

Epidemiology of National Collegiate Athletic Association Men's and Women's Cross-Country Injuries, 2009–2010 Through 2013–2014

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Context: Recent injury-surveillance data for collegiate-level cross-country athletes are limited.

Objective: To describe the epidemiology of National Collegiate Athletic Association (NCAA) men's and women's cross-country injuries during the 2009–2010 through 2013–2014 academic years.

Design: Descriptive epidemiology study.

Setting: Aggregate injury and exposure data collected from 25 men's and 22 women's cross-country programs, providing 47 and 43 seasons of data, respectively.

Patients or Other Participants: Collegiate student-athletes participating in men's and women's cross-country during the 2009–2010 through 2013–2014 academic years.

Main Outcome Measure(s): Injury rates; injury rate ratios (RRs); injury proportions by body site, diagnosis, and apparatus; and injury proportion ratios were reported with 95% confidence intervals (CIs).

Results: The Injury Surveillance Program captured 216 injuries from men's cross-country and 260 injuries from women's cross-country, leading to injury rates of 4.66/1000 athlete-

exposures (AEs) for men (95% CI = 4.04, 5.28) and 5.85/1000 AEs for women (95% CI = 5.14, 6.56). The injury rate in women's cross-country was 1.25 times that of men's cross-country (95% CI = 1.05, 1.50). Most injuries affected the lower extremity (men = 90.3%, women = 81.9%). The hip/groin-injury rate in women (0.65/1000 AEs) was higher than that in men (0.15/1000 AEs; RR = 4.32; 95% CI = 1.89, 9.85). The ankle-injury rate in men (0.60/1000 AEs) was higher than that in women (0.29/1000 AEs; RR = 2.07; 95% CI = 1.07, 3.99). Common diagnoses were strains (men = 19.9%, women = 20.4%) and inflammation (men = 18.1%, women = 23.8%). The majority of injuries were classified as overuse (men = 57.6%, women = 53.3%).

Conclusions: Consistent with prior research, injury distributions varied between male and female athletes, and the injury rate among females was higher. Understanding the epidemiology of these cross-country injuries may be important for developing appropriate preventive interventions.

Key Words: injury prevention, collegiate sports, distance running

Key Points

- Our findings indicate a lower injury burden in men's and women's cross-country than previously reported.
- The injury rate in women's cross-country was 1.25 times that of men's cross-country.
- Most injuries affected the lower extremity and were diagnosed as strains and inflammation.

Distance running is a sport without contact or collision. However, previous research indicates that there is nonetheless a relatively high risk of injury to these athletes through other mechanisms. Given the repetitive nature of the activity, the most frequent injuries among distance runners are from overuse,¹ particularly lower extremity stress fractures.^{2–5}

One such sport, cross-country, includes over 30 000 National Collegiate Athletic Association (NCAA) student-athletes from more than 1000 institutions.⁶ At the collegiate level, cross-country competitions involve racing distances of 5 to 6 kilometers for women and 8 to 10 kilometers for men. Terrains can vary from grass terrain to wooded trails, whereas cross-country training typically occurs on roads. Exposure to varying surface types, many of which contain

challenging footing, may also increase the risk of injury. For example, about one-third of high school cross-country runners have sustained ankle sprains.⁷

Quantifying the type and frequency of injury from sport is important for understanding the burden of injury, assessing whether adequate resources are being deployed to manage these injuries, and identifying whether there may be a need for targeted preventive interventions. In a sample of male and female collegiate cross-country runners during the 2000–2002 seasons, the injury rate per 1000 exposures was estimated at 19.1 for males and 21.0 for females, with the majority of injuries being non-time loss (ie, not restricting participation for more than 1 day [NTL]).⁸ The larger injury rates among females may be attributable to women sustaining more overuse injuries.⁹

Despite these findings, to our knowledge, recent data on collegiate cross-country running injuries are lacking. In addition, to reduce burden on previous data collectors, injury definitions were restricted to those resulting in time loss beyond the day of injury (defined as *time-loss* [TL] *injuries*). Over the past 5 years, the NCAA Injury Surveillance Program (ISP) has monitored all injuries occurring in a sample of men's and women's cross-country varsity teams. Both TL and NTL injuries were captured in an effort to optimally summarize the types of injuries managed and treated by athletic trainers (ATs). This study uses data from the NCAA ISP to describe the epidemiology of men's and women's cross-country injuries occurring within the NCAA competition level during the 2009–2010 through 2013–2014 academic years. Differences in injury frequency and type between male and female athletes are also assessed.

