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

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Context: Women's cross-country is a thriving sport at the National Collegiate Athletic Association (NCAA) level with over 1000 sponsored programs association-wide.

Background: Routine examinations of women's cross-country injuries are important for identifying emerging time trends in injury incidence and outcomes.

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 3.96 per 1000 athlete-exposures. Most reported injuries were inflammatory conditions (33.6%), strains (17.7%), and fractures (9.1%). The most commonly reported injuries were medial tibial stress syndrome (10.0%) and lateral ligament complex tears (ankle sprains; 4.2%).

Summary: Findings of this study were not entirely consistent with existing evidence. Future studies are needed to examine the nature of inflammatory conditions and fractures in this population, as well as temporal patterns in commonly reported injuries.

Key Words: collegiate, descriptive epidemiology, injury surveillance

Key Points

- Across the study period, the competition injury rate was higher than the practice injury rate, and nearly half of all reported injuries resulted in time loss of $\geq$1 day.
- Preseason and regular season injury rates appear to have increased during 2015/16 through 2018/19.
- Lower leg, foot, and thigh injuries accounted for the largest proportion of all reported injuries; while inflammatory conditions, strains, and fractures accounted for most reported injuries, the most commonly reported specific injuries were shin splints and ankle sprains.

Cross-country, a competitive long-distance running sport, demands elite physiological biomechanical attributes for top performance and decreased risk of injury. Cross-country athletes are required to traverse burdensome terrains including roads, wooden trails, and grass at a high velocity. Furthermore, environmental conditions of these routes also present difficulties. Cross-country is a growing sport among athletes in the United States.[1,2] An estimated 219 000 girls competed in high school cross-country during 2018–2019, of whom approximately 7% were forecasted to compete at the National Collegiate Athletic Association (NCAA) level.[2] With regard to the NCAA level in particular, in 2018–2019 a total of 1077 teams and 15 624 athletes participated in NCAA women's cross-country.[2] Given the healthy interest and participation, continued research is necessary to appraise the evolving burden of injury in this population.

Population-level surveillance systems are regularly used to identify patterns related to health outcomes in various contexts. In the interest of capturing a broad scope of injuries among NCAA athletes, the NCAA established an injury surveillance system (now the Injury Surveillance Program [ISP]) in 1982.[3,4] Whereas data collected within the NCAA ISP have been critical in identifying patterns in injury incidence and outcomes among NCAA athletes of various sports, epidemiological investigations of NCAA women's cross-country have been limited. In the limited existing research on this population, it has been reported that the overall injury rate among NCAA women's cross-country runners was 5.85 per 1000 athlete-exposures (AEs).[5] It was also noted that no difference in injury rates existed between practice and competition, and injuries were most often classified as inflammation (23.8%) or strain (20.4%).[5]

Data collected within the NCAA ISP can be used to effectively identify emerging injury trends among women's cross-country athletes. With the dissemination of these findings, athletic trainers (ATs) and sports medicine staff can initiate practices targeted to reduce the overall burden of injury in this population. Particularly considering the aforementioned growth in participation, further research is merited to provide the most up-to-date injury estimates and outcomes in NCAA women's cross-country. Thus, the

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Table 1. Reported and National Estimates of injuries, 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	152	9792	131	8422	21	1371
	43 386	2 731 811	40 075	2 516 403	3312	215 409
	3.50 (2.95, 4.06)	3.58 (3.03, 4.14)	3.27 (2.71, 3.83)	3.35 (2.79, 3.91)	6.34 (3.63, 9.05)	6.36 (3.65, 9.08)
II	114	4764	96	3698	18	1065
	31 294	1 321 711	28 686	1 217 609	2607	104 101
	3.64 (2.97, 4.31)	3.60 (2.94, 4.27)	3.35 (2.68, 4.02)	3.04 (2.37, 3.71)	6.90 (3.71, 10.09)	10.23 (7.04, 13.42)
III	163	8017	149	7382	14	636
	33 667	2 864 540	30 945	2 620 385	2722	244 155
	4.84 (4.10, 5.58)	2.80 (2.06, 3.54)	4.81 (4.04, 5.59)	2.82 (2.04, 3.59)	5.14 (2.45, 7.84)	2.60 (0.00, 5.30)
Overall	429	22 573	376	19 502	53	3071
	108 347	6 918 062	99 706	6 354 397	8641	563 665
	3.96 (3.58, 4.33)	3.26 (2.89, 3.64)	3.77 (3.39, 4.15)	3.07 (2.69, 3.45)	6.13 (4.48, 7.78)	5.45 (3.80, 7.10)

