Elbow Injuries in National Collegiate Athletic Association Athletes

A 5-Season Epidemiological Study

Jeffrey D. Hassebrock,* MD, Karan A. Patel,* MD, Justin L. Makovicka,* MD, Andrew S. Chung,* DO, Sailesh V. Tummala,† BS, Thomas C. Hydrick,‡ BS, Jessica E. Ginn,§ David E. Hartigan,* MD, and Anikar Chhabra,*|| MD

Investigation performed at the Mayo Clinic Phoenix Arizona, Phoenix, Arizona, USA

Background: Little research has focused on the rates and patterns of elbow injuries in National Collegiate Athletic Association (NCAA) student-athletes.

Purpose: To describe the epidemiological patterns of elbow injuries in NCAA athletes during 5 seasons over the academic years 2009 through 2014 using the NCAA Injury Surveillance Program (NCAA-ISP) database.

Study Design: Descriptive epidemiology study.

Methods: A voluntary convenience sample of NCAA varsity teams from 11 sports was examined to determine the rates and patterns of elbow injuries. Rates and distributions of elbow injuries were identified within the context of sport, event type, time in season, mechanism, time lost from sport, surgical treatment, and injury type. Rates of injury were calculated as the number of injuries divided by the total number of athlete-exposures (AEs). An AE was defined as any student participation in 1 NCAA-sanctioned practice or competition with an inherent risk of exposure to potential injury. Injury rate ratios (IRRs) and injury proportion ratios (IPRs) were then calculated to compare the rates within and between sports by event type, season, sex, mechanism, surgical treatment, and time lost from sport. Comparisons between sexes were made using only sports data that had both male and female samples.

Results: Overall, 373 elbow injuries were reported in the NCAA-ISP data set during the 2009-2010 through 2013-2014 academic years among 11 varsity sports. The overall rate of injury was 1.76 per 10,000 AEs. The rate of elbow injuries in men was 0.74 per 10,000 AEs, while women experienced injuries at a rate of 0.63 per 10,000 AEs. In sex-comparable sports, men were 1.17 times more likely to experience an elbow injury compared with women. Men's wrestling (6.00/10,000 AEs) and women's tennis (1.86/10,000 AEs) were the sports with the highest rates of elbow injuries by sex, respectively. The top 3 highest injury rates overall occurred in men's wrestling, baseball, and tennis. Elbow injuries were 3.5 times more likely to occur during competition compared with practice. Athletes were 0.76 times less likely to sustain an elbow injury during the preseason compared with in-season. Contact events were the most common mechanism of injury (67%). For sex-comparable sports, men were 2.41 times more likely than women to have contact as their injury mechanism (95% CI, 0.78-7.38). The majority of athletes missed less than 24 hours of participation time (67%), and only a minority (3%) of patients with elbow injuries went on to have surgical intervention. Elbow ulnar collateral ligament injuries were most common (26% of total injuries).

Conclusion: Analysis of the study data demonstrated a significant rate of elbow injuries, 1.76 injuries per 10,000 AEs in NCAA collegiate athletes. Higher injury rates can be expected in males within sex-comparable sports. Elbow injuries are most common in the setting of competitions and most commonly occur secondary to contact-type mechanisms. Injuries were more likely to occur during in-season play. The majority of injuries required less than 24 hours of time away from sport and did not require surgical intervention.

Keywords: elbow injuries; NCAA; collegiate athletes; epidemiology

Elbow injuries, while relatively uncommon, are a significant source of disability for collegiate athletes.[9] The anatomic structure of this complex joint is important in understanding the injuries and disability that occur. The elbow joint is a modified hinge joint composed of 3 articulations (radiocapitellar, radioulnar, and ulnohumeral) covered by a joint capsule.[19] Elbow stability is imparted by both static and dynamic mechanics. Primary static stabilizers to varus and valgus stress are the lateral collateral ligament and the medial ulnar collateral ligament (UCL),

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respectively.[19] Dynamic stabilizers largely consist of 4 muscle groups that cross the elbow: wrist flexors, wrist extensors, elbow flexors, and elbow extensors.[12,19]

Injury to any of the aforementioned structures can lead to significant pain and disability, limiting the ability of the athlete to participate. Tendinopathies, usually the result of overuse, are relatively common in the general population. The flexor-pronator muscles are frequently involved; however, lateral tendinopathies are still the most common overall.[21] Ligamentous injuries also frequently occur. Rupture of the anterior oblique band of the UCL destabilizes the elbow to a valgus force and this is often injured secondary to the repetitive valgus loads experienced by overhead throwing athletes.[19,21] Traumatic or overuse injuries resulting in posterolateral rotatory instability are secondary to lateral UCL injury and are the most common form of recurrent instability in the elbow.[17,20] Severe instability can lead to subluxation or frank dislocation when multiple stabilizers are compromised.[1] These injuries often result in osseous injury or fractures as well.[1]

Current research investigating the rates of these injuries across multiple disciplines is limited and largely sport specific.[18] Additionally, among the studies covering the collegiate athlete population, few include more than 1 injury type.[9] Therefore, the purpose of this study was to provide the epidemiological background of elbow injuries recorded among National Collegiate Athletic Association (NCAA) athletes from the 2009-2010 through 2013-2014 academic years by use of the NCAA Injury Surveillance Program (NCAA-ISP).