METHODS

Data were obtained from the NCAA ISP, which is managed by the Datalys Center for Sports Injury Research and Prevention, Inc (hereafter known as the Datalys Center), an independent, nonprofit research organization. The methods of the NCAA ISP during the 2009–2010 through 2013–2014 academic years have been previously described¹⁰ but are summarized in the upcoming text.

Data Collection

The ISP depends on a convenience sample of NCAA varsity sport teams with ATs reporting injury data. The ATs from participating programs reported injuries in real time through their electronic health record applications throughout the academic year. These electronic health record applications are used as part of ATs' daily clinical practice. In addition to unintentional injuries, the surveillance system captures other sport-related adverse health (ie, illness) events such as heat-related conditions, general medical conditions, and skin infections. Only varsity-level practice and competition events are included in the ISP data sets. Junior varsity programs, as well as any individual weightlifting and conditioning sessions, are excluded. Thus, all participating programs captured both TL and NTL injuries as long as they were documented within the electronic health record applications.

When an injury event was detected by or reported to an AT, the AT completed a detailed event report on the injury or condition (eg, site, diagnosis) and the circumstances (eg, activity, mechanism, event type [ie, competition or practice]). The ATs were able to view and update previously submitted information as needed during the course of a season. In addition, ATs also provided the number of student-athletes participating in each practice and competition.

Before arriving at the Datalys Center, common data elements from electronic health record applications were recoded, were stripped of any identifiers and personally identifiable information (eg, name, date of birth, insurance information), and retained only relevant variables and values.¹⁰ Exported data passed through an automated verification process that conducted a series or range of consistency checks. Data were reviewed and flagged for invalid values: the automated verification process would notify the AT and data quality-assurance staff, who would assist the AT in resolving the concern. Data that passed the

verification process were then placed into sport-specific aggregate datasets for use by external researchers. For this study, we received the dataset for men's and women's cross-country.

Definitions

A *reportable injury* in the 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 injury event could be included. As opposed to the previous 25 years of NCAA-reported data that monitored only TL injuries, this 5-year data set also included NTL injuries. Body parts were categorized as head/face, neck, shoulder/clavicle, arm/elbow, trunk (including chest, abdomen, upper back, and lower back), hip/groin, thigh (including the upper leg), knee, lower leg (including the Achilles tendon), ankle, foot, and other. Data regarding the types of surfaces on which practices and competitions occurred were also collected during the study period.

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 were included in competition exposures.

Injuries were also categorized by the number of days in which athletes were restricted from participation. First, NTL injuries resulted in restricted participation for less than 1 day. Second, severe injuries resulted in time loss of more than 3 weeks. These severe injuries may have also resulted in the student-athlete prematurely ending his or her season (ie, season-ending injury).

Statistical Analysis

Data were analyzed using SAS-Enterprise Guide software (version 4.3; SAS Institute Inc, Cary, NC) to assess rates and patterns of NCAA men's and women's cross-country injuries. Statistical analyses included calculation of rate ratios (RRs), injury proportion ratios (IPRs), and χ^2 tests. The overall injury rate was calculated as the ratio of injuries per 1000 total AEs. Injury rates were also calculated as the ratio of practice injuries per 1000 practice exposures and the ratio of competition injuries per 1000 competition exposures. The following is an example of an RR comparing competition and practice injury rates:

$$RR = \frac{\left(\frac{\sum \text{Competition Injuries}}{\sum \text{Competition Athlete-Exposures}} \right)}{\left(\frac{\sum \text{Practice Injuries}}{\sum \text{Practice Athlete-Exposures}} \right)}$$

The following is an example of an IPR comparing the proportion of severe injuries sustained in men's and women's cross-country:

$$IPR = \frac{\left(\frac{\sum \text{Severe Injuries in Men's Cross-Country}}{\sum \text{Total Injuries in Men's Cross-Country}} \right)}{\left(\frac{\sum \text{Severe Injuries in Women's Cross-Country}}{\sum \text{Total Injuries in Women's Cross-Country}} \right)}$$

Table 1. Injury Rates and 95% Confidence Intervals (CIs) by School Size/Division and Type of Athlete-Exposure (AE) in National Collegiate Athletic Association Men's and Women's Cross-Country, 2009–2010 Through 2013–2014^a