[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.

purpose of this study was to describe the epidemiology of women's cross-country–related injuries captured by the NCAA ISP from the 2014–2015 through 2018–2019 academic years.

METHODS

Study Data

Women's cross-country exposure and injury data collected in the NCAA ISP during 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 program are described in detail in a separate manuscript within this special issue. In brief, ATs at participating institutions voluntarily contributed exposure and injury data to the ISP 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 time loss). Scheduled team practices and competitions were considered reportable exposures for this study. Data from 14 (1% of membership with sponsored programs) participating women's cross-country programs in 2014–2015, from 10 (1% of membership with sponsored programs) in 2015–2016, from 15 (1% of membership with sponsored programs) in 2016–2017, from 19 (2% of membership with sponsored programs) in 2017–2018, and from 49 (5% of membership with sponsored programs) in 2018–2019 qualified for inclusion in analyses. Qualification criteria are detailed further in the methods manuscript in this issue.[6]

Statistical Analysis

Injury counts and rates per 1000 AEs (in which one AE was defined as 1 athlete participating in 1 exposure event) were assessed by event type (practice, competition), competition level (Division I, II, or III), season segment (preseason, regular season, postseason), and time loss (time loss [TL], non–time loss [NTL]). Weighted and unweighted rates were estimated, with results presented in terms of unweighted rates (due to low injury frequencies across levels of certain explanatory variables) unless otherwise specified. Temporal trends in injury rates across the study period were evaluated using stratified (by levels of aforementioned variables) rate-profile plots. Injury counts and proportions were examined by time loss, body part injured, mechanism of injury, injury diagnosis, and activity at the time of injury. All aforementioned explanatory variables were characterized on the basis of AT reports. Injury rate ratios (IRR) were used to examine differential injury rates across event types, competition levels, and season segments. The IRRs with associated 95% confidence intervals (CIs) excluding 1.00 were considered statistically significant. All analyses were conducted using SAS version 9.4 (SAS Institute).

RESULTS

A total of 429 women's cross-country injuries from 108 347 AEs were reported to the NCAA ISP from 2014–2015 through 2018–2019 (rate = 3.96/1000 AEs). This equated to a national estimate of 22 573 injuries overall (Table 1). Notably, a relatively small number (53) of competition injuries were reported during the study period; however, the competition injury rate was higher than the practice injury rate (IRR = 1.63; 95% CI = 1.22, 2.17). Competition injury rates fluctuated during the study period with notable decreases observed between 2014–2015 and 2015–2016 and between 2016–2017 and 2017–2018 (Figure A). In comparison, practice injury rates decreased sharply between 2014–2015 and 2015–2016, then increased steadily thereafter (Figure A). The overall Division III injury rate (rate = 4.84/1000 AEs) was higher than the

