6] The injury rate in this population has also been reported to be higher during competition (7.36 per 1000 AEs) than practice (4.15 per 1000 AEs).[6] Prior researchers also found that the lower leg, ankle, and trunk were the most commonly injured body parts.[6] Furthermore, the most commonly reported diagnoses in this population were strains, sprains, and inflammatory conditions, and most injuries were non-TL (NTL) injuries.[6] It is important to survey the evolving burden of injuries in this population so that injury prevention and management practices are continually refined. Therefore, the purpose of this study was to describe the epidemiology of tennis-related injuries

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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[a]

	Number AEs Rate per 1000 AEs (95% CI)					
	Overall		Practices		Competitions	
Division	Reported	National Estimate	Reported	National Estimate	Reported	National Estimate
I	189	6945	114	4209	75	2736
	35 527	1 471 292	27 261	1 139 844	8266	331 448
	5.32 (4.56, 6.08)	4.72 (3.96, 5.48)	4.18 (3.41, 4.95)	3.69 (2.92, 4.46)	9.07 (7.02, 11.13)	8.25 (6.20, 10.31)
II	44	3266	27	2049	17	1218
	14 709	840 945	10 881	624 972	3828	215 973
	2.99 (2.11, 3.88)	3.88 (3.00, 4.77)	2.48 (1.55, 3.42)	3.28 (2.34, 4.21)	4.44 (2.33, 6.55)	5.64 (3.53, 7.75)
III	69	5289	44	3024	25	2264
	22 436	2 010 826	16 860	1 525 654	5576	485 172
	3.08 (2.35, 3.80)	2.63 (1.90, 3.36)	2.61 (1.84, 3.38)	1.98 (1.21, 2.75)	4.48 (2.73, 6.24)	4.67 (2.91, 6.42)
Overall	302	15 500	185	9282	117	6218
	72 671	4 323 063	55 002	3 290 470	17 670	1 032 593
	4.16 (3.69, 4.62)	3.59 (3.12, 4.05)	3.36 (2.88, 3.85)	2.82 (2.34, 3.31)	6.62 (5.42, 7.82)	6.02 (4.82, 7.22)

[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.

captured among NCAA women's tennis players between 2014–2015 and 2018–2019.

METHODS

Study Data

Women's tennis exposure and injury data collected in the NCAA ISP from the 2014–2015 through 2018–2019 athletic seasons were analyzed in this study. The methods of the NCAA ISP have been reviewed and approved as an exempt study by the NCAA Research Review Board. The methods of the surveillance system are described in a separate article in this special issue.[7] Briefly, 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 a team certified AT or physician, regardless of TL. Exposures were defined as a school-sanctioned event (scheduled team practices and competitions) and were reported by an AT, often as a result of coverage. Data from 12 (1% of membership) participating programs in 2014–2015, 7 (1% of membership) in 2015–2016, 17 (2% of membership) in 2016–2017, 14 (2% of membership) in 2017–2018, and 42 (5% of membership) in 2018–2019 qualified for inclusion in analyses. Qualification criteria are detailed in the aforementioned methods article.

Statistical Analysis

Injury counts and rates per 1000 AEs were assessed across levels of event type (practice, competition), competition level (Division I, Division II, Division III), season segment (preseason, regular season, postseason), and time loss (TL, NTL). An AE was defined as 1 athlete participating in 1 exposure event. Weighted and unweighted rates were estimated, and results are presented in terms of unweighted rates due to low frequencies of injury observations across levels of certain covariates unless otherwise specified. Temporal trends in injury rates across the study period were evaluated using rate profile plots stratified by levels of exposure characteristics. Injury counts and proportions 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 evaluate 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, Cary).

RESULTS

A total of 302 women's tennis injuries from 72 671 AEs were reported to the NCAA ISP during the 2014–2015 through 2018–2019 athletic seasons (4.16 per 1000 AEs). This equated to a national estimate of 15 500 injuries overall (Table 1). Overall, the competition injury rate was higher than the practice injury rate (IRR = 1.97; 95% CI = 1.56, 2.48). Competition injury rates decreased markedly between 2014–2015 and 2016–2017 before rising in 2017–2018 and decreasing slightly in 2018–2019. Starting in 2015–2016, practice injury rates followed a similar trajectory, albeit at consistently lower degrees (Figure A). The overall Division I injury rate (5.32 per 1000 AEs) was greater than Division II (2.99 per 1000 AEs) and Division III (3.08 per 1000 AEs) injury rates (Table 1); statistically significant differences were observed when comparing Division I rates to Division II (IRR =1.78; 95% CI =1.28, 2.47) and Division III rates (IRR =1.73; 95% CI =1.31, 2.28).

