

# Characteristics of Operative Shoulder Injuries in the National Collegiate Athletic Association, 2009-2010 Through 2013-2014

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**Background:** Injuries to the upper extremity among collegiate athletes are reported to account for approximately 20% of all injuries; however, little is known about the proportion of these injuries that require surgery.

**Purpose/Hypothesis:** The purpose of this study was to examine all shoulder injuries that required a surgical intervention and were recorded in the National Collegiate Athletic Association (NCAA) Injury Surveillance Program (ISP). We hypothesized that contact would be the mechanism causing injuries most at risk for needing surgery and that dislocations would be the injuries most likely to require an operative intervention.

**Study Design:** Cross-sectional study; Level of evidence, 3.

**Methods:** Injury surveillance data between 2009-2010 and 2013-2014 for operative collegiate shoulder injuries and their associated sport exposures were analyzed.

**Results:** A total of 185 operative shoulder injuries occurred over 3,739,004 athlete-exposures (AEs), for an overall incidence of 0.49 per 10,000 AEs. The sports with the highest incidence of operative injuries were men's football (1.31/10,000 AEs), men's wrestling (1.14/10,000 AEs), men's ice hockey (0.60/10,000 AEs), women's gymnastics (0.44/10,000 AEs), and men's swimming (0.41/10,000 AEs). Men were significantly more likely than women to sustain operative injuries for all sports combined. Of the injuries that required surgical treatment, superior labrum from anterior to posterior (SLAP) tears (46.4%), other non-SLAP glenoid labrum tears (46.2%), anterior shoulder dislocations (33.3%), and posterior shoulder dislocations (30.0%) were seen most often. There was no significant difference in injury proportion ratios (IPRs) for injuries requiring surgery when comparing contact versus noncontact mechanisms of injury (IPR, 1.0 [95% CI, 0.6-1.6]). The incidence of operative injuries sustained during competition was significantly higher compared with during practice.

**Conclusion:** The sports with the highest incidence of operative shoulder injuries were men's football, men's wrestling, men's ice hockey, and women's gymnastics. Operative shoulder injuries were more likely to occur during competition. SLAP tears, other non-SLAP glenoid labrum tears, and anterior shoulder dislocations had the highest incidence of requiring surgery. Athletes sustaining these injuries, along with their coaches and medical providers, may benefit from identifying collegiate sport participants who are at highest risk for sustaining an operative injury. This may assist in planning medical care and setting expectations, which may be critical to a young athlete's career.

**Keywords:** upper extremity; shoulder; operative; recurrent; contact

The National Collegiate Athletic Association (NCAA) Injury Surveillance Program (ISP) has recorded injury data from NCAA sports for over 2 decades.<sup>19</sup> This database has been utilized to report injury rates, examine trends in injuries, and evaluate the impact of injury

prevention strategies.<sup>1-8,10-16,18,19,22</sup> Despite an emphasis on improving protective gear and implementing injury prevention strategies, recent studies have reported that the injury rate among collegiate athletes ranges from 35.9 to 40.2 injuries per 1000 athlete-exposures (AEs).<sup>19,23,24</sup> Injuries to the upper extremity are reported to account for approximately 20% of all injuries; however, little is known regarding the proportion of these injuries that require surgery.<sup>19</sup>

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The overall incidence of operative shoulder injuries among collegiate athletes has not been reported.<sup>19,23</sup> Understanding the incidence of operative shoulder injuries is particularly important for collegiate athletes, who often “retire” from their respective sport after sustaining an injury, as these injuries are often more serious and may have longer term sequelae.<sup>9</sup> Although multiple studies have examined injury rates among collegiate athletes, there is a paucity of literature that specifically examines the characteristics of operative shoulder injuries in this population. Mehran et al<sup>23</sup> evaluated the epidemiology of surgical procedures at a single institution, but this study was limited to NCAA Division I football players and was not applicable to the majority of collegiate athletes. The objective of this study was to examine all shoulder injuries that required a surgical intervention and that were recorded in the NCAA ISP. We hypothesized that contact would be the mechanism causing injuries most at risk for needing surgery and that dislocations would be the injuries most likely to require an operative intervention.