Division	Men			Women		
	No. of Injuries	AEs ^b	Rate (95% CI) per 1000 AEs	No. of Injuries	AEs ^b	Rate (95% CI) per 1000 AEs
I						
Practice	121	21 225	5.70 (4.69, 6.72)	130	19 948	6.52 (5.40, 7.64)
Competition	6	1762	3.41 (0.68, 6.13)	16	1684	9.50 (4.85, 14.16)
Total	127	22 986	5.53 (4.56, 6.49)	146	21 632	6.75 (5.65, 7.84)
II						
Practice	14	8627	1.62 (0.77, 2.47)	12	6113	1.96 (0.85, 3.07)
Competition	2	708	2.82 (0.00, 6.74)	3	468	6.41 (0.00, 13.66)
Total	16	9335	1.71 (0.87, 2.55)	15	6581	2.28 (1.13, 3.43)
III						
Practice	64	12 449	5.14 (3.88, 6.40)	89	14 525	6.13 (4.85, 7.40)
Competition	9	1561	5.77 (2.00, 9.53)	10	1734	5.77 (2.19, 9.34)
Total	73	14 011	5.21 (4.01, 6.41)	99	16 259	6.09 (4.89, 7.29)
Overall						
Practice	199	42 301	4.70 (4.05, 5.36)	231	40 586	5.69 (4.96, 6.43)
Competition	17	4030	4.22 (2.21, 6.22)	29	3886	7.46 (4.75, 10.18)
Total	216	46 332	4.66 (4.04, 5.28)	260	44 472	5.85 (5.14, 6.56)

^a Data originated from National Collegiate Athletic Association Injury Surveillance System, 2009–2010 through 2013–2014. *Injuries* are defined as injuries that (1) occurred during a sanctioned practice or competition and (2) were evaluated and/or treated by an athletic trainer, physician, or other health care professional.

^b Sums of practice and competition may not equal total because of rounding. The potential for nonwhole AEs is due to mean imputations for events in which AE information was missing.

All 95% confidence intervals (CIs) not containing 1.0 were considered statistically significant. This study was approved by the Research Review Board at the NCAA.

RESULTS

Overall Frequencies and Rates

Men's Cross-Country. Among 47 team seasons from 25 programs over 5 years, ATs reported 216 injuries. A total of 199 (92.1%) occurred during practice; 17 (7.9%) occurred during competition. Most injuries occurred in the regular season (64.8%); 29.6% and 5.6% occurred in the preseason and postseason, respectively. In addition, 61.1% were NTL and 8.3% were severe. Only 1 injury required surgery.

These 216 injuries occurred during 46 332 AEs, for an injury rate of 4.66/1000 AEs (95% CI = 4.04, 5.28; Table 1). When stratified by time loss, the TL and NTL injury rates were 2.85 and 1.81/1000 AEs, respectively. No difference existed between the injury rates for practice (4.70/1000 AEs) and competition (4.22/1000 AEs; IPR = 1.06; 95% CI = 0.65, 1.75). However, the overall injury rate for Division II (1.71/1000 AEs) was lower than that for Division I (5.53/1000 AEs; RR = 0.31; 95% CI = 0.18, 0.52) and Division III (5.21/1000 AEs; RR = 0.33; 95% CI = 0.19, 0.57).

Women's Cross-Country. Among 43 team seasons from 22 programs over 5 years, ATs reported 260 injuries. A total of 231 (88.8%) occurred during practice; 29 (11.2%) occurred during competition. Most injuries occurred in the regular season (60.8%); 34.2% and 5.0% occurred in the preseason and postseason, respectively. In addition, 58.8% were NTL and 13.1% were severe. No injuries required surgery.

These 260 injuries occurred during 44 472 AEs, for an injury rate of 5.85/1000 AEs (95% CI = 5.14, 6.56; Table

1). When stratified by time loss, the TL and NTL injury rates were 3.44 and 2.41/1000 AEs, respectively. No difference existed between the injury rates for practice (5.69/1000 AEs) and competition (7.46/1000 AEs; IPR = 0.76; 95% CI = 0.52, 1.12). However, the overall injury rate for Division II (2.28/1000 AEs) was lower than that for Division I (6.75/1000 AEs; RR = 0.34; 95% CI = 0.20, 0.57) and Division III (6.09/1000 AEs; RR = 0.37; 95% CI = 0.22, 0.64).

Comparison of Frequencies and Rates. The injury rate in women's cross-country was 1.25 times that of men's cross-country (95% CI = 1.05, 1.50). This difference was present when the analysis was restricted to practice injuries (RR = 1.21; 95% CI = 1.00, 1.46) but not when restricted to TL injuries (RR = 1.21; 95% CI = 0.96, 1.52), NTL injuries (RR = 1.33; 95% CI = 1.00, 1.77), or competitions (RR = 1.77; 95% CI = 0.97, 3.22). The proportion of severe injuries in women's cross-country (13.1%) was larger than that of men's cross-country (8.3%) but not significantly so (IPR = 1.57; 95% CI = 0.91, 2.70).

