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

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Context: Women's gymnastics athletes in the National Collegiate Athletic Association (NCAA) constitute a unique population of NCAA athletes given the nature and dynamics of the sport.

Background: Routine examination of women's gymnastics injuries is important for identifying the evolving burden of injuries in this sport.

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

Results: The overall injury rate was 8.00 per 1000 athlete-exposures; injury incidence was greater in competitions than in practices (injury rate ratio = 1.84; 95% CI = 1.48, 2.29), though practice injury rates increased during 2015–2016 through 2018–2019. Most injuries were classified as strains (16.5%), sprains (16.4%), and inflammatory conditions (12.3%), with overuse injuries prevalent among practice injuries (22.5%). Concussions (8.4%) were the most commonly reported specific injury.

Summary: The increasing trend in practice injury incidence is noteworthy although competition injury rates were higher overall. Findings also suggest that the etiologies of overuse injuries and inflammatory conditions as well as the biomechanical aspects of concussions warrant further attention.

Key Words: collegiate sports, descriptive epidemiology, injury surveillance

Key Points

- The overall competition injury rate was higher than the overall practice injury rate; competition injury rates fluctuated across the study period while practice injury rates steadily increased during 2015-2016 through 2018-2019.
- Nearly half of all reported injuries resulted in time loss of $\geq$ 1 day, and knee, ankle, and foot injuries accounted for the largest proportions of all reported injuries.
- Concussion was the most prevalently reported specific injury, and concussion incidence fluctuated across the study period.

Women's gymnastics first debuted at the Olympics in 1928 and has since evolved significantly to its current form, first seen at the 1952 world championships. The National Collegiate Athletic Association (NCAA) has sponsored national championships in women's gymnastics since 1982, and although participation followed a decreasing trajectory during the late 1980s and early 1990s (from 179 sponsored teams and over 2000 participating student-athletes in 1982 to 90 sponsored teams and approximately 1200 participating student-athletes in 1995), it has stabilized since then and particularly over the last 10 years (with from 81–83 sponsored teams and approximately 1500 student-athletes).[1] Women's gymnastics involves complex movements, and athletes require high levels of balance, strength, flexibility, discipline, psychological fortitude, air sense, and grace to perform technical skills in combinations. Furthermore, gymnastics events result in high impacts to both the lower and upper extremities. As such, there is a notable risk of injury in this sport, and coupled with the high rates of early single-sport specialization (which has been previously associated with high risk of overuse injury) observed in women's gymnastics, these athletes are particularly at risk of overuse injuries.[2] The existing notions surrounding injury risk and the stabilizing participation in NCAA women's gymnastics in recent years necessitate surveillance of injury incidence and outcomes in NCAA women's gymnastics athletes.

Using sports injury surveillance, researchers are able to routinely monitor injury-related patterns in large populations of athletes.[3,4] The NCAA has maintained an injury surveillance system since 1982, and after a series of adaptations, it is now in its current form of the NCAA

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Injury Surveillance Program (ISP).[5,6] Previous epidemiological studies using the NCAA ISP to study women's gymnastics injuries have identified patterns in injury incidence.[7,8] The overall injury rate in women's gymnastics has been previously reported to be the highest among all women's collegiate sports.[7,9] In addition, it has also been reported that injuries in women's gymnastics occur at a higher rate in competitions than in practices,[7,8] most often to the lower extremity,[7,8,10,11] and typically during dismounting and floor events.[7,8,11] Furthermore, overuse injuries such as stress fractures have been reported to occur at higher rates in women's gymnastics than in most other NCAA women's sports.[12] Identifying these injury-related patterns has helped lead to preventative equipment modifications, such as incorporating additional padding into areas for dismounting and landing.[7] Nonetheless, continued surveillance of injury incidence and mechanisms is critical in this highly competitive and physically demanding sport to better inform future policy and rule changes regarding injury prevention. Accordingly, the purpose of this study was to describe the epidemiology of gymnastics-related injuries captured among NCAA women's gymnasts during the 2014–2015 through 2018–2019 academic years.

