

Epidemiology of Elbow Ulnar Collateral Ligament Injuries in Throwing Versus Contact Athletes of the National Collegiate Athletic Association

Analysis of the 2009-2010 to 2013-2014 Seasons

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Background: The management and outcomes of elbow ulnar collateral ligament (UCL) injuries in throwing athletes have been well investigated. However, less is known regarding the management, severity, and outcomes of such injuries in contact athletes.

Purpose: To compare the incidence, severity, and outcomes of elbow UCL injuries between throwing and contact athletes in collegiate sports.

Study Design: Descriptive epidemiology study.

Methods: Elbow UCL injuries were queried from the National Collegiate Athletic Association (NCAA) Injury Surveillance Program between the seasons of 2009-2010 and 2013-2014 in 25 varsity sports. The rates and distribution of injuries by mechanism, participation restriction time, and outcomes (eg, season-ending injury, surgery) were examined. A severe injury was defined as loss of ≥ 21 days from participation, a season-ending injury, or requiring a surgical intervention. The injury frequency, incidence per 10,000 athlete-exposures (AEs), and injury proportion ratio comparing throwing and contact athletes were calculated with 95% CIs.

Results: Over the course of 5 seasons, 109 UCL injuries were recorded, for an overall injury rate of 0.29 per 10,000 AEs. Of these injuries, 83 (76.1%) were a result of contact and 26 (23.9%) from throwing. Men's wrestling (1.78 per 10,000 AEs) and men's baseball (1.12 per 10,000 AEs) sustained the highest injury rates. A larger proportion of throwing ($n = 8$; 36.4%) compared with contact ($n = 7$; 9.1%) ($P < 0.01$) injuries results in >21 days of time loss. Additionally, more throwing-related UCL injuries required surgery ($n = 2$; 11.1%) compared with contact-related injuries ($n = 1$; 1.3%) ($P < 0.01$). As a result, throwing athletes demonstrated a significantly higher proportion of severe injuries than contact athletes (injury proportion ratio, 4.62 [95% CI, 1.72-12.40]).

Conclusion: The evaluation of athletes in 25 collegiate varsity sports across 5 seasons found over 3 times more elbow UCL injuries in contact versus throwing athletes. However, the number of severe injuries in throwing athletes was significantly higher than in contact athletes. These findings demonstrate that although elbow UCL injuries are prone to occur in both contact and throwing athletes, their prevention, management, and outcomes must be framed on a sport-by-sport basis.

Keywords: elbow; ulnar collateral ligament; overhead; throwing; contact; sport; National Collegiate Athletic Association

The ulnar collateral ligament (UCL) of the elbow is crucial for resisting valgus forces during throwing. In a 16-year retrospective study, Zaremski et al¹² found the highest odds of sustaining UCL injuries in javelin (odds ratio, 6.69) and baseball (odds ratio, 1.55) compared with all other sports. In professional baseball, the elbow UCL accounts for 10% of

all injuries, with consequences that can be devastating to a player's career.³⁻⁵

Currently, knowledge of UCL injuries has primarily focused on throwing athletes. However, the prevalence of UCL injuries in nonthrowing athletes who sustain injuries from contact-related mechanisms has not been well developed. Kenter et al⁶ investigated UCL injuries in the National Football League (NFL) between 1991 and 1996 and reported on 14 injuries that were treated conservatively. An exploration into other contact sports and injuries occurring in more recent years remains limited.

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In this study, we utilized a database of injuries from the National Collegiate Athletic Association (NCAA) to explore elbow UCL injuries in 25 varsity sports between the seasons of 2009-2010 to 2013-2014. Our aim was to determine the incidence, severity, and outcomes of elbow UCL injuries in collegiate sports in an effort to understand injury differences between throwing athletes and contact athletes. We hypothesized that the incidence of elbow UCL injuries among throwing and contact athletes would be similar, but that the severity of injuries would be greater in the throwing population, given the mechanics and demands of the associated sports.

METHODS

Approval for this study was obtained from the NCAA Research Review Board, which was deemed exempt by our institutional review board. Deidentified athletes with elbow UCL injuries were queried from the NCAA Injury Surveillance Program (ISP) for the academic years of 2009-2010 and 2013-2014. The ISP is managed by the Datalys Center for Sports Injury Research and Prevention.