Body Sites Injured and Diagnoses

Most injuries affected the lower extremity (men = 90.3%, women = 81.9%; Table 2). Commonly injured body parts were the lower leg (men = 35.2%, women = 23.5%), foot (men = 15.7%, women = 15.4%), thigh (men = 12.5%, women = 14.6%), and knee (men = 10.7%, women = 12.3%). The hip/groin injury rate in women (0.65/1000 AEs) was higher than that in men (0.15/1000 AEs; RR = 4.32; 95% CI = 1.89, 9.85). The ankle injury rate in men (0.60/1000 AEs) was higher than that in women (0.29/1000 AEs; RR = 2.07; 95% CI = 1.07, 3.99).

Among men, the trunk had the largest proportion of severe injuries (16.7%), followed by the hip/groin (14.3%)

Table 2. Number of Injuries, Injury Rates With 95% Confidence Intervals, and Time Loss by Body Part in National Collegiate Athletic Association Men's and Women's Cross-Country, 2009–2010 Through 2013–2014^a

Sex Body Part Injured	Injuries in Sample, No. (%) ^b	Rate (95% Confidence Interval) per 1000 Athlete-Exposures	Non-Time-Loss Injuries, No. (%) ^c	Severe Injuries, No. (%) ^d
Men				
Head/face	2 (0.9)	0.04 (0.00, 0.10)	e	e
Neck	0	0.00	e	e
Shoulder/clavicle	0	0.00	e	e
Arm/elbow ^f	0	0.00	e	e
Hand/wrist	0	0.00	e	e
Trunk	12 (5.6)	0.26 (0.11, 0.41)	8 (66.7)	2 (16.7)
Hip/groin	7 (3.2)	0.15 (0.04, 0.26)	4 (57.1)	1 (14.3)
Thigh	27 (12.5)	0.58 (0.36, 0.80)	16 (59.3)	1 (3.7)
Knee	23 (10.7)	0.50 (0.29, 0.70)	14 (60.9)	2 (8.7)
Lower leg	76 (35.2)	1.64 (1.27, 2.01)	46 (60.5)	10 (13.2)
Ankle	28 (13.0)	0.60 (0.38, 0.83)	13 (46.4)	0 (0.0)
Foot	34 (15.7)	0.73 (0.49, 0.98)	26 (76.5)	2 (5.9)
Other	7 (3.2)	0.15 (0.04, 0.26)	3 (42.9)	0 (0.0)
Total	216 (100.0)	4.66 (4.04, 5.28)	132 (61.1)	18 (8.3)
Women				
Head/face	2 (0.8)	0.04 (0.00, 0.11)	e	e
Neck	2 (0.8)	0.04 (0.00, 0.11)	e	e
Shoulder/clavicle	0	0.00	e	e
Arm/elbow ^f	1 (0.4)	0.02 (0.00, 0.07)	e	e
Hand/wrist	1 (0.4)	0.02 (0.00, 0.07)	e	e
Trunk	22 (8.5)	0.49 (0.29, 0.70)	14 (63.6)	5 (22.7)
Hip/groin	29 (11.2)	0.65 (0.41, 0.89)	17 (58.6)	4 (13.8)
Thigh	38 (14.6)	0.85 (0.58, 1.13)	23 (60.5)	7 (18.4)
Knee	32 (12.3)	0.72 (0.47, 0.97)	22 (68.8)	1 (3.1)
Lower leg	61 (23.5)	1.37 (1.03, 1.72)	35 (57.4)	8 (13.1)
Ankle	13 (5.0)	0.29 (0.13, 0.45)	8 (61.5)	0 (0.0)
Foot	40 (15.4)	0.90 (0.62, 1.18)	21 (52.5)	9 (22.5)
Other	19 (7.3)	0.43 (0.24, 0.62)	11 (57.9)	0 (0.0)
Total	260 (100.0)	5.85 (5.14, 6.56)	153 (58.8)	34 (13.1)

^a Data originated from National Collegiate Athletic Association Injury Surveillance System, 2009–2010 through 2013–2014. *Injuries* are defined as injuries that (1) occurred during a sanctioned practice or competition and (2) were evaluated and/or treated by an athletic trainer, physician, or other health care professional.

^b Percentages were rounded.

^c Includes injuries that resulted in time loss <1 day; does not include any concussions, fractures, or dental injuries, regardless of time loss.

^d Includes injuries that resulted in time loss >3 weeks.

^e Percentages were not calculated for categories with <5 reported injuries.

^f Arm represents injuries spanning upper arm to wrist.

and lower leg (13.2%). Among women, the trunk had the largest proportion of severe injuries (22.7%), followed by the foot (22.5%) and thigh (18.4%).

