

# The Epidemiology of Deltoid Ligament Sprains in 25 National Collegiate Athletic Association Sports, 2009–2010 Through 2014–2015 Academic Years

Thomas J. Kopec, PhD, ATC\*; Elizabeth E. Hibberd, PhD, ATC†; Karen G. Roos, PhD, MSPT, ATC‡; Aristarque Djoko, MS‡; Thomas P. Dompier, PhD, ATC‡; Zachary Y. Kerr, PhD, MPH§

\*Department of Kinesiology, Samford University, Birmingham, AL; †The University of Alabama, Tuscaloosa; ‡DataLys Center for Sports Injury Research and Prevention, Inc, Indianapolis, IN; §University of North Carolina at Chapel Hill

**Context:** Deltoid ligament sprains among collegiate student-athletes have not been extensively investigated. Research regarding the mechanisms, participation-restriction time, and recurrence of deltoid ligament sprains in collegiate student-athletes is lacking.

**Objective:** To describe the epidemiology of deltoid ligament sprains in 25 National Collegiate Athletic Association championship sports.

**Design:** Descriptive epidemiology study.

**Setting:** National Collegiate Athletic Association Injury Surveillance Program.

**Main Outcome Measure(s):** We analyzed deltoid ligament sprains recorded in the Injury Surveillance Program for the 2009–2010 through 2014–2015 academic years. Deltoid ligament sprain injury rates, rate ratios, and injury proportion ratios with 95% confidence intervals (CIs) were reported.

**Results:** During the study period, 380 deltoid ligament sprains were reported, resulting in a combined injury rate of 0.79/10 000 athlete-exposures (AEs; 95% CI = 0.71, 0.87). Most deltoid ligament sprains occurred in practices (54.2%, n = 206). However, the competition injury rate was higher than the

practice injury rate (rate ratio = 3.74; 95% CI = 3.06, 4.57). The highest deltoid ligament sprain rates were in women's gymnastics (2.30/10 000 AEs; 95% CI = 1.05, 3.55), men's soccer (1.73/10 000 AEs; 95% CI = 1.14, 2.32), women's soccer (1.61/10 000 AEs; 95% CI = 1.13, 2.09), and men's football (1.40/10 000 AEs; 95% CI = 1.18, 1.62). Nearly half of all deltoid ligament sprains (49.7%, n = 189) were due to player contact, and 39.5% (n = 150) were non-time-loss injuries (ie, participation restricted for less than 24 hours). Only 8.2% (n = 31) of deltoid ligament sprains were recurrent.

**Conclusions:** The highest deltoid ligament sprain rates were in women's gymnastics, men's and women's soccer, and men's football. However, the rate for women's gymnastics was imprecise (ie, the CI was wide), highlighting the need for further surveillance of deltoid ligament sprains in the sport. Most deltoid ligament sprains were due to player contact. Future researchers should assess interventions that may prevent deltoid ligament sprains.

**Key Words:** eversion sprains, medial ankle sprains, collegiate athletes

## Key Points

- Men's football and men's and women's soccer players had the highest rates of deltoid ligament sprains.
- Women gymnasts also had a high rate of deltoid ligament sprains, but the cell size was small and the confidence interval was wide.
- Player contact was the most common mechanism of injury.

The deltoid is the medial ligament of the ankle joint. The ligament is a fibrous union consisting of 2 layers with multiple contributions from smaller ligaments connecting the medial malleolus to the medial tarsals of the foot.<sup>1–4</sup> The superficial layer of the deltoid comprises the tibionavicular, tibiocalcaneal, and posterior tibiotalar ligaments.<sup>3</sup> The deep layer is larger and broader than the superficial layer and provides more reinforcement to the medial ankle.<sup>1,2,5</sup> Primarily, the deltoid ligament limits eversion of the subtalar joint<sup>1,3</sup> and aids in restricting external rotation of the foot.<sup>2</sup> Forceful eversion causes a deltoid ligament sprain, resulting in pain, restricted ankle total range of motion, and swelling over the medial malleolus.<sup>3</sup> These symptoms can be masked by

damage to other structures as well; though, as the literature suggests, deltoid ligament sprains rarely occur in isolation.<sup>3,6–8</sup>

Deltoid ligament sprains are not as common as lateral and syndesmotomic ankle sprains.<sup>9–11</sup> Nevertheless, injuries to the deltoid ligament may result in significant time loss and disability in the athletic population.<sup>9,10</sup> In active military cadets, 74% of those with deltoid ligament sprains incurred physical-activity restrictions of at least 24 hours.<sup>9</sup> Furthermore, a significant number of deltoid ligament sprains (40%) were of moderate severity, resulting in at least 8 days of physical-activity restriction.<sup>9</sup>

Although previous researchers<sup>9</sup> have reported on deltoid ligament sprains in military cadets, no authors have

examined the incidence of these sprains in a large sample of National Collegiate Athletic Association (NCAA) student-athletes across multiple sports. A population-based, epidemiologic study will help us to understand the prevalence and mechanisms of injury and the recovery from deltoid ligament sprains. These findings can be used to improve the management of these injuries. We analyzed data from the NCAA Injury Surveillance Program (ISP) during the 2009–2010 through 2014–2015 academic years.

## METHODS

The NCAA ISP is a prospective injury-surveillance program managed by the Datalys Center for Sports Injury Research and Prevention, Inc, an independent, nonprofit research organization. This study was approved by the Research Review Board of the NCAA. The methods of the NCAA ISP during the 2009–2010 through 2014–2015 academic years have been previously described<sup>12</sup> but are briefly summarized here.

### Data Collection

The NCAA ISP used a convenience sample of NCAA varsity teams in 25 sports with athletic trainers (ATs) reporting injury data. These 25 sports were men's baseball, football, and wrestling; women's field hockey, gymnastics, softball, and volleyball; and men's and women's basketball, cross-country, ice hockey, lacrosse, soccer, swimming and diving, tennis, indoor track and field, and outdoor track and field. The number of programs providing data varied by sport and year.<sup>12</sup>

The ATs worked with these participating teams and attended school-sanctioned practices and competitions. The ATs logged the number of student-athletes participating in each practice and competition. Injuries were reported in real time through the electronic health record application used by the team medical staff throughout the academic year. This allowed ATs to document injuries normally as part of their daily clinical practice, as opposed to having to report injuries separately for ISP purposes. Data were from varsity-level practices and competitions and team conditioning sessions. Individual weight-lifting and conditioning sessions were excluded.