## METHODS

The NCAA Research Review Board and our institutional review board assessed our methods and deemed this study exempt.

### Data Collection

We retrospectively analyzed deidentified injury surveillance data from the NCAA ISP between the 2009-2010 and 2013-2014 academic years for operative collegiate shoulder injuries and their associated sport exposures. The NCAA ISP is managed by the Datalys Center for Sports Injury Research and Prevention, an independent, nonprofit research organization. The methodology for data collection and organization for the 2009-2010 to 2014-2015 academic years has been described previously.<sup>17,21</sup>

The ISP database represents data from a subset of NCAA teams from 25 sports across all divisions. Selected athletic trainers are tasked with inputting data related to injuries and exposures from all team-sanctioned practices and competitions into a web-based system. The number of programs and data provided vary by sport and by year. The data recorded include type of injury, body part injured, injury severity measures (time loss, need for surgery), mechanism of injury, and player position.

With data provided from the 2009-2010 through 2013-2014 injury data set, body part code “shoulder” was queried. Data were further investigated based on event type, outcome, injury, recurrence, and sport. Injuries were recorded if they occurred during a practice or competition and required

medical attention, even if they did not result in time loss. Injuries were then matched with the associated exposure data set. An AE was defined as 1 athlete participating in a game or practice, regardless of the duration, during which he or she was exposed to the possibility of an athletic injury. All analyses were performed using unweighted injuries and exposures.

### Statistical Analysis

Data were assessed for frequencies and rates of shoulder injuries that required a surgical intervention. The incidence rate of operative shoulder injuries was calculated as the total number of shoulder injuries divided by the number of AEs. For comparison with previous studies, incidence was reported as injuries per 10,000 AEs. Unless specifically noted, all incidences are those of operative injuries rather than overall injuries. Based on large-sample assumptions for normal approximation to Poisson distribution, 95% CIs were reported for all incidence rates.<sup>21</sup> The likelihood that an injury was operative was reported as a percentage. For variables that were associated with specific exposures (sport, sex, division, time in season), injury rate ratios (IRRs) were calculated. The need for surgery was expressed as a percentage of patient injuries that were managed surgically, and injury proportion ratios (IPRs) were calculated to determine risk factors for the surgical management of an injury. All ratios with 95% CIs that did not include 1.00 were considered statistically significant.

## RESULTS

One hundred eighty-five operative shoulder injuries occurred over 3,739,004 AEs, for an overall incidence of 0.49 per 10,000 AEs (Table 1). The sports with the highest incidence of operative shoulder injuries were men’s football (1.31/10,000 AEs), men’s wrestling (1.14/10,000 AEs), men’s ice hockey (0.60/10,000 AEs), women’s gymnastics (0.44/10,000 AEs), and men’s swimming (0.41/10,000 AEs). The sports with the highest proportion of shoulder injuries that required surgery were women’s lacrosse (15.4%), men’s football (9.9%), men’s swimming (7.8%), women’s gymnastics (7.4%), and men’s wrestling (7.3%) (Figure 1).

### Sex

Men were significantly more likely to sustain operative shoulder injuries than women for all sports combined (incidence, 0.72/10,000 AEs vs 0.15/10,000 AEs, respectively; IRR, 4.9 [95% CI, 3.1-7.6];  $P < .001$ ), and men had a higher likelihood of having a shoulder injury that would need surgery (IPR, 1.8 [95% CI, 1.2-2.8];  $P = .009$ ) (Table 1). When considered individually, all sex-matched sports had both

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TABLE 1  
Risk Factors for Operative Shoulder Injuries<sup>a</sup>