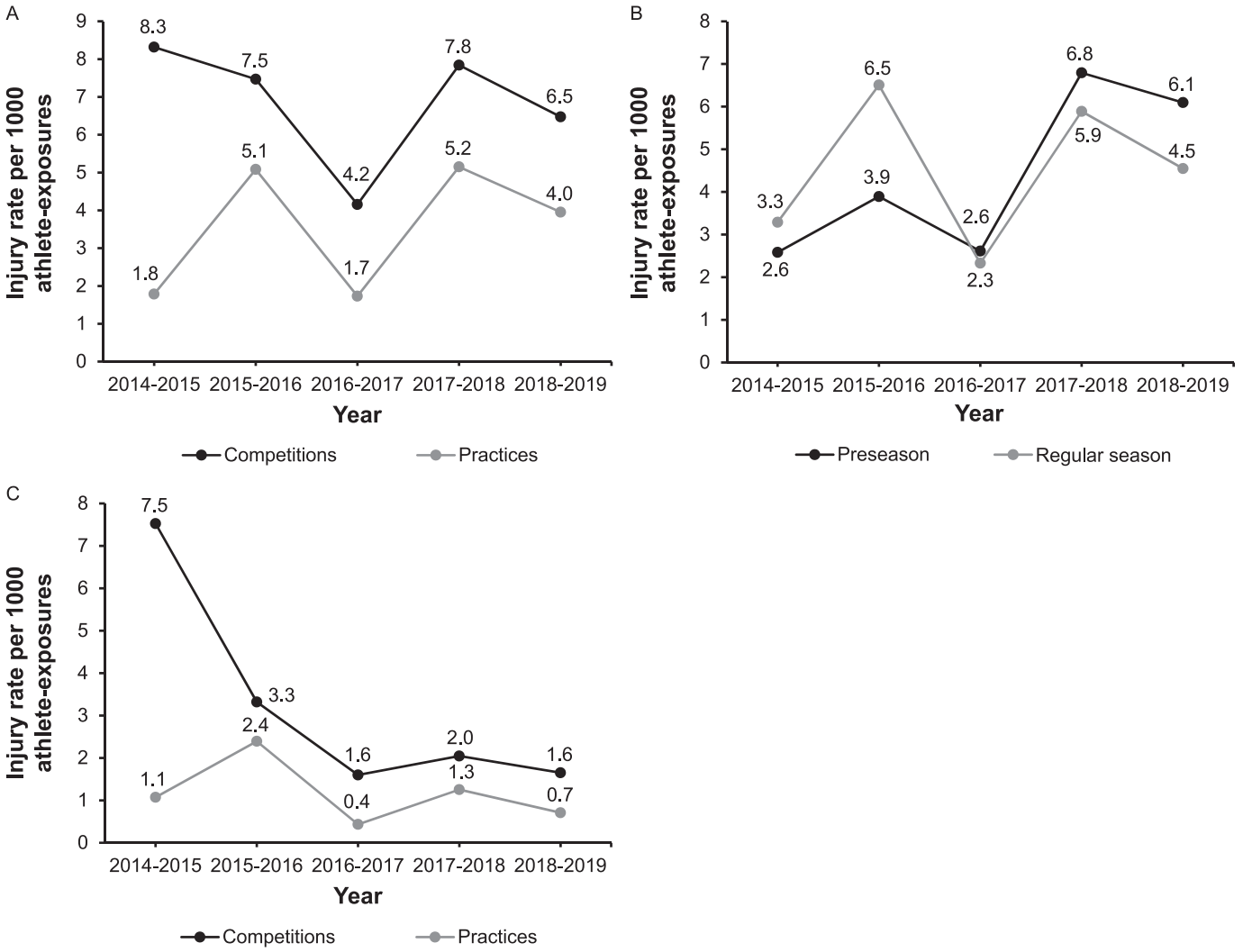

Figure 1. Temporal patterns in injury rates between 2014/15 and 2018/19. A, Overall injury rates (per 1000 athlete exposures [AEs]) stratified by event type (practices, competitions). B, Injury rates (per 1000 AEs) stratified by season segment. C, Rates of time loss injuries stratified by event type (practices, competitions; per 1000 AEs). Rates presented in all figures are unweighted and based on reported data.