The AT completed a detailed event report on the injury or condition, such as the specific diagnosis and how and when the injury occurred. After initially inputting the injury data, the AT could return to view and update the data as needed over the course of a season, such as when the student-athlete returned to sport participation. Deidentified common data elements were extracted from the certified electronic health record applications.<sup>12</sup> Exported data passed through an automated verification process that conducted a series of range and consistency checks. Data that passed the verification process were then placed into the aggregate research dataset.

### Inclusion Criteria for Current Study

The current study used all injuries reported as *deltoid ligament sprains* among the 25 sports included in the NCAA ISP during the 2009–2010 through 2014–2015 academic years.

## Definitions

**Injury.** A reportable *injury* occurred as a result of participation in an NCAA-sanctioned practice or competition and required attention from an AT or physician. We specifically did not provide a working definition of *deltoid ligament sprain*. We relied on the training and expertise of the ATs collecting data, as well as the other members of the team medical staff with whom they worked, to accurately identify and diagnose such injuries.

**Athlete-Exposure.** A reportable *athlete-exposure* (AE) was defined as 1 student-athlete participating in 1 NCAA-sanctioned practice or competition in which he or she was exposed to the possibility of athletic injury, regardless of the time associated with that participation. Only athletes with actual playing time in a competition were included in competition exposures.

**Event Type.** *Event type* was the specific event (practice, competition) in which the injury was reported to have occurred.

**Injury Mechanism.** *Injury mechanism* was defined as the manner in which the student-athlete sustained the injury. In the NCAA ISP, ATs selected from a list of options: player contact, surface contact, equipment contact, contact with out-of-bounds object, noncontact, overuse, illness, infection, or other/unknown. Given the rarity of injuries due to contact with an out-of-bounds object, illness, or infection, these were grouped into the *other/unknown* category.

**Injury Activity.** *Injury activity* was defined as the activity in which the student-athlete was engaged when the injury occurred. In the NCAA ISP, ATs selected from a list of options specific to each sport; in many cases, the same activities were listed across multiple sports.

**Position.** *Position* was defined as the position the student-athlete was playing when the injury occurred. In the NCAA ISP, ATs selected from a list of options specific to each sport.

**Participation-Restriction Time.** Injuries were categorized by the number of days of participation restriction (ie, date of injury subtracted from the date of return). *Non-time-loss (NTL) injuries* were those resulting in participation restriction of less than 24 hours. *Mild injuries* resulted in participation restriction of 1 to 6 days. *Moderate injuries* resulted in participation restriction of 7 to 21 days. *Severe injuries*<sup>13</sup> resulted in participation restriction of more than 21 days, the student-athlete choosing to prematurely end the season (for medical or nonmedical reasons associated with the injury), or a medical professional requiring the student-athlete to prematurely end the season.

**Recurrence.** The ATs identified injuries that were *recurrent* (ie, the same injury had been sustained either earlier in the current academic year or in a prior year) as *yes* or *no*.

**Surgery.** The ATs also identified those injuries that required surgery as *yes* or *no*. The specific type of surgery was not recorded.

### Statistical Analysis

Data were analyzed to assess the rates and patterns of deltoid ligament sprains sustained during collegiate sports.

We first calculated the *deltoid ligament sprain rate*, defined as the number of injuries divided by the number of AEs. Each rate is reported per 10 000 AEs overall (ie, competitions and practices combined) and within competitions and practices separately. We then examined distributions of injuries by injury mechanism, injury activity, position, participation-restriction time (eg, NTL, severe), recurrence, and surgery.

Rate ratios (RRs) compared rates within sports by event type (ie, competitions and practices). The RRs also compared overall rates by sex among sex-comparable sports (ie, baseball or softball, basketball, cross-country, ice hockey, lacrosse, soccer, swimming and diving, tennis, indoor track and field, and outdoor track and field). We compared the sex-comparable sports individually as well as overall. We also used injury proportion ratios (IPRs) to examine sex differences in distributions of injury mechanisms, recurrences, and participation-restriction times.

The following is an example of an RR comparing competition and practice deltoid ligament sprain rates:

$$RR = \left( \frac{\sum \text{competition deltoid ligament sprains}}{\sum \text{competition athlete-exposures}} \right) / \left( \frac{\sum \text{practice deltoid ligament sprains}}{\sum \text{practice athlete-exposures}} \right)$$

The following is an example of an IPR comparing the proportion of severe deltoid ligament sprains sustained in men and women:

$$IPR = \left( \frac{\sum \text{severe deltoid ligament sprains in men}}{\sum \text{total deltoid ligament sprains in men}} \right) / \left( \frac{\sum \text{severe deltoid ligament sprains in women}}{\sum \text{total deltoid ligament sprains in women}} \right)$$

All 95% confidence intervals (CIs) not including 1.00 were considered statistically significant. Data were analyzed using SAS Enterprise Guide software (version 5.1; SAS Institute Inc, Cary, NC).

## RESULTS

### Overall Findings

During the 2009–2010 through 2014–2015 academic years, a total of 380 deltoid ligament sprains were reported, leading to a rate of 0.79/10 000 AEs (95% CI = 0.71, 0.87; Table 1). Men's football comprised the largest proportion of deltoid ligament sprains (41.3%, n = 157). Most deltoid ligament sprains occurred during practices (54.2%, n = 206). However, the competition rate was 3.74 times the practice rate (95% CI = 3.06, 4.57). In sex-comparable sports, the deltoid ligament sprain rate in men and women did not differ (RR = 0.92; 95% CI = 0.70, 1.21).