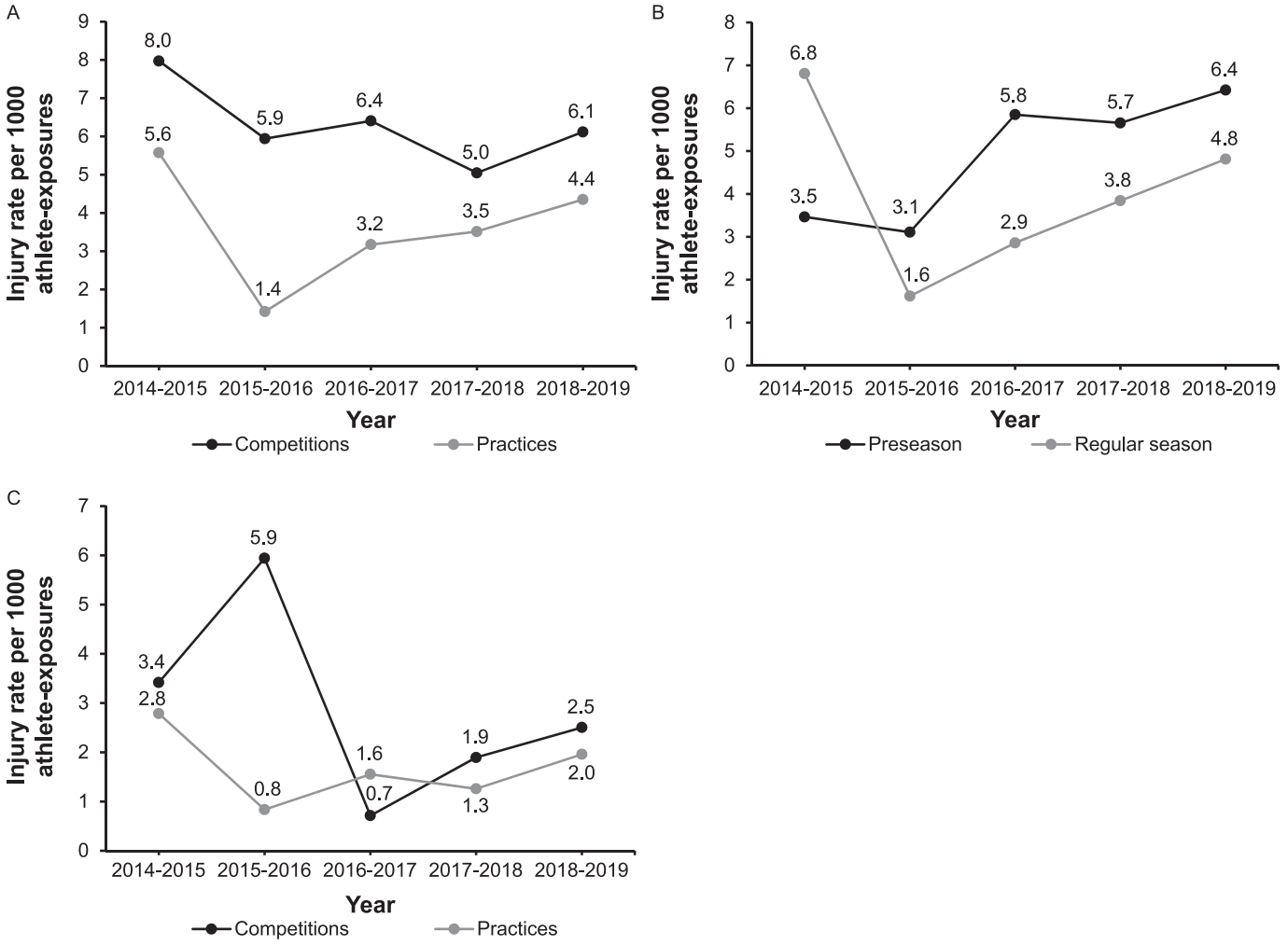

Figure. Temporal patterns in injury rates between 2014–2015 and 2018–2019. A, Overall injury rates (per 1000 AEs) stratified by event type (practices, competitions). B, Injury rates (per 1000 AEs) stratified by season segment (preseason, regular season). C, Rates (per 1000 AEs) of time loss injuries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

Division I (rate = 3.50/1000 AEs) and Division II (rate = 3.64/1000 AEs) injury rates; statistically significant differences were observed when comparing Division I rates with Division III rates (IRR = 0.72; 95% CI = 0.58, 0.90), as well as when comparing Division II rates with Division III rates (IRR = 0.75; 95% CI = 0.59, 0.96).