METHODS

Study Data

Women's gymnastics exposure and injury data collected in the NCAA ISP during 2014–2015 through 2018–2019 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, and the methods of the surveillance program are described in a separate manuscript within this special issue.[13] In brief, athletic trainers (ATs) at participating institutions contributed injury and exposure 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 AT or physician (regardless of time loss). Scheduled team practices and competitions were considered reportable exposures for this study. Data from 7 (9% of membership) participating programs in 2014–2015, from 6 (7% of membership) in 2015–2016, from 9 (11% of membership) in 2016–2017, from 6 (7% of membership) in 2017–2018, and from 14 (17% of membership) in 2018–2019 qualified for inclusion in analyses. Qualification criteria are detailed in the aforementioned methods manuscript.[13]

Statistical Analysis

Injury counts and rates (per 1000 athlete-exposures [AEs], where 1 AE was defined as 1 athlete participating in 1 exposure event) were evaluated by event type (practice, competition), season segment (preseason, regular season, postseason), and time lost (time loss [TL], non–time loss [NTL]). Poststratification sample weights by sport and division have been established within the ISP to compute national estimates of injury events on the basis of the sampled teams; weighted and unweighted rates have been estimated for this study, and results are presented in terms of unweighted rates unless otherwise specified. Temporal patterns in injury rates across the study period were evaluated using rate-profile plots stratified by event type and season segment. Similarly, temporal trends in rates of most commonly reported injuries were also examined across the study period. Injury counts and proportions were examined by TL, body part injured, injury mechanism, injury diagnosis, and sport activity. Injury rate ratios (IRR) were used to examine differential injury rates across event type, competition level, and season segment. IRRs with associated 95% confidence intervals excluding 1.00 were considered statistically significant. All analyses were conducted using SAS version 9.4 (SAS Institute).

RESULTS

A total of 587 women's gymnastics injuries from 73 361 AEs were reported to the NCAA ISP during the 2014–2015 through 2018–2019 academic years (rate = 8.00 per 1000 AEs). This equated to a national estimate of 6220 injuries overall (rate = 7.76 per 1000 AEs). Across the study period, the competition injury rate was higher than the practice injury rate (IRR = 1.84; 95% CI = 1.48, 2.29). Competition injury rates fluctuated across the study period, reaching the highest point in 2017–2018 (Figure A). Practice injury rates consistently increased between 2015–2016 and 2018–2019 (Figure A).

Injuries by Season Segment

A total of 354 preseason injuries (national estimate: 3716), 198 regular season injuries (national estimate: 2146), and 35 postseason injuries (national estimate: 358) were reported between 2014–2015 and 2018–2019. The overall postseason injury rate (4.79/1000 AEs) was lower than the preseason (9.02 per 1000 AEs) and regular season (7.39 per 1000 AEs) injury rates; statistically significant differences were observed when comparing the postseason injury rate to both preseason (IRR = 0.53; 95% CI = 0.38, 0.75) and regular season (IRR = 0.65; 95% CI = 0.45, 0.93) injury rates. Preseason injury incidence decreased between 2014–2015 and 2015–2016, before following an increasing trajectory through the remainder of the study period (Figure B). Regular season injury incidence increased between 2014–2015 and 2017–2018, before decreasing sharply during the final year of the study (Figure B). Temporal patterns in postseason injury incidence were not examined due to low frequencies of postseason injuries ($n \leq 5$) reported during certain years of the study.

Time Loss

Nearly half (44.1%) of all reported injuries resulted in TL of $\geq$1 day, and average TL among those injuries was 23.9 days (SD = 34.1 days; TL was not recorded in approximately 26% of all reported injuries). The TL injuries accounted for a slightly larger proportion of reported practice injuries (45.1%) than competition injuries (39.2%). Among all competition-related TL injuries, average TL was 16.5 days (SD = 17.8 days), and among all practice-related TL injuries, the average TL was 25.2 days (SD = 36.0 days). Temporal patterns in TL injury incidence were not examined due to low frequencies reported during certain years of the study.