Player contact accounted for the largest proportion of deltoid ligament sprains (49.7%, n = 189), followed by noncontact (19.5%, n = 74) and surface contact (18.7%, n = 71; Figure 1). In sex-comparable sports, no differences between men and women were found in injury mechanisms (player contact IPR = 1.09; 95% CI = 0.75, 1.56;

noncontact IPR = 1.28; 95% CI = 0.78, 2.08; surface contact IPR = 0.88; 95% CI = 0.51, 1.52). In total, 39.5% of deltoid ligament sprains were NTL (n = 150) and 6.6% (n = 25) were severe (Figure 2). In sex-comparable sports, men and women did not differ in the proportion of deltoid ligament sprains that were NTL (IPR = 1.07; 95% CI = 0.80, 1.45) or severe (IPR = 0.92; 95% CI = 0.28, 3.09). Of all deltoid ligament sprains, 8.2% (n = 31) were recurrent (Figure 3). The proportions of recurrent deltoid ligament sprains in men and women did not differ (IPR = 0.84; 95% CI = 0.37, 1.89). Only 2 (0.5%) deltoid ligament sprains (both in men's football players) required surgery.

Sport-specific analyses follow. Due to small counts (<10), deltoid ligament sprains in men's baseball and wrestling; women's field hockey, softball, and volleyball; and men's and women's cross-country, swimming and diving, tennis, indoor track and field, and outdoor track and field are not discussed further. Data from women's ice hockey, although <10 (n = 6), are further described to allow comparisons with men's ice hockey.

### Men's Football

A total of 157 deltoid ligament sprains were reported in men's football, leading to a rate of 1.40/10 000 AEs (95% CI = 1.18, 1.62; Table 1). More deltoid ligament sprains occurred in practices (54.1%, n = 85). However, the competition rate was 7.84 times the practice rate (95% CI = 5.73, 10.73).

Most deltoid ligament sprains were due to player contact (69.4%, n = 109; Figure 1) and occurred while blocking (24.2%, n = 38) or during general play (22.9%, n = 36). The most common positions injured were wide receiver (13.4%, n = 21), linebacker (11.5%, n = 18), offensive guard (10.2%, n = 16), offensive tackle (10.2%, n = 16), and running back (10.2%, n = 16). About one-third (32.5%, n = 51) were NTL injuries, and 7.6% (n = 12) were severe (Figure 2). In addition, 5.7% (n = 9) were recurrent (Figure 3).

### Women's Gymnastics

A total of 13 deltoid ligament sprains were reported in women's gymnastics, leading to a rate of 2.30/10 000 AEs (95% CI = 1.05, 3.55; Table 1). The overall, competition, and practice rates were the highest among all 25 sports. Most deltoid ligament sprains occurred in practices (53.8%, n = 7). However, the competition rate was 8.53 times the practice rate (95% CI = 2.87, 25.38).

Most deltoid ligament sprains were due to surface contact (61.5%, n = 8; Figure 1). Gymnasts were injured on the balance beam (38.5%, n = 5), floor routine (38.5%, n = 5), or vault (23.1%, n = 3; Table 2). Of all deltoid ligament sprains, 30.8% (n = 4) were NTL injuries, and 15.4% (n = 2) were severe (Figure 2). In addition, 7.7% (n = 1) were recurrent (Figure 3).

### Ice Hockey

In ice hockey, 10 and 6 deltoid ligament sprains were reported in men and women, respectively, leading to rates of 0.25/10 000 AEs (95% CI = 0.09, 0.40) and 0.41/10 000 AEs (95% CI = 0.08, 0.73; Table 1). The majority occurred during competitions in men (60.0%, n = 6) and practices in

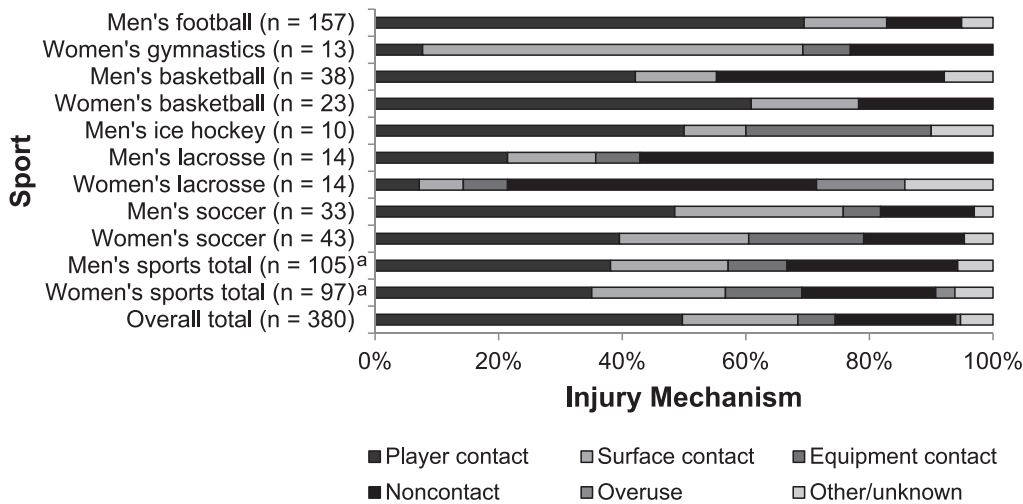
**Table 1. Deltoid Ligament Sprain Counts and Rates Among Student-Athletes in 25 Sports, National Collegiate Athletic Association Injury Surveillance Program, 2009–2010 Through 2014–2015 Academic Years**

