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original research

The Epidemiology of Severe Injuries Sustained by National Collegiate Athletic Association Student-Athletes, 2009–2010 Through 2014–2015

Melissa C. Kay, MS, LAT, ATC*; Johna K. Register-Mihalik, PhD, LAT, ATC*; Aaron D. Gray, MD†; Aristarque Djoko, MS‡; Thomas P. Dompier, PhD, ATC‡; Zachary Y. Kerr, PhD, MPH*

*Department of Exercise and Sport Science, University of North Carolina at Chapel Hill; †School of Medicine, University of Missouri, Columbia; ‡Datalys Center for Sports Injury Research and Prevention, Inc, Indianapolis, IN

Context: Few researchers have described the incidence of the most severe injuries sustained by student-athletes at the collegiate level.

Objective: To describe the epidemiology of severe injuries within 25 National Collegiate Athletic Association (NCAA) sports in the 2009–2010 through 2014–2015 academic years.

Design: Descriptive epidemiology study.

Setting: Aggregate injury and exposure data from 25 NCAA sports.

Patients or Other Participants: Collegiate student-athletes in the 2009–2010 through 2014–2015 academic years.

Main Outcome Measure(s): Injury data from the NCAA Injury Surveillance Program were analyzed. A *severe injury* (1) occurred during a sanctioned competition or practice, (2) required medical attention by an athletic trainer or physician, and (3) resulted in at least 21 days lost from sport activity or a premature end to the sport season. Injury counts, proportions, rates per 1000 athlete-exposures (AEs), rate ratios (RRs), and injury proportion ratios were reported with 95% confidence intervals (CIs).

Results: A total of 3183 severe injuries were reported, for an injury rate of 0.66/1000 AEs. Wrestling had the highest severe injury rate (1.73/1000 AEs), followed by women's gymnastics (1.40/1000 AEs) and football (0.97/1000 AEs). Overall, the severe injury rate was higher in competition than in practice (RR = 4.25, 95% CI = 3.97, 4.56). Most severe injuries were reported during the regular season (69.3%, n = 2206); however, severe injury rates did not differ between the preseason and regular season (RR = 0.98, 95% CI = 0.91, 1.06). Common severely injured body parts were the knee (32.9%, n = 1047), lower leg/ankle/foot (22.5%, n = 715), and head/face/neck (11.2%, n = 358). Common severe injury diagnoses were sprains (32.9%, n = 1048), strains (16.9%, n = 538), and fractures (14.4%, n = 458). Common severe injury mechanisms were player contact (39.3%, n = 1251), noncontact (25.1%, n = 800), and surface contact (12.0%, n = 383).

Conclusions: Severe injuries occurred across many sports and by numerous mechanisms. By identifying these sport-specific patterns, clinicians' efforts can be tailored toward improving injury-prevention strategies and health outcomes.

Key Words: injury surveillance, injury rates, injury prevention

Key Points

- Severe injury rates varied by sport, event type, and sex.
- As patterns within specific sports are identified, health care providers can develop injury-prevention strategies and promote efforts such as rule changes to improve athlete safety.

Given the high demands placed on collegiate student-athletes during sport, injury patterns among this population are a key area of study for facilitating policy and rule changes.[1] As of 2015, more than 480 000 student-athletes were participating in National Collegiate Athletic Association (NCAA) sports, and the numbers continue to rise.[2] Compared with high school or youth populations, collegiate student-athletes may be subject to increased intensity of training, exposure to participation in sports, potential for microtrauma, and prevalence of previous injury.[3]

Student-athletes constantly engage in repetitive activities, which may not initially result in injury; however, cumulative exposure may result in an elevated risk of severe injury and additional time loss.[4,5] These severe injuries have the potential to cause student-athletes to miss large portions of their season.[6] The longer an injury restricts an athlete from sport participation, the more serious ramifications the injury may have for the athlete's physical and mental health.[7] For our purposes, a *severe injury* was defined as resulting in time loss of more than 21 days of participation, as supported by previous literature.[6]

Severe injuries affect student-athletes in several ways, including financially, psychologically, and physiologically,[8–11] thereby highlighting the need for prevention.[6] Much of the current literature focuses on the adolescent population[6] or pertains to particular sports, injury mechanisms, or diagnoses.[12–15] Because the literature on severe

injuries in collegiate student-athletes is limited, we used data from the NCAA Injury Surveillance Program (NCAA ISP) to describe the epidemiology of severe injury in 25 NCAA sports.

METHODS

The NCAA ISP is a prospective surveillance program managed by the Datalys Center for Sports Injury Research and Prevention, Inc, an independent, nonprofit research organization. Data for this study originated from the 2009–2010 through 2014–2015 academic years. This study was approved by the Research Review Board of the NCAA. The methods of the NCAA ISP have been previously described[1] but are briefly summarized here.

Data Collection

The NCAA ISP relies on a convenience sample of NCAA varsity teams from 25 sports with athletic trainers (ATs) reporting injury data. The number of programs providing data varies by sport and year.[1] Overall, participation among teams for the study period ranged from a low of 0.7% in men's tennis to a high of 13.2% in men's ice hockey. The reporting ATs worked with the participating teams and attended school-sanctioned practices and competitions. They logged the number of student-athletes participating in each practice and competition. Injuries were reported in real time through the electronic health record application used by the team medical staff throughout the academic year. In addition to injuries, the NCAA ISP also captured other sport-related adverse health events, such as illnesses, heat-related conditions, general medical conditions, and skin infections. Data were from varsity-level practices and competitions and team conditioning sessions. Individual weight-lifting and conditioning sessions were excluded.

The AT completed a detailed event report on the injury or condition, such as the body site and diagnosis, as well as related circumstances, such as activity, mechanism, event type (ie, competition or practice), and time in season (ie, preseason, regular season, postseason). After entering the injury data, the AT could return to view and update the data as needed over the course of a season, such as when the student-athlete returned to sport participation or additional diagnostic information was available.

Deidentified common data elements were extracted from certified electronic health record applications.[1] The common data elements included injury and exposure information; they were stripped of any identifiers and encrypted before being exported to the central aggregate research database. The frequency of export and submission of data varied slightly among health record application vendors. This common data element standard allowed ATs to document injuries normally as part of their daily clinical practice, as opposed to having them separately report injuries for the NCAA ISP. All certified electronic health record applications were required to successfully undergo a data-validation process to be certified for the ISP.

Exported data passed through an automated verification process that conducted a series of range and consistency checks. Data were reviewed and invalid values were flagged. The AT and data quality-assurance staff were notified and worked together to resolve invalid values. Data that passed the verification process were then placed into the aggregate research dataset.

Definitions

Injury. A reportable *injury* occurred as a result of participation in an organized intercollegiate practice or competition and required attention from an AT or physician. Multiple injuries could be included as the result of 1 injury event.

Severe Injury. Injuries were also categorized by the number of days of restricted participation (ie, the date of return subtracted from the date of injury). *Severe injuries*[6] were those that restricted participation for more than 3 weeks (>21 days). Severe injuries also included those that resulted in the student-athlete choosing to prematurely end the season, courses of recovery extending beyond the end of the season, and medical disqualification.

Athlete-Exposure. 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 student-athletes with actual playing time in a competition were included in competition exposures.

Statistical Analysis

Data were analyzed to assess frequencies and rates of severe injuries sustained during collegiate sports. We first calculated severe injury rates overall and then by event type and time in season. We then examined distributions of injuries by body part injured, diagnosis, injury mechanism, and injury activity.