Data Collection

Methods regarding data collection by the Datalys Center have been previously described by Dick et al² and Kerr et al.⁷ Briefly, the database is composed of input from certified athletic trainers at participating NCAA institutions tasked with injury reporting across 25 sports. These sports include men's football, wrestling, and baseball; women's softball, volleyball, field hockey, and gymnastics; 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. Exported data pass through a verification system in which data are flagged for invalid or inconsistent values and readdressed by trainers and staff. Data that are certified through the verification process are placed into an aggregated data set. The number of programs that are able to provide data varies by sport and year.⁷

Definitions

Injury. A reportable injury was one that occurred during practice or competition and required medical attention, even if it did not result in time loss. In this study, the data set was filtered for the following between the 2009-2010 through 2013-2014 academic years: (1) body part: elbow and (2) injury code: UCL tear (partial or complete).

Athlete-exposure (AE). A reportable AE for an injury was established as 1 student-athlete in 1 NCAA-sanctioned practice or competition for which there was a possibility of an injury, no matter the amount of time associated with participation.

Injury Activity. The activity was defined as one during which the athlete sustained his or her injury. This category was utilized to differentiate contact-associated injuries from those occurring as a result of throwing or pitching.

Injury Severity. Severe injuries were those in which the athlete missed ≥ 21 days from sport, or those that resulted in a premature end to the season or that required surgery.¹¹ Time away from activity was categorized as time loss and was reported as the number of days until the athlete returned to unrestricted practice and competition.

National Estimates

To calculate national estimates of UCL injuries, poststratification sample weights based on sport, division, and academic year were applied to injuries and AEs.¹¹ Weights from all data were adjusted for underreporting as a result of findings from Kucera et al,⁸ who reported that the Injury Surveillance System (previous version of the ISP) captured 88.3% of all time-loss injury events. Weight counts were thus scaled by a factor of 0.883⁻¹.

Statistical Analysis

Data were analyzed to assess the rates and patterns of elbow UCL injuries across all sports. Elbow UCL rates were calculated as the number of injuries divided by the number of AEs; rates are reported per 10,000 AEs for all event types. Injury recurrence and severity were further examined by sport and injury mechanism.

Injury proportion ratios (IPRs) were also used to examine mechanistic differences in the distribution of injury severity. The IPRs that did not include 1.00 within the 95% CIs were considered statistically significant. For study purposes, unweighted data were utilized for this investigation.

RESULTS

Frequencies and Rates

Overall, 109 UCL injuries were reported to the ISP between the 2009-2010 and 2013-2014 academic years, yielding an injury rate of 0.29 per 10,000 AEs (Table 1). The sports with the highest rates of elbow UCL injuries were men's wrestling (1.78 per 10,000 AEs) and men's baseball (1.12 per 10,000 AEs). The 109 UCL injuries translated to an

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Ethical approval was not sought for the present study.

TABLE 1
Elbow UCL Injuries Among NCAA Athletes in 25 Sports^a

Sport	UCL Injury, n (%)	National Estimate, n (%)	Rate per 10,000 AEs (95% CI)
Men's baseball	20 (18.3)	1936 (36.4)	1.12 (0.63-1.62)
Men's basketball	2 (1.8)	101 (1.1)	0.09 (0.00-0.22)
Men's football	36 (32.1)	1082 (20.3)	0.40 (0.27-0.53)
Men's ice hockey	2 (1.8)	29 (0.5)	0.07 (0.00-0.17)
Men's lacrosse	4 (3.7)	136 (2.6)	0.25 (0.00-0.49)
Men's soccer	5 (4.6)	204 (3.8)	0.31 (0.04-0.59)
Men's wrestling	14 (12.8)	582 (11.0)	1.78 (0.85-2.71)
Women's softball	3 (2.8)	116 (2.2)	0.19 (0.00-0.40)
Women's basketball	5 (4.6)	286 (5.4)	0.26 (0.03-0.48)
Women's field hockey	0 (0.0)	0 (0.0)	0.00 (0.00-0.00)
Women's ice hockey	2 (1.8)	10 (0.2)	0.18 (0.00-0.42)
Women's lacrosse	0 (0.0)	0 (0.0)	0.00 (0.00-0.00)
Women's soccer	2 (1.8)	78 (1.5)	0.09 (0.00-0.22)
Women's volleyball	6 (5.5)	249 (4.7)	0.38 (0.08-0.69)
Women's gymnastics	4 (3.7)	61 (1.1)	0.88 (0.02-1.75)
Men's indoor track	1 (0.9)	73 (1.4)	0.09 (0.00-0.27)
Women's indoor track	1 (0.9)	170 (3.2)	0.10 (0.00-0.29)
Men's outdoor track	2 (1.8)	201 (3.8)	0.23 (0.00-0.55)
Women's outdoor track	0 (0.0)	0 (0.0)	0.00 (0.00-0.00)
Men's cross-country	0 (0.0)	0 (0.0)	0.00 (0.00-0.00)
Women's cross-country	0 (0.0)	0 (0.0)	0.00 (0.00-0.00)
Men's tennis	0 (0.0)	0 (0.0)	0.00 (0.00-0.00)
Women's tennis	0 (0.0)	0 (0.0)	0.00 (0.00-0.00)
Men's swimming and diving	0 (0.0)	0 (0.0)	0.00 (0.00-0.00)
Women's swimming and diving	0 (0.0)	0 (0.0)	0.00 (0.00-0.00)
Total	109	5314	0.29 (0.24-0.35)