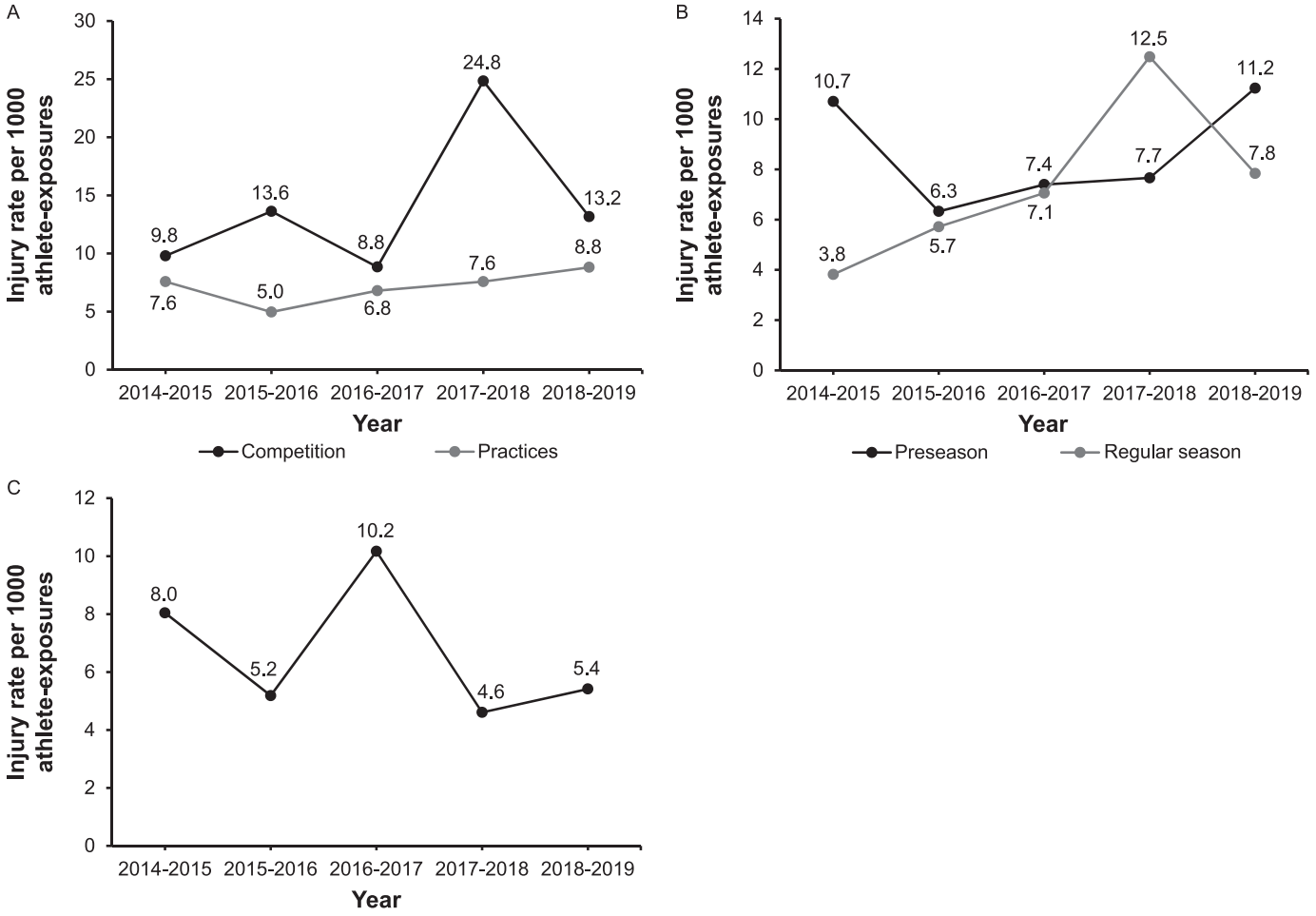

Figure. Temporal patterns in injury rates between 2014–2015 and 2018–2019. A, Depicts overall injury rates (per 1000 AEs) stratified by event type (practices, competitions). B, Depicts injury rates (per 1000 AEs) stratified by season segment. C, Depicts rates (per 10 000 AEs) of most commonly reported injury: concussion. Rates presented in all figures are unweighted and based on reported data. Abbreviation: AEs, athlete-exposures.