A variety of diagnoses were reported (Table 3). Common diagnoses were strains (men = 19.9%, women = 20.4%), inflammation (men = 18.1%, women = 23.8%), tendinitis (men = 13.4%, women = 9.6%), and sprains (men = 12.5%, women = 5.8%). Diagnosis rates did not differ by sex.

Among men, stress fractures constituted the largest proportion of severe injuries (30.0%), followed by strains (11.6%) and spasms (11.1%). Among women, fractures (60.0%) and stress fractures (58.3%) were responsible for the largest proportions of severe injuries, followed by spasms (11.1%).

The top 10 most frequent injuries for men's and women's cross-country are summarized in Table 4. Within both sports, ankle sprains, lower leg tendinitis, lower leg inflammation, thigh strains, foot inflammation, hip/groin strains, and knee inflammation were seen most often. The ankle-sprain rate in men (0.52/1000 AEs) was 2.09 times that in women (0.25/1000 AEs; 95% CI = 1.03, 4.28).

Mechanism of Injury

Mechanism-of-injury data were not available for 13 and 18 of the injuries reported in men's and women's cross-country, respectively. The majority of injuries were classified as overuse (men = 57.6%, women = 53.3%) and without apparent contact (men = 25.1%, women = 31.8%). Many overuse injuries did not result in time loss (men = 71.4%, women = 61.8%). Rates by mechanism of injury did not differ by sex.

Surface Type

Most AEs occurred on the track/trail (men = 45.6%, women = 50.1%), followed by natural grass (men = 34.0%, women = 36.5%; Table 5). Most injuries also occurred on the track/trail (men = 39.8%, women = 51.9%), followed by natural grass (men = 37.5%, women = 32.3%). Among our sample, men and women differed in the distribution of AEs, that is, their exposure to various surface types ($P < .001$). However, no sex differences existed in the distribution of injuries ($P = .08$).

Table 3. Number of Injuries, Injury Rates With 95% Confidence Intervals, and Time Loss by Diagnosis in National Collegiate Athletic Association Men's and Women's Cross-Country, 2009–2010 Through 2013–2014^a

Sex Diagnosis	Injuries in Sample, No. (%)	Rate (95% Confidence Interval) per 1000 Athlete-Exposures	Non-Time-Loss Injuries, No. (%) ^b	Severe Injuries, No. (%) ^c
Men				
Fracture	1 (0.5)	0.02 (0.00, 0.06)	^d	^d
Stress fracture	10 (4.6)	0.22 (0.08, 0.35)	1 (10.0)	3 (30.0)
Inflammation	39 (18.1)	0.84 (0.58, 1.11)	33 (84.6)	1 (2.6)
Respiratory	1 (0.5)	0.02 (0.00, 0.06)	^d	^d
Spasm	9 (4.2)	0.19 (0.07, 0.32)	6 (66.7)	1 (11.1)
Sprain	27 (12.5)	0.58 (0.36, 0.80)	13 (48.2)	0 (0.0)
Strain	43 (19.9)	0.93 (0.65, 1.21)	27 (62.8)	5 (11.6)
Tendinitis	29 (13.4)	0.63 (0.40, 0.85)	16 (55.2)	2 (6.9)
Other	57 (26.4)	1.23 (0.91, 1.55)	34 (59.6)	6 (10.5)
Total	216 (100.0)	4.66 (4.04, 5.28)	132 (61.1)	18 (8.3)
Women				
Fracture	5 (1.9)	0.11 (0.01, 0.21)	0 (0.0)	3 (60.0)
Stress fracture	12 (4.6)	0.27 (0.12, 0.42)	1 (8.3)	7 (58.3)
Inflammation	62 (23.8)	1.39 (1.05, 1.74)	41 (66.1)	9 (14.5)
Respiratory	9 (3.5)	0.20 (0.07, 0.33)	4 (44.4)	0 (0.0)
Spasm	9 (3.5)	0.20 (0.07, 0.33)	5 (55.6)	1 (11.1)
Sprain	15 (5.8)	0.34 (0.17, 0.51)	7 (46.7)	0 (0.0)
Strain	53 (20.4)	1.19 (0.87, 1.51)	30 (56.6)	5 (9.4)
Tendinitis	25 (9.6)	0.56 (0.34, 0.78)	17 (68.0)	1 (4.0)
Other	70 (26.9)	1.57 (1.21, 1.94)	48 (68.6)	8 (11.4)
Total	260 (100.0)	5.85 (5.14, 6.56)	153 (58.8)	34 (13.1)

^a Data originated from National Collegiate Athletic Association Injury Surveillance System, 2009–2010 through 2013–2014. *Injuries* are defined as injuries that (1) occurred during a sanctioned practice or competition and (2) were evaluated and/or treated by an athletic trainer, physician, or other health care professional.

