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TYPE: Article CC:CCL

JOURNAL TITLE: Physician and sportsmedicine

USER JOURNAL TITLE: The Physician and Sportsmedicine

ARTICLE TITLE: Epidemiology of shoulder and elbow injuries in National Collegiate Athletic Association wrestlers, 2009-2010 through 2013-2014

ARTICLE AUTHOR: Avi D. Goodman, John Twomey-Kozak, Steven F. DeFro

VOLUME: 46

ISSUE: 3

MONTH: 1

YEAR: 2018

PAGES: 361-366

ISSN: 0091-3847

OCLC #:

Processed by RapidX: 5/9/2023 8:40:39 PM

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**To cite this article:** Avi D. Goodman, John Twomey-Kozak, Steven F. DeFroda & Brett D. Owens (2018) Epidemiology of shoulder and elbow injuries in National Collegiate Athletic Association wrestlers, 2009-2010 through 2013-2014, The Physician and Sportsmedicine, 46:3, 361-366, DOI: [10.1080/00913847.2018.1425596](https://doi.org/10.1080/00913847.2018.1425596)

**To link to this article:** <https://doi.org/10.1080/00913847.2018.1425596>



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CLINICAL FEATURE  
ORIGINAL RESEARCH



## Epidemiology of shoulder and elbow injuries in National Collegiate Athletic Association wrestlers, 2009–2010 through 2013–2014

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### ABSTRACT

**Objectives:** Examination of the incidence of shoulder and elbow injuries in the collegiate wrestling population is limited. Therefore, we sought to determine the incidence of shoulder and elbow injuries in wrestlers competing in the National Collegiate Athletic Association (NCAA), and investigate the risk factors involved.

**Methods:** All shoulder and elbow injuries in wrestlers from the 2009–2010 through 2013–2014 academic years in the NCAA Injury Surveillance Program database were extracted. The incidence of different injuries, sports, activity, time-in-game, competition status, and injury characteristics was recorded. Risk-ratios were calculated to determine risk factors for injury.

**Results:** Collegiate wrestlers had an incidence of 21.59 shoulder and elbow injuries per 10,000 athletic exposures (AEs). The most frequent injury types included elbow ulnar collateral ligament tears, shoulder impingement, and acromioclavicular joint sprains, although there was significant variability. Freshman collegiate wrestlers suffered a significantly higher percentage of shoulder and elbow injuries than more senior athletes, signifying an association between experience and injury risk. There was a 4-fold higher incidence of injury during competition. Injuries were significantly more likely to occur later in the match, with a 2.5-fold increased risk compared with early. While 26.8% of wrestlers were out of play for at least 14 days, only 5.9% of all injuries required surgery. Lastly, Division I collegiate wrestlers had the highest overall injury rate.

**Conclusions:** Collegiate wrestlers have a high incidence of shoulder and elbow injury, with specific risk factors identified here. This at-risk patient population should be monitored closely for signs of fatigue, which may leave them susceptible to injury. Further prospective investigation of wrestling injuries with a special attention to injury prevention in higher risk athletes are needed to further validate these findings.

### ARTICLE HISTORY

Received 14 November 2017

Accepted 5 January 2018

### KEYWORDS

NCAA; wrestling; elbow instability; shoulder instability; epidemiology; database

### Introduction

Collegiate wrestling has recently grown in popularity, with 232 teams participating in National Collegiate Athletic Association (NCAA) competition [1]. However, recent literature has reported a high incidence of injury in the collegiate wrestler population. Given the high demands and physical nature of this sport, an understanding of the injury profile of men's collegiate wrestling is important for athletes, coaches, and health-care providers.

There are few reports in the recent literature demonstrating the epidemiology of shoulder and elbow injuries in the collegiate wrestler population. Furthermore, the reports that do currently exist fail to distinguish and review the variety of different factors that contribute to the injury rates in collegiate wrestling. An improved understanding of the potential sport-specific risk factors for these types of injuries in collegiate wrestling may help to develop preventative and safety strategies. Therefore, we sought to characterize the epidemiology of shoulder and elbow injuries in collegiate wrestlers using the

NCAA-Injury Surveillance Program (NCAA-ISP) database, and determine the most severe injuries along with the risk factors for their occurrence.