Risk Factor	Operative Injuries, n (%)	Incidence of Operative Injuries (per 10,000 AEs)	Likelihood of Sustaining an Operative Injury, IRR (95% CI)	P	% of Injuries Treated Operatively	Likelihood of the Injury Needing Operative Treatment IPR (95% CI)	P
Sex							
Male	163 (88.1)	0.72	4.9 (3.1-7.6)	<.001 <sup>b</sup>	7.5	1.8 (1.2-2.8)	.009 <sup>b</sup>
Female (ref)	22 (11.9)	0.15			4.1		
Event type							
Competition	73 (39.5)	1.05	2.9 (2.1-3.8)	<.001 <sup>b</sup>	5.7	0.7 (0.5-1.0)	.060
Practice (ref)	112 (60.5)	0.37			7.8		
Season							
Preseason (ref)	49 (26.5)	0.49			6.4		
Regular season	130 (70.3)	0.52	0.9 (0.7-1.3)	.458	7.0	1.1 (0.8-1.5)	.752
Postseason	6 (3.2)	0.29	1.7 (0.7-4.0)	.212	7.4	1.1 (0.5-2.8)	.663
Time in competition							
Early in game (ref)	26 (44.1)	0.34			6.7		
Late in game	33 (55.9)	0.31	0.9 (0.5-1.5)	.712	5.3	0.8 (0.5-1.3)	.386
Division							
Division I (ref)	114 (61.6)	0.60			7.2		
Division II	28 (15.1)	0.49	0.8 (0.5-1.2)	.332	10.3	1.4 (0.9-2.2)	.098
Division III	43 (23.2)	0.34	1.8 (1.3-2.5)	.001 <sup>b</sup>	5.1	0.7 (0.5-1.0)	.064
Injury history							
New injury (ref)	121 (66.1)	0.32			5.3		
Recurrence from prior year	32 (11.4)	N/A	N/A	N/A	11.2	2.1 (1.4-3.2)	<.001 <sup>b</sup>
Recurrence from same year	30 (9.6)	N/A	N/A	N/A	22.7	4.3 (2.8-6.6)	<.001 <sup>b</sup>
Injury mechanism							
Contact	97 (75.2)	N/A	N/A	N/A	5.3	1.0 (0.6-1.6)	.920
Noncontact (ref)	32 (24.8)	N/A	N/A	N/A	11.2		

<sup>a</sup>AE, athlete-exposure; IPR, injury proportion ratio; IRR, injury rate ratio; N/A, not available; ref, reference.

<sup>b</sup>Statistical significance.

similar incidences of operative shoulder injuries and similar likelihoods that the injury would need operative treatment (Figure 1).

## Injury

When considered together, instability injuries were the most common type of operative shoulder injury (61.6% of all operative shoulder injuries; incidence, 0.30/10,000 AEs) (Table 2). Similarly, the injuries that were most likely to require surgery were Hill-Sachs lesions (66.7%), superior labrum from anterior to posterior (SLAP) tears (46.4%), other non-SLAP glenoid labrum tears (46.2%), anterior shoulder dislocations (33.3%), and posterior shoulder dislocations (30.0%). Shoulder instability injuries required surgery in 22.2% of athletes.