Injuries by Season Segment

A total of 63 preseason injuries (national estimate: 3397), 232 regular season injuries (national estimate: 11 815), and 7 postseason injuries (national estimate: 287) were reported between 2014–2015 and 2018–2019 (Table 2). Preseason and regular season injury rates were similar and followed a comparable trajectory across the study period. Overall, both preseason and regular season injury rates increased over the 2014–2015 through 2018–2019 academic years (Figure B). Temporal patterns in postseason injury are not presented due to the low frequency of postseason injuries reported during the study period.

Time Loss

Approximately one-third (32.1%) of all reported injuries resulted in TL $\geq$1 day (45.0% of injuries were NTL injuries; TL was not reported in $\sim$23% of all reported injuries). TL injuries accounted for a greater proportion of reported competition injuries (40.2%) than practice injuries (27.0%). Competition-related TL injury rates decreased sharply from 2014/15 to 2016/17 and remained stable over the remainder of the study period (Figure C). In contrast, practice-related TL injury rates fluctuated throughout the study period (Figure C). TL injuries accounted for a larger proportion of regular season (TL = 34.1%; NTL = 45.7%) than preseason (TL = 23.8%; NTL = 44.4%) injuries. TL injuries accounted for comparable proportions of reported Division I (TL = 33.3%; NTL = 50.3%) and Division III (TL = 37.7%; NTL = 30.4%) injuries (a low frequency of TL injuries [n = 8; 18.2%] was observed among reported Division II injuries).

Injury Characteristics

Injury to the shoulder (15.2%) accounted for the largest proportions of all injuries reported during the study period, and the prevalence of shoulder injuries was comparable among practice-related (14.6%) and competition-related (16.2%) injuries (Table 3). Foot (12.6%), trunk (12%), knee (10.3%), and ankle (9.3%) injuries were also commonly reported (Table 3). Among all injuries, most were attributed to overuse (41.7%) and noncontact (31.1%) mechanisms. Overuse mechanisms accounted for larger proportions of

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	
Division	Reported	National Estimate	Reported	National Estimate
I	29	1241	156	5599
	6097	329 883	27 484	1 070 821
	4.76 (3.03, 6.49)	3.76 (2.03, 5.49)	5.68 (4.79, 6.57)	5.23 (4.34, 6.12)
II	16	988	26	2127
	3162	171 879	10 702	639 944
	5.06 (2.58, 7.54)	5.75 (3.27, 8.23)	2.43 (1.50, 3.36)	3.32 (2.39, 4.26)
III	18	1167	50	4089
	5125	524 674	16 107	1 404 239
	3.51 (1.89, 5.13)	2.22 (0.60, 3.85)	3.10 (2.24, 3.96)	2.91 (2.05, 3.77)
Overall	63	3397	232	11 815
	14 384	1 026 436	54 293	3 115 003
	4.38 (3.30, 5.46)	3.31 (2.23, 4.39)	4.27 (3.72, 4.82)	3.79 (3.24, 4.34)

[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.

practice injuries, while noncontact injuries accounted for larger proportions of competition injuries (Table 3). Surface contact injuries were also common among women's tennis injuries (6.6%) and were more prevalent among competition injuries (7.7%) than practice injuries (6%) (Table 3). The most common diagnoses reported in women's tennis were inflammatory conditions (eg, bursitis, capsulitis, osteochondritis, tendinitis) (27.5%), followed by strains (20.9%) and sprains (11.3%). Inflammatory conditions and strains were the most prevalent diagnoses among both practice and competition injuries. Among practice-related injuries, inflammatory conditions in particular accounted for 30.8% of all injuries, followed by strains, which accounted for nearly 17% of all injuries. Strains were more prevalent among competition-related injuries (27.4%), while inflammatory conditions accounted for more than 22% of all practice-related injuries. The most commonly reported injuries during the study period were partial or complete lateral ligament complex tears (ankle sprain) (6.0%).

Injuries by Tennis-Specific Activities and Playing Positions

Most injuries in women's tennis between 2014–2015 and 2018–2019 occurred during general play (48.0%). Serving (10.3%) and forehand shots (8.0%) also accounted for sizable proportions of activities associated with all reported injuries. The largest proportions of practice- and competition-related injuries were also attributed to general play, followed by serving and forehand shots (Table 4). Larger proportions of women's tennis injuries were reported during singles events than doubles events (Table 4).