### Materials and methods

#### Data collection

Deidentified injury surveillance data from men wrestlers in the NCAA-ISP between the 2009–2010 and 2013–2014 academic years were queried to identify shoulder and elbow injuries. 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 organizing for the 2009–2010 to 2013–2014 academic years has been previously described by Kerr et al., and is commonly used to describe NCAA injury epidemiology [2–7].

All injuries and associated data were recorded (usually by athletic trainers, but also by physicians or other providers) if they occurred during a practice or competition and required medical

attention, even if they did not result in time lost. Data were further investigated based on injury, seniority, recurrence (acute, recurrent from previous academic year, recurrent from same academic year), weight class, contact status, time in match, and time in season. Outcomes included incidence of injury, time loss (included season-ending status), and need for surgery.

Time of injury during each wrestling match was also recorded. In collegiate wrestling, a match consists of two individual wrestlers of the same weight class sparring for three periods, for a total of 7 regulation minutes. The first period is 3 min long, followed by the second and third periods, which are 2 min each. If the score is tied at the end of the third period, an overtime round decides the winner. 'Early-in-match' was considered to be the first period, with 'late-in-match' considered to be the second or third periods, or overtime. As not all matches went the full time, the exposures were considered equal between 'early' and 'late'. A 'severe' injury was defined as one that resulted in 14 days or more lost from competition (including season-ending injuries).

Injuries were then matched with the 2009–2010 through 2013–2014 weighted exposure dataset, which provides information about exposures by academic year, time in season (pre-, regular-, or postseason), and event type (practice or competition). An athlete exposure (AE) is defined by one athlete participating in a competition or practice, during which he is exposed to a possibility of athletic injury.

### Statistical methods

The ISP is drawn from a convenience sample of NCAA varsity teams, for which the athletic trainers input data related to injury and exposure from all team-sanctioned practices and competitions into a web-based system. The number of programs and data provided vary by year. Therefore, each injury and AE are given a post-stratification sampling weight (provided by the NCAA) to allow an extrapolation from the reported sample to a national estimate of the NCAA population. Sampling weights were determined based on sport, division of competition, and academic year. The sampling weights were utilized for all analyses and weighted numbers were reported. It has previously been shown in soccer that this sampling method has a sensitivity of 88.3%, which is taken into account in the weighting [8,9]. Due to the need for privacy, the date of injury or precise time in season (beginning versus end) is not given.

Data were assessed for incidence of shoulder and elbow injuries, calculated as the total number of injuries divided by number of AE, and reported as injuries per 10,000 AEs. Based on large-sample assumptions for normal approximation to Poisson distribution, 95% confidence intervals [95% CIs] were used for all incidence rates. Risk ratios (RRs) were used to determine the rates of injury sustained by players with regard to different risk factors, including type of session, contact, time in game, and time in season. All RRs with 95% CIs that did not include 1.00 were considered statistically significant. Analyses were performed with Microsoft Excel 2016 (Redmond, WA, U.S. A.). The study methods and permission to conduct the study was granted by the NCAA Research Review Board and was deemed exempt by our Institutional Review Board.

## Results

From the 2009–2010 through 2013–2014 academic years, NCAA wrestlers sustained 6200 shoulder and elbow injuries over 2,871,519 AEs, for an incidence of 21.59/10,000 AEs (95% CI: 21.05–22.13). Freshman sustained the highest proportion of injuries (35.9%), significantly higher than those of more senior classes ( $p < 0.0001$ , Figure 1). Wrestlers in the 149 lb weight class had the highest burden of injury (12.6%, Figure 2), followed by heavyweights (12.5%).

The most common injuries were ulnar collateral ligament (UCL) tears, shoulder impingement, acromioclavicular (AC) sprain, and rotator cuff tears (Table 1). Injuries to the shoulder were most common (69.0%), followed by elbow (27.8%), and upper arm (3.2%). Taken together, elbow instability injuries (dislocation, hyperextension, and UCL tear) comprised 19.8% of injuries (4.27/10,000 AEs incidence), while shoulder instability injuries (anterior and posterior dislocation/subluxation, multidirectional instability, and non-SLAP glenoid labrum tear) were 13.7% of all injuries (incidence 2.96/10,000 AEs). Of all injuries, 91.6% were acute, compared to 7.4% that were recurrent from a previous academic year and 1.0% recurrent from the same academic year.

