Lumbar Spine Injuries in National Collegiate Athletic Association Athletes

A 6-Season Epidemiological Study

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Background: Lumbar spine injuries in National Collegiate Athletic Association (NCAA) athletes have not been well studied.

Purpose: To describe the epidemiology of lumbar spine injuries in NCAA athletes during the 2009/2010 through 2014/2015 academic years utilizing the NCAA Injury Surveillance Program (ISP).

Study Design: Descriptive epidemiology study.

Methods: A voluntary convenience sample of NCAA varsity teams from 25 sports was examined. Mechanism of injury, injury recurrence, and time lost from sport were recorded. Injury rates were calculated as the number of injuries divided by the total number of athlete-exposures (AEs). AEs were defined as any student participation in 1 NCAA-sanctioned practice or competition. Injury rate ratios and injury proportion ratios were calculated to compare the rates within and between sports by event type, season, patient sex, mechanism, injury recurrence, and time lost from sport. Comparisons between sexes were made utilizing data that had both male and female samples.

Results: An estimated 37,435 lumbar spine injuries were identified. The overall rate of injuries was 6.01 per 1000 AEs. The rate of injuries was 4.94 per 1000 AEs in men compared with 3.94 per 1000 AEs in women for sex-comparable sports. Men were 1.25 times more likely than women to suffer a lumbar spine injury. Men's football (24.62 injuries/1000 AEs) and women's gymnastics (11.46 injuries/1000 AEs) had the highest rates of lumbar spine injuries. Athletes were 1.83 and 3.71 times more likely to sustain a lumbar spine injury during the preseason than the regular season or postseason, respectively. Noncontact was the most common mechanism of injury (38%). Injury recurrence was most common in men's outdoor track (58%). Most injuries resulted in less than 24 hours of time loss from event participation (61%).

Conclusion: The rate of lumbar spine injuries was high in NCAA athletes, and injuries commonly recurred (20%). In general, men were more likely to sustain a lumbar spine injury compared with women. Higher injury rates occurred during competition and via a noncontact mechanism of injury. In addition to prevention programs, reconditioning programs should be considered to prevent these injuries.

Keywords: epidemiology; NCAA; collegiate sports; back; low back; injury

Injuries to the lumbar spine among collegiate athletes are relatively common.[7] The osseous, musculoligamentous, and neuroanatomical aspects of the spine allow for complex multiplanar movements, and dysfunction of any one of these structural elements can lead to injuries.[7,19] As injuries vary, multiple causes of lumbar spine injuries and disorders are reported among collegiate athletes.[7,17]

Prior nationwide epidemiological studies have suggested that half of adults in the United States experienced back pain within a given year, and 15% reported "frequent" pain or symptoms lasting longer than 2 weeks.[5] In the collegiate athlete, back injuries are also common.[4,10] Injuries can occur from either a direct injury or from subjective muscle imbalances that prevent optimal kinematics during athletic participation, which lead to injuries or disorders.[17-20] The previous literature has described both traumatic injury mechanisms and overuse injuries that lead to back abnormalities.[1] Additionally, there has been a reported association of lumbar spine injuries after any lower extremity injury, with a reported incidence of 24% among collegiate athletes.[18] Despite the prevalence of lumbar spine injuries in collegiate athletes, limited literature exists characterizing these injuries. Further

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characterization of these injuries is needed to develop better prevention and treatment algorithms.

The current literature describing lumbar spine injuries in athletes is limited to the National Football League (NFL) and minimal college samples.[11,16,18] Furthermore, college-level studies have focused on single-university samples with smaller sample sizes.[11,18] As such, a larger epidemiological description of low back injuries in college-level athletes across multiple sports does not yet exist.[1,10,18] Therefore, the purpose of this study was to provide the epidemiological background of lumbar spine injuries recorded among National Collegiate Athletic Association (NCAA) athletes from the 2009/2010 to 2014/2015 academic years using the NCAA Injury Surveillance Program (ISP).

METHODS

The study was granted institutional review board exemption from our institution, given the deidentified nature of the database. It was subsequently approved by the research review board of the NCAA. The NCAA ISP is a prospectively gathered injury surveillance system managed by the Datalys Center for Sports Injury Research and Prevention, which is an independent nonprofit research organization.[6] This study included voluntarily submitted self-reported data available for the 2009/2010 to 2014/2015 academic years. The methodology for data gathered in the NCAA ISP has previously been described in the literature and is briefly reviewed below.[12,13]

Data Collection

The NCAA ISP utilizes a voluntary self-reported convenience sample of NCAA varsity teams from 25 sports. These 25 sports include men's football, wrestling, and baseball; women's volleyball, field hockey, gymnastics, and softball; and men's and women's ice hockey, soccer, basketball, lacrosse, indoor track and field, outdoor track and field, cross-country, swimming and diving, and tennis. There is variability in the number of programs participating and the sports reported among the years in the data set.[9,12]

Athletic trainers (ATs) working with each participating program are responsible for recording injury and exposure data electronically through each institution's electronic health record. Data are collected only from varsity-level organized practices and competitions during the preseason, regular season, and postseason. For each injury occurrence, ATs and/or physicians complete a detailed report on the injury itself as well as the circumstances surrounding the injury.[12] Injury data collected include anatomic site, diagnosis, and circumstances of the injury; real time missed from sport; and event type.[12,23] ATs also record the number of student-athletes participating in each practice and competition to determine exposures.[21] After initially inputting injury data, the ATs can return to view and update the data as needed over the course of a season for a change in performance status/condition or return to participation.

Deidentified common data elements were extracted from these certified electronic health record applications.[9,12] Exported data passed through an automated verification process that conducted a series of range and consistency checks limiting outliers. Data that passed the verification process were then placed into the aggregate research data set.