^b Includes injuries that resulted in time loss <1 day; does not include any concussions, fractures, or dental injuries, regardless of time loss.

^c Includes injuries that resulted in time loss >3 weeks.

^d Percentages were not calculated for categories with <5 reported injuries.

Table 4. Common Injuries in National Collegiate Athletic Association Men's (n = 216) and Women's (n = 260) Cross-Country, 2009–2010 Through 2013–2014^a

Sex Injury	Injuries in Sample, No. (%)	Rate (95% Confidence Interval) per 1000 Athlete-Exposures	Non-Time-Loss Injuries, No. (%) ^b	Severe Injuries, No. (%) ^c
Men				
Ankle sprain	24 (11.1)	0.52 (0.31, 0.73)	11 (45.8)	0 (0.0)
Lower leg tendinitis	21 (9.7)	0.45 (0.26, 0.65)	12 (57.1)	1 (4.8)
Lower leg inflammation	18 (8.3)	0.39 (0.21, 0.57)	16 (88.9)	0 (0.0)
Thigh strain	15 (6.9)	0.32 (0.16, 0.49)	10 (66.7)	0 (0.0)
Lower leg strain	15 (6.9)	0.32 (0.16, 0.49)	9 (60.0)	2 (13.3)
Foot inflammation	10 (4.6)	0.22 (0.08, 0.35)	10 (100.0)	0 (0.0)
Knee inflammation	7 (3.2)	0.15 (0.04, 0.26)	5 (71.4)	0 (0.0)
Hip/groin strain	6 (2.8)	0.13 (0.03, 0.23)	4 (66.7)	1 (16.7)
Knee tendinitis	6 (2.8)	0.13 (0.03, 0.23)	3 (50.0)	1 (16.7)
Lower leg stress fracture	5 (2.3)	0.11 (0.01, 0.20)	0 (0.0)	2 (40.0)
Women				
Thigh strain	17 (6.5)	0.38 (0.20, 0.56)	10 (58.8)	1 (5.9)
Lower leg inflammation	17 (6.5)	0.38 (0.20, 0.56)	12 (70.6)	1 (5.9)
Lower leg tendinitis	16 (6.2)	0.36 (0.18, 0.54)	11 (68.8)	1 (6.3)
Lower leg strain	15 (5.8)	0.34 (0.17, 0.51)	7 (46.7)	1 (6.7)
Foot inflammation	15 (5.8)	0.34 (0.17, 0.51)	10 (66.7)	3 (20.0)
Thigh inflammation	13 (5.0)	0.29 (0.13, 0.45)	10 (76.9)	3 (23.1)
Knee inflammation	13 (5.0)	0.29 (0.13, 0.45)	9 (69.2)	1 (7.7)
Ankle sprain	11 (4.2)	0.25 (0.10, 0.39)	6 (54.5)	0 (0.0)
Hip/groin strain	10 (3.9)	0.22 (0.09, 0.36)	6 (60.0)	1 (10.0)
Respiratory	9 (3.5)	0.20 (0.07, 0.33)	4 (44.4)	0 (0.0)

^a Data originated from National Collegiate Athletic Association Injury Surveillance System, 2009–2010 through 2013–2014. *Injuries* are defined as injuries that (1) occurred during a sanctioned practice or competition and (2) were evaluated and/or treated by an athletic trainer, physician, or other health care professional.

^b Includes injuries that resulted in time loss <1 day; does not include any concussions, fractures, or dental injuries, regardless of time loss.

^c Includes injuries that resulted in time loss >3 weeks.

Table 5. Distributions of Injuries and Athlete-Exposures by Surface Type in National Collegiate Athletic Association Men's and Women's Cross-Country, 2009–2010 Through 2013–2014^a

Surface Type	Men		Women	
	Injuries in Sample, No. (%)	Athlete-Exposures, No. (%)	Injuries in Sample, No. (%) ^b	Athlete-Exposures, No. (%)
Gym/court floor	22 (10.2)	2643 (5.7)	22 (8.5)	1818 (4.1)
Natural grass	81 (37.5)	15 742 (34.0)	84 (32.3)	16 211 (36.5)
Turf	23 (10.6)	3173 (6.8)	16 (6.2)	1667 (3.7)
Track/trail	86 (39.8)	21 119 (45.6)	135 (51.9)	22 266 (50.1)
Other	4 (1.9)	3655 (7.9)	3 (1.2)	2510 (5.6)
Total	216 (100.0)	46 332 (100.0)	260 (100.0)	44 472 (100.0)

^a Data originated from National Collegiate Athletic Association Injury Surveillance System, 2009–2010 through 2013–2014. *Injuries* are defined as injuries that (1) occurred during a sanctioned practice or competition and (2) were evaluated and/or treated by an athletic trainer, physician, or other health care professional.