SUMMARY

This study aimed to describe the epidemiology of NCAA women's tennis-related injuries during the 2014–2015 through 2018–2019 academic years. In agreement with previous findings, the present study identified a higher overall competition injury rate than practice injury rate.[6] Over the 5-year period, competition injury rates varied, with dramatic decreases followed by equally sharp increases. Practice injury rates similarly fluctuated over the 5-year period. The stark changes year to year of school participation, along with nuances in athletic trainer documentation, may have contributed to the unstable nature of competition and practice injury rates observed in NCAA women's tennis.[8] Additionally, NCAA ISP recruitment strategies evolved over the study period, and the improvements in participation reflect the success of recent recruitment strategies (eg, support and communication from the NCAA Sport Science Institute). Despite the increase in participation over the course of the 5-year study period, low participation and its associated implications with regard to generalizability of findings is an important limitation to note while interpreting the results of the present study. Surveillance of tennis injuries also offers specific injury reporting challenges given the individualized nature of the sport. Using team-based methods of surveillance may affect injury rates, particularly competition related, as a tennis player may compete in multiple matches during 1 documented competition exposure.[9] Matches can vary greatly by number of points played in a match, number of sets within each match, number of sets that determine the match, and relative intensity of the match depending on the opponent.[9,10] While the benefits of having standardized measurements of exposures within the NCAA ISP allows for greater interpretation across and between sports, additional variables may need to be

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 (%)
Injury site						
Head/face	13 (4.30)	538 (3.47)	8 (6.84)	359 (5.77)	5 (2.70)	179 (1.93)
Neck	1 (0.33)	140 (0.90)	0(0)	0(0)	1 (0.54)	140 (1.51)
Shoulder	46 (15.23)	2579 (16.64)	19 (16.24)	857 (13.78)	27 (14.59)	1722 (18.55)
Arm/elbow	18 (5.96)	876 (5.65)	4 (3.42)	229 (3.68)	14 (7.57)	647 (6.97)
Hand/wrist	22 (7.28)	1500 (9.68)	6 (5.13)	456 (7.33)	16 (8.65)	1043 (11.24)
Trunk	35 (11.59)	1883 (12.15)	15 (12.82)	1011 (16.26)	20 (10.81)	872 (9.39)
Hip/groin	16 (5.30)	939 (6.06)	8 (6.84)	530 (8.52)	8 (4.32)	409 (4.41)
Thigh	20 (6.62)	863 (5.57)	12 (10.26)	512 (8.23)	8 (4.32)	351 (3.78)
Knee	31 (10.26)	1122 (7.24)	14 (11.97)	559 (8.99)	17 (9.19)	563 (6.07)
Lower leg	25 (8.28)	1333 (8.60)	5 (4.27)	179 (2.88)	20 (10.81)	1154 (12.43)
Ankle	28 (9.27)	1591 (10.26)	11 (9.40)	839 (13.49)	17 (9.19)	752 (8.10)
Foot	38 (12.58)	1702 (10.98)	13 (11.11)	588 (9.46)	25 (13.51)	1114 (12.00)
Other	9 (2.98)	434 (2.80)	2 (1.71)	98 (1.58)	7 (3.78)	336 (3.62)
Mechanism						
Noncontact	106 (35.10)	5166 (33.33)	51 (43.59)	2330 (37.47)	55 (29.73)	2836 (30.55)
Surface contact	20 (6.62)	753 (4.86)	9 (7.69)	323 (5.19)	11 (5.95)	430 (4.63)
Contact with ball	8 (2.65)	331 (2.14)	6 (5.13)	276 (4.44)	2 (1.08)	55 (0.59)
Contact with net	1 (0.33)	427 (2.75)	1 (0.85)	427 (6.87)	0 (0)	0 (0)
Contact with racket	5 (1.66)	219 (1.41)	1 (0.85)	85 (1.37)	4 (2.16)	134 (1.44)
Contact with wall	1 (0.33)	23 (0.15)	0 (0)	0 (0)	1 (0.54)	23 (0.25)
Overuse	126 (41.72)	6934 (44.74)	40 (34.19)	2329 (37.46)	86 (46.49)	4605 (49.61)
Illness/infection	6 (1.99)	248 (1.60)	1 (0.85)	20 (0.32)	5 (2.70)	228 (2.46)
Other/unknown	29 (9.60)	1398 (9.02)	8 (6.84)	428 (6.88)	21 (11.35)	970 (10.45)
Diagnosis						
Abrasion/laceration	2 (0.66)	309 (1.99)	1 (0.85)	45 (0.72)	1 (0.54)	264 (2.84)
Concussion	7 (2.32)	290 (1.87)	5 (4.27)	234 (3.76)	2 (1.08)	55 (0.59)
Contusion	8 (2.65)	352 (2.27)	5 (4.27)	225 (3.62)	3 (1.62)	127 (1.37)
Dislocation/subluxation	3 (0.99)	436 (2.81)	0(0)	0(0)	3 (1.62)	436 (4.70)
Entrapment/Impingement	7 (2.32)	285 (1.84)	3 (2.56)	130 (2.09)	4 (2.16)	155 (1.67)
Fracture	6 (1.99)	439 (2.83)	4 (3.42)	278 (4.47)	2 (1.08)	161 (1.73)
Illness/infection/dermatologic	3 (0.99)	72 (0.46)	1 (0.85)	20 (0.32)	2 (1.08)	52 (0.56)
Inflammatory condition	83 (27.48)	4114 (26.54)	26 (22.22)	1346 (21.65)	57 (30.81)	2768 (29.82)
Spasm	18 (5.96)	1014 (6.54)	5 (4.27)	453 (7.29)	13 (7.03)	561 (6.04)
Sprain	34 (11.26)	1743 (11.25)	16 (13.68)	924 (14.86)	18 (9.73)	819 (8.82)
Strain	63 (20.86)	3253 (20.99)	32 (27.35)	1663 (26.74)	31 (16.76)	1591 (17.14)
Other	68 (22.52)	3193 (20.60)	19 (16.24)	900 (14.47)	49 (26.49)	2293 (24.70)