Definitions

Injury. A reportable injury in the NCAA ISP was defined as an injury that (1) occurred as a result of participation in an organized intercollegiate practice or competition, (2) required attention from an AT or physician, and (3) resulted in restriction of the student-athlete's participation for $\geq$1 days beyond the injury.[12] Multiple injuries occurring from 1 injury event could be included. If an off-day followed the injury event, the AT was asked to assess whether the injured athlete would have been able to participate.[12] For muscle imbalances or overuse events that restricted an athlete's participation but did not have associated imaging or a specific diagnosis, the term "sports-associated lumbar disorders" was more appropriately used.

The current study considered all injuries referencing "lower back" or "lumbar" in the definition of lumbar spine injuries. We relied on the training and expertise of the ATs collecting data, as well as other members of the team medical staff assisting in documentation, to accurately diagnose and report all lower back injuries. Radiological studies were not required before inclusion in the data set. The most recently updated diagnoses were used.

Athlete-Exposure. An 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 an athletic injury, regardless of the time associated with that participation.[12] For the competition to be considered an exposure, the athlete had to have actual playing time during the event.[12] AEs were limited to varsity-level NCAA-sanctioned practices and competitions

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occurring in the preseason, regular season, or postseason.[12] AEs were recorded by ATs entering data.

Event Type. Event type was the event, either practice or competition, during which the injury occurred.

Season of Play. Season of play was the season segment (ie, preseason, regular season, postseason) in which the injury occurred.

Injury Mechanism. Injury mechanism was defined as the manner in which the student-athlete sustained his or her injury. In the NCAA ISP, ATs selected from a preset list of options, including player contact, surface contact, equipment contact, contact with an out-of-bounds object, noncontact, overuse, illness, infection, and other/unknown. All contact events were condensed under the title "contact." Given the lack of lumbar spine injuries being caused by illness or infections (none reported in the convenience sample), these 2 mechanisms were excluded from analysis. Additionally, missing, unknown, or unreported data were demarcated "missing."

Recurrence. Recurrent injuries were defined as a recurrence of the same injury that occurred previously in the same athlete, either during the current or previous seasons after the athlete had returned to play from a prior injury.

Participation Restriction Time. Injuries were categorized by the number of days that participation was restricted (ie, the date of return subtracted by the date of injury). Participation was considered restricted until an athlete was cleared for unrestricted competition. Injuries resulting in participation restriction <24 hours were also included.

Computing National Estimates

To calculate national estimates of the number of lower back injuries, poststratification sample weights based on sport, division, and academic year were applied to each reported injury and AE. Poststratification sample weights were calculated with the following formula:

$$sample\ weight_{abc} = \left(\frac{number\ of\ teams\ participating\ in\ ISP_{abc}}{number\ of\ teams\ in\ NCAA_{abc}}\right)^{-1},$$

where $weight_{abc}$ is the weight for the ath sport of the bth division in the cth year. Weights for all data were further adjusted to correct for underreporting, accounting for the estimated 88.3% capture rate of all time-loss medical care injury events within the NCAA ISP previously reported in the literature.[15]

Statistical Analysis

Data were analyzed to assess the rates and patterns of lumbar spine injuries sustained by collegiate athletes. Lumbar spine injuries were analyzed for injury type, time loss, time of season, event type, recurrence, injury mechanism, and participation restriction. The injury rate was defined as the number of injuries divided by the number of AEs. The rates were reported as the ratio of injuries per 1000 AEs and were calculated for an overall rate as well as individual rates for event type (practice vs competition) and time of season (preseason, regular season, and postseason).

TABLE 1
Lumbar Spine Injury Rates
Among Student-Athletes in 25 Sports[a]

Sport	n	Annual National Estimate[b]	Injury Rate per 1000 AEs (95% CI)[c]
Men's baseball	23	6211	3.70 (2.19 to 5.21)
Men's basketball	70	15,273	4.58 (3.51 to 5.61)
Women's basketball	41	15,498	2.64 (1.83 to 3.45)
Men's cross-country	5	3121	1.60 (0.19 to 3.00)
Women's cross-country	3	2854	1.05 (–0.14 to 2.24)
Men's football	245	9950	24.62 (21.58 to 27.67)
Women's field hockey	4	1771	2.25 (0.04 to 4.47)
Women's gymnastics	35	3053	11.46 (7.68 to 15.24)
Men's ice hockey	85	11,609	7.32 (5.77 to 8.87)
Women's ice hockey	37	5203	7.11 (4.82 to 9.39)
Men's lacrosse	35	4363	8.02 (5.37 to 10.67)
Women's lacrosse	9	4838	1.86 (0.64 to 3.07)
Women's softball	27	9899	2.72 (1.70 to 3.75)
Men's soccer	24	6529	3.67 (2.20 to 5.14)
Women's soccer	55	9701	5.66 (4.17 to 7.16)
Men's swimming	8	4234	1.88 (0.58 to 3.19)
Women's swimming	15	5164	2.90 (1.43 to 4.37)
Men's tennis	10	2695	3.71 (1.41 to 6.00)
Women's tennis	15	3671	4.08 (2.02 to 6.15)
Men's indoor track	24	3123	7.68 (4.62 to 10.75)
Women's indoor track	27	3055	8.83 (5.51 to 12.16)
Men's outdoor track	12	2737	4.38 (1.90 to 6.86)
Women's outdoor track	16	2268	7.05 (3.61 to 10.50)
Women's volleyball	62	11,300	5.48 (4.12 to 6.84)
Men's wrestling	25	3616	6.91 (4.21 to 9.61)
Men's sports total[d]	296	59,895	4.94 (4.38 to 5.50)
Women's sports total[d]	245	62,151	3.94 (3.44 to 4.43)
Overall total	912	151,736	6.01 (5.62 to 6.39)

[a]AE, athlete-exposure.
[b]National estimates for sports may not sum to total because of rounding.
[c]One student-athlete participating in 1 practice or 1 competition.
[d]Includes only sports in which both sexes participated (ie, soccer, basketball, ice hockey, lacrosse, baseball/softball, indoor track, outdoor track, cross-country, swimming and diving, tennis).