Rate ratios (RRs) compared rates within sports by event type (ie, competition or practice) and time in season (ie, preseason, regular season, or postseason). Because of low postseason counts, RRs compared the rates between the preseason and the regular season only. No rate comparisons were made for postseason injuries. The RRs also compared overall competition and practice rates between sex-comparable sports (ie, baseball and softball, basketball, cross-country, ice hockey, lacrosse, indoor track and field, outdoor track and field, soccer, swimming and diving, tennis). For sex-comparable sports, we used injury proportion ratios (IPRs)[6] to examine sex differences in distributions of body parts injured, diagnoses, and injury mechanisms.

All 95% confidence intervals (CIs) computed for ratio measures (RRs and IPRs) that did not include 1.00 were considered statistically significant. Data were analyzed using SAS-Enterprise Guide software (version 4.3; SAS Institute Inc, Cary, NC).

RESULTS

Overall Severe Injury Counts and Rates

A total of 3183 severe injuries were reported during the 2009–2010 through 2014–2015 academic years, resulting in a severe injury rate of 0.66/1000 AEs (Table 1). Men's football contributed the greatest number of severe injuries overall (34.4%, n = 1094), followed by men's ice hockey (12.0%, n = 381) and women's soccer (7.4%, n = 236;

Table 1. Severe Injury Counts and Rates Among Student-Athletes in 25 Sports, National Collegiate Athletic Association Injury Surveillance Program, 2009–2010 Through 2014–2015 Academic Years

Sport	Severe Injuries, No. (% of Total)[a]	Rate per 1000 Athlete-Exposures[b] (95% Confidence Interval)	Sex-Comparable Sport Rate Ratio (95% Confidence Interval)
Men's football	1094 (10.2)	0.97 (0.92, 1.03)	NA
Men's wrestling	173 (14.2)	1.73 (1.48, 1.99)	NA
Women's field hockey	14 (6.9)	0.29 (0.14, 0.45)	NA
Women's gymnastics	79 (15.6)	1.40 (1.09, 1.71)	NA
Women's volleyball	101 (7.7)	0.51 (0.41, 0.61)	NA
Baseball/softball			
Men's baseball	90 (9.3)	0.40 (0.32, 0.48)	1.38 (0.99, 1.91)
Women's softball	61 (6.1)	0.29 (0.22, 0.36)	1.00
Basketball			
Men's	117 (5.1)	0.41 (0.34, 0.49)	1.00
Women's	154 (9.4)	0.64 (0.54, 0.74)	1.55 (1.22, 1.98)
Cross-country			
Men's	22 (8.1)	0.38 (0.22, 0.54)	1.00
Women's	41 (12.9)	0.75 (0.52, 0.98)	1.97 (1.18, 3.31)
Ice hockey			
Men's	381 (10.3)	0.94 (0.85, 1.04)	2.11 (1.63, 2.74)
Women's	66 (7.0)	0.45 (0.34, 0.55)	1.00
Lacrosse			
Men's	115 (10.9)	0.58 (0.47, 0.68)	1.45 (1.05, 1.99)
Women's	57 (8.1)	0.40 (0.30, 0.50)	1.00
Soccer			
Men's	115 (7.4)	0.60 (0.49, 0.71)	1.00
Women's	236 (10.4)	0.88 (0.77, 1.00)	1.46 (1.17, 1.83)
Swimming and diving			
Men's	5 (2.5)	0.04 (0.00, 0.07)	1.00
Women's	9 (3.5)	0.06 (0.02, 0.10)	1.52 (0.51, 4.53)
Tennis			
Men's	20 (11.0)	0.63 (0.35, 0.91)	2.20 (1.10 , 4.43)
Women's	13 (5.7)	0.29 (0.13, 0.44)	1.00
Indoor track and field			
Men's	59 (10.6)	0.38 (0.28, 0.48)	1.00
Women's	71 (11.7)	0.45 (0.35, 0.56)	1.20 (0.85, 1.69)
Outdoor track and field			
Men's	33 (9.5)	0.31 (0.20, 0.42)	1.00
Women's	57 (15.4)	0.62 (0.46, 0.79)	2.00 (1.31, 3.08)
Sex-comparable sports[c]			
Men's	957 (8.6)	0.54 (0.50, 0.57)	1.06 (0.96, 1.17)
Women's	765 (9.2)	0.51 (0.47, 0.54)	1.00
Overall total	3183 (9.5)	0.66 (0.64, 0.68)	NA

Abbreviation: NA, not applicable.

[a] Rate estimates with cell sizes smaller than 5 should be interpreted with caution.

[b] One athlete-exposure = 1 athlete participating in 1 practice or competition.

[c] Includes only sex-comparable sports (baseball/softball, basketball, cross-country, ice hockey, lacrosse, soccer, swimming and diving, tennis, indoor track and field, and outdoor track and field).

Table 1). However, the highest severe injury rates were in men's wrestling (1.73/1000 AEs), women's gymnastics (1.40/1000 AEs), and men's football (0.97/1000 AEs). Of all severe injuries, 974 (30.6%) of the 3183 required surgery and 1504 (47.3%) were season ending.

Among all sex-comparable sports, no differences were found in the severe injury rates between men and women (RR = 1.06, 95% CI = 0.96, 1.17; Table 1). However, differences were noted in sport-specific sex comparisons. The severe injury rate was higher in men than in women for ice hockey (RR = 2.11, 95% CI = 1.63, 2.74) and lacrosse (RR = 1.45, 95% CI = 1.05, 1.99). In contrast, the severe injury rate was higher in women than in men for outdoor track and field (RR = 2.00, 95% CI = 1.31, 3.08), cross-country (RR = 1.97, 95% CI = 1.18, 3.31), basketball (RR = 1.55, 95% CI = 1.22, 1.98), and soccer (RR = 1.46, 95% CI = 1.17, 1.83).

Proportion of Severe Injuries

Severe injuries accounted for 9.5% of all injuries reported to the NCAA ISP (Table 1). Among men's sports, the

Table 2. Severe Injury Rates Among Student-Athletes in 25 Sports by Event Type, National Collegiate Athletic Association Injury Surveillance Program, 2009–2010 Through 2014–2015 Academic Years

