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Epidemiology of Injuries in National Collegiate Athletic Association Men's Swimming and Diving: 2014–2015 Through 2018–2019

Adrian J. Boltz, MSH*; Hannah J. Robison, MS, LAT, ATC*; Sarah N. Morris, PhD*; Bernadette A. D'Alonzo, MPH†; Christy L. Collins, PhD*; Avinash Chandran, PhD, MS*

*Datalys Center for Sports Injury Research and Prevention, Indianapolis, IN; †Penn Injury Science Center, University of Pennsylvania, Philadelphia

Context: The National Collegiate Athletic Association (NCAA) has sponsored men's swimming and diving since 1937.

Background: Routine examinations of men's swimming and diving injuries are important for identifying emerging injury-related patterns.

Methods: Exposure and injury data collected in the NCAA Injury Surveillance Program during the 2014–2015 through 2018–2019 academic years were analyzed. Injury counts, rates, and proportions were used to describe injury characteristics, and injury rate ratios were used to examine differences in injury rates.

Results: The overall injury rate was 1.56 per 1000 athlete-exposures (AEs) for swimmers and 1.52 per 1000 AEs for divers. Shoulder (27.0%) injuries accounted for the largest proportion of all swimming injuries, and most injuries were attributed to overuse mechanisms (42.6%). Shoulder (23.3%) and trunk (23.3%) injuries accounted for the largest proportion of all diving injuries, and most injuries resulted from surface contact (32.6%).

Conclusions: Findings were consistent with existing literature on swimming and diving. The need for continued surveillance, coupled with more robust participation by swimming and diving programs was also highlighted.

Key Words: collegiate, sport-related, surveillance

Key Points

- Overall, competition and practice injury rates were similar in men's swimming.
- The most common specific injuries in men's swimming were biceps tendinitis, shoulder impingement, rotator cuff tear (partial or complete), and rotator cuff tendinitis.
- In both men's swimming and men's diving, most injuries were attributed to the shoulder or trunk and were classified as non-time loss injuries.

The National Collegiate Athletic Association (NCAA) has sponsored men's swimming and diving since 1937.[1] In recent years, participation has continued to grow, with an estimated 444 sponsored teams and 9800 athletes competing[2] in 2018–2019. Despite the large number of NCAA student athletes and steady increases in membership over the years, few studies have explored the epidemiology of collegiate swimming- and diving-related injuries.[3,4] An updated investigation is needed to appraise the overall health and safety of this population and to assess temporal patterns in injury incidence within this group.

The NCAA initiated an injury surveillance system to monitor injuries within collegiate athletics[5,6] in 1982. After its evolution to an electronic platform, this system is currently known as the NCAA Injury Surveillance Program (ISP). The NCAA ISP has collected data on men's swimming and diving[4] since 2009–2010. The most recent study using these data identified similar injury rates between men's swimming and men's diving.[4] The overall injury rate in men's swimming was approximately 1.5 injuries per 1000 athlete-exposures (AEs); and in men's diving, approximately 2 injuries per 1000 AEs.[4] It was also reported that most injuries in swimmers and divers were shoulder related and that injuries were most commonly classified as overuse and noncontact mechanisms.[4]

Routine examination of injury incidence in this population is necessary to highlight areas that may warrant further attention and to inform the implementation of targeted interventions aimed at injury prevention. As such, the purpose of this study was to describe the epidemiology of sport-related injuries among men's swimming and diving student-athletes in a sample of NCAA teams recorded in the NCAA ISP during the 2014–2015 through 2018–2019 academic years.

METHODS

Study Data

Men's swimming and diving exposure and injury data collected in the NCAA ISP during the 2014–2015 through

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Table 1. Reported and National Estimates of Injuries, Athlete Exposure (AEs), and Rates per 1000 AEs by Athlete Type and Event Type[a]