Injury rate ratios (IRRs) were calculated to compare rates between event types and by time of season, as they are useful for determining whether one participation type has an increased rate of injuries compared with another. The following is an example of an IRR comparing injury rates between competition and practice:

$$IRR = \frac{\left(\frac{\Sigma\ Number\ of\ competition\ injuries}{\Sigma\ Competition\ AEs}\right)}{\left(\frac{\Sigma\ Number\ of\ practice\ injuries}{\Sigma\ Practice\ AEs}\right)}.$$

Injury proportion ratios (IPRs) were calculated to examine differences in injury rates and the distribution among sex-comparable sports (ie, soccer, basketball, ice hockey, lacrosse, baseball/softball, indoor track, outdoor track, cross-country, swimming and diving, and tennis). The following is an example of an IPR comparing the proportion of lower back injuries that were severe in men and women:

TABLE 2
Lumbar Spine Injury Rates Among Student-Athletes in 25 Sports by Event Type[a]

Sport	Competition, n	Practice, n	Injury Rate per 1000 AEs (95% CI)[b]		
			Competition	Practice	IRR, Competition vs Practice
Men's baseball	4	19	1.42 (0.02 to 2.81)	5.58 (3.08 to 8.09)	0.25 (0.08 to 0.74)
Men's basketball	34	36	8.94 (5.95 to 11.94)	3.13 (2.11 to 4.16)	2.85 (1.78 to 4.55)[c]
Women's basketball	14	27	3.55 (1.69 to 5.41)	2.33 (1.45 to 3.21)	1.52 (0.79 to 2.89)
Men's cross-country	0	5	N/A	1.79 (0.22 to 3.36)	N/A
Women's cross-country	0	3	N/A	1.17 (–0.15 to 2.50)	N/A
Men's football	66	179	48.06 (36.75 to 59.38)	20.86 (17.84 to 23.90)	2.30 (1.74 to 3.03)[c]
Women's field hockey	1	3	2.14 (0.37 to 12.02)	2.30 (0.78 to 6.74)	0.93 (0.09 to 8.92)
Women's gymnastics	6	29	18.01 (8.28 to 38.74)	10.66 (7.43 to 15.27)	1.69 (0.70 to 4.04)
Men's ice hockey	31	54	9.50 (6.70 to 13.45)	6.47 (4.96 to 8.43)	1.46 (0.94 to 2.27)
Women's ice hockey	8	29	5.55 (2.81 to 10.92)	7.70 (5.37 to 11.04)	0.72 (0.33 to 1.57)
Men's lacrosse	12	23	14.76 (8.46 to 25.62)	6.47 (4.32 to 9.70)	2.27 (1.13 to 4.55)[c]
Women's lacrosse	3	6	2.95 (1.00 to 8.66)	1.56 (0.71 to 3.41)	1.88 (0.47 to 7.52)
Women's softball	10	17	2.37 (1.29 to 4.36)	2.98 (1.86 to 4.77)	0.79 (0.36 to 1.73)
Men's soccer	8	16	4.69 (2.38 to 9.24)	3.31 (2.04 to 5.37)	1.41 (0.60 to 3.30)
Women's soccer	20	35	7.67 (4.97 to 11.82)	4.93 (3.54 to 6.85)	1.55 (0.90 to 2.69)
Men's swimming	0	8	N/A	2.08 (1.05 to 4.10)	N/A
Women's swimming	1	14	1.99 (0.35 to 11.21)	3.00 (1.78 to 5.03)	0.66 (0.08 to 5.04)
Men's tennis	2	8	2.84 (–1.09 to 6.78)	4.01 (1.23 to 6.79)	0.70 (0.15 to 3.32)
Women's tennis	2	13	2.01 (–0.77 to 4.79)	4.85 (2.22 to 7.49)	0.41 (0.09 to 1.83)
Men's indoor track	1	23	2.66 (–2.55 to 7.88)	8.36 (4.96 to 11.77)	0.31 (0.04 to 2.35)
Women's indoor track	4	23	11.59 (0.29 to 22.89)	8.48 (5.03 to 11.91)	1.36 (0.47 to 3.92)
Men's outdoor track	1	11	1.93 (–1.85 to 5.73)	4.95 (2.03 to 7.87)	0.39 (0.05 to 3.02)
Women's outdoor track	3	13	6.01 (–0.77 to 12.79)	7.34 (3.36 to 11.32)	0.81 (0.23 to 2.86)
Women's volleyball	12	50	3.26 (1.42 to 5.10)	6.55 (4.74 to 8.37)	0.48 (0.26 to 0.93)[c]
Men's wrestling	5	20	7.30 (0.92 to 13.69)	6.82 (3.84 to 9.80)	1.07 (0.40 to 2.84)
Men's sports total[d]	93	203	6.32 (5.04 to 7.60)	4.49 (3.87 to 5.10)	1.40 (1.10 to 1.79)[c]
Women's sports total[d]	65	180	4.10 (3.10 to 5.09)	3.88 (3.32 to 4.45)	1.05 (0.79 to 1.40)
Overall total	248	664	6.68 (5.85 to 7.51)	5.79 (5.35 to 6.23)	1.15 (0.99 to 1.33)

[a]AE, athlete-exposure; IRR, injury rate ratio; N/A, not applicable.
[b]One student-athlete participating in 1 practice or 1 competition.
[c]Denotes statistical significance.
[d]Includes only sports in which both sexes participated (ie, soccer, basketball, ice hockey, lacrosse, baseball/softball, indoor track, outdoor track, cross-country, swimming and diving, tennis).

$$IPR = \left(\frac{\frac{\sum severe\ lower\ back\ injuries\ in\ men}{\sum total\ lower\ back\ injuries\ in\ men}}{\frac{\sum severe\ lower\ back\ injuries\ in\ women}{\sum total\ lower\ back\ injuries\ in\ women}} \right).$$

All 95% CIs not containing 1.0 were considered statistically significant. Participation restriction time was reported as intervals (<24 hours, 1-6 days, 7-21 days, and >21 days), and descriptive data were presented as percentages of injuries (recurrence, event type, mechanism of injury, etc). Data were analyzed using SPSS software (IBM) and Excel (Microsoft).