METHODS

The NCAA-ISP is a prospectively gathered injury surveillance program managed by the Datalys Center for Sports Injury Research and Prevention, an independent nonprofit research organization. Data for this study are from the 2009-2010 through 2013-2014 academic years. This study was approved by our institutional review board and the research review board of the NCAA. The method for data gathered in the NCAA-ISP has previously been described in the literature and is briefly reviewed below.[21]

Data Collection

The NCAA-ISP uses a voluntary convenience sample of NCAA varsity teams from 11 sports. These 11 sports include men's baseball, football, tennis, indoor track, outdoor track, wrestling, and lacrosse and women's lacrosse, softball, tennis, and indoor track. Variability is found in the number of programs and the sports reported among the years in the data set (range of 4-84 teams reporting per sport per year; average, 32 for 2004-2005 through 2008-2009 and 12 for 2009-2010 through 2013-2014).[7,14]

The athletic trainers (ATs) working with participating teams attended all school-sanctioned athletic practices and competitions and logged the number of student-athletes participating in each event. Injuries were reported in real time through the electronic health record application by the team medical staff. This allowed ATs to document injuries as part of their daily clinical practice in real time, as opposed to separately reporting injuries for research or surveillance purposes.[22] Data included team practices, competitions, and conditioning sessions. Individual athletic sessions (eg, weight lifting or self-directed conditioning) were excluded.

Event and injury reports for each injury were completed daily by the ATs. After initially inputting injury data, the ATs could 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. De-identified common data elements were extracted from these certified electronic health record applications.[7,14] Exported data were 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 was one that occurred as a result of participation in an NCAA-sanctioned practice or competition, where the athlete required attention from an AT or physician and where the athlete was removed from the field of play for any period of time . The current study considered all injuries referencing "elbow" in the elbow injuries definition. We relied on the training and expertise of the ATs collecting data, as well as the other members of the team medical staff assisting in documentation, to accurately diagnose and report all elbow injuries. 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 injury, regardless of the time associated with that participation.

Event Type. Event type was determined by when the injury took place. These were classified as either practice or competition.

‖Address correspondence to Anikar Chhabra, MD, Department of Orthopedic Surgery, Mayo Clinic Arizona, 5777 East Mayo Blvd, Phoenix, AZ 85054, USA (email: chhabra.anikar@mayo.edu).

*Department of Orthopedics, Mayo Clinic, Phoenix, Arizona, USA.

†University of Hawaii School of Medicine, Honolulu, Hawaii, USA.

‡Mayo Clinic School of Medicine, Scottsdale, Arizona, USA.

§Arizona State University, Tempe, Arizona, USA.

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Ethical approval for this study was obtained from the Mayo Clinic Institutional Review Board.

Time in Season. Time of sporting season was also determined by when the injury took place: preseason, in-season, or postseason.

Injury Mechanism. Injury mechanism was defined as the manner in which the student-athlete sustained his or her injury. In the NCAA-ISP, ATs select from a preset list of options, including player contact, surface contact, equipment contact, contact with out-of-bounds object, noncontact, overuse, illness, infection, and other/unknown. All contact events were condensed under the title "contact." Given the rarity and/or lack of elbow injuries being due to illness, this mechanism was excluded from analysis. Additionally, missing, unknown, or unreported data were demarcated as "missing."

Recurrence. ATs identified injuries that were recurrent (ie, a recurrence of an injury that was sustained earlier in the athlete's career).

Participation Restriction Time. Injuries were categorized by the number of days that participation was restricted (ie, 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 for less than 24 hours were also included. Severe injuries were defined as injuries resulting in participation restriction for more than 3 weeks, the student-athlete choosing to prematurely end his or her season (for medical or nonmedical reasons associated with the injury), or a medical professional having the student-athlete prematurely end his or her season.[3]

Computing National Estimates for the Sports Surveyed

To calculate national estimates of the number of elbow 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, to account for an estimated 88.3% capture rate of all time-loss medical care injury events with the NCAA-ISP previously reported in the literature.[15]

Statistical Analysis

Data were analyzed to assess rates and patterns of elbow injuries sustained in collegiate sports. First, elbow injury rates were calculated, defined as the number of injuries divided by the number of AEs, and were reported per 10,000 AEs. An overall injury rate, in addition to competition and practice injury rates, was calculated. Distributions of these injuries were then examined by event type, time in season, injury mechanism, participation restriction, surgery required, and injury type. Injury rate ratios (IRRs) were calculated to compare injury rates between event type and time of season. These were calculated for overall rates and also for individual sports.