Injury incidence varied substantially by time in season. Preseason injuries had an incidence of 22.30/10,000 AEs (95% CI: 21.30–23.30), while the incidence during regular season was 22.68/10,000 AEs (95% CI: 21.99–23.38), and

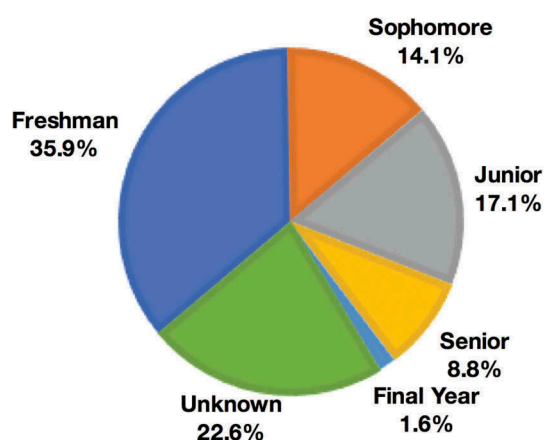


Figure 1. Injuries by class.

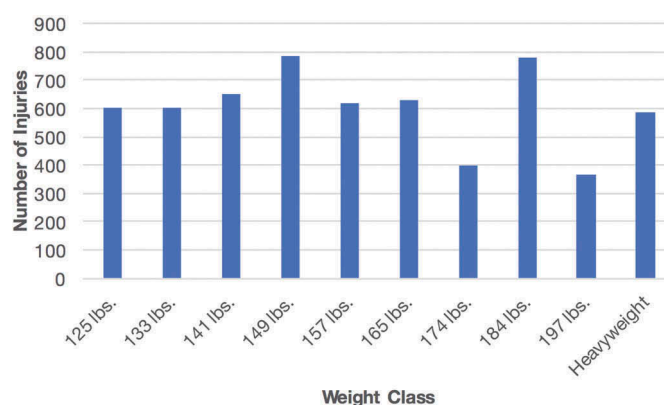


Figure 2. Injuries by weight class.

**Table 1.** Incidence of shoulder and elbow injuries in NCAA wrestlers.

Injury	Injuries (weighted)	Percentage of injuries (%)	Incidence (/10,000 AEs)	95% CI
Ulnar collateral ligament tear – partial or complete	582	9.4	2.03	1.86–2.19
Shoulder impingement	578	9.3	2.01	1.85–2.18
Acromioclavicular sprain – partial or complete	482	7.8	1.68	1.53–1.83
Other shoulder injury	430	6.9	1.50	1.35–1.64
Rotator cuff tear – partial or complete	389	6.3	1.35	1.22–1.49
Anterior subluxation	372	6.0	1.30	1.16–1.43
Elbow hyperextension	332	5.3	1.15	1.03–1.28
Elbow dislocation	311	5.0	1.08	0.96–1.2
Other injuries	2724	43.9	9.13	9.13–9.84
<b>Total injuries</b>	<b>6200</b>	<b>100.0</b>	<b>21.59</b>	<b>21.05–22.13</b>

AE: athletic exposure; CI: confidence interval; NCAA: National Collegiate Athletic Association.

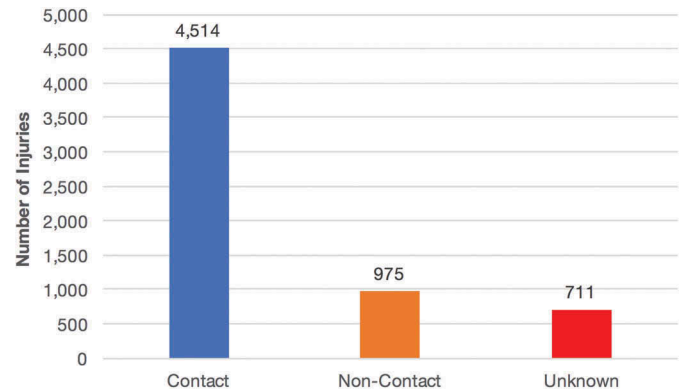
postseason incidence was 9.30/10,000 AEs (95% CI: 8.00–10.61). While the incidence of pre- and regular-season injuries was similar, they were both 2.4-fold higher than that of the postseason (95% CI: 2.1–2.8,  $p < 0.0001$  for both).