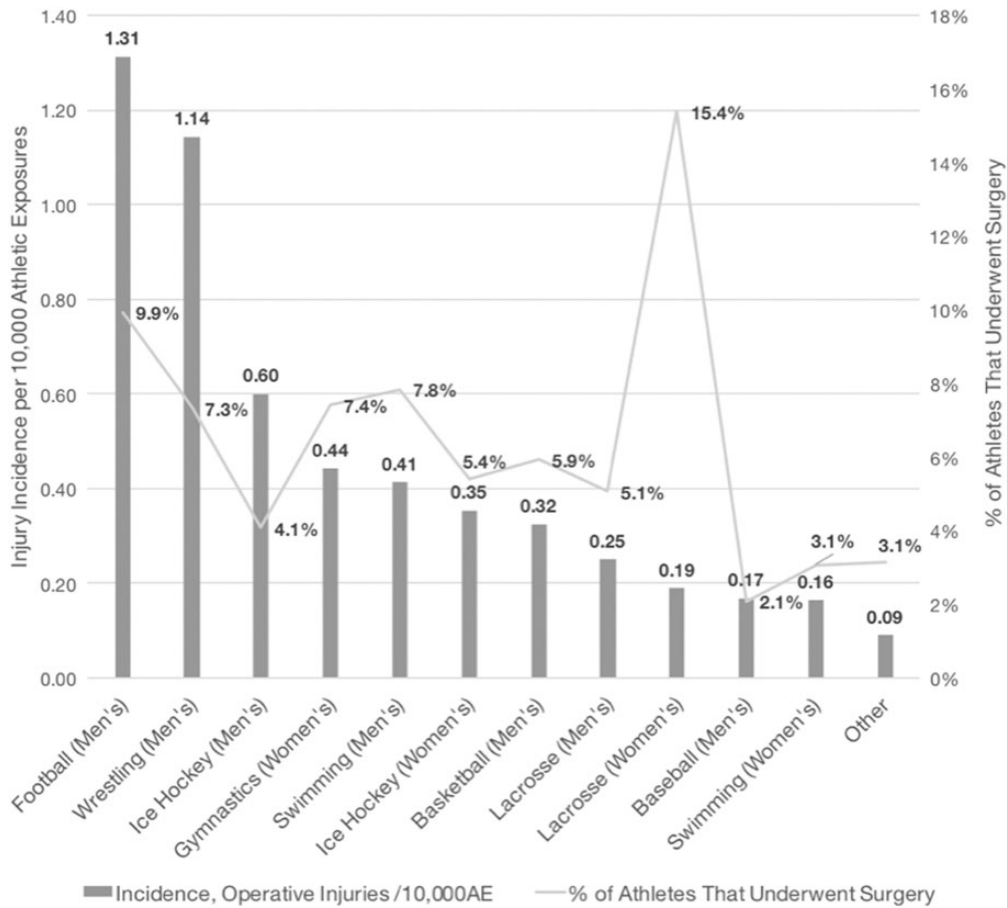
## Timing

The incidence of operative shoulder injuries during competition was 1.05 per 10,000 AEs, while the incidence of operative shoulder injuries sustained during practice was 0.37 per 10,000 AEs (Table 1). While the IRR was significantly higher in competition (IRR, 2.9 [95% CI, 2.1-3.8];  $P < .001$ ), shoulder injuries sustained during competition were only

slightly less likely to require surgery compared with injuries sustained during practice (IPR, 0.7 [95% CI, 0.5-1.0];  $P = .060$ ). There was no significant difference between the incidence of shoulder injuries early and late in the game (IRR, 0.9 [95% CI, 0.5-1.5];  $P = .712$ ) or in the likelihood that those injuries would require surgery (IPR, 0.8 [95% CI, 0.5-1.3];  $P = .386$ ). Similarly, there was no significant difference between the different times of the season (preseason, regular season, postseason) in either the incidence of operative shoulder injuries or the likelihood that they would require surgery.

## Other

There was no significant difference in the percentage of shoulder injuries requiring surgery when comparing contact versus noncontact mechanisms of injury (IPR, 1.0 [95% CI, 0.6-1.6];  $P = .920$ ), although operative injuries were 5.1-fold more likely to occur with a contact mechanism. In comparison with new shoulder injuries, recurrent injuries were significantly more likely to require surgery (injury recurrent from the previous season: IPR, 2.1 [95% CI, 1.4-3.2]; injury recurrent from the same season: IPR, 4.3 [95% CI, 2.8-6.6];  $P < .001$  for both). Of note, 11.2% of recurrent shoulder injuries that occurred during the previous season,



**Figure 1.** Incidence of operative shoulder injuries in National Collegiate Athletic Association (NCAA) athletes and percentage of athletes with a shoulder injury that required an operative intervention. AE, athlete exposures.