	Number AEs Rate per 1000 AEs (95% CI)					
	Overall		Practices		Competitions	
Athlete Type	Reported	National Estimate	Reported	National Estimate	Reported	National Estimate
Swimmers	296	10 956	274	10 040	22	917
	189 704	7 740 041	169 885	6 863 653	19 818	876 388
	1.56 (1.38, 1.74)	1.42 (1.24, 1.9)	1.61 (1.42, 1.80)	1.46 (1.27, 1.65)	1.11 (0.65, 1.57)	1.05 (0.58, 1.51)
Divers	43	2565	34	2137	9	428
	28 346	1 156 558	25 385	1 025 603	2961	130 954
	1.52 (1.06 , 1.97)	2.22 (1.76, 2.67)	1.34 (0.89, 1.79)	2.08 (1.63, 2.53)	3.04 (1.05, 5.03)	3.27 (1.28, 5.25)
Overall	339	13 521	308	12 176	31	1345
	218 050	8 896 599	195 270	7 889 257	22 780	1 007 342
	1.55 (1.39, 1.72)	1.52 (1.35, 1.69)	1.58 (1.40, 1.75)	1.54 (1.37, 1.72)	1.36 (0.88, 1.84)	1.34 (0.86, 1.81)

[a] Data presented in the order of reported number, followed by athlete exposures (AEs), estimated injury rates, and associated 95% Confidence Intervals (CIs). Data pooled association-wide are presented overall, and separately for practices and competitions. National estimates were produced using sampling weights estimated on the basis of sport, division, and year. All CIs were constructed using variance estimates calculated on the basis of reported data. A reportable injury was one that occurred due to participation in an organized intercollegiate practice or competition, and required medical attention by a team Certified Athletic Trainer or physician (regardless of time loss). Only scheduled team practices and competitions were retained in this analysis.

2018–2019 athletic seasons were analyzed in this study. The methods of the NCAA ISP have been reviewed and approved as an exempt study by the NCAA Research Review Board. In brief, athletic trainers (ATs) at participating institutions contributed exposure and injury data using their clinical electronic medical record systems. A reportable injury was one that occurred due to participation in an organized intercollegiate practice or competition and required medical attention by a team AT or physician, regardless of time lost. Scheduled team practices and competitions were considered reportable exposures for this analysis. Data from 7 (2% of membership) participating programs in 2014–2015, from 4 (1% of membership) in 2015–2016, from 8 (2% of membership) in 2016–2017, from 8 (2% of membership) in 2017–2018, and from 23 (5% of membership) in 2018–2019 qualified for inclusion in analyses. Qualification criteria are detailed further in the methods article within this special issue.[7]

Classifying Injuries and Athlete-Exposures by Swimming Versus Diving

Injured athletes were identified as either swimmers or divers when injury records were submitted by the AT. For injury records with unknown athlete type, it was assumed that the athlete was a swimmer if the corresponding activity at the time of injury was reported as backstroke, breaststroke, butterfly, freestyle, or medley. The athlete was assumed to be a diver if the corresponding activity was reported as 1.0-m board, 1.0-m platform, 3.0-m board, 3.0-m platform, 5.0-m platform, 7.5-m platform, or 10.0-m platform. Injury records without an identifiable athlete type were not retained in the analysis (n = 11). Combined AEs were collected for swimming and diving teams in the NCAA ISP. Previous researchers studying this population determined that on average, 87% of athletes on swimming and diving team rosters were swimmers, whereas 13% were divers.[4] Injury rates for swimming and diving were calculated separately according to their respective distribution of AEs.

Statistical Analysis

Injury counts and rates per 1000 AEs for each athlete type (swimmers, divers) were examined by event type (practice, competition) and time lost (time loss [TL], non–time loss [NTL]). Poststratification sample weights by sport, year, and division are established within the surveillance system to compute national estimates of injury events on the basis of the sampled teams. An AE was defined as 1 athlete participating in 1 exposure event. Weighted and unweighted rates were estimated; however, results have been presented in terms of unweighted rates (unless otherwise specified) due to low frequencies of injury observations across levels of certain explanatory variables. Temporal trends in injury rates (pooled for practices and competitions) across the study period were evaluated using rate profile plots stratified by athlete type. Injury counts and proportions were examined by body part injured, mechanism of injury, injury diagnosis, and activity at the time of injury. Respiratory infections (n = 40) were not included in analyses due to reporting inconsistencies (by program and year) across the study period. Injury rate ratios were used to examine differential injury rates across event types. The injury rate ratios with associated 95% confidence intervals (CIs) excluding 1.00 were considered statistically significant. All analyses were conducted using SAS version 9.4 (SAS Institute).