The following is an example of an IRR comparing injury rates between competition and practice:

$$IRR = \frac{\left(\frac{\sum competition\ elbow\ inuries}{\sum competition\ athlete\text{-}exposures}\right)}{\left(\frac{\sum practice\ elbow\ injuries}{\sum practice\ athlete\text{-}exposures}\right)}.$$

Injury proportion ratios (IPRs) were calculated to compare rates between sex-comparable sports and also to examine sex differences in distributions of injury mechanism, recurrence, participation restriction, time of season, and injury type. The following is an example of an IPR comparing the proportion of elbow injuries that were contact related in men and women:

$$IPR = \left(\frac{\frac{\sum contact\ elbow\ injuries\ in\ men}{\sum total\ elbow\ injuries\ in\ men}}{\frac{\sum contact\ elbow\ injuries\ in\ women}{\sum total\ elbow\ injuries\ in\ women}}\right)$$

All 95% CIs not including 1.00 were considered statistically significant. Data were analyzed by use of SPSS (IBM) and Microsoft Excel.

RESULTS

Frequencies and Rates

Overall, 373 elbow injuries were reported in the NCAA-ISP data set during the 2009-2010 through 2013-2014 academic years among the 11 varsity sports (Table 1). The 373 injuries in this sample represented a national estimate of 16,754 total elbow injuries in the NCAA over the time period examined. The overall injury rate was 1.76 elbow injuries per 10,000 AEs. In sex-comparable sports (lacrosse, tennis, and indoor track), a total of 27 elbow injuries were reported within men's sports and a total of 13 elbow injuries were reported in women's sports. The injuries corresponded to injury rates of 0.74 and 0.63 per 10,000 AEs for men's and women's sex-comparable sports, respectively. Among all sports recorded by the NCAA-ISP during the seasons studied, men's football sustained the highest number of injuries (184; national estimate of 4875); however, men's wrestling had the highest rate of injury, with 6.00 elbow injuries per 10,000 AEs (Table 1 and Figure 1).

Event Type

The overall number of elbow injuries was highest during practice (206 injuries); however, the rate of injury during competition was 3.5 times higher than during practice (4.27 vs 1.23 per 10,000 AEs). Injury rates were significantly higher during competition versus practice in men's baseball, football, lacrosse, and wrestling (Table 2). In sex-comparable sports, a significantly higher injury rate was seen in competition versus practice for men's sports (IRR, 2.78; 95% CI, 1.29-5.98). A higher injury rate during competition was also seen in women's sports, however this

TABLE 1
Elbow Injury Rates Among Student-Athletes by Sport:
NCAA-ISP, 2009-2010 Through 2013-2014 Academic Years[a]

Sport	Count	Annual National Estimate[b]	Percentage of Total	Total Exposures	Injury Rate per 10,000 AEs[c]
Men's baseball	75	6175	37	14,257,352	4.33
Men's football	184	4875	29	25,767,731	1.89
Men's lacrosse	17	503	3	4,256,690	1.18
Women's lacrosse	3	95	1	2,869,466	0.33
Women's softball	30	1222	7	8,250,393	1.48
Men's tennis	6	593	4	3,117,535	1.90
Women's tennis	6	617	4	3,306,950	1.86
Men's indoor track	4	215	1	10,441,798	0.21
Women's indoor track	4	442	3	12,177,090	0.36
Men's outdoor track	4	293	2	7,816,037	0.37
Men's wrestling	40	1724	10	2,871,519	6.00
Overall total	373	16,754	100	95,132,561	1.76
Men's total[d]	27	1312	8	17,816,023	0.74
Women's total[d]	13	1154	7	18,353,506	0.63

[a]AE, athlete-exposure; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.
[b]National estimates for sports may not sum to total because of rounding.
[c]AE defined as 1 student-athlete participating in 1 practice or 1 competition.
[d]Includes only sports in which both sexes participated (ie, lacrosse, indoor track, and tennis).