Although competition comprised only 15.8% of AEs, wrestlers suffered 31.5% of injuries during competition (incidence 65.80/10,000 AEs), 4.0-fold higher than practice (16.50/10,000 AEs,  $p < 0.0001$ ). When stratified by setting (practice vs. competition), injuries suffered in competition were more likely to be severe (5.0-fold greater than practice, Table 2), than those in practice (3.6-fold greater than practice). Furthermore, in competition, injuries were 2.5-fold more common late in a match (15.6% of all, incidence 32.54/10,000 AEs) than early in a match (6.3% of all, incidence 13.17/10,000 AEs,  $p < 0.0001$ ).

The majority of the injuries to NCAA wrestlers were due to contact type mechanism (4514, or 72.8%, Figure 3). This included contact with a person (43.6%), contact with a surface (25.9%), and contact with an out-of-bounds object (3.3%). Contact injuries were significantly more common than either noncontact injuries (15.7%) or those with an unknown mechanism (11.5%,  $p < 0.0001$ ).

Division I wrestlers had a significantly higher incidence of injury (31.02/10,000 AEs) than did Division II (6.63/10,000 AEs) and Division III (21.26/10,000 AEs), for RRs of 4.7- and 1.5-fold, respectively ( $p < 0.0001$ ). Division I also accounted for the majority of injuries (54.4%), despite having only 37.9% of the total AEs.

Substantial variation existed in the outcomes of shoulder and elbow injuries. A minority of the injuries (26.8%) required more than 14 days of time away from play, while the remainder (67.8%) required less. The incidence of severe injuries was fourfold higher in competition than in practice (Table 2). Of all injuries, 35.1% did not interfere with the session, while 10.1% of injuries were season-ending. Surgery was performed in 5.9% of injured athletes while 88.9% were treated non-operatively (the remaining 5.2% were unknown.)

**Figure 3.** Injuries by contact event.

## Discussion

Prior studies have noted the comparatively high incidence of injuries in wrestlers compared with other athletes, although these injuries have not recently been investigated in detail. Kay et al. described the epidemiology of injuries within the 25 NCAA sports from the 2009–2010 through 2014–2015 academic years, and found that wrestling had the highest injury rate (17.3/10,000 AEs) of any collegiate sport; others have shown similar results [3–5,10–13]. We found a similar incidence of 21.59/10,000 AEs shoulder and elbow injuries in this population of collegiate wrestlers.

## Class year

Freshman collegiate wrestlers suffered a significantly higher percentage of shoulder and elbow injuries (35.9%) than sophomores (14.1%), juniors (17.1%), and seniors (8.8%). This may be attributed to the transition from high school to the collegiate athletic and academic schedule, characterized by a more intense and frequent workouts, newer and more

**Table 2.** Injury incidence by severity and session type, expressed per 10,000 AEs.

Injury severity	Injury incidence (practice)	Injury incidence (competition)	Risk ratio (competition vs. practice)	95% CI (competition vs. practice)	Injury incidence (total)
<14 days time loss	11.50	41.76	3.63	3.4–3.88	14.63
14+ days time loss	4.39	22.05	5.02	4.56–5.53	6.22
Total	16.50	65.80	3.99	3.78–4.21	21.59

95% CI: 95% confidence interval; AEs: athletic exposures.

challenging weight-lifting plans, tougher opponent competition, and increased match length. This sharply increased workload presents a potential opportunity for fatigue in those who have not yet mentally and/or physically adjusted to the transition. Furthermore, the almost twofold longer collegiate season may contribute to the increased injury incidence in freshman as they acclimate to their new conditions. The training and coaching staff should be aware of this and attempt to closely monitor these athletes who may be at higher risk of an upper extremity injury.

### **Weight class**

There were no particular weight classes that were significantly more prone to injury than others (although exposure data were not specifically available, leaving only the relative injury frequencies, rather than incidence). However, we did observe slightly higher percentages of injury among the middleweights (141–165 lbs) than the light or heavyweights. Further investigation with a larger sample size is needed to determine if there exists an association between weight class and upper extremity injury risk.

### **Injury type**

Examining the NCAA-ISP from 1988–1989 through 2003–2004, Agel et al. found that the most common upper extremity injuries involved the shoulder (14.2% in competition, 8.1% in practice). Injuries included shoulder muscle-tendon strains, ligament sprains, subluxations, and AC injuries [3]. While we also found that shoulder injuries were more common than elbow injuries, the patterns differed from prior results (we found that the most frequent injury types included UCL tears, shoulder impingement, and AC joint sprains). When taken together, elbow instability injuries were the most common pattern in our data, followed by shoulder instability. Identifying the most frequent injuries is a crucial step for improving safe techniques and regulations.