RESULTS

A total of 339 men's swimming and diving injuries (swimmers: 296; divers: 43) from 218 050 AEs (swimmers: 189 704; divers: 28 346) were reported to the NCAA ISP during the 2014–2015 through 2018–2019 athletic seasons (rate: swimmers = 1.56/1000 AEs; divers = 1.52/1000 AEs). This equated to a national estimate of 13 521 injuries overall (swimmers: 10 956; divers: 2 565; Table 1). Across the study period overall, there were no significant differences in swimming injury rates by event type (practice, competition). Differences in diving injury rates by event type were not examined due to a low number of

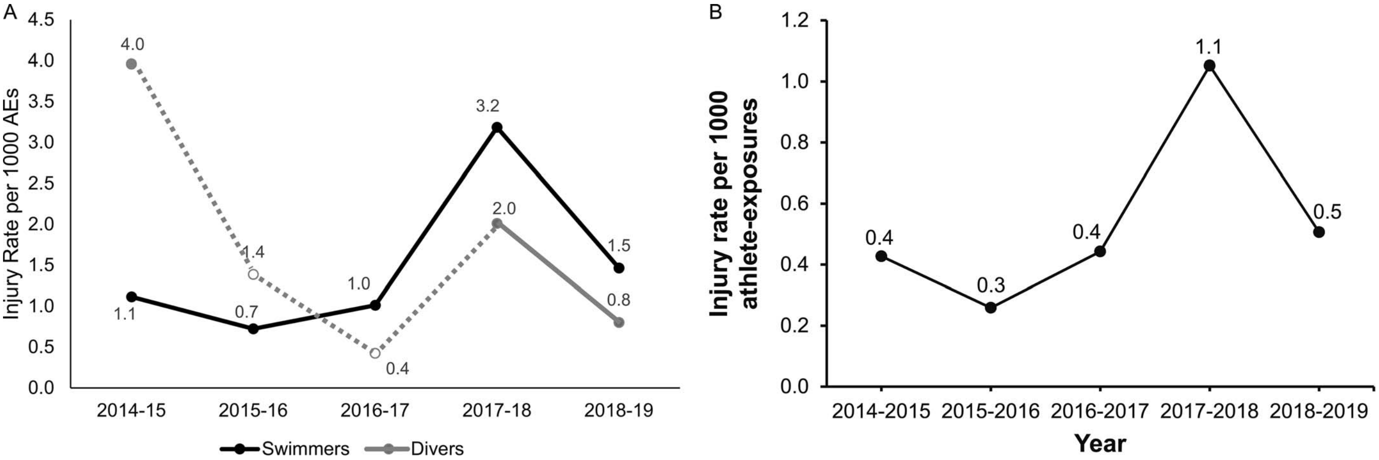

Figure. **Temporal patterns in injury rates between 2014–2015 and 2018–2019. A, Depicts overall injury rates (per 1000 AEs) stratified by men's swimming and men's diving. B, Depicts rates of time loss injuries among men's swimming. Rates presented in all figures are unweighted and based on reported data. Abbreviation: AE, athlete-exposures.**

competition-related injuries ($n < 10$) reported across the study period. In swimmers, injury rates remained relatively stable between 2014–2015 and 2016–2017, then increased sharply during 2017–2018 before falling again in 2018–2019 (Figure A). The diving injury rates appeared to decrease across the study period (Figure A). However, injury rates for divers in 2015–2016 and 2016–2017 were potentially unstable due to low numbers of reported injuries during these years ($n < 5$). Accordingly, estimated injury rates corresponding to these years are illustrated in Figure A as open circles and connected to other annual estimates with a dotted line, and these estimates should be interpreted with caution.

Time Loss

In both men's swimming and diving, NTL injuries represented a larger proportion of all reported injuries than TL injuries (swimmers: NTL: 51.3%, TL: 35.5%, missing: 13.2%; divers: NTL: 51.2%, TL: 32.5%, missing: 16.3%). In men's swimming, TL injuries accounted for 34.3% of reported practice injuries and 50.0% of competition injuries; whereas in men's diving, TL injuries accounted for 35.3% of reported practice injuries and 22.2% of competition injuries. Overall TL injury rates for swimmers remained relatively stable between 2014–2015 and 2016–2017, then increased sharply in 2017–2018, followed by a decrease in 2018–2019 (Figure B).