Injury Characteristics

Knee injuries (13.1%), ankle injuries (12.6%), and foot injuries (12.1%) accounted for the largest proportions of all women's gymnastics injuries reported during 2014–2015 through 2018–2019. Lower leg injuries (11.6%) and head and face injuries (10.4%) were also prevalent among all reported injuries. Knee injuries and ankle injuries accounted for larger proportions of competition injuries than practice injuries during the study period (Table 2). Surface-contact injuries (35.4%) and overuse injuries (20.3%) accounted for over half of all reported injuries. A notable proportion (19.1%) of all injuries was also attributed to noncontact mechanisms. Surface-contact injuries accounted for a larger proportion of competition injuries (48.5%) than practice injuries (32.9%), whereas overuse injuries accounted for a larger proportion of practice injuries (22.5%) than competition injuries (9.3%).

Women's gymnastics injuries reported during the study period were most often classified as strains (16.5%) and sprains (16.4%). Inflammatory conditions (eg, bursitis, capsulitis, osteochondritis, tendinitis; 12.3%) and contusions (10.6%) were also prevalent among all reported injuries. Strains and sprains accounted for larger proportions of competition injuries than practice injuries, whereas contusions accounted for a larger proportion of practice injuries than competition injuries (Table 2). The most commonly reported specific injury during the study period was concussion (8.4%), and 79.6% of all reported concussions were attributed to surface contact. The rate of concussions fluctuated throughout the study period and was highest in 2016–2017 (Figure C).

Injuries by Gymnastics Activities

Most injuries in women's gymnastics between 2014–2015 and 2018–2019 occurred during floor routines (26.9%). A notable proportion of injuries also occurred during activities on uneven bars (22.7%). Uneven bar injuries accounted for larger proportions of practice injuries than competition injuries (Table 3). Vault-related injuries accounted for a larger proportion of competition injuries (23.7%) than practice injuries (6.7%).

SUMMARY

This study aimed to describe the epidemiology of gymnastics-related injuries among NCAA women's gymnasts during the 2014–2015 through 2018–2019 athletic seasons. Across the study period, the overall competition injury rate was nearly twice as high as the practice injury

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

	Number AEs Rate per 1000 AEs (95% CI)					
	Overall		Competitions		Practices	
	Reported	National Estimate	Reported	National Estimate	Reported	National Estimate
Preseason	354	3716	1	17	353	3699
	39 260	436 204	28	369	39 232	435 835
	9.02 (8.08, 9.96)	8.52 (7.58, 9.46)	35.71 (0.00, 105.71)	46.07 (0.00, 116.07)	9.00 (8.06, 9.94)	8.49 (7.55, 9.43)
Regular season	198	2146	84	951	114	1195
	26 795	289 191	6023	64 343	20 772	224 848;
	7.39 (6.36, 8.42)	7.42 (6.39, 8.45)	13.95 (10.96, 16.93)	14.78 (11.80, 17.76)	5.49 (4.48, 6.50)	5.31 (4.31, 6.32)
Postseason	35	358	12	99	23	259
	7306	76 453	1061	11 090	6245	65 363
	4.79 (3.20, 6.38)	4.68 (3.10, 6.27)	11.31 (4.91, 17.71)	8.93 (2.53, 15.33)	3.68 (2.18, 5.19)	3.96 (2.46, 5.47)
Overall	587	6220	97	1068	490	5153
	73 361	801 848	7112	75 801	66 249	726 047
	8.00 (7.35, 8.65)	7.76 (7.11, 8.40)	13.64 (10.92, 16.35)	14.09 (11.38, 16.80)	7.40 (6.74, 8.05)	7.10 (6.44, 7.75)