^b Percentages were rounded.

DISCUSSION

We used injury-surveillance data to describe the epidemiology of men's and women's cross-country injuries at the NCAA level from 2009–2010 through 2013–2014. The study extends the literature on collegiate cross-country running injuries, using surveillance data that include NTL injuries and have been thoroughly checked for data quality.¹⁰ Such data have the potential to drive the development of targeted interventions for prevention and health care related to those injuries in cross-country athletes.

Comparison With Previous Studies

Overall injury rates (4.66 and 5.85/1000 AEs for men and women, respectively) were smaller than those seen in previous studies. In a study of high school cross-country student-athletes, injury rates were 16.7 and 10.9/1000 AEs for girls and boys, respectively.¹¹ In addition, authors⁸ of a similar study collected TL and NTL injuries from collegiate cross-country athletes competing between 2000 and 2002 and reported rates of 19.1 and 21.0/1000 AEs for men and women, respectively. Injury rates were also lower than those seen in track and field data from multiple levels of competition.¹² These differences may be attributable to variability in the study duration or the characteristics of the participating teams. Because of variations in study design, future surveillance using the NCAA ISP is needed to better determine time trends in injury.

Decreases in injury rates may also be attributable to improved recovery methods or training strategies to limit injury risk. Shoe technology may also be a mitigating factor. Although limited evidence exists about the efficacy of new sport shoe technologies in preventing injury,¹³ advances have occurred, such as the more widespread availability of shoes for every foot type (eg, flat feet, high arches). This may mean that more individuals are wearing appropriate shoes for their biomechanics than previously, when costly shoe inserts (orthotics) may have been the primary option for injury prevention. However, more experimental and longitudinal studies are required to support the benefits of better shoe technology.

Overuse and NTL Injuries

Consistent with previously published studies,^{1,2,7,8} the majority of injuries among both male and female cross-country runners were attributable to overuse mechanisms of injury and affected the lower extremity. Cross-country

athletes may benefit from training guidelines that limit the number of miles of running per week. Adequate recovery, including but not limited to proper postworkout nutrition, compression, icing, foam rolling, and rest, must also be emphasized.¹⁴ Furthermore, because cross-country runners may be multisport athletes who also participate in indoor and outdoor track and field and summer conditioning, researchers must examine how such athletes' recovery time is further limited and whether this may place them at further risk for injury.

At the same time, differences in how ATs from our samples may have examined NTL and overuse injuries might have varied from previous research. This is most evident when comparing the non-time-loss injury rates in our study (1.81 and 2.41/1000 AEs for men and women, respectively) with those reported by Powell and Dompier⁸ (15.8 and 17.2/1000 AEs for men and women, respectively). The extent to which ATs monitored NTL injuries may have varied between the populations. For example, ATs may have treated but not recorded the most minor injuries such as bruises, cuts, and scrapes, all of which had injury counts of less than 5 in our data. The ATs in the Powell and Dompier⁸ investigation may have reported such injuries, although the diagnoses were not described. Also, in our data-collection process, we emphasized to ATs that overuse injuries, many of which were NTL, should only be reported the first time the athlete brought the injury to their attention. Last, it is possible that previous researchers¹² who examined only TL injuries may have recorded the same injury every instance it caused time loss. Other authors¹⁵ have considered examining the prevalence of injuries, including conditions causing unspecified pain. Future work should involve methods to better track overuse injuries or conditions that result in pain or functional limitations independent of TL or injury diagnosis.^{16–18}

Sex Differences

Overall, female athletes had a higher injury rate than male athletes. However, this finding was not significant when restricted by TL or event type (ie, competition, practice). Existing evidence about sex differences in reported injury rates among collegiate athletes is mixed, with 1 study¹⁹ finding no significant differences and another⁸ finding higher rates among female athletes as compared with male athletes. Where female rates are higher than male rates, differences are typically explained by behavioral pathways. Playing through pain and injury has

been described as normative in many sport contexts, and sport has been considered a setting in which orthodox conceptions of masculinity are reinforced.²⁰ Although some female sport contexts have also been portrayed as valuing a similar ethos of toughness,²¹ it is possible that injury reporting and safety behaviors are nonetheless more normative on many female teams as compared with male teams. To the extent this is true, the higher rate of injury among female cross-country runners we found may be an artifact of sex differences in reporting behavior. Future researchers are encouraged to assess the role of subjectivity in rates of reported injuries in collegiate sport.