Sport	Deltoid Ligament Sprains, No.			Rate per 10 000 Athlete-Exposures <sup>a</sup> (95% Confidence Interval)			Competition Versus Practice Rate Ratio (95% Confidence Interval)		
	Competition	Practice	Overall	Competition	Practice	Overall	Competition	Practice	Overall
Men's football	72	85	157	6.58 (5.06, 8.10)	0.84 (0.66, 1.02)	1.40 (1.18, 1.62)	7.84 (5.73, 10.73)		
Men's wrestling	2	0	2	1.88 (0.00, 4.48)	0.00	0.20 (0.00, 0.48)	NA		
Women's field hockey	0	1	1	0.00	0.28 (0.00, 0.82)	0.21 (0.00, 0.62)	NA		
Women's gymnastics	6	7	13	11.62 (2.32, 20.92)	1.36 (0.35, 2.37)	2.30 (1.05, 3.55)	8.53 (2.87, 25.38)		
Women's volleyball	2	3	5	0.35 (0.00, 0.84)	0.21 (0.00, 0.45)	0.25 (0.03, 0.47)	1.66 (0.28, 9.91)		
Men's baseball	4	2	6	0.48 (0.01, 0.95)	0.14 (0.00, 0.34)	0.27 (0.05, 0.48)	3.38 (0.62, 18.46)		
Women's softball	0	2	2	0.00	0.15 (0.00, 0.37)	0.10 (0.00, 0.23)	NA		
Men's basketball	11	27	38	1.79 (0.73, 2.85)	1.22 (0.76, 1.67)	1.34 (0.91, 1.77)	1.47 (0.73, 2.97)		
Women's basketball	11	12	23	1.95 (0.80, 3.11)	0.65 (0.28, 1.02)	0.96 (0.57, 1.35)	2.99 (1.32, 6.78)		
Men's cross-country	1	1	2	1.99 (0.00, 5.9)	0.19 (0.00, 0.56)	0.35 (0.00, 0.82)	10.54 (0.66, 168.56)		
Women's cross-country	0	1	1	0.00	0.20 (0.00, 0.59)	0.18 (0.00, 0.54)	NA		
Men's ice hockey	6	4	10	0.61 (0.12, 1.10)	0.13 (0.00, 0.26)	0.25 (0.09, 0.40)	4.67 (1.32, 16.56)		
Women's ice hockey	2	4	6	0.51 (0.00, 1.21)	0.37 (0.01, 0.73)	0.41 (0.08, 0.73)	1.38 (0.25, 7.53)		
Men's lacrosse	7	7	14	2.13 (0.55, 3.71)	0.42 (0.11, 0.73)	0.70 (0.33, 1.07)	5.07 (1.78, 14.47)		
Women's lacrosse	4	10	14	1.47 (0.03, 2.92)	0.86 (0.33, 1.4)	0.98 (0.47, 1.49)	1.70 (0.53, 5.44)		
Men's soccer	19	14	33	4.64 (2.55, 6.73)	0.93 (0.45, 1.42)	1.73 (1.14, 2.32)	4.97 (2.49, 9.90)		
Women's soccer	23	20	43	3.56 (2.10, 5.01)	0.99 (0.55, 1.42)	1.61 (1.13, 2.09)	3.61 (1.98, 6.57)		
Men's swimming and diving	0	0	0	0.00	0.00	0.00	NA		
Women's swimming and diving	0	0	0	0.00	0.00	0.00	NA		
Men's tennis	0	1	1	0.00	0.40 (0.00, 1.18)	0.31 (0.00, 0.93)	NA		
Women's tennis	1	0	1	0.97 (0.00, 2.86)	0.00	0.22 (0.00, 0.65)	NA		
Men's indoor track and field	0	0	0	0.00	0.00	0.00	NA		
Women's indoor track and field	0	5	5	0.00	0.35 (0.04, 0.66)	0.32 (0.04, 0.60)	NA		
Men's outdoor track and field	1	0	1	0.65 (0.00, 1.92)	0.00	0.09 (0.00, 0.28)	NA		
Women's outdoor track and field	2	0	2	1.31 (0.00, 3.13)	0.00	0.22 (0.00, 0.52)	NA		
Men's sports total <sup>b</sup>	49	56	105	1.32 (0.95, 1.69)	0.40 (0.29, 0.50)	0.59 (0.48, 0.70)	3.34 (2.28, 4.90)		
Women's sports total <sup>b</sup>	43	54	97	1.32 (0.93, 1.72)	0.45 (0.33, 0.58)	0.64 (0.51, 0.77)	2.91 (1.95, 4.35)		
Overall total	174	206	380	1.96 (1.67, 2.25)	0.52 (0.45, 0.60)	0.79 (0.71, 0.87)	3.74 (3.06, 4.57)		

Abbreviation: NA, not applicable.

<sup>a</sup> One athlete-exposure = 1 athlete participating in 1 practice or competition.

<sup>b</sup> Includes only those sports in which both sexes participated (ie, baseball/softball, basketball, cross-country, ice hockey, lacrosse, soccer, swimming and diving, tennis, indoor track and field, and outdoor track and field).



**Figure 1.** Injury-mechanism data for deltoid ligament sprains among student-athletes, National Collegiate Athletic Association Injury Surveillance Program, 2009–2010 through 2014–2015 academic years. <sup>a</sup> Only includes sports in which both sexes participated (ie, baseball/softball, basketball, cross-country, ice hockey, lacrosse, soccer, swimming and diving, tennis, indoor track and field, and outdoor track and field).

women (66.7%, n = 4). The deltoid ligament sprain rate was higher in competition than in practice for men (RR = 4.67; 95% CI = 1.32, 16.56) but not for women (RR = 1.38; 95% CI = 0.25, 7.53). Also, deltoid ligament sprain rates did not differ between men and women (RR = 0.61; 95% CI = 0.22, 1.68).

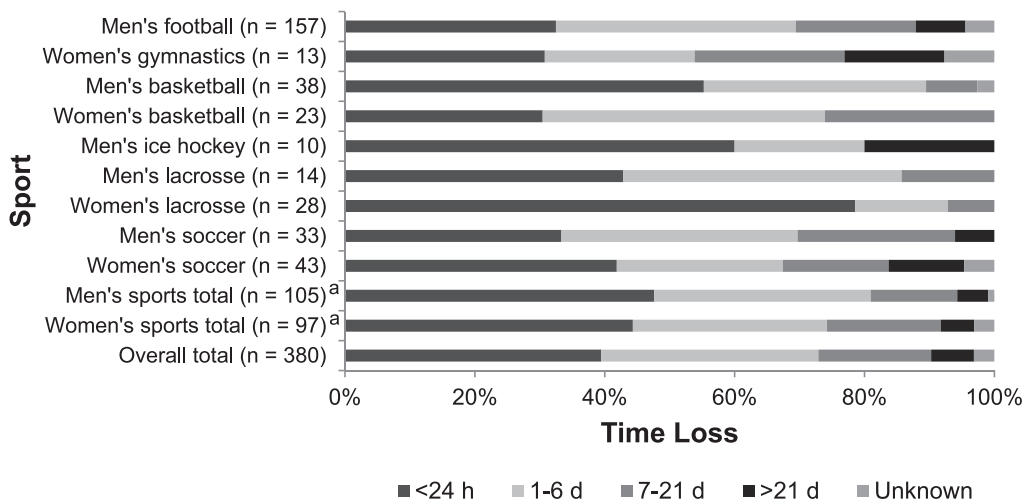
Most deltoid ligament sprains were due to player contact (men: 48.5%, n = 5; women: 33.3%, n = 2; Figure 1) and occurred during general play (men: 50.0%, n = 5; women: 66.7%, n = 4; Table 2). The positions injured most commonly were wings in men (50.0%, n = 5) and defense in women (50.0%, n = 3; Table 3). No sex differences in distributions of injury mechanism, activity, or position were found.