^aAE, athlete-exposure; NCAA, National Collegiate Athletic Association; UCL, ulnar collateral ligament.

estimated 5314 injuries nationally, with men's baseball (n = 1936; 36.4%), men's football (n = 1082; 20.3%), and men's wrestling (n = 582; 11.0%) comprising the highest number of injuries (Table 1).

Injury Activity

The majority of elbow UCL injuries occurred from contact-related mechanisms (n = 83; 76.1%). Within contact injuries, men's football accounted for the majority (n = 35; 42.2%), followed by men's wrestling (n = 15; 18.1%) (Table 2). Men's baseball accounted for the majority of throwing injuries (n = 19; 73.1%), followed by women's softball (n = 3; 11.5%). In men's outdoor track, both of the reported UCL injuries were a result of javelin throwing (Table 2).

Participation Restriction and Surgery by Sport

Excluding athletes who missed the remainder of the season, athletes lost a mean of 9.7 days from play (range, 0-178 days) after a UCL injury. Furthermore, 78.0% (n = 85) of athletes missed <21 days of play, while 16.5% (n = 18) missed ≥21 days, including 10 athletes with season-ending injuries (Table 3). Men's baseball had the highest

TABLE 2
Elbow UCL Injuries Among NCAA Athletes in 25 Sports by Injury Mechanism^a

Sport	Throwing	Contact
Men's baseball	19 (73.1)	1 (1.2)
Men's basketball	0 (0.0)	2 (2.4)
Men's football	0 (0.0)	35 (42.2)
Men's ice hockey	0 (0.0)	2 (2.4)
Men's lacrosse	0 (0.0)	4 (4.8)
Men's soccer	0 (0.0)	5 (6.0)
Men's wrestling	0 (0.0)	14 (16.9)
Women's softball	3 (11.5)	0 (0.0)
Women's basketball	0 (0.0)	5 (6.0)
Women's field hockey	0 (0.0)	0 (0.0)
Women's ice hockey	0 (0.0)	2 (2.4)
Women's lacrosse	0 (0.0)	0 (0.0)
Women's soccer	0 (0.0)	2 (2.4)
Women's volleyball	0 (0.0)	6 (7.2)
Women's gymnastics	0 (0.0)	4 (4.8)
Men's indoor track	1 (3.8)	0 (0.0)
Women's indoor track	1 (3.8)	0 (0.0)
Men's outdoor track	2 (7.7)	0 (0.0)
Women's outdoor track	0 (0.0)	0 (0.0)
Men's cross-country	0 (0.0)	0 (0.0)
Women's cross-country	0 (0.0)	0 (0.0)
Men's tennis	0 (0.0)	0 (0.0)
Women's tennis	0 (0.0)	0 (0.0)
Men's swimming and diving	0 (0.0)	0 (0.0)
Women's swimming and diving	0 (0.0)	0 (0.0)
Total	26	83

^aData are reported as n (%). NCAA, National Collegiate Athletic Association; UCL, ulnar collateral ligament.

number of injuries resulting in ≥21 days out of play (n = 7; 38.9%), followed by men's football (n = 4; 22.2%).

A majority of injuries were managed conservatively (n = 95; 87.2%), with 3.7% (n = 4) requiring surgery and listed as season-ending injuries (Table 3). Injuries that required surgery were isolated to those in men's baseball and men's wrestling, representing 75.0% (n = 3) and 25.0% (n = 1) of surgically managed injuries, respectively.

Injury Severity by Activity

Assessing time loss by activity, 36.4% (8/22) of throwing injuries required ≥21 days away from play compared with 9.1% (7/77) of contact injuries (P < .01). The proportion of throwing injuries that required surgery (n = 2/18; 11.1%) was also significantly greater than that of contact injuries (n = 1/75; 1.3%) (P < .01) (Figure 1). Overall, the number of severe UCL injuries was significantly greater in throwing (n = 9/22; 40.9%) than contact (n = 7/79; 8.9%) (P < .01) athletes. Among these 2 activities, throwing demonstrated a significantly higher proportion of severe injuries than contact (IPR, 4.62 [95% CI, 1.72-12.40]).