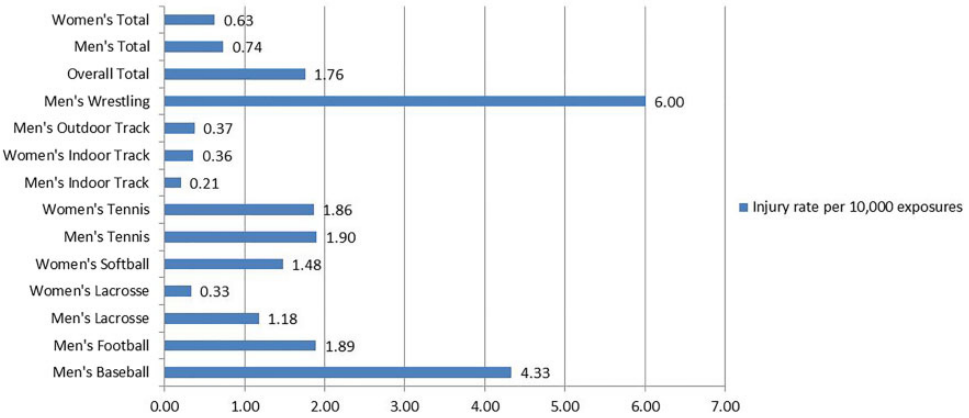

Figure 1. Injury rate per 10,000 exposures among National Collegiate Athletic Association (NCAA) student-athletes: NCAA Injury Surveillance Program (NCAA-ISP), 2009-2010 through 2013-2014 academic years.

difference was not statistically significant (IRR, 1.22; 95% CI, 0.33-4.42) (Table 2).

Injury by Season

Most injuries occurred in-season (1.93 per 10,000 AEs; 251 total elbow injuries). This also represents the highest rate of injury among the 3 times during the season (preseason, in-season, and postseason). Among sex-comparable sports, men and women both had higher rates of in-season injury, 0.95 and 0.93, respectively (Table 3). Overall, injuries were less likely to occur during the preseason compared with in-season (IRR, 0.76; 95% CI, 0.61-0.96). However, both preseason and in-season rates were not significantly different compared with the postseason rates: IRRs 0.84 (95% CI, 0.50-1.40) and 1.10 (95% CI, 0.67-1.79), respectively (Table 4).

Injury Mechanism

Among injury mechanisms, injury through contact was the most common (n = 249; 67%), followed by overuse or gradual injuries (n = 64; 17%). Among sex-comparable sports alone, contact injuries were the most common for men (48%) whereas overuse or gradual injuries comprised the largest proportion of injury mechanisms for women (54%) (Table 5). Among sex-comparable sports, men's sports had a higher ratio of contact injuries compared with women's sports (IPR, 2.41; 95% CI, 0.78-7.38), however this difference did not reach statistical significance. Additionally, men's sports had a statistically lower ratio of gradual or overuse injuries (IPR, 0.73; 95% CI, 0.26-2.01) and noncontact injuries (IPR, 0.95; 95% CI, 0.18-4.89) compared with women's sports that failed to reach statistical significance (Table 6).

TABLE 2
Elbow Injury Rates Among Student-Athletes by Event Type: NCAA-ISP, 2009-2010 Through 2013-2014 Academic Years[a]

Sport	Competition Injuries	Competition Exposures	Competition Injury per 10,000 AEs[b]	Practice Injuries	Practice Exposures	Practice Injuries per 10,000 AEs[b]	Relative Rate (95% CI) Competition/Practice
Men's baseball	39	5,089,303	6.27	36	9,168,049	3.25	1.93 (1.22-3.03)[c]
Men's football	82	2,502,993	9.06	102	23,264,738	1.12	8.08 (6.04-10.81)[c]
Men's lacrosse	8	792,550	2.55	9	3,464,141	0.87	2.93 (1.13-7.58)[c]
Women's lacrosse	2	581,911	1.39	1	2,287,555	0.06	21.80 (1.98-240.38)[c]
Women's softball	13	3,200,385	1.54	17	3,200,385	2.28	0.67 (0.33-1.38)
Men's tennis	3	650,541	3.19	3	2,466,994	1.56	2.04 (0.41-10.12)
Women's tennis	1	802,736	1.33	5	2,504,214	2.04	0.65 (0.08-5.58)
Men's indoor track	0	1,059,513	0.00	4	9,382,284	0.23	—
Women's indoor track	0	1,138,032	0.00	4	11,039,058	0.40	—
Men's outdoor track	1	1,199,060	1.30	3	6,616,978	0.21	6.23 (0.65-59.93)
Men's wrestling	18	296,516	23.53	22	2,575,003	3.99	5.90 (3.17-11.01)[c]
Total	167	17,313,539	4.27	206	75,969,399	1.23	3.47 (2.83-4.26)[c]
Men's total[d]	11	2,502,604	1.64	16	153,13,419	0.59	2.78 (1.29-5.98)[c]
Women's total[d]	3	2,522,678	0.74	10	15,830,828	0.61	1.22 (0.33-4.42)

[a]AE, athlete-exposure; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program. Dashes indicate not available.
[b]AE defined as 1 student-athlete participating in 1 practice or 1 competition.
[c]Denotes statistical significance.
[d]Includes only sports in which both sexes participated (ie, lacrosse, indoor track, and tennis).