RESULTS

Frequencies and Rates

Overall, 912 lumbar spine injuries and disorders were reported to the NCAA ISP during the 2009/2010 to 2014/2015 academic years among 25 varsity sports (Table 1). The 912 injuries in this sample represent a national estimate of 151,736 total lumbar spine injuries/sports-associated lumbar spine disorders, estimated by using the weighted calculation outlined above. The overall injury rate was 6.01 (95% CI, 5.62-6.39) lumbar spine injuries per 1000 AEs based on the reported 912 injuries in our sample. In sex-comparable sports, a total of 296 injuries occurring in men's sports were reported to the database, while a total of 245 injuries in women's sports were reported. These injuries corresponded to injury rates of 4.94 and 3.94 per 1000 AEs, respectively. Among all sports recorded by the NCAA ISP during the 2009/2010 to 2014/2015 academic years, men's football sustained the highest number of injures (n = 245; national estimate of 9950) as well as the highest injury rate with 24.62 lumbar spine injuries per 1000 AEs (Table 1).

Event Type

The overall number of lumbar spine injuries was highest during practice (n = 664); however, the injury rate during

TABLE 3
Distribution of Lumbar Spine Injuries Among Student-Athletes in 25 Sports by Injury Mechanism[a]

Sport	Contact	Missing	Noncontact	Overuse	Total
Men's baseball	0 (0.00)	13 (56.52)	9 (39.13)	1 (4.35)	23 (100.00)
Men's basketball	27 (38.57)	6 (8.57)	29 (41.43)	8 (11.43)	70 (100.00)
Women's basketball	17 (41.46)	7 (17.07)	13 (31.71)	4 (9.76)	41 (100.00)
Men's cross-country	0 (0.00)	0 (0.00)	1 (20.00)	4 (80.00)	5 (100.00)
Women's cross-country	0 (0.00)	1 (33.33)	1 (33.33)	1 (33.33)	3 (100.00)
Men's football	98 (40.00)	29 (11.84)	95 (38.78)	23 (9.39)	245 (100.00)
Women's field hockey	0 (0.00)	1 (25.00)	1 (25.00)	2 (50.00)	4 (100.00)
Women's gymnastics	8 (22.86)	7 (20.00)	4 (11.43)	16 (45.71)	35 (100.00)
Men's ice hockey	35 (41.18)	12 (14.12)	17 (20.00)	21 (24.71)	85 (100.00)
Women's ice hockey	9 (24.32)	8 (21.62)	14 (37.84)	6 (16.22)	37 (100.00)
Men's lacrosse	10 (28.57)	0 (0.00)	15 (42.86)	10 (28.57)	35 (100.00)
Women's lacrosse	1 (11.11)	0 (0.00)	3 (33.33)	5 (55.56)	9 (100.00)
Women's softball	2 (7.41)	1 (3.70)	14 (51.85)	10 (37.04)	27 (100.00)
Men's soccer	9 (37.50)	5 (20.83)	6 (25.00)	4 (16.67)	24 (100.00)
Women's soccer	17 (30.91)	7 (12.73)	20 (36.36)	11 (20.00)	55 (100.00)
Men's swimming	1 (12.50)	0 (0.00)	4 (50.00)	3 (37.50)	8 (100.00)
Women's swimming	0 (0.00)	1 (6.67)	7 (46.67)	7 (46.67)	15 (100.00)
Men's tennis	0 (0.00)	2 (20.00)	4 (40.00)	4 (40.00)	10 (100.00)
Women's tennis	0 (0.00)	1 (6.67)	7 (46.67)	7 (46.67)	15 (100.00)
Men's indoor track	0 (0.00)	1 (4.17)	11 (45.83)	12 (50.00)	24 (100.00)
Women's indoor track	4 (14.81)	3 (11.11)	10 (37.04)	10 (37.04)	27 (100.00)
Men's outdoor track	2 (16.67)	0 (0.00)	8 (66.67)	2 (16.67)	12 (100.00)
Women's outdoor track	1 (6.25)	2 (12.50)	10 (62.50)	3 (18.75)	16 (100.00)
Women's volleyball	6 (9.68)	2 (3.23)	28 (45.16)	26 (41.94)	62 (100.00)
Men's wrestling	6 (24.00)	3 (12.00)	12 (48.00)	3 (12.00)	24 (100.00)
Men's sports total[b]	6 (2.03)	39 (13.18)	104 (35.14)	69 (23.31)	296 (100.00)
Women's sports total[b]	6 (2.45)	31 (12.65)	99 (40.41)	64 (26.12)	245 (100.00)
Overall total	253 (27.77)	112 (12.28)	343 (37.61)	203 (22.26)	911 (100.00)

[a]Data are presented as n (%).
[b]Includes only sports in which both sexes participated (ie, soccer, basketball, ice hockey, lacrosse, baseball/softball, indoor track, outdoor track, cross-country, swimming and diving, tennis).

competition was higher than during practice (6.68 vs 5.79 per 1000 AEs, respectively; IRR, 1.15 [95% CI, 0.99-1.33]), which failed to reach statistical significance. Injury rates were significantly higher during competition in men's basketball (IRR, 2.85 [95% CI, 1.78-4.55]), men's football (IRR, 2.30 [95% CI, 1.74-3.03]), men's lacrosse (IRR, 2.27 [95% CI, 1.13-4.55]), and men's sports overall (IRR, 1.40 [95% CI, 1.10-1.79]). The only sport in which the injury rate was higher during practice was women's volleyball (IRR, 0.48 [95% CI, 0.26-0.93]) (Table 2).