Sport	Severe Injuries, No. (% of Total)[a]		Rate per 1000 Athlete-Exposures[b] (95% Confidence Interval)		Competition : Practice Rate Ratio (95% Confidence Interval)
	Competition	Practice	Competition	Practice	
Men's football	524 (11.5)	570 (9.3)	4.79 (4.38, 5.20)	0.56 (0.52, 0.61)	8.51 (7.56, 9.58)
Men's wrestling	88 (21.1)	85 (10.6)	8.26 (6.54, 9.99)	0.95 (0.75, 1.16)	8.66 (6.43, 11.67)
Women's field hockey	6 (7.0)	8 (6.8)	0.53 (0.11, 0.95)	0.22 (0.07, 0.38)	2.38 (0.82, 6.85)
Women's gymnastics	11 (15.7)	68 (15.6)	2.13 (0.87, 3.39)	1.32 (1.01, 1.64)	1.61 (0.85, 3.04)
Women's volleyball	52 (14.2)	49 (5.1)	0.91 (0.66, 1.16)	0.35 (0.25, 0.44)	2.63 (1.78, 3.89)
Men's baseball	54 (10.5)	36 (7.9)	0.65 (0.47, 0.82)	0.26 (0.17, 0.34)	2.54 (1.66, 3.87)
Women's softball	33 (7.0)	28 (5.3)	0.42 (0.28, 0.56)	0.21 (0.14, 0.29)	1.95 (1.18, 3.23)
Men's basketball	52 (6.1)	65 (4.5)	0.85 (0.62, 1.08)	0.29 (0.22, 0.36)	2.90 (2.01, 4.17)
Women's basketball	61 (10.0)	93 (9.1)	1.08 (0.81, 1.36)	0.51 (0.40, 0.61)	2.14 (1.55, 2.96)
Men's cross-country	3 (11.5)	19 (7.8)	0.60 (0.00, 1.28)	0.36 (0.20, 0.52)	1.66 (0.49, 5.63)
Women's cross-country	2 (5.6)	39 (13.8)	0.42 (0.00, 1.00)	0.78 (0.54, 1.03)	0.54 (0.13, 2.23)
Men's ice hockey	279 (11.2)	102 (8.5)	2.84 (2.50, 3.17)	0.33 (0.27, 0.40)	8.52 (6.79, 10.69)
Women's ice hockey	43 (8.7)	23 (5.2)	1.09 (0.77, 1.42)	0.21 (0.13, 0.30)	5.16 (3.11, 8.56)
Men's lacrosse	48 (11.9)	67 (10.3)	1.46 (1.05, 1.88)	0.40 (0.31, 0.50)	3.64 (2.51, 5.27)
Women's lacrosse	19 (8.7)	38 (7.8)	0.70 (0.39, 1.01)	0.33 (0.22, 0.43)	2.13 (1.23, 3.70)
Men's soccer	73 (10.0)	42 (5.1)	1.78 (1.37, 2.19)	0.28 (0.20, 0.37)	6.36 (4.35, 9.29)
Women's soccer	144 (13.0)	92 (7.9)	2.23 (1.86, 2.59)	0.45 (0.36, 0.55)	4.91 (3.78, 6.38)
Men's swimming and diving	0	5 (2.7)	0.00	0.04 (0.01, 0.08)	NA
Women's swimming and diving	1 (5.0)	8 (3.4)	0.07 (0.00, 0.21)	0.06 (0.02, 0.10)	1.25 (0.16, 10.01)
Men's tennis	4 (5.8)	16 (14.3)	0.60 (0.01, 1.19)	0.64 (0.33, 0.95)	0.94 (0.31, 2.82)
Women's tennis	10 (12.8)	3 (2.0)	0.97 (0.37, 1.56)	0.09 (0.00, 0.18)	11.30 (3.11, 41.07)
Men's indoor track and field	15 (16.7)	44 (9.5)	1.01 (0.50, 1.52)	0.31 (0.22, 0.41)	3.23 (1.80, 5.80)
Women's indoor track and field	12 (14.1)	59 (11.3)	0.87 (0.38, 1.37)	0.41 (0.31, 0.52)	2.11 (1.13, 3.93)
Men's outdoor track and field	14 (13.7)	19 (7.7)	0.91 (0.43, 1.39)	0.21 (0.12, 0.30)	4.34 (2.18, 8.66)
Women's outdoor track and field	12 (12.8)	45 (16.4)	0.79 (0.34, 1.23)	0.59 (0.42, 0.76)	1.33 (0.71, 2.52)
Men's sports overall[c]	542 (10.3)	415 (7.1)	1.46 (1.34, 1.59)	0.29 (0.27, 0.32)	4.99 (4.39, 5.67)
Women's sports overall[c]	337 (10.5)	428 (8.4)	1.04 (0.93, 1.15)	0.36 (0.33, 0.39)	2.88 (2.50, 3.32)
Overall total	1560 (11.2)	1623 (8.4)	1.76 (1.67, 1.84)	0.41 (0.39, 0.43)	4.25 (3.97, 4.56)

Abbreviation: NA, not applicable.

[a] Rates estimates with cell sizes smaller than 5 should be interpreted with caution.

[b] One athlete-exposure = 1 athlete participating in 1 practice or competition.

[c] Includes only sex-comparable sports (baseball/softball, basketball, cross-country, ice hockey, lacrosse, soccer, swimming and diving, tennis, indoor track and field, and outdoor track and field).

largest proportions of severe injuries were in wrestling (14.2%, n = 173), tennis (11.0%, n = 20), and lacrosse (10.9%, n = 115). Among women's sports, the largest proportions of severe injuries were in gymnastics (15.6%, n = 79), outdoor track and field (15.4%, n = 57), and cross-country (12.9%, n = 41).

Severe Injury Distributions

Event Types. A similar number of severe injuries were reported in practice (51.0%, n = 1623) and competition (49.0%, n = 1560; Table 2). However, the severe injury rate was higher in competition than in practice (RR = 4.25, 95% CI = 3.97, 4.56). The men's sports with the largest competition versus practice RRs were wrestling (RR = 8.66, 95% CI = 6.43, 11.67), ice hockey (RR = 8.52, 95% CI = 6.79, 10.69), and football (RR = 8.51, 95% CI = 7.56, 9.58). The women's sports with the largest competition versus practice RRs were tennis (RR = 11.30, 95% CI = 3.11, 41.07), ice hockey (RR = 5.16, 95% CI = 3.11, 8.56), and soccer (RR = 4.91, 95% CI = 3.78, 6.38).

Time in Season. Most severe injuries were reported during the regular season (69.3%, n = 2206), followed by the preseason (27.3%, n = 868) and postseason (3.4%, n = 109; Table 3). Yet the severe injury rates in the preseason and regular season did not differ (RR = 0.98, 95% CI = 0.91, 1.06). In addition, within specific sports, severe injury rates for the preseason compared with the regular season differed: men's cross-country (RR = 2.66, 95% CI = 1.12, 6.31), women's gymnastics (RR = 2.05, 95% CI = 1.22, 3.44), women's basketball (RR = 1.88, 95% CI = 1.34, 2.63), women's outdoor track and field (RR = 1.75, 95% CI = 1.03, 2.97), men's wrestling (RR = 0.67, 95% CI = 0.46, 0.96), and men's soccer (RR = 0.49, 95% CI = 0.29, 0.83).

Body Parts. Overall, body parts accounting for the largest proportions of severe injuries were the knee (32.9%, n = 1047), lower leg/ankle/foot (22.5%, n = 715), and head/face/neck (11.2%, n = 358; Table 4). Among sex-comparable sports, the proportion of severe injuries was higher in men than in women for the shoulder (IPR = 3.05, 95% CI = 2.02, 4.61), wrist/hand (IPR = 2.78, 95% CI = 1.83, 4.22), elbow (IPR = 2.17, 95% CI = 1.18, 3.97), and hip/groin/upper leg (IPR = 1.40, 95% CI = 1.06, 1.85). In contrast, the proportion of severe injuries was higher in women than in men for the knee (IPR = 1.51, 95% CI = 1.30, 1.76) and lower leg/ankle/foot (IPR = 1.36, 95% CI = 1.16, 1.60).

Diagnoses. Common diagnoses for severe injuries were sprains (32.9%, n = 1048), followed by strains (16.9%, n = 538) and fractures (14.4%, n = 458; Table 5). Among sex-comparable sports, the proportion of severe injuries was

Table 3. Severe Injury Rates Among Student-Athletes in 25 Sports by Time in Season, National Collegiate Athletic Association Injury Surveillance Program, 2009–2010 Through 2014–2015 Academic Years