Injuries by Season Segment

During the 2014–2015 through 2018–2019 academic years, 123 preseason injuries (national estimate: 6049), 244 regular season injuries (national estimate: 14 130), and 62 postseason injuries (national estimate: 2394) were reported in women's cross-country. The overall preseason injury rate was higher than the regular season injury rate (IRR = 1.33; 95% CI = 1.07, 1.66; postseason injury rates were not compared due to low or 0 counts of postseason injuries reported during certain years of the study period). Preseason injury rates increased sharply between 2015–2016 and 2016–2017, then remained relative stable thereafter (Figure B). In comparison, regular season injury rates decreased notably between 2014–2015 and 2015–2016, then increased steadily thereafter (Figure B).

Time Loss

Approximately 45% (average TL = 26.3 days) of all reported injuries resulted in TL of ≥1 day (TL was not reported in approximately 21% of all reported injuries). The TL injuries accounted for comparable proportions of both practice (45.2%; average TL = 24.7 days) and competition (43.4%; average TL = 37.7 days) injuries. Rates of TL injuries in practices and competitions fluctuated, albeit differentially, throughout the study period (Figure C). The competition-related TL injury rate varied drastically between 2014–2015 and 2016–2017, then increased thereafter; the practice-related TL injury rate decreased sharply between 2014–2015 and 2015–2016, then remained relatively stable thereafter (Figure C).

Injury Characteristics

Lower leg injuries (30.3%) accounted for the largest proportion of all injuries reported during the study period. Foot injuries (18.2%) and thigh injuries (14.0%) were also common overall. Lower leg and foot injuries accounted for larger proportions of practice injuries than competition injuries, whereas thigh injuries accounted for

Table 2. Reported and National Estimates of Injuries, AEs, and Rates per 1000 AEs by Season Segment Across Divisions[a]

	Number AEs Rate per 1000 AEs (95% CI)					
	Preseason		Regular Season		Post Season	
Division	Reported	National Estimate	Reported	National Estimate	Reported	National Estimate
I	25	1413	100	7060	27	1319
	7731	473 015	25 965	1 738 638	9691	520 158
	3.23 (1.97, 4.50)	2.99 (1.72, 4.25)	3.85 (3.10, 4.61)	4.06 (3.31, 4.82)	2.79 (1.74, 3.84)	2.54 (1.48, 3.59)
II	46	2174	54	2203	14	387
	7285	336 749	15 767	709 014	8242	275 947
	6.31 (4.49, 8.14)	6.46 (4.63, 8.28)	3.42 (2.51, 4.34)	3.11 (2.19, 4.02)	1.70 (0.81, 2.59)	1.40 (0.51, 2.29)
III	52	2462	90	4867	21	688
	7565	752 378	18 033	1 499 389	8069	612 773
	6.87 (5.01, 8.74)	3.27 (1.40, 5.14)	4.99 (3.96, 6.02)	3.25 (2.21, 4.28)	2.60 (1.49, 3.72)	1.12 (0.01, 2.24)
Overall	123	6049	244	14 130	62	2394
	22 582	1 562 143	59 764	3 947 041	26 002	1 408 878
	5.45 (4.48, 6.41)	3.87 (2.91, 4.83)	4.08 (3.57, 4.60)	3.58 (3.07, 4.09)	2.38 (1.79, 2.98)	1.70 (1.11, 2.29)

[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.

larger proportions of competition injuries than practice injuries. However, it is important to note that the proportional distribution of competition injuries was compromised by the relatively small number of competition injuries recorded overall (Table 3). Overuse (53.9%) and noncontact (26.3%) injuries accounted for most reported injuries; surface contact injuries also accounted for approximately 8% of all reported injuries (Table 3). Overuse injuries accounted for a larger proportion of practice injuries (55.1%) than competition injuries (45.3%), whereas noncontact injuries accounted for a larger proportion of competition injuries (30.2%) than practice injuries (25.8%).