Injury Characteristics

Injuries to the shoulder (27.0%) and trunk (16.2%) accounted for the largest proportions of all men's swimming injuries reported during the study period (Table 2). Among shoulder injuries, nearly half (47.5%) were NTL, approximately a third (30.0%) were TL, and roughly a quarter (22.5%) had missing TL data. Similarly, a greater proportion of trunk injuries involved NTL (NTL: 50.0%; TL: 33.3%; missing TL data: 16.7%). The most commonly reported mechanisms of injury were overuse (42.6%) and noncontact (18.9%) injuries. Overuse injuries accounted for a larger proportion of practice injuries (43.4%) than competition injuries (31.8%), whereas noncontact injuries accounted for a larger proportion of competition injuries (27.3%) than practice injuries (18.3%). Most men's swimming injuries reported during 2014–2015 through 2018–2019 were strains (19.6%) and inflammatory conditions (18.6%). Strains were more prevalent among reported competition injuries (36.4%) than practice injuries (18.3%), whereas inflammatory conditions were more prevalent among reported practice injuries (19.0%) than competition injuries (13.6%). The most commonly reported specific injuries during the study period were biceps tendinitis (shoulder) (7.8%; Rate = 1.21 per 10000 AEs), shoulder impingement (4.7%; Rate = 0.74 per 10000 AEs), rotator cuff tear (partial or complete) (3.4%; Rate = 0.53 per 10000 AEs), and rotator cuff tendinitis (3.4%; Rate = 0.53 per 10000 AEs).

Injuries to the shoulder (23.3%) and trunk (23.3%) accounted for the largest proportions of all men's diving injuries reported during the study period (Table 3). Injuries were most commonly attributed to surface contact (32.6%), noncontact (30.2%), and overuse (20.9%) mechanisms. Most men's diving injuries reported during the study period were strains (18.6%) and inflammatory conditions (16.3%); no specific injury was observed to be notably prevalent among all reported diving injuries.

Injuries by Swimming- and Diving-Specific Activities

Most injuries in men's swimming between 2014–2015 and 2018–2019 occurred during freestyle swim (34.1%), conditioning (16.9%), and breaststroke swim (10.8%). Injuries occurring during freestyle and breaststroke events were more prevalent among reported competition injuries than practice injuries (Table 4). Most injuries in men's divers during the study period occurred during unspecified diving activities (44.2%).

SUMMARY

This study aimed to describe the epidemiology of NCAA men's swimming- and diving-related injuries reported to the NCAA ISP between the 2014–2015 and 2018–2019 academic years. Injury rates in men's swimming remained relatively stable and low during the first 3 years of the study

Table 2. Distribution of Swimmer Injuries by Body Part, Mechanism, and Injury Diagnosis; Stratified by Event Type[a]