### **Practice vs. competition**

There has been a debate in the recent literature whether injuries are more common during practice or competition in collegiate wrestling [3,5,10,11,14,15]. The higher incidence in competition (fourfold in our study) may be attributed in part to rapid weight loss techniques immediately leading up to match competition that leads to adverse physiological effects in the match itself. The combative nature and higher stakes in a match, may explain the higher incidence rate in competition. Efforts should be made to decrease the severity of competition injuries through methods such as improved proper technique instruction, as well as measures to prevent dangerous weight-cutting techniques that weaken the body.

Despite the lower incidence, more total injuries were sustained during practice. This may be due simply to spending much more time in practice than competition; a typical practice may range anywhere from 1 to 3 h, up to seven times each week, while an entire match only lasts 7 min, usually once per week. Thus, the greater time spent in practice

provides more of an opportunity for injury; an AE for a brief match is weighted the same as a long practice.

### **Time in match**

The relative incidence of injuries between early- and late-in-match has not been investigated previously. We found that injuries were significantly more likely to occur later in the match, with a 2.5-fold increased risk compared with early. This may be due to wrestlers being more fatigued and not being able to generate as much power in the later periods, possibly leading the fatigued wrestler to concede a riskier, more dangerous position. Grindstaff et al. support this claim, suggesting that central and neuromuscular fatigue potentially decreases motor control, balance, proprioception and may alter joint mechanics [16]. This increased fatigue may increase the likelihood of injury.

### **Time in season**

There was a significant difference in injury rates between different times in the season, with the incidence of preseason and regular-season injuries more than double that of postseason injuries. These high preseason injury rates are somewhat surprising; Agel et al. attributed these findings to poorly planned attempts to quickly reduce body weight for the upcoming season [3]. The NCAA requires a body composition test that uses a specific weight loss formula, and aims to predict the lowest safe weight class [17]. Many wrestlers practice rapid weight loss techniques leading up to this body composition test, believing that their chances of competitive success will increase if they reach their minimum target weight class [18]. This rapid weight loss in the preseason period entails a combination of food restriction and fluid deprivation that can create adverse physiological effects on the body and may contribute to the injury rate. Therefore, it is essential that coaches and athletic trainers closely monitor their athletes during the preseason period leading up to the weight-certification test, to ensure there are no improper weight-assessment or reduction procedures outside of the approved weight-management protocol.

Alternatively, the higher proportion of practices in preseason may contribute as well. This explanation is limited and the preseason injury population requires further study for more accuracy. An explanation for the higher incidence of regular-season injuries may be overuse and overtraining. During the regular season, wrestlers tend to be in the best shape and are competing in the bulk of the match competition in the middle of the season. The lower incidence rate of injury in the post-season period can be attributed to the more experienced evenly matched nature of competition: the best-skilled wrestlers (who tend to use proper techniques and are more familiar with dangerous moves) are usually the only athletes still competing.

### **Contact vs. noncontact**

Several authors have shown that wrestling is one of the most injurious sports given its high-contact nature, which may be expected with a sport of a high speed, full-body contact nature [12,14]. We found that the majority (72.8%) of these shoulder and



elbow injuries are due to contact. These high-contact injuries primarily involve person-to-person contact (43.6%) and person-to-surface contact (25.9%). The person-to-person injuries are direct wrestler contact, characterized by forceful body collision and maneuvers between two opponents. These commonly occur during takedowns, blows from errant body parts, or forceful twisting and leverage in different holds and maneuvers where limbs and joints are forced past their normal ranges of motion. This may help to explain why elbow and shoulder dislocations were the most common injury types. Further, these person-to-person-based injuries can occur during trips, throws, and takedowns where the weight of the opponent's body lands on the bottom/other wrestler.

The person-to-surface contact injuries usually occur when a wrestler completely extends an arm to brace their fall when landing on the mat after a takedown or mat return, or when a wrestler is forcibly lifted into the air and returned to the mat with the shoulder making the first point of contact with no bracing of the fall. This 'posting' maneuver can also lead to hyperextensions, dislocations, and labral injuries, while the forceful blow to the shoulder when impacting with the mat may lead to AC joint injuries, dislocations, and others.