[a] Data presented in the order of reported number, followed by athlete exposures (AEs), estimated injury rates, and associated 95% Confidence Intervals (CIs) for each cross-tabulation of season segment and event types. Data pooled association-wide are presented overall, and separately for practices and competitions, as well as for preseason, regular season, and postseason. 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.

rate. Whereas competition injury rates fluctuated throughout the study period, practice injury rates steadily increased during the latter years of the study. The drastic increase in competition injury rates between 2016–2017 and 2017–2018 is striking and warrants further attention. Given that the competition injury rate in 2017–2018 was considerably higher than those observed during the other years of the study, playing rule changes that were enacted during 2017–2018 or other changes to the competition environment that were unique to the year could be examined more closely for their impacts on injury risk. For instance, the rule book for the 2017–2018 season included a scoring amendment that afforded athletes greater leniency in their landing technique.[14,15] It may be noted that playing-rule changes typically involve such event-specific scoring amendments aimed at rewarding greater technical skill and advanced movements.[14,15] The implementation of such rule changes imposes a natural fluidity in the dynamics of the sport because increasingly difficult maneuvers are awarded a greater point value. It is reasonable to suggest that an inherent element of risk is related to such advanced movements and may contribute to observed competition injury rates. Future researchers should target relationships between specific movements and skills attempted during competition and competition-related injury incidence. Furthermore, given the nature of typical rule changes in the sport, clinicians caring for women's gymnastics athletes may consider staying abreast of such rules changes in the interest of being best positioned to provide nuanced clinical care to these athletes.

The upward trajectory of practice injury rates through the majority of the study period, albeit gradual, was also noteworthy. Furthermore, overuse injuries were especially prevalent among reported practice injuries in this study. Together, these findings may be unsurprising given the amount of repetition required to perfect complex movements in gymnastics and the resultant burden placed on specific body parts or regions.[16–19] In addition, given that high rates of early sport specialization are observed in women's gymnastics, these findings are also in alignment with existing research suggesting that the risk of overuse injuries may be higher in athletes who specialize in a sport at an early age.[20,21] Nonetheless, the etiology of practice-related overuse injuries in this population may be an area to target in future research. While evaluating the injury rates observed in this study, it is salient to concurrently consider participation in NCAA ISP among women's gymnastics programs. Although participation was generally higher during the latter years of the study, it was markedly lower in 2017–2018 than in the adjacent years. Furthermore, given the convenience sampling strategy of the ISP, regional or conference representation in the ISP also generally varies from year to year. Poststratification sample weights are useful for adjusting national estimates (presented in the tables in this article) according to sampling inadequacies, albeit not flawless; though unweighted estimates corresponding to years in which participation was relatively low may have limited external validity. With that said, although the latter years of the study, in aggregate, may be considered a more accurate reflection of the injury burden in this population than the years prior, it is yet reasonable to approach results from the 2017–2018 athletic season with particular caution. In addition, the well-established method of expressing exposure time as AEs in sports injury surveillance may not be the most robust representation of at-risk exposure time in women's gymnastics. Indeed, given the inherent individual nature of the sport, exposure time is better measured in more nuanced and individually oriented methods in women's gymnastics. The NCAA ISP is not well positioned for such individual-