**TABLE 2**  
Epidemiology of Shoulder Injuries in NCAA Athletes Stratified Based on Injury Type<sup>a</sup>

Injury	No. of Operative Injuries	Incidence of Operative Shoulder Injuries		% of Operative Injuries	Total No. of Injuries	Incidence of All Shoulder Injuries		% of Total Injuries	% of Injuries Needing Operative Treatment
		Per 10,000 AEs	95% CI			Per 10,000 AEs	95% CI		
Shoulder instability (anterior + posterior dislocation or subluxation, Hill-Sachs lesion, non-SLAP glenoid labrum tear)	111	0.30	0.25-0.36	61.6	499	1.47	1.35-1.59	18.4	22.2
Glenoid labrum tear (SLAP)	32	0.09	0.06-0.12	17.3	69	0.18	0.14-0.23	2.5	46.4
Clavicular fracture	8	0.02	0.01-0.04	4.3	33	0.09	0.06-0.12	1.2	24.2
Rotator cuff tear	6	0.02	0.00-0.03	3.2	275	0.74	0.65-0.82	10.1	2.2
Acromioclavicular sprain	7	0.02	0.00-0.03	3.8	695	1.86	1.72-2.00	25.6	1.0
Multidirectional instability	3	0.01	0.00-0.02	1.6	51	0.14	0.10-0.17	1.9	5.9
Scapular fracture	2	0.01	0.00-0.01	1.1	10	0.03	0.01-0.04	0.4	20.0
Other injury	16	0.04	0.02-0.06	8.6	1079	2.89	2.71-3.06	39.8	1.5
<b>Total</b>	<b>185</b>	<b>0.49</b>	<b>0.42-0.57</b>	<b>100.0</b>	<b>2711</b>	<b>7.25</b>	<b>6.98-7.52</b>	<b>100.0</b>	<b>6.8</b>

<sup>a</sup>AE, athlete-exposure; NCAA, National Collegiate Athletic Association; SLAP, superior labrum from anterior to posterior.

and 22.7% of those recurrent from the same season, required surgery.

The incidence of operative shoulder injuries in Division I athletes was 0.60 per 10,000 AEs, in Division II athletes it was 0.49 per 10,000 AEs, and in Division III athletes it was 0.34 per 10,000 AEs. Compared with Division III, the incidence of operative shoulder injuries was higher in Division I (IRR, 1.8 [95% CI, 1.3-2.5];  $P = .001$ ), but the injury incidence and severity were otherwise similar between divisions.

## DISCUSSION

The objective of this investigation was to report the characteristics of operative shoulder injuries in the NCAA ISP database. Sports with the highest incidence of operative shoulder injuries were men's football, men's wrestling, men's ice hockey, women's gymnastics, and men's swimming. This is likely related to the degree of contact that occurs in football, wrestling, and ice hockey and the overuse that occurs in swimming, and it follows the pattern of operative shoulder injuries being more likely to occur in male athletes, during competition, and with a contact mechanism. Of the injuries that required surgical treatment, SLAP tears, other non-SLAP glenoid labrum tears, and anterior shoulder dislocations were seen most often. In contrast to our hypothesis, there was no significant difference in the percentage of shoulder injuries requiring surgery when comparing contact versus noncontact mechanisms of injury. Recurrent shoulder injuries had a significantly higher likelihood of requiring surgery, as did injuries in male athletes. Recurrence often indicates a failure of non-operative treatment and is likely why athletes with recurrence were more likely to require an operative intervention.

Although multiple studies have examined injury rates among collegiate athletes, there is a paucity of literature that specifically examines the characteristics of operative shoulder injuries in this population. Mehran et al<sup>23</sup> evaluated the epidemiology of all surgical procedures (ie, upper and lower extremities) that were conducted on collegiate athletes from a single Division I football team over the course of 10 seasons. Labral repair for shoulder instability was the most common shoulder procedure performed on these athletes, accounting for 12.2% ( $n = 31$ ) of all the injuries. The majority of operative procedures were anterior labral repairs (67.7%), while 19.4% were posterior labral repairs. Other surgical procedures were the open Bristow procedure (6.5%), combined anterior and posterior labral repair (3.2%), and superior labral repair (3.2%). Similarly, we found that shoulder instability (anterior + posterior dislocation or subluxation, Hill-Sachs lesion, non-SLAP glenoid labrum tear) accounted for the highest incidence of operative shoulder injuries among collegiate athletes across all sports and divisions.