TABLE 3
Distribution of Elbow Injuries Among Student-Athletes by Time in Season: NCAA-ISP, 2009-2010 Through 2013-2014 Academic Years[a]

Sport	Preseason Injuries	Preseason Exposures	Injuries per 10,000 Preseason AEs[b]	In-season Injuries	In-season Exposures	Injuries per 10,000 In-season AEs[b]	Postseason Injuries	Postseason Exposures	Injuries per 10,000 Postseason AEs[b]
Men's baseball	25	4,743,082	4.09	44	8,915,867	4.19	6	598,403	8.34
Men's football	56	7,969,763	1.85	122	16,866,008	1.94	6	931,960	1.42
Men's lacrosse	1	1,292,361	0.60	14	2,664,757	1.33	2	299,572	2.41
Women's lacrosse	0	913,470	0.00	2	1,778,830	0.35	1	177,165	1.87
Women's softball	10	2,507,685	1.61	19	5,322,011	1.45	1	420,697	1.10
Men's tennis	2	696,943	2.85	4	2,145,328	1.84	0	275,264	0.00
Women's tennis	0	632,127	0.00	6	2,424,767	2.54	0	250,056	0.00
Men's indoor track	1	5,069,646	0.00	3	4,818,930	0.35	0	553,222	0.86
Women's indoor track	2	5,966,532	0.36	2	5,530,373	0.41	0	680,186	0.00
Men's outdoor track	0	1,788,471	0.26	3	5,568,959	0.44	0	458,607	0.00
Men's wrestling	7	862,249	4.75	32	1,799,412	7.18	1	209,858	1.08
Total	105	32,442,329	1.47	251	27,835,242	1.93	17	4,854,990	1.76
Men's total[c]	4	7,058,949	0.39	21	9,629,016	0.95	2	2,185,068	0.55
Women's total[c]	2	7,512,129	0.28	10	9,733,970	0.93	1	1,107,407	0.30

[a]AE, athlete-exposure; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.
[b]AE defined as 1 student-athlete participating in 1 practice or 1 competition.
[c]Includes only sports in which both sexes participated (ie, lacrosse, indoor track, and tennis).

Participation Restriction

Among athletes who had an elbow injury, the majority spent less than 24 hours away from sport (n = 226; 67%). Overall, only 7% of athletes experienced an injury that required 3 or more weeks away from sport. For sex-comparable sports, the majority of injuries required less than 24 hours away from sport (Table 7). However, among sex-comparable sports, men's sports had a nonsignificantly higher ratio of injuries requiring less than 24 hours

TABLE 4
Relative Rates (95% CI) of Elbow Injuries by Time in Season Among Student-Athletes in 11 Sports: NCAA-ISP, 2009-2010 Through 2013-2014 Academic Years[a]

Sport	RR Preseason/In-season	RR Preseason/Postseason	RR In-season/Postseason
Men's baseball	0.98 (0.60-1.60)	0.49 (0.20-1.20)	0.50 (0.21-1.18)
Men's football	0.96 (0.70-1.31)	1.30 (0.56-3.02)	1.36 (0.60-3.10)
Men's lacrosse	0.45 (0.06-3.46)	0.25 (0.02-2.76)	0.55 (0.12-2.42)
Women's lacrosse	NA	NA	0.19 (0.02-2.06)
Women's softball	1.11 (0.51-2.38)	1.47 (0.19-11.45)	1.32 (0.18-9.89)
Men's tennis	1.55 (0.28-8.45)	NA	NA
Women's tennis	NA	NA	NA
Men's indoor track	NA	NA	NA
Women's indoor track	0.86 (0.12-6.14)	NA	NA
Men's outdoor track	0.58 (0.06-5.56)	NA	NA
Men's wrestling	0.66 (0.29-1.50)	4.40 (0.54-35.76)	6.64 (0.91-48.62)
Total	0.76 (0.61-0.96)[b]	0.84 (0.50-1.40)	1.10 (0.67-1.79)
Men's total[b]	0.41 (0.14-1.20)	0.71 (0.13-3.90)	1.73 (0.41-7.40)
Women's total[b]	0.30 (0.07-1.39)	0.95 (0.09-10.44)	3.11 (0.40-24.29)

[a]NA, not applicable; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program; RR, relative rate.
[b]Includes only sports in which both sexes participated (ie, lacrosse, indoor track, and tennis).