One biologic explanation relates to the hormonal consequences of low energy availability among female athletes.²² Among distance runners, concern about energy deficits is heightened because of the prevalence of eating disorders and the female athlete triad, both of which may contribute to bone loss and bone injury.^{11,23–26} We did not formally evaluate the female athlete triad, although the number of reported fractures and stress fractures is small. Nevertheless, primary prevention of disordered eating is an important strategy for risk reduction related to compromised bone density and other physiologic health consequences of inadequate energy intake.²⁷

The sex difference in injury rates is also interesting because male athletes compete over a longer distance than female athletes (national championship race distances in Division I are 10 km for men and 6 km for women). The higher training volume needed to prepare for this longer-duration competition may result in male cross-country runners systematically experiencing a greater physical burden for a given AE. A larger training volume has been associated with higher injury risk.^{7,28–30} Individuals who increase their training load too quickly or ignore early signs of pain and continue training or competing make themselves vulnerable to injury.³¹ Among collegiate cross-country runners, weekly mileage can range from less than 30 miles per week to more than 100 miles per week.^{5,32} Because our AE measurement was unit based, we could not differentiate distances run per practice and per competition. As a result, student-athletes running longer distances per practice would be analyzed the same as those running shorter distances per practice. This recording method provides consistency for comparisons across various sports injury-surveillance research outcomes and is necessary for limiting reporter burden. However, future investigators need to identify whether the relative difference in injury between male and female athletes we found may understate either the higher burden among female athletes or the extent to which male athletes are underreporting injury.

In addition, several notable differences related to specific injuries were found between male and female athletes. Women sustained a higher injury rate to the hip/groin than men. This difference is consistent with prior literature²⁹ that suggested a higher rate of hip injuries among female runners than among male runners. Encouraging other activities such as strength training and plyometric exercises may help to reduce the incidence and severity of hip/groin injuries.³³ Meanwhile, men sustained a higher rate of ankle sprains than women. No current researchers have explored this disparity, although ankle-joint mobility may be associated with injury risk.³⁴ It is also possible that male runners within our sample may have been less careful with

footing or running on more rugged terrain, had more difficulty accommodating the terrain in a safe manner, or had higher fatigue levels because of running longer distances. Nevertheless, these findings may present an opportunity for ATs and coaches to incorporate targeted strengthening and proprioceptive exercises into the training regimes of cross-country runners to address underlying vulnerabilities to specific types of injury.

Limitations

The study is not without limitations. First, AEs were unit based rather than time or distance based. Thus, we were unable to report injury rates by minute or hour of practice and competition or miles or kilometers run. Our study might have benefited from the tracking of training volume, typically expressed as distance covered per week. Second, the current data examined only the surface type on which the student-athlete was running when the injury occurred, as opposed to the cumulative exposures of multiple surface types over the course of the training regime. This is particularly relevant given the high fraction of injuries that were overuse. Similarly, categorizing overuse injuries as occurring in practice or competition may have resulted in an artificial distinction. This categorization likely reflects the setting in which the athlete decided to report the injury to medical personnel, as opposed to the setting in which the injury actually occurred. Third, team participation in data collection was low, although the Datalys Center is currently making efforts to increase participation. As a result, our findings may not be generalizable to all US collegiate cross-country running programs. Fourth, as suggested in other sports such as swimming, pain may not be associated with injury and analgesics may be used to self-medicate.³⁵ As a result, these injuries would not be recorded unless they were detected by or reported to an AT. Thus, our methods may have not sufficiently captured all overuse injuries. Or, injuries may have been captured but attributed to an incorrect time period (ie, student-athlete initially had pain onset from overuse injury in a preseason practice but did not report the pain to an AT until regular-season competition). In sports with high proportions of overuse injuries such as cross-country, it may be beneficial to consider other models of injury surveillance.¹⁵

CONCLUSIONS

Developing effective and appropriately targeted preventive interventions and ensuring that adequate resources are being deployed to manage athletic injuries require an accurate assessment of the extent to which injuries occur. The present study provides a comprehensive assessment of injury in male and female collegiate cross-country that is largely consistent with prior literature on mechanisms and body sites. Our findings indicate a lower injury burden in men's and women's cross-country than previously reported. Furthermore, our results support those of previous researchers who found differences in the incidence and type of injuries sustained by male and female cross-country runners, suggesting possible areas for targeted prevention and avenues for future examination. This may include variations in training guidelines that limit strength training, cross training, plyometric exercises, and the number of miles of running per week.

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