DISCUSSION

Elbow UCL injuries in collegiate athletics over the course of 5 seasons were reviewed across 25 varsity sports. Although

TABLE 3
Elbow UCL Injury Outcomes Among NCAA Athletes in 25 Sports^a

Sport	Participation Restriction			Intervention		
	<21 d	≥21 d	Unidentified	No Surgery	Surgery	Unidentified
Men's baseball	13 (15.3)	7 (38.9)	0 (0.0)	14 (14.7)	3 (75.0)	3 (30.0)
Men's basketball	2 (2.4)	0 (0.0)	0 (0.0)	2 (2.1)	0 (0.0)	0 (0.0)
Men's football	29 (34.1)	4 (22.2)	3 (50.0)	34 (35.8)	0 (0.0)	2 (20.0)
Men's ice hockey	2 (2.4)	0 (0.0)	0 (0.0)	2 (2.1)	0 (0.0)	0 (0.0)
Men's lacrosse	3 (3.5)	0 (0.0)	1 (16.7)	4 (4.2)	0 (0.0)	0 (0.0)
Men's soccer	5 (5.9)	0 (0.0)	0 (0.0)	5 (5.3)	0 (0.0)	0 (0.0)
Men's wrestling	12 (14.1)	2 (11.1)	0 (0.0)	11 (11.6)	1 (25.0)	2 (20.0)
Women's softball	1 (1.2)	2 (11.1)	0 (0.0)	3 (3.2)	0 (0.0)	0 (0.0)
Women's basketball	5 (5.9)	0 (0.0)	0 (0.0)	5 (5.3)	0 (0.0)	0 (0.0)
Women's field hockey	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Women's ice hockey	2 (2.4)	0 (0.0)	0 (0.0)	2 (2.1)	0 (0.0)	0 (0.0)
Women's lacrosse	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Women's soccer	2 (2.4)	0 (0.0)	0 (0.0)	2 (2.1)	0 (0.0)	0 (0.0)
Women's volleyball	5 (5.9)	1 (5.6)	0 (0.0)	5 (5.3)	0 (0.0)	1 (10.0)
Women's gymnastics	2 (2.4)	2 (11.1)	0 (0.0)	3 (3.2)	0 (0.0)	1 (10.0)
Men's indoor track	0 (0.0)	0 (0.0)	1 (16.7)	1 (1.1)	0 (0.0)	0 (0.0)
Women's indoor track	1 (1.2)	0 (0.0)	0 (0.0)	1 (1.1)	0 (0.0)	0 (0.0)
Men's outdoor track	1 (1.2)	0 (0.0)	1 (16.7)	1 (1.1)	0 (0.0)	1 (10.0)
Women's outdoor track	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Men's cross-country	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Women's cross-country	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Men's tennis	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Women's tennis	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Men's swimming and diving	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Women's swimming and diving	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Total	85	18	6	95	4	10

^aData are reported as n (%). NCAA, National Collegiate Athletic Association; UCL, ulnar collateral ligament.

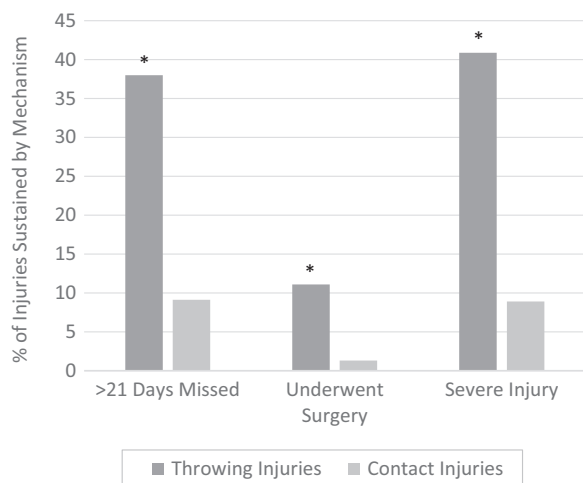


Figure 1. Differences in time loss, need for surgery, and injury severity within throwing- and contact-associated elbow ulnar collateral ligament injuries. *Statistically significant difference between injury mechanisms ($P < .05$).

men's football had the highest number of UCL injuries, men's wrestling was found to have the highest rate of injuries. When evaluating by mechanism, approximately 75% of injuries were a result of contact. However, injuries in

throwing athletes resulted in more time loss and a higher rate of surgery. As a result, the number of severe UCL injuries was significantly greater in throwing versus contact athletes, despite contact athletes sustaining a larger number of injuries.