Sex Differences

Among sex-comparable sports, men sustained a significantly higher injury rate overall than women (4.94 vs 3.94 per 1000 AEs, respectively; IRR, 1.25 [95% CI, 1.05-1.48]). Within specific pairs of comparable sports, men sustained a higher rate of lumbar spine injuries than women in lacrosse (8.02 vs 1.86 per 1000 AEs, respectively; IRR, 4.31 [95% CI, 2.07-8.96]) and basketball (4.58 vs 2.64 per 1000 AEs, respectively; IRR, 1.73 [95% CI, 1.17-2.54]). There was no statistical difference in event type, season of injury, injury mechanism, or injury type among the sex-comparable sports in terms of frequencies.

Injury Mechanism

Noncontact mechanisms of injury were the most common (n = 343; 38%), with contact injuries comprising the second largest overall proportion (n = 265; 29%) of lower back injuries. Among sex-comparable sports, noncontact injuries comprised the largest proportion of injuries in both sexes (men's sports, 35%; women's sports, 40%) (Table 3).

Recurrence

Overall, 20.24% of lumbar spine injuries were recurrent. The sports with the highest rates of recurrent lumbar spine injuries were men's outdoor track, men's tennis, and women's volleyball (58.33%, 40.00%, and 33.87%, respectively). Of note, men's outdoor track was the only sport with a higher rate of recurrent injuries when compared with new injuries (Figure 1).

Time Away From Sport

Among athletes suffering a lumbar spine injury, the majority spent <24 hours away from sport (n = 555; 61%) with a 1–calendar day restriction from play. Overall, only 3% of

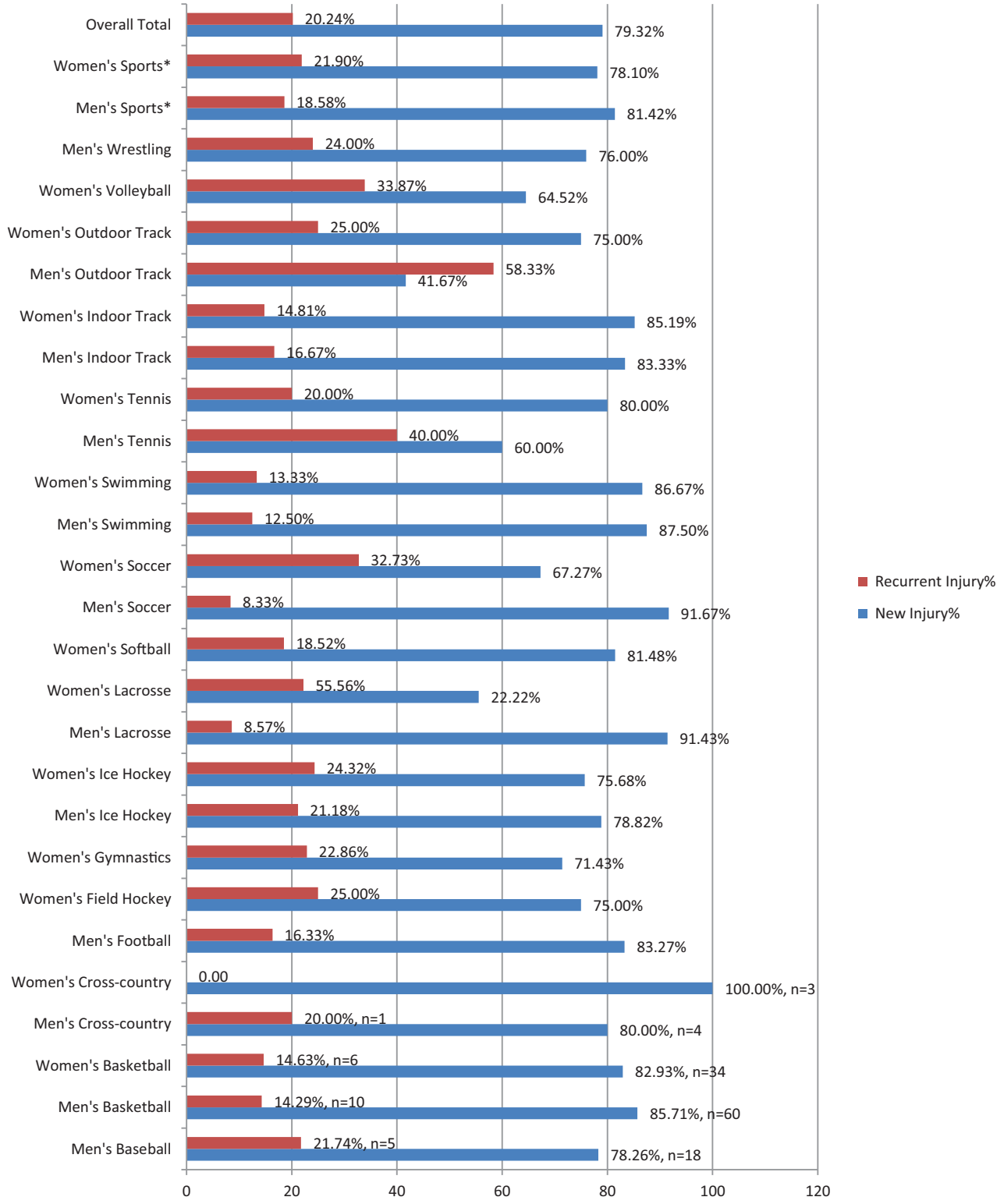

Figure 1. Proportion of recurrent (red) and new (blue) lower back injuries among student-athletes in 25 sports: National Collegiate Athletic Association Injury Surveillance Program, 2009/2010 to 2014/2015 academic years. *Includes only sports in which both sexes participated (ie, soccer, basketball, ice hockey, lacrosse, baseball/softball, indoor track, outdoor track, cross-country, swimming and diving, tennis).