From 2014–2015 through 2018–2019, inflammatory conditions (33.6%), strains (17.7%), and fractures (9.1%) accounted for most reported women's cross-country injuries. Inflammatory conditions (most reported in the lower leg or Achilles, foot or toes, and knees) accounted for a larger proportion of practice injuries (35.9%) than competition injuries (17.0%), whereas strains accounted for a larger proportion of competition injuries (28.3%) than practice injuries (16.2%). Notably, fractures accounted for comparable proportions of competition (9.8%) and practice (9.0%) injuries. Inflammatory conditions also occurred at a notably higher rate in preseason (rate = 2.35/1000 AEs) than in regular season (rate = 1.15/1000 AEs) and postseason (rate = 0.85/1000 AEs). The most commonly reported injuries during the study period were medial tibial stress syndrome (shin splints; 10.0%) and partial or complete lateral ligament complex tears (ankle sprains; 4.2%). During the study period, the overall rate of medial tibial stress syndrome was 3.97 per 10 000 AEs (95% CI = 2.78, 5.15), and the overall rate of lateral ligament complex tears (ankle sprains) was 1.66 per 10 000 AEs (95% CI = 0.89, 2.43).

Injuries by Cross-Country–Specific Activities

Most injuries in women's cross-country during academic years 2014–2015 through 2018–2019 occurred during 800-m to 10 000-m distance running (64.8%). Fitness or conditioning and running 10 000-m (6-mile) events were other notable activities to which injuries were attributed (Table 4).

SUMMARY

This study aimed to describe the epidemiology of NCAA women's cross-country injuries from 2014–2015 through 2018–2019. During the study period, the competition injury rate was higher than the practice injury rate. However, whereas the competition injury rates fluctuated throughout the study period, the practice injury rates appeared to increase during the latter years in conjunction with increasing participation among women's cross-country programs within the ISP. The observed difference in injury rates by event type is inconsistent with findings reported previously for this population,[5] and continued juxtaposition of practice and competition injury incidence during periods of healthy and stable ISP participation will be important in determining the true differences in injury incidence between practice and competition events. Inferential limitations posed by low participation during the early years of the study period extend beyond comparisons made between event types. Indeed, whereas the overall preseason injury rate was higher than the regular season injury rate during the study period, both preseason and regular season injury rates appeared to vary differentially with increasing participation during the latter years of the study period. These observations, coupled with the sparse postseason data collected during the early years of the study, preclude the capacity to truly appraise injury incidence across season segments in NCAA women's cross-country during the

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	2 (0.47)	111 (0.49)	0 (0.0)	0 (0.0)	2 (0.53)	111 (0.57)
Neck	2 (0.47)	43 (0.19)	0 (0.0)	0 (0.0)	2 (0.53)	43 (0.22)
Trunk	26 (6.06)	1438 (6.37)	3 (5.66)	141 (4.59)	23 (6.12)	1296 (6.65)
Hip/groin	35 (8.16)	1643 (7.28)	6 (11.32)	212 (6.90)	29 (7.71)	1431 (7.34)
Thigh	60 (13.99)	4094 (18.14)	8 (15.09)	580 (18.89)	52 (13.83)	3514 (18.02)
Knee	44 (10.26)	1851 (8.20)	5 (9.43)	324 (10.55)	39 (10.37)	1527 (7.83)
Lower leg	130 (30.30)	6239 (27.64)	13 (24.53)	791 (25.76)	117 (31.12)	5448 (27.94)
Ankle	35 (8.16)	1977 (8.76)	3 (5.66)	141 (4.59)	32 (8.51)	1836 (9.41)
Foot	78 (18.18)	4088 (18.11)	7 (13.21)	354 (11.53)	71 (18.88)	3735 (19.15)
Other	17 (3.96)	1090 (4.83)	8 (15.09)	530 (17.26)	9 (2.39)	561 (2.88)
Mechanism						
Surface contact	34 (7.93)	2010 (8.90)	4 (7.55)	239 (7.78)	30 (7.98)	1771 (9.08)
Other contact	3 (0.70)	190 (0.84)	0 (0.0)	0 (0.0)	3 (0.80)	190 (0.97)
Noncontact	113 (26.34)	6217 (27.54)	16 (30.19)	1047 (34.09)	97 (25.80)	5171 (26.52)
Overuse	231 (53.85)	11 644 (51.58)	24 (45.28)	1194 (38.88)	207 (55.05)	10 450 (53.58)
Other/unknown	48 (11.19)	2512 (11.13)	9 (16.98)	591 (19.24)	39 (10.37)	1921 (9.85)
Diagnosis						
Contusion	7 (1.63)	374 (1.66)	1 (1.89)	97 (3.16)	6 (1.60)	277 (1.42)
Dislocation/subluxation	2 (0.47)	38 (0.17)	0 (0.0)	0 (0.0)	2 (0.53)	38 (0.19)
Fracture	39 (9.09)	2201 (9.75)	5 (9.43)	258 (8.40)	34 (9.04)	1943 (9.96)
Inflammatory condition	144 (33.57)	6437 (28.52)	9 (16.98)	402 (13.09)	135 (35.90)	6035 (30.95)
Spasm	28 (6.53)	1313 (5.82)	1 (1.89)	88 (2.87)	27 (7.18)	1225 (6.28)
Sprain	31 (7.23)	1760 (7.80)	4 (7.55)	210 (6.84)	27 (7.18)	1551 (7.95)
Strain	76 (17.72)	4786 (21.20)	15 (28.30)	838 (27.29)	61 (16.22)	3948 (20.24)
Other	102 (23.78)	5664 (25.09)	18 (33.96)	1178 (38.36)	84 (22.34)	4486 (23.00)