Our data are consistent with previous studies demonstrating a high frequency of UCL injuries in baseball.^{1,9,12} With respect to contact athletes, our data captured a high number of injuries in men's football, men's soccer, and men's wrestling. In comparison, a 16-year retrospective analysis at a single institution of 136 UCL injuries in athletes between 11 and 22 years old participating in sports competition reported injuries in football ($n = 8$; 5.9%), gymnastics ($n = 2$; 1.5%), and cheerleading ($n = 2$; 1.5%).¹² The differences in the number of contact athletes sustaining UCL injuries may be a result of the varying intensity of play in varsity athletes versus a predominantly recreational population. Participation in varsity athletics brings not only higher intensity but also a higher frequency of practice and competition, increasing the risk for injuries. In addition, the ISP includes more contact-related sports, which may lead to a more comprehensive capture of injury patterns.

Outcomes after a UCL injury in contact athletes consisted of less time loss and a lower rate of surgery. Kenter et al⁶ evaluated acute elbow injuries in the NFL, noting 14 (20%) elbow UCL injuries. The authors found that a

majority of injuries were a result of a planted hand with a valgus load or from blocking. All injuries were treated nonoperatively, with a time loss of 0 to 4 games. Similarly, Dodson et al⁴ evaluated 10 UCL injuries in professional football quarterbacks between 1994 and 2008, identifying 9 cases (90%) that were treated nonoperatively. The authors noted differences in the requirements for an operative intervention to be secondary to biomechanics and the demands related to each position and associated sport.⁴ Cain et al¹ conducted a review of 743 athletes who underwent UCL reconstruction and identified that only 5.5% of reconstructions were performed for athletes competing in sports other than baseball. Similarly, our study identified the rate of surgical interventions for contact athletes to be significantly lower at 1.3% compared with 11.1% in throwing athletes.

The severity of UCL injuries can be understood by the amount of force and stress placed on the ligament during throwing. In sports such as javelin and baseball, angular velocities of nearly 2000 and 2500 deg/s, respectively, are achieved.¹² Given such velocities, the stresses placed across the medial elbow are the highest for these athletes compared with other overhead athletes, thus requiring optimal stability and strength. In contrast, for sports that do not require such demands and for UCL injuries related to a contact mechanism, the prospect of missing time or requiring surgery is not as warranted. As such, NFL quarterbacks in the Dodson et al⁴ study did not undergo any reconstruction of the UCL, thus exemplifying the differing mechanics between throwing a baseball and a football. As explained by Redler et al,¹⁰ a football's larger size produces slower arm velocities and subsequently less stress. In addition, the frequency of throws in football is much lower than in baseball and is limited to the quarterback.

There are several limitations to this study. This was a retrospective analysis utilizing a convenience sample database that consists of voluntary documentation by athletic trainers. Although quality control is monitored by the Datalys Center and has been validated previously, there remains a risk of inaccurate coding, misrepresentation, or injuries that were not documented.⁷ As a result, there is a possibility of underestimating the number of UCL injuries across the various sports. Another limitation is the specificity of the UCL injury; whether the UCL had a sprain, partial tear, or complete tear is not specified, as imaging and physical examination data are not available for review. Furthermore, without this patient-specific information, the indications for surgery are not available, which may limit generalizability. The amount of time loss and management with surgery were our determinants for the severity of a UCL injury, while other data fields (such as number of games missed or time in season) are withheld for deidentification purposes.

Future studies will assist in further understanding the incidence and outcomes of elbow UCL injuries in nonoverhead athletes in varying levels of play. Given the differences in age and level of activity, further factors involved in understanding management options and counseling between nonoperative and operative pathways can be explored. Moreover, tracking outcomes after the nonoperative and

operative management of UCL injuries in nonoverhead athletes will better assist in determining the time and number of games that are missed in addition to who would best benefit from operative interventions in a sport-specific fashion.

CONCLUSION

Our findings demonstrate that UCL injuries of the elbow have a high incidence in contact athletes but are more severe in throwing athletes. Throwing athletes, who are required to place consistent stresses and forces on the elbow during repetitive overhead actions, are subjected to greater time loss with higher risks of a prematurely ended season or surgical treatment compared with contact athletes. Nonetheless, given the high incidence of contact-related injuries, further discussions on the most appropriate methods of prevention through changes in biomechanics and in protection and training may be considered and implemented at the collegiate level.

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