TABLE 4
Distribution of Lumbar Spine Injuries Among Student-Athletes in 25 Sports by Participation Restriction Time[a]

Sport	<24 h	1-6 d	7-21 d	>21 d	Missing	Total
Men's baseball	14 (61)	4 (17)	1 (4)	0 (0)	4 (17)	23 (100)
Men's basketball	48 (69)	16 (23)	3 (4)	0 (0)	3 (4)	70 (100)
Women's basketball	23 (56)	9 (22)	7 (17)	0 (0)	2 (5)	41 (100)
Men's cross-country	0 (0)	0 (0)	5 (100)	0 (0)	0 (0)	5 (100)
Women's cross-country	2 (67)	0 (0)	1 (33)	0 (0)	0 (0)	3 (100)
Men's football	130 (53)	52 (21)	17 (7)	4 (2)	42 (17)	245 (100)
Women's field hockey	3 (75)	1 (25)	0 (0)	0 (0)	0 (0)	4 (100)
Women's gymnastics	23 (66)	6 (17)	2 (6)	2 (6)	2 (6)	35 (100)
Men's ice hockey	56 (66)	18 (21)	4 (5)	4 (5)	3 (4)	85 (100)
Women's ice hockey	24 (65)	6 (16)	5 (14)	1 (3)	1 (3)	37 (100)
Men's lacrosse	30 (86)	4 (11)	1 (3)	0 (0)	0 (0)	35 (100)
Women's lacrosse	7 (78)	2 (22)	0 (0)	0 (0)	0 (0)	9 (100)
Women's softball	17 (63)	4 (15)	3 (11)	1 (4)	2 (7)	27 (100)
Men's soccer	15 (63)	9 (38)	0 (0)	0 (0)	0 (0)	24 (100)
Women's soccer	34 (62)	13 (24)	3 (5)	3 (5)	2 (4)	55 (100)
Men's swimming	6 (75)	0 (0)	1 (13)	0 (0)	1 (13)	8 (100)
Women's swimming	11 (73)	2 (13)	1 (7)	1 (7)	0 (0)	15 (100)
Men's tennis	4 (40)	0 (0)	2 (20)	3 (30)	1 (10)	10 (100)
Women's tennis	9 (60)	4 (27)	1 (7)	1 (7)	0 (0)	15 (100)
Men's indoor track	17 (71)	5 (21)	0 (0)	0 (0)	2 (8)	24 (100)
Women's indoor track	13 (48)	7 (26)	3 (11)	2 (7)	2 (7)	27 (100)
Men's outdoor track	6 (50)	1 (8)	1 (8)	2 (17)	2 (17)	12 (100)
Women's outdoor track	8 (50)	1 (6)	4 (25)	2 (13)	1 (6)	16 (100)
Women's volleyball	42 (68)	7 (11)	3 (5)	0 (0)	10 (16)	62 (100)
Men's wrestling	13 (52)	4 (16)	6 (24)	0 (0)	2 (8)	25 (100)
Men's sports total[b]	196 (66)	57 (19)	18 (6)	9 (3)	16 (5)	296 (100)
Women's sports total[b]	148 (60)	48 (20)	28 (11)	11 (4)	10 (4)	245 (100)
Overall total	555 (61)	175 (19)	74 (8)	26 (3)	82 (9)	912 (100)

[a]Data are presented as n (%).
[b]Includes only sports in which both sexes participated (ie, soccer, basketball, ice hockey, lacrosse, baseball/softball, indoor track, outdoor track, cross-country, swimming and diving, tennis).

athletes suffered an injury that required >21 days away from sport. There was no difference between time missed because of an injury between men or women for sex-comparable sports (Table 4).

Season of Play

The overall season of play in which most injuries occurred was the regular season, with 549 total injuries (injury rate of 5.16/1000 AEs) (Table 5). However, the highest injury rate occurred during the preseason (9.46/1000 AEs). Among sex-comparable sports, men and women both had higher injury rates, 6.60 and 6.18, respectively, during the preseason when compared with either the regular season or postseason (IRR preseason to regular season, 1.83 [95% CI, 1.60-2.09]; IRR preseason to postseason, 3.71 [95% CI, 2.47-5.56]). There was no difference between the sexes in injury rates per season.

Injury Types

Among all lumbar spine injuries included in the data set, the majority were classified as lower back strains (n = 492; 54%). Lower back strains were the most common types of injury in both men's and women's comparable sports as well (55% and 56%, respectively). The second most common injury type was pain (unspecified); this accounted for 31% of the overall injury types (Table 6).

DISCUSSION

The major strength of this study is the ability to characterize a relatively common set of injuries in collegiate athletes. The current literature describing back injuries in athletes is limited to the professional level or smaller sample size studies. Our study is the first to examine the epidemiology of these lower back injuries in collegiate athletes from a convenience sample across 25 NCAA sports. Examining the injury rates, event type, sex-comparable differences, recurrence, injury mechanism, type, and time away from sport will allow for better estimates of injuries at the collegiate level. This potentially helps athletes better understand the potential risks of sports-associated lumbar spine disorders/injuries involved with collegiate athletics. Further work could focus on the use of epidemiological studies such as this to help with the development of prevention and rehabilitation programs that can be sport/sex/mechanism dependent.