The proportion of deltoid ligament sprains that were NTL injuries in men (60.0%, n = 6) and women (33.3%, n = 2) did not differ (IPR = 1.80; 95% CI = 0.52, 6.22; Figure 2). Severe deltoid ligament sprains totaled 2 (20.0%) in men

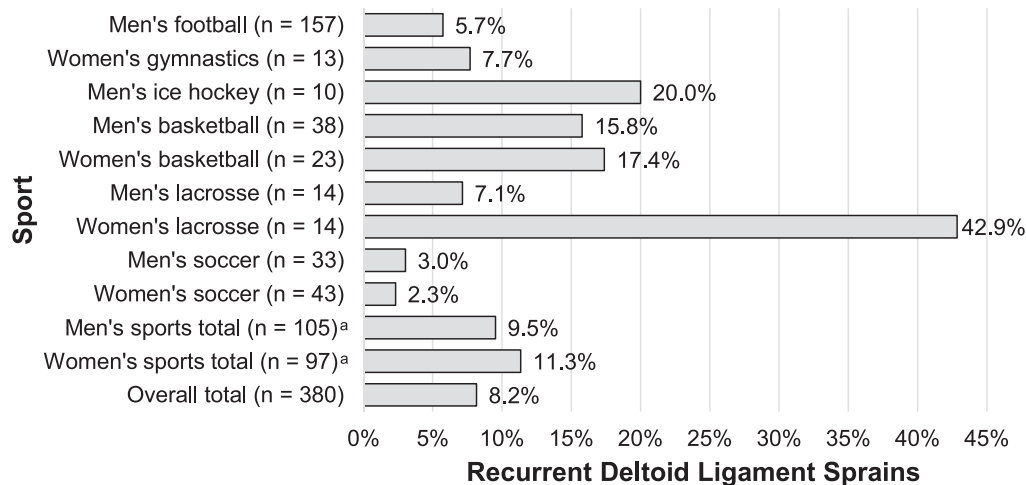
(Figure 2) and none in women. Also, 2 deltoid ligament sprains (20.0%) in men were recurrent (Figure 3); no recurrent sprains were reported in women.

### Soccer

In soccer, 33 and 43 deltoid ligament sprains were reported in men and women, respectively, leading to rates of 1.73/10 000 AEs (95% CI = 1.14, 2.32) and 1.61/10 000 AEs (95% CI = 1.13, 2.09; Table 1). The majority occurred during competitions (men: 57.6%, n = 19; women: 53.5%, n = 23). The deltoid ligament sprain rate was higher in competition than in practice in both men (RR = 4.97; 95% CI = 2.49, 9.90) and women (RR = 3.61; 95% CI = 1.98, 6.57). However, overall deltoid ligament sprain rates did not differ between men and women (RR = 1.08; 95% CI = 0.68, 1.69).



**Figure 2.** Participation-restriction data for deltoid ligament sprains among student-athletes, National Collegiate Athletic Association Injury Surveillance Program, 2009–2010 through 2014–2015 academic years. <sup>a</sup> Only includes sports in which both sexes participated (ie, baseball/softball, basketball, cross-country, ice hockey, lacrosse, soccer, swimming and diving, tennis, indoor track and field, and outdoor track and field).



**Figure 3.** Proportion of deltoid ligament sprains that were recurrent among student-athletes, National Collegiate Athletic Association Injury Surveillance Program, 2009–2010 through 2014–2015 academic years. <sup>a</sup> Only includes sports in which both sexes participated (ie, baseball/softball, basketball, cross-country, ice hockey, lacrosse, soccer, swimming and diving, tennis, indoor track and field, and outdoor track and field).

Most deltoid ligament sprains were due to player contact (men: 48.5%,  $n = 16$ ; women: 39.5%,  $n = 17$ ; Figure 1) and occurred during general play (men: 30.3%,  $n = 10$ ; women: 27.9%,  $n = 12$ ; Table 2). Forwards sustained the largest proportion of deltoid ligament sprains (men: 30.3%,  $n = 10$ ; women: 34.9%,  $n = 15$ ; Table 3). No sex differences in distributions of injury mechanism, activity, or position were found.

The proportion of deltoid ligament sprains that were NTL injuries in men (33.3%,  $n = 11$ ) and women (41.9%,  $n = 18$ ) did not differ (IPR = 0.80; 95% CI = 0.44, 1.45; Figure 2). The proportion of deltoid ligament sprains that were severe in men (6.1%,  $n = 2$ ) and women (11.6%,  $n = 5$ ) also did not differ (IPR = 1.92; 95% CI = 0.40, 9.28; Figure 2). In addition, men and women each had 1 recurrent deltoid ligament sprain reported (3.0% and 2.3%, respectively; Figure 3). The proportions of recurrent deltoid ligament sprains in men and women did not differ (IPR = 1.30; 95% CI = 0.08, 20.07).