TABLE 5
Distribution of Elbow Injuries Among Student-Athletes by Injury Mechanism: NCAA-ISP, 2009-2010 Through 2013-2014 Academic Years[a]

Sport	Contact	Infection	No Apparent Contact	Overuse/Gradual	Unknown	Total
Men's baseball	22	0	22	31	0	75
Men's football	160	2	10	5	7	184
Men's lacrosse	13	0	2	1	1	17
Women's lacrosse	3	0	0	0	0	3
Women's softball	13	0	5	12	0	30
Men's tennis	0	0	0	6	0	6
Women's tennis	0	0	0	6	0	6
Men's indoor track	0	0	3	1	0	4
Women's indoor track	1	0	2	1	0	4
Men's outdoor track	1	0	1	1	1	4
Men's wrestling	36	0	2	0	2	40
Total	249	2	47	64	11	373
Men's total[b]	13	0	5	8	1	27
Women's total[b]	4	0	2	7	0	13

[a]NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.
[b]Includes only sports in which both sexes participated (ie, lacrosse, indoor track, and tennis).

TABLE 6
Relative Rates of Elbow Injuries by Injury Mechanism Among Student-Athletes in 11 Sports: NCAA-ISP, 2009-2010 Through 2013-2014 Academic Years[a]

Injury Mechanism	Sex-Comparable Injury Proportion Ratio: Men's to Women's Sports
Contact	2.41 (0.78-7.38)
Infection	NA
No apparent contact	0.95 (0.18-4.89)
Overuse/gradual	0.73 (0.26-2.01)
Unknown	NA

[a]Values are expressed as injury proportion ratio (95% CI). NA, not applicable; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.

of restriction time (IPR, 1.23; 95% CI, 0.52-2.87). Men's sports also entailed fewer injuries that required between 1 and 6 days away from sport (IPR, 0.37; 95% CI, 0.07-2.02) (Table 8).

Surgery Required

Overall, the majority of elbow injuries were treated nonsurgically (n = 346; 93%) (Table 9). Only 3% of total elbow injuries in this study went on to require surgical intervention. Among sex-comparable sports, men's sports injuries required surgery less often compared with women's sports (IPR, 0.96; 95% CI, 0.50-1.88) (Table 10).

TABLE 7
Distribution of Elbow Injuries Among Student-Athletes in 11 Sports, by Participation Restriction Time: NCAA-ISP, 2009-2010 Through 2013-2014 Academic Years[a]

	Time Loss				
Sport	<24 h	1-6 d	7-21 d	>21 d	Total
Men's baseball	37	8	12	7	64
Men's football	121	32	10	7	170
Men's lacrosse	14	2	0	0	16
Women's lacrosse	1	2	0	0	3
Women's softball	21	4	1	1	27
Men's tennis	6	0	0	0	6
Women's tennis	3	1	0	0	4
Men's indoor track	2	0	0	0	2
Women's indoor track	3	1	0	0	4
Men's outdoor track	3	0	0	0	3
Men's wrestling	15	5	10	7	37
Total	226	55	33	22	336
Men's total[b]	22	2	0	0	24
Women's total[b]	7	4	0	0	11

[a]NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.
[b]Includes only sports in which both sexes participated (ie, lacrosse, indoor track, and tennis).

TABLE 8
Relative Rates of Elbow Injuries by Participation Restriction Time Among Student-Athletes in 11 Sports: NCAA-ISP, 2009-2010 Through 2013-2014 Academic Years[a]

Time Loss	Sex-Comparable Injury Proportion Ratio: Men's to Women's Sports
<24 h	1.23 (0.52-2.87)
1-6 d	0.37 (0.07-2.02)
7-21 d	NA
>21 d	NA

[a]Values are expressed as injury proportion ratio (95% CI). NA, not applicable; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.

TABLE 9
Distribution of Elbow Injuries Among Student-Athletes in 11 Sports, by Surgical Treatment: NCAA-ISP, 2009-2010 Through 2013-2014 Academic Years[a]

	Surgical Treatment of Injury			
Sport	No	Unknown	Yes	Total
Men's baseball	62	6	7	75
Men's football	179	2	3	184
Men's lacrosse	17	0	0	17
Women's lacrosse	3	0	0	3
Women's softball	29	1	0	30
Men's tennis	6	0	0	6
Women's tennis	6	0	0	6
Men's indoor track	3	1	0	4
Women's indoor track	4	0	0	4
Men's outdoor track	2	2	0	4
Men's wrestling	35	3	2	40
Total	346	15	12	373
Men's total[b]	26	1	0	27
Women's total[b]	13	0	0	13

[a]NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.
[b]Includes only sports in which both sexes participated (ie, lacrosse, indoor track, and tennis).

TABLE 10
Relative Rates of Elbow Injuries by Surgical Treatment Among Student-Athletes in 11 Sports: NCAA-ISP, 2009-2010 Through 2013-2014 Academic Years[a]

Surgical Treatment	Sex-Comparable Injury Proportion Ratio: Men's to Women's Sports
No	0.96 (0.50-1.88)
Unknown	NA
Yes	NA

[a]Values are expressed as injury proportion ratio (95% CI). NA, not applicable; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.