TABLE 5
Distribution of Lumbar Spine Injuries Among Student-Athletes in 25 Sports by Season of Play[a]

Sport	Preseason, n	Regular Season, n	Postseason, n	Injury Rate per 1000 AEs[b]		
				Preseason	Regular Season	Postseason
Men's baseball	9	14	0	5.17	3.35	0.00
Men's basketball	13	56	1	4.31	4.88	1.25
Women's basketball	13	24	4	4.01	2.08	5.40
Men's cross-country	0	5	0	0.00	2.36	0.00
Women's cross-country	1	2	0	1.77	1.01	0.00
Men's football	96	147	2	33.47	22.02	4.90
Women's field hockey	2	2	0	4.76	1.69	0.00
Women's gymnastics	25	9	1	15.49	7.83	3.43
Men's ice hockey	17	65	3	15.62	6.70	3.60
Women's ice hockey	8	29	0	13.00	6.77	0.00
Men's lacrosse	10	23	2	7.61	8.33	6.87
Women's lacrosse	6	2	1	3.91	0.66	3.28
Women's softball	11	16	0	3.86	2.42	0.00
Men's soccer	13	11	0	8.75	2.44	0.00
Women's soccer	23	28	4	10.34	4.04	7.28
Men's swimming	3	5	0	3.02	1.76	0.00
Women's swimming	5	8	2	4.06	2.35	3.71
Men's tennis	4	5	1	7.89	2.57	4.11
Women's tennis	7	8	0	10.32	2.92	0.00
Men's indoor track	11	12	1	7.91	7.82	5.00
Women's indoor track	13	13	1	8.99	9.13	5.34
Men's outdoor track	4	8	0	7.22	4.18	0.00
Women's outdoor track	5	10	1	9.90	6.69	3.71
Women's volleyball	29	32	1	12.04	3.77	2.41
Men's wrestling	10	15	0	12.25	6.05	0.00
Men's sports total[c]	84	204	8	6.60	4.75	1.87
Women's sports total[c]	92	140	13	6.18	3.23	3.30
Overall total	338	549	25	9.46	5.16	2.55

[a]AE, athlete-exposure.
[b]One student-athlete participating in 1 practice or 1 competition.
[c]Includes only sports in which both sexes participated (ie, soccer, basketball, ice hockey, lacrosse, baseball/softball, indoor track, outdoor track, cross-country, swimming and diving, tennis).

The overall high injury rates (see Table 1) in this study complement the previous literature, which has demonstrated a high rate of injuries associated with the lumbar spine region in collegiate athletes.[2,11,24] Kerr et al[13] found that men's football and men's wrestling have the highest rates of overall injuries. Our results corroborated that the highest lumbar spine injury rates were in men's football; however, the second highest results were found in women's gymnastics. The incidence of lumbar spine injuries reported to the NCAA ISP over the 2009/2010 to 2014/2015 time frame was greater than hamstring, hip flexor, hip adductor, and quadriceps injury rates (0.35, 0.16, 0.12, and 0.10 per 1000 AEs, respectively).[3,8,9] The reported injury rates from this study suggest that there is an area for potential improvement, as they are higher than for other common collegiate athletic injuries.

Analysis by event setting demonstrated a higher number of total injuries in practice but a higher injury rate in competition. This was consistent with previous work analyzing event type for injury rates in NCAA athletes.[3] Men's football, men's basketball, men's lacrosse, and men's sports overall demonstrated significantly higher injury rates during competition versus practice. Interestingly, women's volleyball demonstrated the opposite trend, with both the total number of injuries and injury rate being higher during practice versus competition.

Among sex-comparable sports in our study, the rates of lumbar spine injuries were higher for men. The previous literature examining differences in injury rates between male and female athletes of the same sport is mixed.[18,22] Overall, there is a paucity of studies isolating sex as a main variable between the comparable sports, and this is a potential area for further research. Among injury mechanisms, noncontact injuries predominated. The previous literature has described higher rates of strains, noncontact injuries, and sequela of repetitive rotational movements as the causative agents in lumbar spine injuries among athletes.[7,11]

Previous studies have described a relatively high risk of recurrence for lumbar spine injuries, especially among contact sports (18.3%).[10] While new injuries accounted for 80% of the lumbar spine injuries reported, this study also demonstrated a high risk of recurrence, with 20% of all injuries being classified as recurrent. Men's outdoor track was an outlier, with 58% of the injuries being recurrent. This can

TABLE 6
Distribution of Lumbar Spine Injuries Among Student-Athletes in 25 Sports by Injury Type[a]