### Basketball

In basketball, 38 and 23 deltoid ligament sprains were reported in men and women, respectively, leading to rates of 1.34/10 000 AEs (95% CI = 0.90, 1.77) and 0.96/10 000 AEs (95% CI = 0.57, 1.35; Table 1). The majority occurred during practices (men: 71.1%,  $n = 27$ ; women: 52.2%,  $n = 12$ ). The deltoid ligament sprain rate was higher in competition than in practice in women (RR = 2.99; 95% CI = 1.32, 6.78) but not in men (RR = 1.47; 95% CI = 0.73, 2.97). Overall deltoid ligament sprain rates did not differ between men and women (RR = 1.40; 95% CI = 0.83, 2.35).

Most deltoid ligament sprains were due to player contact (men: 42.1%,  $n = 16$ ; women: 60.9%,  $n = 14$ ; Figure 1) and occurred during general play (men: 31.6%,  $n = 12$ ; women: 34.5%,  $n = 8$ ; Table 2). Forwards experienced the largest proportion of deltoid ligament sprains in men (44.7%,  $n = 17$ ), whereas guards accounted for the largest proportion in women (73.9%,  $n = 17$ ; Table 3). No sex differences in distributions of injury mechanism or activity were found.

However, the proportion of deltoid ligament sprains sustained by female guards was 2.34 times that of male guards (95% CI = 1.38, 3.97).

The proportion of deltoid ligament sprains that were NTL injuries in men (55.3%,  $n = 21$ ) and women (30.4%,  $n = 7$ ) did not differ (IPR = 1.82; 95% CI = 0.92, 3.59; Figure 2). No severe deltoid ligament sprains were reported in men or women (Figure 2). The proportion of deltoid ligament sprains that were recurrent in men (15.8%,  $n = 6$ ) and women (17.4%,  $n = 4$ ) did not differ (IPR = 0.91; 95% CI = 0.29, 2.88; Figure 3).

### Lacrosse

In lacrosse, 14 deltoid ligament sprains each were reported in men and women, leading to respective rates of 0.70/10 000 AEs (95% CI = 0.33, 1.07) and 0.98/10 000 AE (95% CI = 0.47, 1.49; Table 1). Men sustained equal numbers of injuries during competitions and practices, whereas women experienced more during practices (71.4%,  $n = 10$ ). The deltoid ligament sprain rate was higher in competition than in practice for men (RR = 5.07; 95% CI = 1.78, 14.47) but not for women (RR = 1.70; 95% CI = 0.53, 5.44). Deltoid ligament sprain rates did not differ between men and women (RR = 0.72; 95% CI = 0.34, 1.50).

Most deltoid ligament sprains were due to noncontact (men: 57.1%,  $n = 8$ ; women: 50.0%,  $n = 7$ ; Figure 1) and occurred during general play in men (42.9%,  $n = 6$ ) and running in women (35.7%,  $n = 5$ ; Table 2). Midfielders incurred the largest proportion of deltoid ligament sprains in men (35.7%,  $n = 5$ ), whereas attacks and defense experienced the largest proportions in women (each 35.7%,  $n = 5$ ; Table 3). No sex differences in distributions of injury mechanism, activity, or position were found.

The proportion of deltoid ligament sprains that were NTL injuries in men (42.9%,  $n = 6$ ) and women (78.6%,  $n = 11$ ) did not differ (IPR = 0.55; 95% CI = 0.28, 1.06; Figure 2). No severe deltoid ligament sprains were reported in men or women (Figure 2). The proportion of deltoid ligament sprains that were recurrent in men (7.1%,  $n = 1$ ) and women

**Table 2. Injury Activity Data for Deltoid Ligament Sprains Among Student-Athletes, National Collegiate Athletic Association Injury Surveillance Program, 2009–2010 Through 2014–2015 Academic Years<sup>a</sup>**

Sport and Injury Activity	n (%)
<b>Men's football</b>	
Blocking	38 (24.2)
General play	36 (22.9)
Being tackled	19 (12.1)
Tackling	19 (12.1)
Being blocked	17 (10.8)
Running	13 (8.3)
Receiving pass	6 (3.8)
Chasing loose ball	1 (0.6)
Other/unknown	8 (5.1)
<b>Women's gymnastics</b>	
Balance beam	5 (38.5)
Floor routine	5 (38.5)
Vault	3 (23.1)
<b>Men's basketball</b>	
General play	12 (31.6)
Defending	10 (26.3)
Rebounding	9 (23.7)
Chasing loose ball	3 (7.9)
Shooting	3 (7.9)
Other/unknown	1 (2.6)
<b>Women's basketball</b>	
General play	8 (34.8)
Rebounding	5 (21.7)
Defending	4 (17.4)
Shooting	3 (13.0)
Chasing loose ball	1 (4.3)
Running	1 (4.3)
Other/unknown	1 (4.3)
<b>Men's ice hockey</b>	
General play	5 (50.0)
Goalkeeping	1 (10.0)
Passing	1 (10.0)
Shooting	1 (10.0)
Other/unknown	2 (20.0)
<b>Women's ice hockey</b>	
General play	4 (66.7)
Defending	1 (16.7)
Other/unknown	1 (16.7)
<b>Men's lacrosse</b>	
General play	6 (42.9)
Running	3 (21.4)
Ball handling	2 (14.3)
Defending	2 (14.3)
Chasing loose ball	1 (7.1)
<b>Women's lacrosse</b>	
Running	5 (35.7)
Defending	3 (21.4)
General play	2 (14.3)
Ball handling	1 (7.1)
Checking	1 (7.1)
Other/unknown	2 (14.3)

(42.9%, n = 6) did not differ (IPR = 0.17; 95% CI = 0.02, 1.21; Figure 3). However, the proportion of recurrent deltoid ligament sprains for women was the largest reported among all sports.