	Overall		Competitions		Practices	
	Injuries Reported (%)	National Estimate (%)	Injuries Reported (%)	National Estimate (%)	Injuries Reported (%)	National Estimate (%)
Body part						
Head/face	20 (6.76)	838 (7.65)	1 (4.55)	38 (4.14)	19 (6.93)	801 (7.98)
Neck	3 (1.01)	148 (1.35)	0 (0.0)	0 (0.0)	3 (1.09)	148 (1.47)
Shoulder	80 (27.03)	3269 (29.84)	5 (22.73)	408 (44.49)	75 (27.37)	2860 (28.49)
Arm/elbow	19 (6.42)	543 (4.96)	4 (18.18)	97 (10.58)	15 (5.47)	446 (4.44)
Hand/wrist	7 (2.36)	222 (2.03)	1 (4.55)	30 (3.27)	6 (2.19)	192 (1.91)
Trunk	48 (16.22)	2349 (21.44)	4 (18.18)	132 (14.39)	44 (16.06)	2217 (22.08)
Hip/groin	19 (6.42)	626 (5.71)	4 (18.18)	113 (12.32)	15 (5.47)	513 (5.11)
Thigh	7 (2.36)	208 (1.90)	1 (4.55)	43 (4.69)	6 (2.19)	166 (1.65)
Knee	15 (5.07)	392 (3.58)	0 (0.0)	0 (0.0)	15 (5.47)	392 (3.90)
Lower leg	5 (1.69)	114 (1.04)	1 (4.55)	19 (2.07)	4 (1.46)	96 (0.96)
Ankle	8 (2.70)	233 (2.13)	0 (0.0)	0 (0.0)	8 (2.92)	233 (2.32)
Foot	8 (2.70)	215 (1.96)	0 (0.0)	0 (0.0)	8 (2.92)	215 (2.14)
Other	57 (19.26)	1799 (16.42)	1 (4.55)	38 (4.14)	56 (20.44)	1761 (17.54)
Mechanism						
Player contact	7 (2.36)	197 (1.80)	1 (4.55)	38 (4.14)	6 (2.19)	159 (1.58)
Surface contact	19 (6.42)	554 (5.06)	3 (13.64)	86 (9.38)	16 (5.84)	468 (4.66)
Water	6 (31.58)	222 (40.07)	1 (33.33)	38 (44.19)	5 (31.25)	185 (39.53)
Deck	10 (52.63)	265 (47.83)	2 (66.67)	49 (56.98)	8 (50.00)	216 (46.15)
Other	3 (15.79)	67 (12.09)	0 (0.0)	0 (0.0)	3 (18.75)	67 (14.32)
Other apparatus contact	8 (2.70)	164 (1.50)	3 (13.64)	54 (5.89)	5 (1.82)	110 (1.10)
Noncontact	56 (18.92)	2690 (24.55)	6 (27.27)	402 (43.84)	50 (18.25)	2288 (22.79)
Overuse	126 (42.57)	4777 (43.60)	7 (31.82)	268 (29.23)	119 (43.43)	4509 (44.91)
Other/unknown	80 (27.03)	2574 (23.49)	2 (9.09)	68 (7.42)	78 (28.47)	2505 (24.95)
Diagnosis						
Abrasion/laceration	6 (2.03)	142 (1.30)	0 (0.0)	0 (0.0)	6 (2.19)	142 (1.41)
Concussion	5 (1.69)	133 (1.21)	1 (4.55)	38 (4.14)	4 (1.46)	95 (0.95)
Contusion	1 (0.34)	19 (0.17)	1 (4.55)	19 (2.07)	0 (0.0)	0 (0.0)
Dislocation/subluxation	11 (3.72)	808 (7.37)	2 (9.09)	289 (31.52)	9 (3.28)	518 (5.16)
Entrapment/impingement	18 (6.08)	519 (4.74)	0 (0.0)	0 (0.0)	18 (6.57)	519 (5.17)
Fracture	3 (1.01)	86 (0.78)	0 (0.0)	0 (0.0)	3 (1.09)	86 (0.86)
Illness/infection	12 (4.05)	394 (3.60)	0 (0.0)	0 (0.0)	12 (4.38)	394 (3.92)
Inflammatory condition	55 (18.58)	1966 (17.94)	3 (13.64)	128 (13.96)	52 (18.98)	1839 (18.32)
Spasm	19 (6.42)	1133 (10.34)	2 (9.09)	68 (7.42)	17 (6.20)	1065 (10.61)
Sprain	11 (3.72)	302 (2.76)	2 (9.09)	60 (6.54)	9 (3.28)	242 (2.41)
Strain	58 (19.59)	1943 (17.73)	8 (36.36)	213 (23.23)	50 (18.25)	1730 (17.23)
Other	97 (32.77)	3512 (32.06)	3 (13.64)	102 (11.12)	94 (34.31)	3410 (33.96)

[a] Data presented in the order of reported number, followed by the proportion of all injuries attributable to a given category. Data pooled across event types are presented overall, and separately for practices and competitions. National estimates were produced using sampling weights estimated on the basis of sport, division, and year. A reportable injury was one that occurred due to participation in an organized intercollegiate practice or competition, and required medical attention by a team Certified Athletic Trainer or physician (regardless of time loss). Only scheduled team practices and competitions were retained in this analysis.

period before fluctuating during the final years of the study. The observed fluctuations in the final 2 years of the study may be reflective of variation in AT documentation practices.[8] The relatively low number of participating schools during the 2017–2018 academic year may predispose overall trends to vary more dramatically in reaction to small differences in AT reporting practices. Furthermore, it is salient to note that during the final year of the study period, participation increased almost 3-fold, due largely to revised recruitment strategies (for instance, support and communication from the NCAA Sport Science Institute). It is reasonable to suggest that the estimates associated with 2018–2019 may be a more appropriate representation of the injury burden in this population than estimates from previous years. The overall men's swimming injury rate observed in this study was comparable to previous reports of this population.[4] However, the competition injury rate in men's swimming was notably lower in the present study than in previous reports.[4] Despite the relative stability, the changes observed among competition injuries as well as the observed fluctuations in the final years of the study may also be reflective of changes in training patterns. *High intensity interval training* (HIIT), which generally refers to repeated short to long bouts of high-intensity exercise interspersed with recovery periods,[9] had become a popular style of training among strength coaches in the previous 5 years.[10] HIIT has been studied in several populations and found to be a highly effective training technique in endurance sports.[11,12] In sprint-distance triathlon participants, HIIT has been shown to both increase muscular performance and improve athletic performance in swim, cycling, and running time.[9] Although outside the scope of information collected by the NCAA ISP, changes in overall training techniques (such as a transition from long periods of low-speed swimming to a HIIT approach) may be an important area of future study in traditional endurance