[a] Data are 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.

collected to most accurately capture competition exposures in tennis. Future surveillance efforts of tennis competition exposures should consider including the number of matches and match duration.[9] The intensity of play is a more difficult variable to quantify, yet nonetheless important to capture, and may be best examined in targeted, small-scale studies through monitoring of match- and exercise-related factors, such as heart rate, lactate concentrations, rate of perceived exertion, or rally duration.[10–13]

Injury rates were found to be similar between preseason and regular season. This finding is in contrast to previous literature, which found the preseason injury rate to be higher than the regular season injury rate in NCAA women's tennis.[6] This finding also differs from previous reports that have demonstrated a higher risk of sport-related injury across 15 NCAA sports during preseason practices.[14] Although tennis was not included in these examinations, the relatively higher injury risk in preseason has been attributed to the competitive and intense atmosphere during preseason, which often follows a period of rest for most athletes.[14] The risk of injury during the preseason in women's tennis remains in question. The results observed here may at least be partially attributed to the fact that tennis can be played year round, and elite NCAA players may seek private instruction through clubs and public tennis courts to remain engaged year round.[1] Capturing player activity during the off-season or through non–NCAA-related training is not a feature of the ISP in its current form. Future studies may consider capturing such information to more comprehensively examine exposure and injury characteristics in this population.

TL injuries accounted for approximately one-third of all reported injuries and were more prevalent among competition injuries than practice injuries. TL injuries were also more prevalent among regular season injuries than preseason injuries. These results potentially indicate a

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

	Overall\		Competitions\		Practices\	
	Injuries Reported (%)	National Estimate (%)	Injuries Reported (%)	National Estimate (%)	Injuries Reported (%)	National Estimate (%)
Activity						
Serving	31 (10.26)	1637 (10.56)	14 (11.97)	956 (15.37)	17 (9.19)	681 (7.34)
Volley shot	5 (1.66)	239 (1.54)	2 (1.71)	90 (1.45)	3 (1.62)	150 (1.62)
Running	16 (5.30)	703 (4.54)	8 (6.84)	371 (5.97)	8 (4.32)	332 (3.58)
Conditioning	13 (4.30)	880 (5.68)	0 (0)	0 (0)	13 (7.03)	880 (9.48)
General play	145 (48.01)	7467 (48.17)	54 (46.15)	2437 (39.19)	91 (49.19)	5030 (54.19)
Forehand shot	24 (7.95)	1080 (6.97)	10 (8.55)	499 (8.03)	14 (7.57)	581 (6.26)
Backhand shot	9 (2.98)	269 (1.74)	6 (5.13)	197 (3.17)	3 (1.62)	72 (0.78)
Overhand Smash shot	1 (0.33)	36 (0.23)	1 (0.85)	36 (0.58)	0 (0)	0 (0)
Drop shot	3 (0.99)	160 (1.03)	1 (0.85)	65 (1.05)	2 (1.08)	95 (1.02)
Other/unknown	1 (0.33)	32 (0.21)	0 (0)	0 (0)	1 (0.54)	32 (0.34)
Position						
Singles	101 (33.44)	5903 (38.08)	53 (45.30)	2853 (45.88)	48 (25.95)	3050 (32.86)
Doubles	16 (5.30)	1416 (9.14)	10 (8.55)	1038 (16.69)	6 (3.24)	378 (4.07)
Other/unknown	185 (61.26)	8181 (52.78)	54 (46.15)	2327 (37.42)	131 (70.81)	5854 (63.07)