Injury Types

Among all elbow injuries recorded over this time frame, UCL injuries were the most common (n = 4269; 26%). Medial-lateral epicondylitis injuries were the most common injuries among sex-comparable sports for both men and women (n = 340 [26%] and n = 392 [34%], respectively) (Table 11 and Figure 2).

DISCUSSION

The current literature surrounding elbow injuries in professional and collegiate athletes is largely limited to single sports or a specific injury type.[9,13,18] As such, this study is the first to examine the epidemiological patterns of multiple different elbow injuries at the collegiate level across a convenience sample of 11 NCAA sports. Examining the rates of injuries, event types, time in season, mechanism of injury, participation time loss, surgical treatment, and injury types will allow for better estimates of injuries at the collegiate level. Critical analysis of these findings will help with development of prevention and rehabilitation programs that can be sport and sex specific.

The overall injury rates reported in this study are in line with previously cited rates of elbow injury.[2,4,8,9,18,23-25] Previous studies have mainly focused on injuries in overhead throwing athletes, specifically baseball players. These rates have ranged from 18.5 to 58.3 injuries per 10,000 AEs.[5,16] Literature specifically discussing NCAA football players has reported a higher overall incidence as well—13.20 per 10,000 AEs.[10] The injury rate reported in the baseball-specific literature is an order of magnitude higher than our

TABLE 11
5-Year Average Weighted Distribution of Elbow Injuries Among Student-Athletes in 11 Sports, by Injury Type: NCAA-ISP, 2009-2010 Through 2013-2014 Academic Years[a]

Sport	Elbow Capsular Sprain, Hyperextension, Subluxation	Elbow Contusion, Laceration	Elbow Dislocation	Elbow Neuropathy or Ulnar Nerve Subluxation	Medial or Lateral Epicondylitis	Elbow Impingement	Infection	Osteochondritis Dissecans	Bursitis or Tendonitis	Ulnar Collateral Ligament Injury	Fracture	Other	Total
Men's baseball	185	216.2	0	10.6	122.6	0	0	0	189.8	387.2	9.4	114	1234.8
Men's football	346.8	202.4	31.6	11.6	12.8	10.2	12.6	4.2	59.8	216.4	0	66.4	974.8
Men's lacrosse	19.6	40.2	0	0	2	0	4.6	0	0	27.2	0	7	100.6
Women's lacrosse	3	16.2	0	0	0	0	0	0	0	0	0	0	19.2
Women's softball	7.4	96	0	18.2	24.4	7.4	0	0	62.2	23.2	0	5.8	244.6
Men's tennis	0	0	0	0	56.4	0	0	0	62.2	0	0	0	118.6
Women's tennis	0	0	0	0	78.4	0	0	0	21.4	0	0	23.6	123.4
Men's indoor track	9.6	0	0	0	9.6	0	0	0	0	14.6	0	9.6	43.4
Women's indoor track	0	27.4	0	0	0	270	0	0	0	34	0	0	331.4
Men's outdoor track	0	18.4	0	0	0	0	0	0	0	40.2	0	0	58.6
Men's wrestling	88.6	9	62.2	0	0	0	0	5.8	20.2	116.4	20.2	22.4	344.8
Total	660	625.4	93.8	40.6	306	44.4	17.2	10	415.4	853.8	29.6	249	3345.2
Men's total[b]	29.2	40.2	0	0	68	0	4.6	0	62.2	41.8	0	16.6	262.6
Women's total[b]	3	43.4	0	0	78.4	27	0	0	21.4	34	0	23.6	230.8

[a]NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.
[b]Includes only sports in which both sexes participated (ie, lacrosse, indoor track, and tennis).