**Table 2. Continued**

Sport and Injury Activity	n (%)
<b>Men's soccer</b>	
General play	10 (30.3)
Slidetackle (being tackled)	5 (15.2)
Blocking shot	3 (9.1)
Defending	2 (6.1)
Chasing loose ball	2 (6.1)
Running	2 (6.1)
Ball handling	1 (3.0)
Goalkeeping	1 (3.0)
Heading ball	1 (3.0)
Passing	1 (3.0)
Receiving pass	1 (3.0)
Shooting	1 (3.0)
Slidetackle (tackler)	1 (3.0)
Other/unknown	2 (6.1)
<b>Women's soccer</b>	
General play	12 (27.9)
Ball handling	5 (11.6)
Chasing loose ball	5 (11.6)
Running	4 (9.3)
Defending	3 (7.0)
Passing	3 (7.0)
Blocking shot	2 (4.7)
Receiving pass	2 (4.7)
Slidetackle (being tackled)	2 (4.7)
Slidetackle (tackler)	2 (4.7)
Shooting	1 (2.3)
Other/unknown	2 (4.7)

<sup>a</sup> Sports with deltoid ligament sprain counts <10 (ie, men's baseball and wrestling; women's field hockey, ice hockey, softball, and volleyball; and men's and women's cross-country, swimming and diving, tennis, indoor track and field, and outdoor track and field) were excluded from this table.

## DISCUSSION

We examined the descriptive epidemiology of deltoid ligament sprains in a sample of 25 NCAA sports. Most deltoid ligament sprains occurred due to player contact, and higher rates were found in competitions. Although sex differences were not found when we controlled for similar sports, variations among sports were present. Thus, these findings support the development of sport-specific prevention strategies to reduce the incidence and severity of deltoid ligament sprains.

### Incidence

The highest rates of deltoid ligament sprains were in men's football, women's gymnastics, and men's and women's soccer. However, the rate for women's gymnastics was imprecise (ie, had a wide CI), thereby highlighting the need for further surveillance of deltoid ligament sprains in the sport. Nevertheless, these sports include game play on soft surfaces such as grass or field turf and floor matting. In the systematic review of Fong et al,<sup>14</sup> the highest incidence of ankle sprains occurred in sports played on hard-court surfaces (basketball, handball, netball, tennis, volleyball). These findings differ from our results, given that the highest incidence rates in the NCAA ISP occurred in sports played on soft surfaces. However, Fong et al<sup>14</sup> did not report distinctions between lateral and medial ankle sprains, so lateral ankle sprains may be more common on

**Table 3. Position Data for Deltoid Ligament Sprains Among Student-Athletes, National Collegiate Athletic Association Injury Surveillance Program, 2009–2010 Through 2014–2015 Academic Years<sup>a</sup>**

Sports and Position	n (%)
<b>Men's football</b>	
Wide receiver	21 (13.4)
Linebacker	18 (11.5)
Offensive guard	16 (10.2)
Offensive tackle	16 (10.2)
Running back	16 (10.2)
Defensive tackle	13 (8.3)
Defensive back	12 (7.6)
Defensive end	11 (7.0)
Quarterback	7 (4.5)
Cornerback	6 (3.8)
Tight end	5 (3.2)
Center	3 (1.9)
Safety	3 (1.9)
Special teams	6 (3.8)
Other/unknown	4 (2.5)
<b>Men's basketball</b>	
Forward	17 (44.7)
Guard	12 (31.6)
Center	3 (7.9)
Other/unknown	6 (15.8)
<b>Women's basketball</b>	
Guard	17 (73.9)
Forward	4 (17.4)
Other/unknown	2 (8.7)
<b>Men's ice hockey</b>	
Wing	5 (50.0)
Defense	3 (30.0)
Center	1 (10.0)
Goalkeeper	1 (10.0)
<b>Women's ice hockey</b>	
Defense	3 (50.0)
Wing	2 (33.3)
Other/unknown	1 (16.7)
<b>Men's lacrosse</b>	
Midfielder	5 (35.7)
Defensive back	4 (28.6)
Attack	4 (28.6)
Goalkeeper	1 (7.1)
<b>Women's lacrosse</b>	
Attack	5 (35.7)
Midfielder	5 (35.7)
Other/unknown	4 (28.6)
<b>Men's soccer</b>	
Forward	10 (30.3)
Defensive back	8 (24.2)
Midfielder	8 (24.2)
Goalkeeper	4 (12.1)
Other/unknown	3 (9.1)
<b>Women's soccer</b>	
Forward	15 (34.9)
Defensive back	10 (23.3)
Midfielder	8 (18.6)
Other/unknown	10 (23.3)

<sup>a</sup> Sports with deltoid ligament sprain counts <10 (ie, men's baseball and wrestling; women's field hockey, ice hockey, softball, and volleyball; and men's and women's cross-country, swimming and diving, tennis, indoor track and field, and outdoor track and field) were excluded from this table. Women's gymnastics was not included because it does not use positions.

firmer surfaces, whereas deltoid ligament (medial) sprains are more common on softer surfaces.

The most frequent injury mechanism of deltoid ligament sprains was player contact. Because the medial ankle is reinforced by the contributing ligaments, the amount of force necessary to cause damage must be substantial; thus, sports involving more player contact may increase the likelihood that enough eversion force is generated to damage the deltoid ligament. Athletes in these contact sports may be at greater risk of deltoid ligament sprains due to the eversion produced by valgus forces when they are struck on the lateral ankle by another player. The findings of our study agree with those of the previous literature: the highest incidence of ankle sprains occurred in team sports that involve contact between players (American football, Australian football, field hockey, Gaelic football, lacrosse, rugby, and soccer).<sup>14</sup> We did not examine other factors related to deltoid ligament sprains that may increase (eg, previous injury history)<sup>2,6,8</sup> or reduce (eg, taping and bracing techniques,<sup>15,16</sup> shoe design,<sup>17</sup> team-specific strengthening programming) injury risk. Future investigators should evaluate these potential injury risk factors and prevention strategies.

Compared with lateral ankle-sprain rates in the collegiate sports setting,<sup>3,6–8</sup> deltoid ligament sprains are relatively uncommon. Deltoid ligament sprains are rarely isolated and may occur concurrently with other structural damage, including lateral or bimalleolar fractures.<sup>3,5,15,18</sup> In a study of 288 acute ankle fractures, 39.6% involved the deltoid ligaments,<sup>19</sup> and so deltoid ligament sprains may be underreported due to evaluation and treatment of the ancillary fracture.<sup>20</sup> Properly diagnosing a deltoid ligament sprain is important in order to provide appropriate rehabilitation to prevent chronic ankle instability.<sup>6</sup> The ligamentous stress tests currently used may be unreliable for diagnosing deltoid ligament sprains.<sup>5,21</sup> Further research on a larger patient sample will permit better examinations of the associations between instability and surgical intervention. In addition, validation studies of diagnostic tools and stress tests for deltoid ligament sprains may be beneficial.