[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.

study period. Future studies may not only target the examination of temporal patterns in postseason injury incidence among NCAA women's cross-country athletes but also a juxtaposition of all season segments to better understand differential injury risk across season segments in this population.

Given the novel finding of differential injury incidence by event type, as well as the observed trajectory of practice injury rates between academic years 2015–2016 and 2018–2019, practice injury incidence rates immediately after 2018–2019 warrant particular attention. It may be salient to target specific body parts (such as lower leg or Achilles and the foot) and injury mechanisms (such as overuse) that were most prevalent among practice-related injuries in this analysis. The prevalence of lower leg or Achilles and foot injuries may be of particular clinical relevance given the historic association of foot pathomechanics and lower leg injuries.[7] Because these 2 body parts and injuries are closely linked, these descriptive results could further point to a relationship between the 2 pathologies that investigators of biomechanics have described previously.[8,9] In examining practice-related injuries, though the distribution of practice injuries by body part and mechanism observed herein may be unsurprising when also considering the

Table 4. Distribution of injuries by Women's Cross-Country–Specific Activities[a]

	Overall		Competitions		Practices	
	Injuries Reported (%)	National Estimate (%)	Injuries Reported (%)	National Estimate (%)	Injuries Reported (%)	National Estimate(%)
Fitness/conditioning	45 (10.49)	2664 (11.80)	0 (0.0)	0 (0.0)	45 (11.97)	2664 (13.66)
10 000 m/6 mi	31 (7.23)	1618 (7.17)	3 (5.66)	202 (6.58)	28 (7.45)	1416 (7.26)
Distance running	278 (64.80)	14 396 (63.78)	44 (83.02)	2542 (82.77)	234 (62.23)	11 854 (60.78)
Sprints	14 (3.26)	924 (4.09)	1 (1.89)	56 (1.82)	13 (3.46)	868 (4.45)
Other/unknown	61 (14.22)	2971 (13.16)	5 (9.43)	272 (8.86)	56 (14.89)	2700 (13.84)

[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. Distance running includes 800m to 10000m events.

nature and volume of practice-related workload in this sport, it may be noted that the NCAA ISP in its current form relies on AT expertise for classification of injury characteristics and explanatory variables (such as characterizing injury mechanism). With that said, these results also indicate the need to direct attention towards factors distinguishing mechanisms of injury, particularly noncontact and overuse injuries in this population. Furthermore, injury rates across the study period were also higher in Division III than in Divisions I and II. Higher injury rates among Division III programs could be indicative of smaller sports medicine operations in these institutions than in their Divisions I and II counterparts, resulting in lower AT to student-athlete ratios.[10,11] This resource limitation may have restricted access to preventive treatments and services for Division III athletes. Given that the NCAA ISP does not collect data regarding sports-medicine staffing and health care services provided to athletes, it is difficult to comment further on these findings on the basis of the data collected within the ISP. Future, targeted studies may be needed to better describe these patterns.