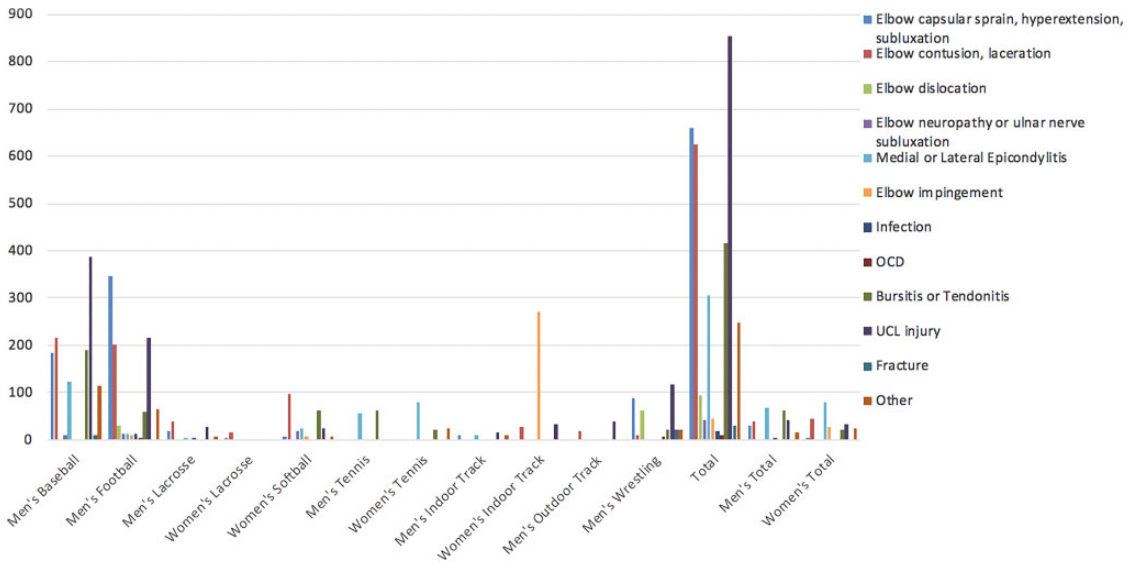

Figure 2. Weighted elbow injuries among student athletes in 11 sports by injury type: National Collegiate Athletic Association Injury Surveillance Program (NCAA-ISP), 2009-2010 through 2013-2014 academic years. OCD, osteochondritis dissecans; UCL, ulnar collateral ligament.

all-athletes overall rate of 1.76 injuries per 10,000 AEs. However, the prior football literature has reported rates comparable with the rates in our study. Uniquely, our study revealed that these injuries are also common in sports not typically associated with overhead motion. In fact, men's wrestling demonstrated the highest rate of elbow injury in our study. Although some of the injuries can be attributed to the overhead leverage motion of wrestlers, the majority of positions do not entail this type of motion. Consequently, the high rate of elbow injury in wrestling athletes suggests that elbow injuries are not exclusive to overhead athletes. Men's football and wrestling have traditionally been associated with the highest rates of elbow subluxation-dislocation events, which was consistent with the highest and second highest number of injuries in these 2 sports, respectively (see Tables 1 and 11).[6,9-11] Additionally, wrestling and football are contact sports, which may contribute to the overall higher number of injuries secondary to a contact mechanism. Many positions in which the athlete's hand is on the ground while a contact force is applied may be the cause of the high injury rates seen in these particular sports.

Previous literature suggests that injuries are most likely to occur in the setting of competition and during in-season play.[4,9,10] These findings were consistent with results of our analysis, which suggested a significant 3.5-times higher

injury rate during competition than practice and higher IRRs for in-season events. Contact was the most common injury mechanism, comprising 67% of total injuries. Additionally, among sex-comparable sports, men were 2.41 times more likely than women to have a contact injury mechanism.

The majority of athletes in this study missed less than 24 hours of time away from their sport (67%) and the minority went on to have surgical treatment (3%). In sex-comparable sports, men were less likely to require surgical treatment compared with women; however, no surgeries occurred in either group (Table 10).

Overall, UCL injuries not requiring surgery were most common. These findings are consistent with existing literature.[4,12,13,23,24] Interestingly, however, for sex-comparable sports, higher rates of elbow medial and lateral epicondylitis were seen among both men's and women's groups. The relative lack of isolated overhead throwing athletics in women's sports may result in a difference in the leading injury type in these settings. Additionally, the exclusion of football and baseball from men's sex-comparable sports may again bias the data with removal of the majority of overhead throwing activity for the men's sex-comparable sports.

This study has limitations. Participation in the NCAA-ISP is voluntary, and as such this program is inherently subject to selection bias even among sports that participate. Many sports with high rates of injuries (hockey, golf, rodeo, etc) were not available for this analysis. This would limit the generalizability to other collegiate programs or professional programs with similarly aged players. The standardization of diagnoses reported depends on uniform diagnostic criteria among all ATs from all programs participating for this time period, a weakness of any multicenter data set study. Additionally, variability in team injury prevention protocols and injury reporting protocols were not considered with these data. Finally, some injuries occured infrequently, resulting in low numbers and consequent underpowering during relevant analyses. Future research should include larger sample sizes and more specific diagnostic protocols to better enable generalizability. However, a significant lack of prior research evaluating multiple elbow injury types across multiple collegiate sports makes this study a valuable contribution to understanding overall epidemiological patterns of elbow injury.

CONCLUSION

Analysis of the study data demonstrated a significant rate of elbow injuries (1.76 injuries per 10,000 AEs) in the NCAA collegiate athlete. Higher injury rates can be expected in male athletes within sex-comparable sports. Elbow injuries were more common in the setting of competitions and more commonly occured secondary to contact-type mechanisms. Injuries were more likely to occur during in-season play. The majority of injuries required less than 24 hours of time away from sport and did not require surgical intervention.

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