[a] Data are 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.

higher burden of regular season and competition injuries in this population. Further attention may be directed toward the recovery process after regular season and competition injuries among NCAA women's tennis athletes. Approximately half of all injuries were reported to be NTL injuries (with notable differential prevalence between reported Division I and Division III injuries). This was a marked decrease from findings of a previous study of this population that found NTL injuries to constitute closer to 60% of all reported injuries.[6] This may be considered intuitively consistent with common mechanisms of injury reported during the study period. Noncontact injuries were one of the most common mechanisms of injury and the most common during competition. Conversely, overuse injuries accounted for the greatest proportion of all practice-related injuries. Injuries related to overuse mechanisms, while serious and often chronic, may not lead to the same TL response as an acute injury.[15] The response to injuries associated with an overuse mechanism and TL after such injuries could serve as an important avenue for future study. It is also important to note that TL was not recorded in approximately 22% of injuries, and this limits the appraisal of TL after injuries among women's tennis athletes. For instance, the differential prevalence of NTL injuries between Division I and Division III was comparable to the difference in missing TL data between the 2 divisions. As such, while it is reasonable to posit that the observed differences across competition levels may result from a multitude of factors (eg, off-season training patterns or AT staffing), it is difficult to comment further on this given the observed proportion of missing TL data. Future studies should also aim to more comprehensively capture TL data.

The most common injury diagnoses reported in NCAA women's tennis during 2014–2015 through 2018–2019 were inflammatory conditions, strains, and sprains. Inflammatory conditions were more common among practice-related injuries, while strains were more common among competition-related injuries. During the study period, most reported injuries were attributed to the shoulder, followed by the foot and trunk. Previous NCAA women's tennis surveillance has revealed the shoulder to be a common source of injury, but the present study has shown a higher frequency of shoulder injury than previously reported.[6] The prevalence of injury to the shoulder is not unexpected given that outside of general play, serving and forehand shots accounted for notable proportions of activities associated with injury, and both produce immense force through the shoulder joint.[16,17] In-depth analyses of serving and forehand kinematics have reveled that the timing of shoulder horizontal adduction and external or internal rotation can play important roles in glenohumeral shearing forces that may predispose an athlete to overuse shoulder injury, such as impingement syndromes of the shoulder.[16,17] Serving and forehand motions also require appropriate input and control of the trunk musculature.[16,17] Given that a substantial portion of injuries in the present study were attributed to overuse mechanisms and serving and forehand activities and affected the shoulder and trunk, the dynamic relationship between these 2 structures should be further explored. The sequence of injury and how an injury to 1 structure may predispose the athlete to another injury in a different structure warrant targeted attention from researchers and clinicians. Furthermore, the prevalence of foot injuries is also of particular interest. In a previous study of professional women's tennis athletes, researchers noted that the prevalence of foot injuries was comparable to that of upper extremity body parts in this population.[18] The findings of the current study and investigations of professional athletes differ from a previous examination of NCAA women's tennis athletes, which found injury to the foot to be less prevalent among all reported injuries.[6] Interestingly, while the foot was not previously reported as a prevalently injured body part, it was reported to be the most common body part associated with severe injury.[6] The pathoetiology of foot injuries in tennis was not investigated

in the present study, but both the type of foot injury and the resulting impact of foot injury in women's tennis warrants further exploration.

Women's tennis is a popular and competitive sport worldwide that exposes athletes to a unique burden of injury. Continual monitoring of NCAA women's tennis will aid researchers and clinicians in efforts to maintain and improve the health of these athletes. Higher and stable participation in injury surveillance efforts will be necessary to produce consistent observations of specific injuries and to examine temporal patterns in injury incidence. The findings of the present study can be used to inform areas for future targeted studies that will allow for better understanding of injuries in NCAA women's tennis.

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