Sport	Severe Injuries, No. (% of Total)[a]			Rate per 1000 Athlete-Exposures[b] (95% Confidence Interval)			Preseason : Regular-Season Rate Ratio (95% Confidence Interval)
	Preseason	Regular Season	Postseason	Preseason	Regular Season	Postseason	
Men's football	327 (9.2)	740 (10.7)	27 (11.4)	0.95 (0.85, 1.06)	1.01 (0.94, 1.08)	0.55 (0.35, 0.76)	0.94 (0.83, 1.08)
Men's wrestling	37 (11.0)	127 (15.0)	9 (21.4)	1.30 (0.88, 1.71)	1.94 (1.60, 2.28)	1.55 (0.54, 2.56)	0.67 (0.46, 0.96)
Women's field hockey	2 (3.8)	12 (8.5)	0	0.17 (0.00, 0.41)	0.38 (0.16, 0.59)	0.00	0.46 (0.10, 2.04)
Women's gymnastics	58 (17.9)	19 (11.9)	2 (9.5)	1.85 (1.38, 2.33)	0.90 (0.50, 1.31)	0.47 (0.00, 1.12)	2.05 (1.22, 3.44)
Women's volleyball	30 (6.0)	69 (8.7)	2 (9.1)	0.63 (0.41, 0.86)	0.48 (0.37, 0.59)	0.30 (0.00, 0.72)	1.32 (0.86, 2.03)
Men's baseball	31 (9.7)	57 (9.2)	2 (6.7)	0.42 (0.27, 0.56)	0.40 (0.30, 0.50)	0.28 (0.00, 0.66)	1.04 (0.67, 1.61)
Women's softball	20 (5.3)	41 (6.8)	0	0.30 (0.17, 0.43)	0.31 (0.21, 0.40)	0.00	0.98 (0.57, 1.67)
Men's basketball	32 (4.9)	78 (5.0)	7 (8.1)	0.51 (0.33, 0.69)	0.38 (0.29, 0.46)	0.53 (0.14, 0.93)	1.36 (0.90, 2.05)
Women's basketball	53 (11.7)	94 (8.3)	7 (14.9)	1.00 (0.73, 1.28)	0.54 (0.43, 0.64)	0.60 (0.16, 1.05)	1.88 (1.34, 2.63)
Men's cross-county	9 (11.0)	12 (6.9)	1 (7.1)	0.78 (0.27, 1.29)	0.29 (0.13, 0.46)	0.18 (0.00, 0.55)	2.66 (1.12, 6.31)
Women's cross-country	13 (13.4)	27 (12.9)	1 (7.7)	1.16 (0.53, 1.79)	0.69 (0.43, 0.95)	0.24 (0.00, 0.70)	1.69 (0.87, 3.27)
Men's ice hockey	30 (9.4)	335 (10.4)	16 (11.9)	0.73 (0.47, 1.00)	1.00 (0.89, 1.11)	0.55 (0.28, 0.81)	0.73 (0.50, 1.06)
Women's ice hockey	11 (8.5)	51 (6.5)	4 (18.2)	0.60 (0.25, 0.96)	0.42 (0.30, 0.53)	0.51 (0.01, 1.02)	1.44 (0.75, 2.76)
Men's lacrosse	32 (9.7)	80 (11.8)	3 (6.5)	0.52 (0.34, 0.70)	0.65 (0.51, 0.80)	0.20 (0.00, 0.42)	0.80 (0.53, 1.20)
Women's lacrosse	13 (5.0)	42 (10.0)	2 (7.7)	0.28 (0.13, 0.44)	0.48 (0.33, 0.62)	0.21 (0.00, 0.51)	0.59 (0.32, 1.10)
Men's soccer	16 (3.9)	92 (8.9)	7 (6.6)	0.35 (0.18, 0.52)	0.71 (0.56, 0.85)	0.47 (0.12, 0.83)	0.49 (0.29, 0.83)
Women's soccer	48 (7.2)	173 (11.7)	15 (11.9)	0.74 (0.53, 0.95)	0.92 (0.78, 1.05)	1.04 (0.51, 1.56)	0.81 (0.59, 1.12)
Men's swimming and diving	3 (4.3)	2 (1.5)	0	0.10 (0.00, 0.22)	0.02 (0.00, 0.05)	0.00	4.82 (0.81, 28.85)
Women's swimming and diving	1 (1.0)	7 (4.6)	1 (16.7)	0.02 (0.00, 0.07)	0.07 (0.02, 0.12)	0.09 (0.00, 0.26)	0.37 (0.05, 3.02)
Men's tennis	6 (17.1)	14 (9.9)	0	0.90 (0.18, 1.62)	0.61 (0.29, 0.93)	0.00	1.47 (0.56, 3.83)
Women's tennis	1 (1.3)	12 (8.2)	0	0.09 (0.00, 0.28)	0.37 (0.16, 0.58)	0.00	0.25 (0.03, 1.93)
Men's indoor track and field	24 (10.3)	33 (11.2)	2 (7.7)	0.31 (0.19, 0.44)	0.46 (0.30, 0.61)	0.33 (0.00, 0.79)	0.68 (0.40, 1.16)
Women's indoor track and field	40 (14.0)	30 (9.8)	1 (6.3)	0.54 (0.37, 0.71)	0.39 (0.25, 0.53)	0.21 (0.00, 0.62)	1.39 (0.87, 2.24)
Men's outdoor track and field	8 (10.5)	25 (9.5)	0	0.31 (0.09, 0.52)	0.34 (0.20, 0.47)	0.00	0.91 (0.41, 2.02)
Women's outdoor track and field	23 (23.0)	34 (13.7)	0	0.96 (0.57, 1.35)	0.55 (0.36, 0.73)	0.00	1.75 (1.03, 2.97)
Men's sports overall[c]	191 (7.6)	728 (8.9)	38 (8.3)	0.44 (0.38, 0.50)	0.59 (0.54, 0.63)	0.36 (0.24, 0.47)	0.75 (0.64, 0.88)
Women's sports overall[c]	223 (8.8)	511 (9.3)	31 (10.4)	0.55 (0.47, 0.62)	0.50 (0.46, 0.54)	0.39 (0.25, 0.52)	1.09 (0.93, 1.28)
Overall total	868 (8.8)	2206 (9.8)	109 (10.0)	0.66 (0.62, 0.71)	0.68 (0.65, 0.70)	0.43 (0.35, 0.51)	0.98 (0.91, 1.06)

[a] Rate estimates with cell sizes smaller than 5 should be interpreted with caution.
[b] One athlete-exposure = 1 athlete participating in 1 practice or competition.
[c] Includes only sex-comparable sports (baseball/softball, basketball, cross-country, ice hockey, lacrosse, soccer, swimming and diving, tennis, indoor track and field, and outdoor track and field).

Table 4. Severe Injury Counts and Proportions Among Student-Athletes in 25 Sports by Body Part Injured, National Collegiate Athletic Association Injury Surveillance Program, 2009–2010 Through 2014–2015 Academic Years