Table 2. 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	61 (10.39)	690 (11.09)	12 (12.37)	147 (13.76)	49 (10.00)	543 (10.54)
Neck	19 (3.24)	188 (3.02)	0 (0.0)	0 (0.0)	19 (3.88)	188 (3.65)
Shoulder	50 (8.52)	572 (9.20)	6 (6.19)	53 (4.96)	44 (8.98)	520 (10.09)
Arm/elbow	25 (4.26)	253 (4.07)	3 (3.09)	29 (2.72)	22 (4.49)	224 (4.35)
Hand/wrist	25 (4.26)	232 (3.73)	3 (3.09)	27 (2.53)	22 (4.49)	205 (3.98)
Trunk	52 (8.86)	471 (7.57)	4 (4.12)	33 (3.09)	48 (9.80)	438 (8.50)
Hip/groin	20 (3.41)	174 (2.80)	3 (3.09)	22 (2.06)	17 (3.47)	152 (2.95)
Thigh	27 (4.60)	283 (4.55)	3 (3.09)	43 (4.03)	24 (4.90)	240 (4.66)
Knee	77 (13.12)	841 (13.52)	19 (19.59)	242 (22.66)	58 (11.84)	598 (11.60)
Lower leg	68 (11.58)	699 (11.24)	14 (14.43)	150 (14.04)	54 (11.02)	549 (10.65)
Ankle	74 (12.61)	746 (11.99)	16 (16.49)	156 (14.61)	58 (11.84)	590 (11.45)
Foot	71 (12.10)	823 (13.23)	13 (13.40)	158 (14.79)	58 (11.84)	665 (12.91)
Other	18 (3.07)	249 (4.00)	1 (1.03)	9 (0.84)	17 (3.47)	240 (4.66)
Mechanism						
Player contact	5 (0.85)	52 (0.84)	2 (2.06)	17 (1.59)	3 (0.61)	35 (0.68)
Surface contact	208 (35.43)	2169 (34.87)	47 (48.45)	515 (48.22)	161 (32.86)	1654 (32.10)
Equipment contact	95 (16.18)	1094 (17.59)	17 (17.53)	196 (18.35)	78 (15.92)	898 (17.43)
Out of bounds contact	3 (0.51)	31 (0.50)	0 (0.0)	0 (0.0)	3 (0.61)	31 (0.60)
Noncontact	112 (19.08)	1245 (20.02)	17 (17.53)	195 (18.26)	95 (19.39)	1050 (20.38)
Overuse	119 (20.27)	1132 (18.20)	9 (9.28)	82 (7.68)	110 (22.45)	1051 (20.40)
Other/unknown	45 (7.67)	497 (7.99)	5 (5.15)	63 (5.90)	40 (8.16)	434 (8.42)
Diagnosis						
Abrasion/laceration	6 (1.02)	90 (1.45)	1 (1.03)	17 (1.59)	5 (1.02)	73 (1.42)
Concussion	49 (8.35)	551 (8.86)	9 (9.28)	104 (9.74)	40 (8.16)	447 (8.67)
Contusion	62 (10.56)	752 (12.09)	7 (7.22)	96 (8.99)	55 (11.22)	656 (12.73)
Dislocation/subluxation	15 (2.56)	128 (2.06)	2 (2.06)	13 (1.22)	13 (2.65)	115 (2.23)
Entrapment/impingement	19 (3.24)	196 (3.15)	2 (2.06)	25 (2.34)	17 (3.47)	171 (3.32)
Fracture	37 (6.30)	390 (6.27)	5 (5.15)	50 (4.68)	32 (6.53)	340 (6.60)
Illness/infection	5 (0.85)	79 (1.27)	1 (1.03)	17 (1.59)	4 (0.82)	62 (1.20)
Inflammatory condition	72 (12.27)	689 (11.08)	11 (11.34)	128 (11.99)	61 (12.45)	561 (10.89)
Spasm	14 (2.39)	131 (2.11)	2 (2.06)	16 (1.50)	12 (2.45)	116 (2.25)
Sprain	96 (16.35)	995 (16.00)	22 (22.68)	207 (19.38)	74 (15.10)	788 (15.29)
Strain	97 (16.52)	1017 (16.35)	21 (21.65)	260 (24.34)	76 (15.51)	757 (14.69)
Other	115 (19.59)	1200 (19.29)	14 (14.43)	133 (12.45)	101 (20.61)	1067 (20.71)

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

level exposure ascertainment and future, therefore small-scale studies may consider leveraging video footage or wearable technology to better ascertain exposure time in this sport.