Sport	Pain	Stenosis	Fracture	Strain	Degenerative	Disc Injury	Pars	Sciatica	Total
Men's baseball	2 (9)	0 (0)	0 (0)	18 (78)	0 (0)	1 (4)	0 (0)	2 (9)	23 (100)
Men's basketball	30 (43)	0 (0)	0 (0)	38 (54)	0 (0)	1 (1)	0 (0)	1 (1)	70 (100)
Women's basketball	12 (29)	0 (0)	0 (0)	23 (56)	2 (5)	3 (7)	1 (2)	0 (0)	41 (100)
Men's cross-country	1 (20)	0 (0)	0 (0)	4 (80)	0 (0)	0 (0)	0 (0)	0 (0)	5 (100)
Women's cross-country	0 (0)	0 (0)	0 (0)	3 (100)	0 (0)	0 (0)	0 (0)	0 (0)	3 (100)
Men's football	73 (30)	0 (0)	1 (0)	137 (56)	4 (2)	21 (9)	5 (2)	4 (2)	245 (100)
Women's field hockey	1 (25)	0 (0)	0 (0)	3 (75)	0 (0)	0 (0)	0 (0)	0 (0)	4 (100)
Women's gymnastics	11 (31)	2 (6)	1 (3)	10 (29)	3 (9)	2 (6)	6 (17)	0 (0)	35 (100)
Men's ice hockey	27 (32)	0 (0)	0 (0)	44 (52)	2 (2)	8 (9)	3 (4)	1 (1)	85 (100)
Women's ice hockey	9 (24)	0 (0)	0 (0)	21 (57)	1 (3)	5 (14)	1 (3)	0 (0)	37 (100)
Men's lacrosse	12 (34)	0 (0)	0 (0)	20 (57)	1 (3)	1 (3)	1 (3)	0 (0)	35 (100)
Women's lacrosse	5 (56)	0 (0)	0 (0)	4 (44)	0 (0)	0 (0)	0 (0)	0 (0)	9 (100)
Women's softball	4 (15)	0 (0)	0 (0)	19 (70)	2 (7)	1 (4)	0 (0)	1 (4)	27 (100)
Men's soccer	12 (50)	0 (0)	0 (0)	10 (42)	0 (0)	0 (0)	1 (4)	1 (4)	24 (100)
Women's soccer	16 (29)	0 (0)	0 (0)	32 (58)	1 (2)	3 (5)	2 (4)	1 (2)	55 (100)
Men's swimming	1 (13)	0 (0)	0 (0)	7 (88)	0 (0)	0 (0)	0 (0)	0 (0)	8 (100)
Women's swimming	5 (33)	0 (0)	0 (0)	5 (33)	0 (0)	1 (7)	2 (13)	2 (13)	15 (100)
Men's tennis	4 (40)	0 (0)	0 (0)	4 (40)	0 (0)	1 (10)	1 (10)	0 (0)	10 (100)
Women's tennis	6 (40)	0 (0)	0 (0)	6 (40)	0 (0)	1 (7)	1 (7)	1 (7)	15 (100)
Men's indoor track	7 (29)	0 (0)	0 (0)	14 (58)	2 (8)	0 (0)	1 (4)	0 (0)	24 (100)
Women's indoor track	5 (19)	0 (0)	0 (0)	16 (59)	2 (7)	1 (4)	2 (7)	1 (4)	27 (100)
Men's outdoor track	6 (50)	0 (0)	0 (0)	4 (33)	0 (0)	2 (17)	0 (0)	0 (0)	12 (100)
Women's outdoor track	6 (38)	0 (0)	0 (0)	7 (44)	2 (13)	0 (0)	1 (6)	0 (0)	16 (100)
Women's volleyball	22 (35)	0 (0)	0 (0)	27 (44)	2 (3)	5 (8)	3 (5)	3 (5)	62 (100)
Men's wrestling	6 (24)	0 (0)	0 (0)	16 (64)	0 (0)	1 (4)	2 (8)	0 (0)	25 (100)
Men's sports total[b]	102 (34)	0 (0)	0 (0)	163 (55)	5 (2)	14 (5)	7 (2)	5 (2)	296 (100)
Women's sports total[b]	68 (28)	0 (0)	0 (0)	136 (56)	10 (4)	15 (6)	10 (4)	6 (2)	245 (100)
Overall total	283 (31)	2 (0)	2 (0)	492 (54)	24 (3)	58 (6)	33 (4)	18 (2)	912 (100)

[a]Data are presented as n (%).
[b]Includes only sports in which both sexes participated (ie, soccer, basketball, ice hockey, lacrosse, baseball/softball, indoor track, outdoor track, cross-country, swimming and diving, tennis).

likely be explained by the small number of injuries that occurred within our sample set for this sport. Overall, this study and previous work identified prior lumbar spine injuries as a strong risk factor for future back injuries.[10]

The majority of athletes in our study missed <24 hours of sports-related participation because of their injury. This knowledge that time loss extending >21 days is rare is quite valuable, as Mall et al[16] demonstrated greater time loss (mean, 25.7 days) at the professional level after back injuries. However, NCAA surveillance mechanisms and NFL surveillance mechanisms may differ. While lumbar spine injuries that required >21 days away from sport were the minority in our study (3%), there were still 26 injuries in this category, indicating that severe lumbar spine injuries, while uncommon, do occur. This may explain why other epidemiological studies looking at all injuries by severity have back injuries classified highly in terms of time loss.[13]

The majority of athletes in our study were injured during the regular season; however, the highest rates of injury occurred in the preseason. There was no significant difference between injury rates by season of play between sex-comparable sports.

Further differentiation of injuries by type demonstrated that soft tissue back sprains were the most prevalent injury mechanism, irrespective of sex differences. Previous work has demonstrated a link between poor core strength and limited endurance and an increased risk of mild low back pain without a specific osseous or ligamentous injury.[1,14] This coincides with the injury types most prevalent in our study and suggests areas for future research into preventive conditioning programs.

Limitations

Participation in the NCAA ISP is voluntary, and as such, there may be a selection bias among those programs choosing to participate during the elected study period. In addition to selection bias, there may be underreporting of injuries because of the voluntary self-reported nature of the database. This would limit the generalizability to other collegiate programs or professional programs with similarly aged players. The standardization of diagnoses and injury types reported depends on uniform diagnostic criteria among all ATs from all programs participating for this time period, which is a weakness of any multicenter data set study. The ATs reporting injuries are also confined by the NCAA ISP's definition of an injury, which does not require imaging to make a diagnosis. Additionally, variability in

team injury prevention protocols and injury reporting protocols was not considered with these data. Finally, some injuries occur infrequently and are underreported in this data set, resulting in low numbers and underpowered analysis for some sports, which again makes generalizability to professional sports or sports-related practices difficult.

CONCLUSION

Analysis of the NCAA ISP data demonstrated a relatively high rate of lumbar spine injuries (6.01/1000 AEs) among collegiate athletes. Men's football and women's gymnastics had the highest rates of lumbar spine injuries. There was a significantly higher injury rate for men in sex-comparable sports and an overall higher injury rate in competition settings, with the majority of injuries being noncontact in nature. While the majority of injuries (80%) were new, there was a relatively high recurrence rate (20%). This high rate of injury recurrence suggests that there is an area of possible further research for reconditioning programs in addition to prevention programs. This study helps to better inform athletes, trainers, and coaching staff of the risk of sports-associated lumbar disorders and injuries related to collegiate athletic participation.

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