### Event Type

Although the number of reported deltoid ligament sprains was higher in practices than in competitions, the competition rate was higher. Players may be more aggressive during competition and engage in more contact with other players, thus increasing their risk of deltoid ligament sprains.<sup>10,22–24</sup> However, practices may reflect more controlled environments, which help to minimize risk. The different findings related to event type may highlight both competitions and practices as areas of intervention to reduce the incidence of injury,<sup>25</sup> such as taping or bracing for external ankle support during both practices and competitions.

### Sex Differences

Sex differences were not present among sex-comparable sports. Our findings differ from those of previous researchers<sup>9</sup> who observed that among cadets at a military academy, men had a higher deltoid ligament sprain rate than women. Furthermore, men in that study lost an average of 6 more days of participation from deltoid ligament sprains,<sup>9</sup> although we observed no differences in participation-restriction time among sex-comparable sports. Differ-



ences between sexes in injury rates and participation-restriction time may be attributable to population variations, yet they warrant continued assessment to better define sex differences that occur not only in collegiate student-athletes but also in individuals of all ages who are physically active.

### **Injury Mechanisms**

Most deltoid ligament sprains occurred from player contact. Player contact can produce excessive eversion and external rotation if the athlete lands on another player's foot or if another player contacts the athlete on the lateral aspect of the leg during a tackle, check, or attempt for the ball, puck, or other object. Earlier investigators<sup>26,27</sup> reported that athletes who were fully (or partially) compliant with warm-up and proprioceptive training programs substantially reduced their risk of lower limb injuries. Therefore, improved proprioception may reduce the risk of ankle injuries by counteracting the hazardous forces acting on the ankle during athletic participation. However, these studies did not differentiate among types of ankle sprains; more research is needed to determine the effectiveness of the programming in reducing the risk of specific types of ankle sprains.

### **Participation-Restriction Time**

Approximately 40% of deltoid ligament sprains were NTL injuries. An additional one-third resulted in loss of 1 to 6 days of participation. The proportion of deltoid ligament sprains that required participation restriction of less than 1 week (72.9%) in our sample of NCAA athletes was higher than that of previous authors.<sup>9</sup> Among military cadets participating in intercollegiate and intramural athletics, 51% returned to sport within 8 days of a deltoid ligament sprain, which was classified as a minor injury.<sup>9</sup> However, the researchers did not specify whether they included NTL deltoid ligament sprains. Similarly, in a study<sup>10</sup> of amateur soccer players who sustained deltoid ligament sprains, the average time lost was 7.28 days; yet again, whether NTL injuries were included is unknown, given that the lowest time-loss category was 7 or fewer days. We included NTL injuries in the analyses and so the overall number of deltoid ligament sprains diagnosed was higher than in the previous literature. Participation-restriction times may have differed among investigations due to variations in injury definitions, the manners in which ATs and team medical staff diagnosed (and potentially misdiagnosed) deltoid ligament sprains, the sports included in the studies, or the availability of treatment and rehabilitation. Future authors should evaluate the effectiveness of specific treatment and rehabilitation protocols for return to play after a deltoid ligament sprain.

### **Recurrence**

Prior injury has been reported to predispose the deltoid ligament to further damage and instability.<sup>2,6,8</sup> The deltoid ligament is the main supporting structure of the medial ankle, and incomplete healing of this ligament may lead to chronic ankle instability.<sup>4,6,8,28</sup> Injury to the deltoid ligament may also lead to multidirectional instability of the ankle joint and necessitate surgical correction.<sup>2</sup> The proportion of recurrent deltoid ligament sprains was very low in this sample, despite the literature suggesting that those with

previous sprains are prone to further laxity.<sup>8</sup> Moreover, only 2 deltoid ligament sprains in this study necessitated surgical repair. Disparate results between our findings and previous findings may reflect variations in reporting and diagnosis. However, it is also possible that rehabilitation protocols improved the predisposing factors leading to the injury, including ankle strength, postural stability, joint positioning, muscle reaction time, range of motion, and ligament stability.<sup>29</sup> In addition, athletes who have sustained previous injuries usually wear supportive bracing or taping to reduce the risk of reinjury, though we did not collect information on whether athletes or programs used interventions aimed at preventing a recurrence. Further investigations are necessary to examine the use and effectiveness of such interventions.

### **LIMITATIONS**

Our study relied on the training and expertise of ATs, alongside other members of the team medical staff, to accurately identify and diagnose patients with deltoid ligament sprains. However, as part of the NCAA ISP, data regarding actual diagnostic protocols, such as the use of magnetic resonance imaging, were not collected. Also, for many sports, injury counts were small and, therefore, cell sizes for deltoid ligament sprains were small. This is likely due to the inherent rarity of these injuries overall and specifically within those sports, as well as potential underreporting due to comorbidity of other anatomical structures. These factors will affect the precision of measurements, which may lead to a higher proportion of statistically insignificant findings. Another limitation is that AEs were not collected according to activity but only by practice and competition. This restricts the assessment of activities that may increase the athlete's risk of injury. Furthermore, an injury's inclusion in the ISP depended on the presence of an AT and an athlete seeking care. Lack of reporting may result in an underestimation of the calculated incidence.

### **CONCLUSIONS**

The highest rates of deltoid ligament sprains were in men's football, women's gymnastics, and men's and women's soccer. Yet the CI for the rate in women's gymnastics was wide, indicating a lack of precision and the need for further surveillance. Most deltoid ligament sprains were due to player contact. Future researchers should assess interventions that may prevent deltoid ligament sprains and provide timely and effective rehabilitative techniques.

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Address correspondence to Elizabeth E. Hibberd, PhD, ATC, The University of Alabama, 483 Russell Hall, Box 870311, Tuscaloosa, AL 35487. Address e-mail to eehibberd@ches.ua.edu.