### **NCAA Division**

We found that Division I collegiate wrestlers had the highest injury rate overall (31/10,000 AEs). Furthermore, Division I participants had a significantly higher rate of injury than Division II or III. This higher injury rate in Division I may be attributed to the higher level of competition and athleticism, as well as higher overall frequency of match competition in this collegiate wrestling population compared to Divisions II and III.

### **Injury outcomes**

Return-to-play is a major consideration following collegiate injury. Our findings agreed with others in that the majority of collegiate wrestling injuries, 67.8% were short-term, requiring <2 weeks away from sport [3,10]. We found that 42.3% of athletes returned within the same session, while only 10.3% were out for the remainder of the season; the rest fell in between. Interestingly, we found that competition has a higher incidence of severe injury (14+ days of time lost) than does practice. Only 5.9% of all injuries resulted in surgery, similar to Yard et al. (7.9%), who also found that surgery was more common for injuries sustained during matches than practice [10].

### **Limitations**

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; many sponsoring schools are not sampled. This introduces the possibility for either overestimation or underestimation of the true incidence of injury. This database also generally relies on entry of the injuries by the team trainers, without the confirmation of the diagnosis by physicians, which could have led 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 (such as the position of injuries or events leading up to it), or classification of injury severity. The NCAA-ISP does not provide any diagnostic imaging results, physical exam findings, or differentiate between similar pathologies (i.e. simple dislocation vs. a terrible triad injury). Furthermore, clinical follow-up (aside from time loss and need for surgery) and treatment decision-making are not captured in this database. The type of surgical repair as well as time it took for an athlete to return to play following surgical reconstruction is not given. In addition, the use of 'season-ending' also does not provide specific information regarding the timing of the injury within the season, which is withheld by the NCAA for privacy. Thus, season-ending could mean any number of actual days lost, and reflects a complex decision by the athlete, physicians, coaches, and parents to remove the athlete from play. Despite these limitations listed above, this method of data collection has been previously validated in a number of epidemiologic studies of American collegiate athletics [19–27]. Therefore, we believe that this method allows the most current and representative presentation of shoulder and elbow injuries in NCAA athletes.

### **Conclusion**

We found an incidence of 21.59/10,000 AEs of shoulder and elbow injuries in this population of collegiate wrestlers, with the most frequent injury types including UCL tears, shoulder impingement, and AC joint sprains. Freshman collegiate wrestlers suffered a significantly higher percentage of shoulder and elbow injuries than other classes, signifying an association between experience and injury risk. Additionally, there was a fourfold higher incidence of injury during competition; within a match, injuries were significantly more likely to occur later in the match, with a 2.5-fold increased risk compared with early. Lastly, Division I collegiate wrestlers had the highest overall injury rate. Risk factors and characteristics such as these are important for coaches and athletic trainers to consider, specifically due to the strenuous physical nature associated with wrestling and its preparation. At-risk patient populations should be monitored closely for signs of fatigue, which may leave them susceptible to injury. Further prospective investigation of wrestling injuries with a special attention to injury prevention in higher risk athletes are needed to further validate these findings.

### **Acknowledgment**

This publication contains materials created, compiled or produced by the Datalys Center for Sports Injury Research and Prevention, Inc. on behalf of the National Collegiate Athletic Association ©. [2018] National Collegiate Athletic Association. All rights reserved. The NCAA Injury Surveillance Program data were provided by the Datalys Center for Sports Injury Research and Prevention. The Injury Surveillance Program was funded by the National College Athletic Association (NCAA). The content of this manuscript is solely the responsibility of the authors and does not necessarily represent the official views of the Datalys Center or the NCAA. We thank the many athletic trainers who have volunteered their time and efforts to submit data to the NCAA Injury Surveillance Program. Their efforts are greatly appreciated and have had a tremendously positive effect on the safety of collegiate athletes.

## Funding

None.

## Declaration of interest

B Owens declares the following potential conflicts of interest: Dr. Owens or an immediate family member serves as a paid consultant to ConMed Linvatec, DePuy Synthes, DePuy Mitek, the Musculoskeletal Transplant Foundation, and Rotation Medical; has received research or institutional support from Histogenics; serves as a board member, owner, officer, or committee member of the American Academy of Orthopaedic Surgeons, the American Orthopaedic Association, the American Orthopaedic Society for Sports Medicine, and the Arthroscopy Association of North America. The authors have no other relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript apart from those disclosed. Peer reviewers on this manuscript have no relevant financial relationships to disclose.

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