Kaplan et al<sup>20</sup> examined the prevalence of shoulder injuries in 336 elite collegiate football players at a single National Football League Combine. Of this cohort, 50% of the players had a history of at least 1 shoulder injury (226 shoulder injuries), and 34% of those players ( $n = 56$ ) reported requiring at least 1 surgical intervention (73

surgical procedures). The most common surgical procedures were anterior instability stabilization (48%), Mumford/Weaver-Dunn surgery (15%), posterior instability stabilization (10%), and rotator cuff repair (7%). Our study similarly demonstrated that injuries or abnormalities associated with shoulder instability were among the leading shoulder injuries in collegiate athletes, both in the overall number and in the likelihood of requiring surgery. In contrast, acromioclavicular injuries accounted for only 3.8% of operative shoulder injuries among collegiate athletes. This suggests that these injuries could be successfully managed conservatively.

The current study has a number of limitations. It is a retrospective analysis of the NCAA ISP, a prospectively collected database, which collects data from a convenience sample of institutions sponsoring intercollegiate sports and assigns weights to injuries and exposures to allow extrapolation to the entire NCAA population. Sampling varies by year and is not complete, although the NCAA supplies a weighting formula in an attempt to extrapolate national estimates and account for reporting differences annually and between divisions. This introduces the possibility for either overestimation or underestimation of the incidence of injuries. This database also relies on the entry of injuries by the team athletic trainers, without the confirmation of a diagnosis by physicians, which could lead to either overreporting or underreporting of injury rates. The athletic trainers are also limited to the confines of the designed system in that it is a simplified system, with no allowance for free-text comments or the classification of injury severity.

The NCAA ISP does not provide any diagnostic imaging results or physical examination findings, nor does it have the ability to differentiate between similarly classified clinical entities with a range of severity (ie, rotator cuff tear), which would be useful in classifying the severity of injury. The lack of disease severity can further result in the overestimation or underestimation of rates of operative injuries. For instance, minor rotator cuff strains could be incorrectly labeled as tears, which would misrepresent the proportion of actual tears that fail conservative management and require surgery. Furthermore, clinical follow-up (aside from time loss and the need for surgery) and treatment decision making are not captured in this database. The type of surgical repair, as well as the time that it took for an athlete to return to play after surgical reconstruction, is not provided. Finally, shoulder injuries sustained by collegiate athletes may undergo surgical treatment in the future (ie, after graduation or transfer) and may not be captured in the database. This would result in an underestimation of the actual number of operative shoulder injuries. Despite these limitations, this method of data collection has been previously validated in a number of epidemiological studies of American collegiate athletics. Therefore, we believe that this method allows the most current and accurate description of operative shoulder injuries in NCAA athletes.

## CONCLUSION

This study demonstrates that the collegiate sports with the highest incidence of operative shoulder injuries are

men's football, men's wrestling, men's ice hockey, and women's gymnastics. Operative shoulder injuries were more likely to occur during competition. SLAP tears, other non-SLAP glenoid labrum tears, and anterior shoulder dislocations had the highest incidence of injuries that required surgery. This study reports the characteristics of collegiate athletes at risk of sustaining operative shoulder injuries. Coaches, physicians, and athletic trainers can take this into account to better counsel athletes, set expectations, and more appropriately plan medical care.