	Body Part Injured, n (%)									
Sport	Head/Face/Neck	Shoulder	Elbow	Wrist/Hand	Trunk	Hip/Groin/ Upper Leg	Knee	Lower Leg/ Ankle/Foot	Other	Overall
Men's football	103 (9.41)	104 (9.5)	42 (3.8)	42 (3.8)	58 (5.3)	68 (6.2)	444 (40.6)	219 (20.0)	14 (1.3)	1094 (100.0)
Men's wrestling	43 (24.9)	29 (16.8)	10 (5.8)	11 (6.4)	10 (5.8)	4 (2.3)	56 (32.4)	6 (3.5)	4 (2.3)	173 (100.0)
Women's field hockey	3 (21.4)	0	1 (7.1)	2 (14.3)	0	1 (7.1)	0	6 (42.9)	1 (7.1)	14 (100.0)
Women's gymnastics	8 (10.1)	2 (2.5)	10 (12.7)	1 (1.3)	7 (8.9)	2 (2.5)	20 (25.3)	29 (36.7)	0	79 (100.0)
Women's volleyball	7 (6.9)	5 (5.0)	3 (3.0)	3 (3.0)	7 (6.9)	3 (3.0)	52 (51.5)	19 (18.8)	2 (2.0)	101 (100.0)
Men's baseball	7 (7.8)	16 (17.8)	25 (27.8)[a]	16 (17.8)	3 (3.3)	5 (5.6)	9 (10.0)	6 (6.7)	3 (3.3)	90 (100.0)
Women's softball	7 (11.5)	8 (13.1)	5 (8.2)	8 (13.1)	4 (6.6)	4 (6.6)	14 (23.0)[b]	10 (16.4)	1 (1.6)	61 (100.0)
Men's basketball	4 (3.4)	3 (2.6)	0	16 (13.7)	4 (3.4)	5 (4.3)	46 (39.3)	37 (31.6)	2 (1.7)	117 (100.0)
Women's basketball	19 (12.3)	1 (0.6)	2 (1.3)	9 (5.8)	4 (2.6)	7 (4.5)	69 (44.8)	42 (27.3)	1 (0.6)	154 (100.0)
Men's cross-country	0	0	0	0	2 (9.1)	3 (13.6)	2 (9.1)	15 (68.2)	0	22 (100.0)
Women's cross-country	0	0	0	0	5 (12.2)	12 (29.3)	2 (4.9)	21 (51.2)	1 (2.4)	41 (100.0)
Men's ice hockey	80 (21.0)	62 (16.3)	10 (2.6)	41 (10.8)	17 (4.5)	41 (10.8)	68 (17.8)	57 (15.0)	5 (1.3)	381 (100.0)
Women's ice hockey	22 (33.3)	9 (13.6)	1 (1.5)	2 (3.0)	2 (3.0)	1 (1.5)	18 (27.3)	7 (10.6)	4 (6.1)	66 (100.0)
Men's lacrosse	10 (8.7)	11 (9.6)	1 (0.9)	14 (12.2)	1 (0.9)	8 (7.0)	41 (35.7)	26 (22.6)	3 (2.6)	115 (100.0)
Women's lacrosse	10 (17.5)	1 (1.8)	0	1 (1.8)	2 (3.5)	4 (7.0)	25 (43.9)	14 (24.6)	0	57 (100.0)
Men's soccer	10 (8.7)	8 (7.0)	0	2 (1.7)	2 (1.7)	26 (22.6)	35 (30.4)	31 (27.0)	1 (0.9)	115 (100.0)
Women's soccer	18 (7.6)	6 (2.5)	4 (1.7)	5 (2.1)	7 (3.0)	18 (7.6)	114 (48.3)	63 (26.7)	1 (0.4)	236 (100.0)
Men's swimming and diving	0	1 (20.0)	0	2 (40.0)	1 (20.0)	0	0	0	1 (20.0)	5 (100.0)
Women's swimming and diving	4 (44.4)	0	0	1 (11.1)	2 (22.2)	0	0	2 (22.2)	0	9 (100.0)
Men's tennis	1 (5.0)	2 (10.0)	0	2 (10.0)	4 (20.0)	0	2 (10.0)	8 (40.0)	1 (5.0)	20 (100.0)
Women's tennis	1 (7.7)	2 (15.4)	2 (15.4)	1 (7.7)	2 (15.4)	0	1 (7.7)	4 (30.8)	0	13 (100.0)
Men's indoor track and field	0	0	0	1 (1.7)	5 (8.5)	21 (35.6)	9 (15.3)	19 (32.2)	4 (6.8)	59 (100.0)
Women's indoor track and field	0	0	0	0	11 (15.5)	15 (21.1)	10 (14.1)	34 (47.9)	1 (1.4)	71 (100.0)
Men's outdoor track and field	0	0	2 (6.1)	0	3 (9.1)	14 (42.4)[a]	3 (9.1)	10 (30.3)	1 (3.0)	33 (100.0)
Women's outdoor track and field	1 (1.8)	0	0	0	5 (8.8)	9 (15.8)	7 (12.3)	30 (52.6)	5 (8.8)	57 (100.0)
Men's sports overall[c]	112 (11.7)	103 (10.8)	38 (4.0)[a]	94 (9.8)[a]	42 (4.4)	123 (12.9)[a]	215 (22.5)	209 (21.8)	21 (2.2)	957 (100.0)
Women's sports overall[c]	82 (10.7)	27 (3.5)	14 (1.8)	27 (3.5)	44 (5.8)	70 (9.2)	260 (34.0)[b]	227 (29.7)[b]	14 (1.8)	765 (100.0)
Overall total	358 (11.2)	270 (8.5)	118 (3.7)	180 (5.7)	168 (5.3)	271 (8.5)	1047 (32.9)	715 (22.5)	56 (1.8)	3183 (100.0)

[a] The proportion of injuries in men was greater than in women.

[b] The proportion of injuries in women was greater than in men.

[c] Includes only sex-comparable sports (baseball/softball, basketball, cross-country, ice hockey, lacrosse, soccer, swimming and diving, tennis, indoor track and field, and outdoor track and field).

Table 5. Severe Injury Counts and Proportions Among Student-Athletes in 25 Sports by Diagnosis, National Collegiate Athletic Association Injury Surveillance Program, 2009–2010 Through 2014–2015 Academic Years