Most injuries reported among NCAA women's cross-country athletes during the years 2014–2015 through 2018–2019 were inflammatory conditions, strains, and sprains. Inflammatory conditions were most prevalent, and the rate of inflammatory conditions reported during preseason was also notably higher than during regular and postseason. Further attention may be directed towards better appraising how inflammatory conditions develop during the early phases of the season. Inflammatory conditions have been previously reported to account for notable proportions of all reported injuries among collegiate runners.[5,12,13] Given the results observed in this study, it may yet be important to conceptualize differential prevention strategies that address the progressive nature of inflammatory conditions over season segments. Nonetheless, further work is needed to better understand the burden of such injuries in this population. While surveillance data are equipped to identify emerging patterns and note the body parts most commonly associated with such injuries (as mentioned earlier), inflammatory conditions are not only inherently heterogeneous but may also be considered more athlete-specific than other injuries. It is important to note that inflammatory conditions are made up of several potential injury diagnoses (eg, bursitis, capsulitis, osteochondritis, tendinitis) in the ISP, and data on specific athlete characteristics are also not collected within the system. Targeted studies on inflammatory conditions within this population are important to gain further insight into the dynamics of such injuries in this population. Targeted, small-sample work in the future may also be able to examine dynamic changes through the course of a season in factors such as running economy, which has been previously shown to be associated with injury risk among runners.[14] It may also be noted that fractures accounted for comparable proportions of injuries in both practice and competition settings, approximately 10% (most commonly tibial and femoral stress fractures). Stress fractures are often overuse in nature and therefore may be associated with greater levels of pain before care-seeking.[15] The prevalence of competition-related stress fractures in particular warrants greater attention to better understand the sequence of events and activities during competition that may have led to overuse injury diagnosis attributed to competition exposure. Prior studies have investigated risk of bone trauma in female athletes and have discussed it in the context of the female athlete triad: low bone mineral density, low energy availability, and menstrual dysfunction.[16–18] Given the physical demands of this sport coupled with the anthropometric changes, further research is warranted to investigate therapeutic targets aimed at ameliorating the risk of fractures in this group.

The specific injuries most commonly reported among women's cross-country athletes during the study period were medial tibial stress syndrome and partial or complete lateral ligament complex tears (ankle sprains). Time trends in the rates of these injuries over the study period were not examined due to low yearly frequencies of both injuries (although they were the most commonly reported injuries overall). Nonetheless, given the rate of medial tibial stress syndrome observed in this study overall, continued monitoring of the incidence trajectory of this injury among women's cross-country athletes may be warranted. Future studies may also target a better understanding of these injuries among women's cross-country athletes. Whereas the NCAA ISP relies on AT expertise for diagnosis, such studies should consider providing more diagnostic guidelines for reporters, given the inherent heterogeneity in the nature of this injury. Further in this regard, it is important to note that the ISP does not collect data on individual-level workload, and such granularity may be critical in better understanding how this particular injury develops over the course of a season. Therefore, future researchers in this area may additionally consider modes of collecting more granular exposure data to better capture the etiology of such injuries.

Continued monitoring of NCAA women's cross-country injuries will be important in providing insight into injury incidence and outcomes within this group. Furthermore, large-scale examinations are needed, as are continued efforts to improve participation in injury surveillance. These efforts, in parallel, will aid in drawing clearer inferences from observed temporal instabilities in injury incidence and outcomes. Ultimately, such continued efforts will offer the platform upon which to build targeted small-sample evaluations that reconcile the etiology underpinning injury risk and sequelae in this population.

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