Most injuries reported in NCAA women's gymnastics between 2014–2015 through 2018–2019 were strains, sprains, and inflammatory conditions. While this is consistent with previous findings in this population,[7,8] the

Table 3. Distribution of Injuries by Injury Activity; Stratified by Event Type[a]

	Overall		Competitions		Practices	
Activity	Injuries Reported (%)	National Estimate (%)	Injuries Reported (%)	National Estimate (%)	Injuries Reported (%)	National Estimate (%)
Balance beam	91 (15.50)	1056 (16.98)	16 (16.49)	212 (19.85)	75 (15.31)	844 (16.38)
Floor routine	158 (26.92)	1566 (25.18)	27 (27.84)	271 (25.37)	131 (26.73)	1295 (25.13)
Fitness/conditioning	15 (2.56)	133 (2.14)	1 (1.03)	8 (0.75)	14 (2.86)	125 (2.43)
Uneven bars	133 (22.66)	1487 (23.91)	15 (15.46)	162 (15.17)	118 (24.08)	1326 (25.73)
Vault	56 (9.54)	573 (9.21)	23 (23.71)	237 (22.19)	33 (6.73)	336 (6.52)
Other/unknown	134 (22.83)	1405 (22.59)	15 (15.46)	178 (16.67)	119 (24.29)	1227 (23.81)

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

comparable prevalence of inflammatory conditions among practice and competition injuries is noteworthy. Limited research exists with regards to the etiology of inflammatory conditions in this population. The pathoetiology of inflammatory conditions are generally condition specific, but they typically result from a failed healing response due to repetitive tissue damage coupled with inadequate rest.[22] This inflammatory cycle may be further exacerbated in women's gymnastics given the rigorous training regime, the aesthetic nature of the sport, the impacts sustained during landing, and early sports specialization.[18,21,23–25] Future researchers should examine the development of inflammatory conditions in this population and consider the application of preventive techniques (aimed at inflammatory conditions) that have been shown to be effective in other athlete populations.[26] Furthermore, unique characteristics such as the aesthetic nature of the sport and the high prevalence of early sport specialization may also affect athlete health and wellness with regards to nutrition and metabolic health.[27–29] Sports medicine staff working with women's gymnastics athletes may consider these factors as well as the competitive structure of youth gymnastics in contextualizing the individual needs of athletes competing in this sport. The NCAA ISP does not capture information on nutritional compromises, and future researchers may also consider this area as an avenue for further examination in this population.

Most reported injuries during the study period were among the lower extremity body parts. With that said, approximately 10% of all reported injuries were head or face injuries, which were comparably prevalent among practice and competition injuries. Furthermore, concussion was the most commonly reported specific injury during the study period. Sport-related concussions have gained much attention in recent years, though there exists a dearth of research related to concussion incidence in women's gymnastics. Although player contact is not an inherent element of the sport, it has been previously classified as a contact sport given the frequency of surface and equipment or apparatus contact involved. Notably, over half of all reported injuries in the present study were attributable to surface or equipment contact mechanisms, and most concussions resulted from surface contact. It is reasonable to suggest that the biomechanical characteristics of head impacts associated with surface or equipment or apparatus contact (given, for example, that athletes may be falling from heights) are distinct to those associated with player contact. Athletes may be in a more vulnerable position while coming in contact with the surface or equipment (as compared with another athlete), and therefore less equipped to dissipate the biomechanical forces sustained during an impact. The NCAA ISP does not capture detailed information on the mechanism of injury such as the nature or biomechanics of injury-causing impacts. Future researchers should closely examine concussion incidence in women's gymnastics and target the head-impact biomechanics associated with concussive injury to better understand the concussion burden in this population.

Continued monitoring of NCAA women's gymnastics is important and will yield meaningful insight into the changing landscape of injury incidence in this population. Future researchers should examine the etiology of overuse injuries among NCAA women's gymnastics athletes, and routine injury surveillance should also involve monitoring incidence trajectories of commonly observed injuries such as concussion. Clinicians caring for women's gymnastics athletes may also consider unique aspects of the sport (such as scoring nuances and the aesthetic nature of the sport) in informing clinical practice. Whereas surveillance-based studies are important for identifying emerging patterns in injury incidence, small-sample studies are needed to reconcile the observed results and better understand injury etiology.

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