	Diagnosis, n (%)										
Sport	Concussion	Contusion	Dislocation	Fracture	Inflammatory Condition	Sprain	Strain	Stress Fracture	Subluxation	Other	Overall
Men's football	74 (6.8)	22 (2.0)	48 (4.4)	157 (14.4)	9 (0.8)	431 (39.4)	189 (17.3)	11 (1.0)	39 (3.6)	114 (10.4)	1094 (100.0)
Men's wrestling	30 (17.3)	3 (1.7)	5 (2.9)	13 (7.5)	7 (4.0)	47 (27.2)	37 (21.4)	1 (0.6)	7 (4.0)	23 (13.3)	173 (100.0)
Women's field hockey	3 (21.4)	2 (14.3)	0	2 (14.3)	0	2 (14.3)	1 (7.1)	2 (14.3)	0	2 (14.3)	14 (100.0)
Women's gymnastics	8 (10.1)	3 (3.8)	7 (8.9)	9 (11.4)	2 (2.5)	25 (31.6)	11 (13.9)	2 (2.5)	3 (3.8)	9 (11.4)	79 (100.0)
Women's volleyball	7 (6.9)	2 (2.0)	3 (3.0)	8 (7.9)	9 (8.9)	47 (46.5)	12 (11.9)	3 (3.0)	1 (1.0)	9 (8.9)	101 (100.0)
Men's baseball	2 (2.2)	2 (2.2)	3 (3.3)	17 (18.9)	6 (6.7)	21 (23.3)	15 (16.7)	0	1 (1.1)	23 (25.6)	90 (100.0)
Women's softball	3 (4.9)	0	3 (4.9)	12 (19.7)	4 (6.6)	16 (26.2)	10 (16.4)	3 (4.9)	0	10 (16.4)	61 (100.0)
Men's basketball	4 (3.4)	2 (1.7)	1 (0.9)	29 (24.8)[a]	10 (8.5)	32 (27.4)	22 (18.8)	4 (3.4)	2 (1.7)	11 (9.4)	117 (100.0)
Women's basketball	19 (12.3)[b]	1 (0.6)	5 (3.2)	23 (14.9)	6 (3.9)	55 (35.7)	22 (14.3)	9 (5.8)	2 (1.3)	12 (7.8)	154 (100.0)
Men's cross-country	0	1 (4.5)	0	0	4 (18.2)	0	6 (27.3)	4 (18.2)	0	7 (31.8)	22 (100.0)
Women's cross-country	0	0	0	4 (9.8)	12 (29.3)	0	5 (12.2)	10 (24.4)	0	10 (24.4)	41 (100.0)
Men's ice hockey	70 (18.4)	20 (5.2)	10 (2.6)	71 (18.6)	9 (2.4)	121 (31.8)	35 (9.2)	1 (0.3)	7 (1.8)	37 (9.7)	381 (100.0)
Women's ice hockey	22 (33.3)[b]	0	1 (1.5)	13 (19.7)	0	17 (25.8)	5 (7.6)	0	2 (3.0)	6 (9.1)	66 (100.0)
Men's lacrosse	6 (5.2)	4 (3.5)	6 (5.2)	26 (22.6)[a]	5 (4.3)	38 (33.0)	19 (16.5)	2 (1.7)	1 (0.9)	8 (7.0)	115 (100.0)
Women's lacrosse	9 (15.8)[b]	1 (1.8)	1 (1.8)	5 (8.8)	5 (8.8)	21 (36.8)	5 (8.8)	4 (7.0)	2 (3.5)	4 (7.0)	57 (100.0)
Men's soccer	7 (6.1)	2 (1.7)	1 (0.9)	18 (15.7)	3 (2.6)	36 (31.3)	34 (29.6)[a]	2 (1.7)	0	12 (10.4)	115 (100.0)
Women's soccer	13 (5.5)	5 (2.1)	4 (1.7)	27 (11.4)	6 (2.5)	122 (51.7)[b]	26 (11.0)	7 (3.0)	4 (1.7)	22 (9.3)	236 (100.0)
Men's swimming and diving	0	0	0	0	0	0	1 (20.0)	0	0	4 (80.0)	5 (100.0)
Women's swimming and diving	3 (33.3)	1 (11.1)	0	1 (11.1)	0	1 (11.1)	1 (11.1)	0	0	2 (22.2)	9 (100.0)
Men's tennis	1 (5.0)	1 (5.0)	2 (10.0)	3 (15.0)	1 (5.0)	3 (15.0)	7 (35.0)	1 (5.0)	0	1 (5.0)	20 (100.0)
Women's tennis	0	0	0	3 (23.1)	4 (30.8)	0	2 (15.4)	2 (15.4)	0	2 (15.4)	13 (100.0)
Men's indoor track and field	0	0	0	5 (8.5)	12 (20.3)	1 (1.7)	26 (44.1)	3 (5.1)	0	3 (5.1)	59 (100.0)
Women's indoor track and field	0	2 (2.8)	0	4 (5.6)	13 (18.3)	6 (8.5)	17 (23.9)	7 (9.9)	0	22 (31.0)	71 (100.0)
Men's outdoor track and field	0	1 (3.0)	0	4 (12.1)	2 (6.1)	2 (6.1)	17 (51.5)[a]	1 (3.0)	0	6 (18.2)	33 (100.0)
Women's outdoor track and field	1 (1.8)	1 (1.8)	1 (1.8)	4 (70.)	10 (17.5)	4 (7.0)	13 (22.8)	5 (8.8)	0	18 (31.6)	57 (100.0)
Men's sports overall[c]	90 (9.4)	33 (3.4)[a]	23 (2.4)	173 (18.1)[a]	52 (5.4)	254 (26.5)	182 (19.0)[a]	18 (1.9)	11 (1.1)	121 (12.6)	957 (100.0)
Women's sports overall[c]	70 (9.2)	11 (1.4)	15 (2.0)	96 (12.5)	60 (7.8)	242 (31.6)[b]	106 (13.9)	47 (6.1)[b]	10 (1.3)	108 (14.1)	765 (100.0)
Overall total	282 (8.9)	76 (2.4)	101 (3.2)	458 (14.4)	139 (4.4)	1048 (32.9)	538 (16.9)	84 (2.6)	71 (2.2)	386 (12.1)	3183 (100.0)

[a] The proportion of injuries in men was greater than in women.
[b] The proportion of injuries in women was greater than in men.
[c] Includes only sex-comparable sports (baseball/softball, basketball, cross-country, ice hockey, lacrosse, soccer, swimming and diving, tennis, indoor track and field, and outdoor track and field).

Table 6. Common Severe-Injury Mechanisms Sustained by Student-Athletes in 25 Sports, National Collegiate Athletic Association Injury Surveillance Program, 2009–2010 Through 2014–2015 Academic Years

Sport	Injury Mechanism, n (%)
Men's football	Player contact, 629 (57.5)
	Noncontact, 258 (23.6)
Men's wrestling	Player contact, 98 (56.6)
	Surface contact, 34 (19.7)
Women's field hockey	Player contact, 3 (21.4)
	Noncontact, 3 (21.4)
Women's gymnastics	Surface contact, 37 (46.8)
	Equipment contact, 16 (20.3)
Women's volleyball	Noncontact, 40 (39.6)
	Surface contact, 21 (20.8)
Men's baseball	Noncontact, 30 (33.3)
	Overuse, 20 (22.2)
Women's softball	Noncontact, 22 (36.1)
	Equipment contact, 12 (19.7)
Men's basketball	Player contact, 50 (42.7)
	Noncontact, 27 (23.1)
Women's basketball	Noncontact, 53 (34.4)
	Player contact, 49 (31.8)
Men's cross-country	Overuse, 9 (40.9)
	Noncontact, 8 (36.4)
Women's cross-country	Overuse, 31 (75.6)
	Noncontact, 7 (17.1)
Men's ice hockey	Player contact, 190 (49.9)
	Equipment contact, 44 (11.6)
Women's ice hockey	Player contact, 25 (37.9)
	Surface contact, 14 (21.2)
Men's lacrosse	Noncontact, 40 (34.8)
	Player contact, 30 (26.1)
Women's lacrosse	Noncontact, 21 (36.8)
	Overuse, 11 (19.3)
Men's soccer	Player contact, 43 (37.4)
	Noncontact, 27 (23.5)
Women's soccer	Player contact, 93 (39.4)
	Noncontact, 70 (29.7)
Men's indoor track and field	Noncontact, 30 (50.9)
	Overuse, 18 (30.5)
Women's indoor track and field	Noncontact, 27 (38.0)
	Overuse, 30 (42.3)
Men's outdoor track and field	Noncontact, 15 (45.5)
	Overuse, 7 (21.2)
Women's outdoor track and field	Noncontact, 27 (47.4)
	Overuse, 21 (36.8)

Table 7. Common Specific Severe Injuries Sustained by Student-Athletes in 25 Sports, National Collegiate Athletic Association Injury Surveillance Program, 2009–2010 Through 2014–2015 Academic Years[a]

Sport	Injury, n (%)
Men's football	ACL tear, 153 (14.0)
	MCL tear, 121 (11.1)
Men's wrestling	Concussion, 30 (17.3)
	Lateral collateral ligament tear, 13 (7.5)
Women's field hockey	Concussion, 3 (21.4)
Women's gymnastics	ACL tear, 11 (13.9)
	Concussion, 8 (10.1)
Women's volleyball	ACL tear, 26 (25.7)
	Lateral ligament complex strain, 9 (8.9)
Men's baseball	Ulnar collateral ligament strain, 8 (8.9)
	Rotator cuff strain, 6 (6.7)
Women's softball	ACL tear, 9 (14.8)
	Metacarpal fracture, 4 (6.6)
Men's basketball	ACL tear, 14 (12.0)
	Metatarsal (5th) fracture, 10 (8.6)
Women's basketball	ACL tear, 32 (20.8)
	Concussion, 19 (12.3)
Men's cross-country	Tibial stress fracture, 3 (13.6)
Women's cross-country	Metatarsal (2–4) fractures, 4 (9.8)
	Tibial stress fracture, 4 (9.8)
Men's ice hockey	Concussion, 79 (18.4)
	MCL tear, 37 (9.7)
Women's ice hockey	Concussion, 22 (33.3)
	MCL tear, 11 (16.7)
Men's lacrosse	ACL tear, 20 (17.4)
	Concussion, 6 (5.2)
Women's lacrosse	ACL tear, 16 (28.1)
	Concussion, 9 (15.8)
Men's soccer	Hamstrings strain, 16 (13.9)
	ACL tear, 12 (10.4)
Women's soccer	ACL tear, 61 (25.9)
	MCL tear, 21 (8.9)
Men's indoor track and field	Hamstrings strain, 14 (23.7)
Women's indoor track and field	Hamstrings strain, 8 (11.3)
Men's outdoor track and field	Hamstrings strain, 8 (24.2)
Women's outdoor track and field	Hip-flexor strain, 4 (7.0)

Abbreviations: ACL, anterior cruciate ligament; MCL, medial collateral ligament.