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## REFERENCES

- Agel J, Arendt EA, Bershadsky B. Anterior cruciate ligament injury in National Collegiate Athletic Association basketball and soccer: a 13-year review. *Am J Sports Med.* 2005;33(4):524-531.
- Agel J, Dick R, Nelson B, Marshall SW, Dompier TP. Descriptive epidemiology of collegiate women's ice hockey injuries: National Collegiate Athletic Association Injury Surveillance System, 2000-2001 through 2003-2004. *J Athl Train.* 2007;42(2):249-254.
- Agel J, Dompier TP, Dick R, Marshall SW. Descriptive epidemiology of collegiate men's ice hockey injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. *J Athl Train.* 2007;42(2):241-248.
- Agel J, Evans TA, Dick R, Putukian M, Marshall SW. Descriptive epidemiology of collegiate men's soccer injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2002-2003. *J Athl Train.* 2007;42(2):270-277.
- Agel J, Olson DE, Dick R, Arendt EA, Marshall SW, Sikka RS. Descriptive epidemiology of collegiate women's basketball injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. *J Athl Train.* 2007;42(2):202-210.
- Agel J, Palmieri-Smith RM, Dick R, Wojtys EM, Marshall SW. Descriptive epidemiology of collegiate women's volleyball injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. *J Athl Train.* 2007;42(2):295-302.
- Agel J, Ransone J, Dick R, Oppliger R, Marshall SW. Descriptive epidemiology of collegiate men's wrestling injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. *J Athl Train.* 2007;42(2):303-310.
- Arendt E, Dick R. Knee injury patterns among men and women in collegiate basketball and soccer: NCAA data and review of literature. *Am J Sports Med.* 1995;23(6):694-701.
- Brophy RH, Gill CS, Lyman S, Barnes RP, Rodeo SA, Warren RF. Effect of shoulder stabilization on career length in National Football League athletes. *Am J Sports Med.* 2011;39(4):704-709.
- Dick R, Ferrara MS, Agel J, et al. Descriptive epidemiology of collegiate men's football injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. *J Athl Train.* 2007;42(2):221-233.
- Dick R, Hertel J, Agel J, Grossman J, Marshall SW. Descriptive epidemiology of collegiate men's basketball injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. *J Athl Train.* 2007;42(2):194-201.
- Dick R, Hootman JM, Agel J, Vela L, Marshall SW, Messina R. Descriptive epidemiology of collegiate women's field hockey injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2002-2003. *J Athl Train.* 2007;42(2):211-220.
- Dick R, Lincoln AE, Agel J, Carter EA, Marshall SW, Hinton RY. Descriptive epidemiology of collegiate women's lacrosse injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. *J Athl Train.* 2007;42(2):262-269.
- Dick R, Putukian M, Agel J, Evans TA, Marshall SW. Descriptive epidemiology of collegiate women's soccer injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2002-2003. *J Athl Train.* 2007;42(2):278-285.
- Dick R, Romani WA, Agel J, Case JG, Marshall SW. Descriptive epidemiology of collegiate men's lacrosse injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. *J Athl Train.* 2007;42(2):255-261.
- Dragoo JL, Braun HJ, Durham JL, Chen MR, Harris AHS. Incidence and risk factors for injuries to the anterior cruciate ligament in National Collegiate Athletic Association football: data from the 2004-2005 through 2008-2009 National Collegiate Athletic Association Injury Surveillance System. *Am J Sports Med.* 2012;40(5):990-995.
- Eckard TG, Padua DA, Dompier TP, Dalton SL, Thorborg K, Kerr ZY. Epidemiology of hip flexor and hip adductor strains in National Collegiate Athletic Association athletes, 2009/2010-2014/2015. *Am J Sports Med.* 2017;45(12):2713-2722.
- Gardner EC, Chan WW, Sutton KM, Blaine TA. Shoulder injuries in men's collegiate lacrosse, 2004-2009. *Am J Sports Med.* 2016;44(10):2675-2681.
- Hootman JM, Dick R, Agel J. Epidemiology of collegiate injuries for 15 sports: summary and recommendations for injury prevention initiatives. *J Athl Train.* 2007;42(2):311-319.
- Kaplan LD, Flanigan DC, Norwig J, Jost P, Bradley J. Prevalence and variance of shoulder injuries in elite collegiate football players. *Am J Sports Med.* 2005;33(8):1142-1146.
- Kerr ZY, Dompier TP, Snook EM, et al. National Collegiate Athletic Association Injury Surveillance System: review of methods for 2004-2005 through 2013-2014 data collection. *J Athl Train.* 2014;49(4):552-560.
- Kerr ZY, Quigley A, Yeargin SW, et al. The epidemiology of NCAA men's lacrosse injuries, 2009/10-2014/15 academic years. *Inj Epidemiol.* 2017;4(1):6.
- Mehran N, Photopoulos CD, Narvy SJ, Romano R, Gamradt SC, Tibone JE. Epidemiology of operative procedures in an NCAA Division I football team over 10 seasons. *Orthop J Sports Med.* 2016;4(7):2325967116657530.
- Shankar PR, Fields SK, Collins CL, Dick RW, Comstock RD. Epidemiology of high school and collegiate football injuries in the United States, 2005-2006. *Am J Sports Med.* 2007;35(8):1295-1303.