[a] Sports with severe injury counts ≥20 were excluded.

higher in men than in women for contusions (IPR = 2.40, 95% CI = 1.22, 4.71), fractures (IPR = 1.44, 95% CI = 1.14, 1.81), and strains (IPR = 1.37, 95% CI = 1.10, 1.71). Conversely, the proportion of severe injuries was higher in women than in men for stress fractures (IPR = 3.27, 95% CI = 1.91, 5.58) and sprains (IPR = 1.19, 95% CI = 1.03, 1.38).

Injury Mechanisms. Common injury mechanisms for severe injuries were player contact (39.3%, n = 1251), noncontact (25.1%, n = 800), and surface contact (12.0%, n = 383; Table 6). Among sex-comparable sports, the proportion of severe injuries was higher in men than in women for equipment-contact (IPR = 1.96, 95% CI = 1.46, 2.65) and player-contact (IPR = 1.42, 95% CI = 1.21, 1.65) mechanisms. In contrast, the proportion of severe injuries was higher in women than in men for overuse (IPR = 1.81, 95% CI = 1.44, 2.27) and noncontact (IPR = 1.31, 95% CI = 1.12, 1.53) mechanisms.

Common Injuries. Several specific severe injuries were commonly sustained by student-athletes in particular sports (Table 7). For example, anterior cruciate ligament (ACL) tears were the most frequent severe injury in women's lacrosse (28.1%, n = 16), women's soccer (25.9%, n = 61), women's volleyball (25.7%, n = 26), women's basketball (20.8%, n = 32), men's lacrosse (17.4%, n = 20), softball (14.8%, n = 9), men's football (14.0%, n = 153), women's gymnastics (13.9%, n = 11), and men's basketball (12.0%, n = 14). Concussions were the most common severe injury in women's ice hockey (33.3%, n = 22), women's field hockey (21.4%, n = 3), men's ice hockey (18.4%, n = 70), and men's wrestling (17.3%, n = 30). Hamstrings strains were a frequent severe injury in men's outdoor track and field (24.2%, n = 8), men's indoor track and field (23.7%, n = 14), men's soccer (13.9%, n = 16), and women's indoor track and field (11.3%, n = 8). Unique but common severe injuries in other sports were tibial stress fractures in men's

cross-country (13.6%, n = 3), tibial stress fractures and metatarsal fractures in women's cross-country (9.8%, n = 4 each), ulnar collateral ligament strains in baseball (8.9%, n = 8), and hip-flexor strains in women's outdoor track and field (7.0%, n = 4).

DISCUSSION

Most of the available literature on severe injuries has focused solely on the high school population[6,16–20] or catastrophic injuries[16–23] sustained in sports. Although previous researchers have briefly examined severe injuries in collegiate student-athletes in relation to overall injury patterns, we are the first to examine a large dataset of such injuries across multiple sports. Our findings highlight the many diagnoses and mechanisms related to severe injury. It is important to note that severe injuries are not only those that require surgery but also those that result in extended time lost due to injury severity and symptoms. For data reporting by ATs, we emphasized that the category of *season ending* should be limited to those injuries that were season ending due to severity and not simply because a minor injury happened within a week of the end of the season. The sport-specific variations of severe injury highlight the need for the development of injury-prevention interventions that take into account the dynamics of each sport.

Overall Severe Injury Counts, Rates, and Proportions

Approximately 1 in 10 injuries reported in the NCAA ISP over the 6 seasons studied were severe, which is lower than the estimate of 14.9% in high school student-athletes.[6] Our overall severe injury rate was higher than rates reported in high school athletes, meaning that more severe injuries occurred per 1000 AEs in college than in high school.[6] Again, this may be due to variations in the sports included in each study. Nevertheless, the proportion of severe injuries at the high school level may exceed that at the collegiate level even though more overall injuries (both severe and nonsevere) occurred within the collegiate population. With regard to specific sports, our findings are similar to those of others at the high school level for football, wrestling, and women's soccer, all of which have high severe injury rates (women's gymnastics and men's ice hockey were not examined).[6] Among the 25 sports examined, the highest severe injury rates were in football, men's ice hockey, women's gymnastics, women's soccer, and wrestling. Three of these activities (football, men's ice hockey, and wrestling) are collision sports. Women's soccer typically results in unintentional collisions and contact. Women's gymnastics involves skills that require various levels of difficulty and equipment, resulting in more opportunities for falls and surface contact.

Although similar sports had the highest rates of severe injury, the hierarchy of rates differed and could be attributed to a few factors. For example, adolescent athletes may not be fully mature, and their risk of bone-related injuries may be greater. Levels of care may also have had an effect because personnel resources for injury management tend to be vastly different at the high school and collegiate levels. Unlike NCAA member institutions, not all high schools have access to a full-time AT.[24] Although the High School Reporting Information Online (RIO) surveillance program includes only schools with ATs,[6] the amount of coverage and care may vary by competition level. Thus, future researchers should examine the effect of clinician presence and care on injury incidence, severity, and time lost from sport participation.

Event Type and Time in Season

The severe injury rate was higher in competition than in practice, which is well supported by the literature[25–39] concerning overall injuries. One reason for these contextual differences may be the pressure on athletes to perform at a higher intensity during competitions.[26,40] Also, practices may occur in environments that are easier for coaching staff to control, thus mitigating the injury risk.[28] At the same time, despite the regular season being longer than the preseason, severe injury rates were similar overall. However, the varied findings within specific sports may explain the null finding overall. Higher rates of severe injuries occurred during preseason in men's and women's cross-country, women's basketball, and women's gymnastics. In contrast, men's soccer and men's wrestling had higher rates of severe injuries within the regular season. During preseason training, student-athletes are often competing for a starting position on their team.[26,41] Training regimens may be more intense (eg, 2-a-day practices) and cause more fatigue.[27,41,42] Athletes may also not be acclimated to these high-intensity training regimens, particularly those who are new to the team. Yet activities in the regular season (eg, competitions) may be more intense than those in the preseason.[40] In addition, athletes may experience increased fatigue from the cumulative exposure that, in effect, places them at greater risk for severe injury. Another possible reason for the discrepancy between the literature on the high school setting and our collegiate sample findings is season length. High school sport seasons are often much shorter than their respective collegiate counterparts. This factor may increase the training and fatigue experienced by collegiate athletes and highlight the lack of acclimatization of high school athletes. The relationships among potential risk factors must be investigated in order to develop strategies that better protect athletes from severe injuries, particularly those related to fatigue.

Common Injuries and Injury Mechanisms

Of all severe injuries sustained by collegiate student-athletes, the majority occurred to the lower extremity; were diagnosed as sprains, strains, or fractures; and were due to player-contact or noncontact mechanisms. These findings are similar to previous results at the high school level.[6] However, a proportion of severe injuries also affected the head/face/neck, particularly in ice hockey and swimming and diving. Most of the severe injuries occurred from player contact, so the low counts and rates in noncontact sports, such as swimming and diving, are not surprising. These noncontact sports involve little to no contact with others. Typically, the contact that occurs is only with surfaces in the environment, potentially decreasing the exposure to common severe-injury mechanisms during participation. Unlike previous researchers,[18] we also explored specific injuries and observed that most severe injuries were ACL tears, concussions, and hamstrings

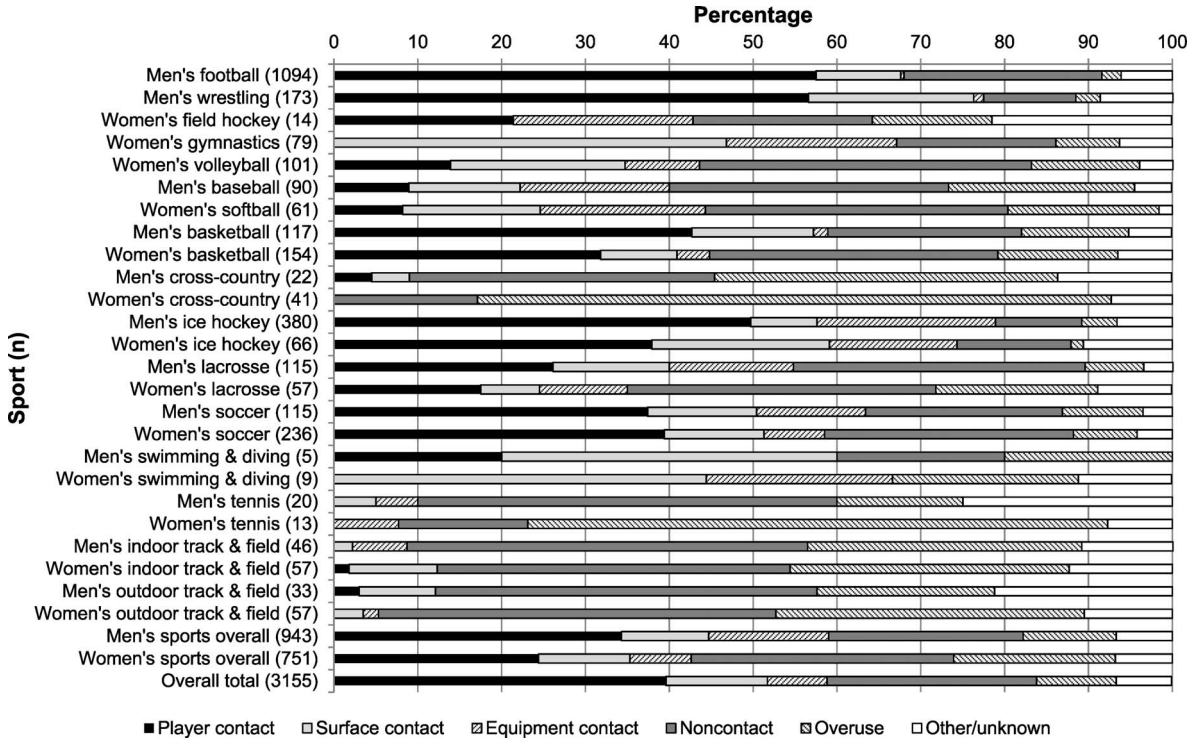

Figure. Mechanisms of severe injuries among National Collegiate Athletic Association student-athletes in 25 sports, National Collegiate Athletic Association Injury Surveillance Program, 2009–2010 through 2014–2015 academic years.

strains. Thus, our findings emphasize the need for concurrent prevention strategies for multiple injuries, particularly those related to the lower extremity and the head/face/neck. Although we identified differences in body region, diagnosis, and specific injuries by sport and sex, we did not examine this aspect across categories. Therefore, it would be unfair to say, for example, that the differences in women's overall severe knee injuries are because of ACL injuries. Future authors should also focus on the occurrence, management, and treatment of hamstrings injuries, as they are common but have received little attention in previous literature.[43]

Sex Differences

Among sex-comparable sports, severe injury rates did not differ between men and women overall. However, this null result most likely reflects the contrasting findings in specific sex-comparable sport pairs. The men's severe injury rate was higher in ice hockey and lacrosse, whereas the women's rate was higher in basketball, cross-country, soccer, and track and field. Past researchers looking at the high school level noted higher rates in girls than in boys, particularly in soccer,[12] but sports such as ice hockey and lacrosse were not examined. In these sports, checking is allowed by the males but not by the females. In comparison, many of the sports in which women sustained the higher severe injury rates had no notable rule differences. This may indicate the need for rule adjustments in men's sports, particularly those with large amounts of routine contact. Rule changes require the discussion of multiple factors among multiple parties; with this knowledge, the matter can be addressed with the appropriate personnel (eg, the athletic director). Thus, our findings may reflect biological differences or the care provided to male and female athletes. For instance, our finding that the proportion of severe lower extremity injuries was higher in women than in men may point to biological predispositions to lower extremity injuries, such as dynamic knee valgus and quadriceps dominance.[44–46] Women also had larger proportions of sprains and stress fractures, which are more often associated with noncontact or overuse injuries.[6,44] This may indicate that prevention programs focused on the lower extremity may be more beneficial and appropriate for women. Because such programs are already being followed at some schools, these additions could be made immediately to better serve the athletes in these high-risk sports. Further research is warranted to better understand such sex differences.

Limitations

Because the NCAA ISP is a convenience sample, our findings may not be generalizable to those programs that did not participate or to athletes participating at other levels of play. Also, several definitions of severe injuries exist within the literature,[47] making it difficult to achieve consensus. However, we selected our definition of *severe injury* (ie, time loss of more than 21 days) because it has been used most frequently in previous research and allows studies to be compared. It is also important to note that some of the sports we examined had low cell sizes (<5), so these ratio measures must be interpreted cautiously. Despite the large sample size of severe injuries in the dataset, examinations across numerous cross-sections (such as by sport, injury diagnosis, and injury mechanism) are not always possible due to low counts and a lack of statistical power. Surveillance data are prone to miss those injuries

that go unreported or undetected by data collectors; yet given our examination of severe injuries, the training and expertise of the ATs collecting the data, and the use of preexisting electronic medical records that were part of the ATs' daily clinical practice, we believe a large majority of severe injuries were reported and included in the NCAA ISP. It is possible that some injuries occurring near season ends were misclassified, but *season-ending injuries* were intended to describe only those that prematurely ended an athlete's season due to severity and not minor injuries that occurred shortly before the season ended. Last, AE data are event based as opposed to time based and do not account for variations in playing time among student-athletes; however, this approach minimizes the burden of data collection.

CONCLUSIONS

Severe injury rates and distributions varied by sport, event type, and sex. Given the prevalence of severe injuries in the collegiate student-athlete population, it is imperative that health care providers work together to improve preventive efforts and overall health outcomes. Common efforts toward injury reduction include injury-prevention programs and rule changes. These have the potential to be tailored by sport and by sex to target deficits identified in our findings, such as the higher incidence of hip injuries in men's than in women's outdoor track and field. These results can affect both the athlete and the health care staff in either a positive or negative manner. By using this information to improve clinical practice and preventive efforts, we may be able to reduce the incidence of the most common severe injuries. This would allow athletes to continue participating, thereby improving their mental and physical health while lessening the financial burden of severe injuries on the institution and the workload of the medical staff responsible for the sport. Future researchers should continue to develop interventions to reduce the severity and incidence of such injuries and to assess the effectiveness of those already being used.

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Address correspondence to Zachary Y. Kerr, PhD, MPH, Department of Exercise and Sport Science, University of North Carolina at Chapel Hill, 313 Woollen Gym, CB#8700, Chapel Hill, NC 27599-8700. Address e-mail to zkerr@email.unc.edu.