Table 3. Distribution of Diver Injuries by Body Part, Mechanism, and Injury Diagnosis; Stratified by Event Type[a]

	Overall		Competitions		Practices	
	Injuries Reported (%)	National Estimate (%)	Injuries Reported (%)	National Estimate (%)	Injuries Reported (%)	National Estimate (%)
Body part						
Head/face	3 (6.98)	311 (12.12)	1 (11.11)	30 (7.01)	2 (5.88)	281 (13.15)
Neck	1 (2.33)	30 (1.17)	0 (0.0)	0 (0.0)	1 (2.94)	30 (1.40)
Shoulder	10 (23.26)	720 (28.07)	2 (22.22)	49 (11.45)	8 (23.53)	672 (31.45)
Hand/wrist	5 (11.63)	128 (4.99)	2 (22.22)	49 (11.45)	3 (8.82)	79 (3.70)
Trunk	10 (23.26)	671 (26.16)	4 (44.44)	300 (70.09)	6 (17.65)	371 (17.36)
Hip/groin	2 (4.65)	61 (2.38)	0 (0.0)	0 (0.0)	2 (5.88)	61 (2.85)
Thigh	1 (2.33)	50 (1.95)	0 (0.0)	0 (0.0)	1 (2.94)	50 (2.34)
Knee	3 (6.98)	91 (3.55)	0 (0.0)	0 (0.0)	3 (8.82)	91 (4.26)
Lower leg	3 (6.98)	110 (4.29)	0 (0.0)	0 (0.0)	3 (8.82)	110 (5.15)
Ankle	1 (2.33)	50 (1.95)	0 (0.0)	0 (0.0)	1 (2.94)	50 (2.34)
Foot	2 (4.65)	282 (10.99)	0 (0.0)	0 (0.0)	2 (5.88)	282 (13.20)
Other	2 (4.65)	60 (2.34)	0 (0.0)	0 (0.0)	2 (5.88)	60 (2.81)
Mechanism						
Surface contact	14 (32.56)	409 (15.95)	3 (33.33)	79 (18.46)	11 (32.35)	330 (15.44)
Water	11 (78.57)	310 (75.79)	3 (100.00)	79 (100.00)	8 (72.73)	231 (70.00)
Other	3 (21.43)	99 (24.21)	0 (0.0)	0 (0.0)	3 (27.27)	99 (30.00)
Other apparatus contact	2 (4.65)	269 (10.49)	1 (11.11)	19 (4.44)	1 (2.94)	251 (11.75)
Noncontact	13 (30.23)	907 (35.36)	2 (22.22)	144 (33.64)	11 (32.35)	762 (35.66)
Overuse	9 (20.93)	609 (23.74)	3 (33.33)	186 (43.46)	6 (17.65)	423 (19.79)
Other/unknown	5 (11.63)	372 (14.50)	0 (0.0)	0 (0.0)	5 (14.71)	372 (17.41)
Diagnosis						
Abrasion/laceration	1 (2.33)	19 (0.74)	1 (11.11)	19 (4.44)	0 (0.0)	0 (0.0)
Concussion	3 (6.98)	311 (12.12)	1 (11.11)	30 (7.01)	2 (5.88)	281 (13.15)
Contusion	1 (2.33)	19 (0.74)	0 (0.0)	0 (0.0)	1 (2.94)	19 (0.89)
Dislocation/subluxation	3 (6.98)	91 (3.55)	0 (0.0)	0 (0.0)	3 (8.82)	91 (4.26)
Entrapment/impingement	3 (6.98)	299 (11.66)	2 (22.22)	49 (11.45)	1 (2.94)	251 (11.75)
Fracture	2 (4.65)	282 (10.99)	0 (0.0)	0 (0.0)	2 (5.88)	282 (13.20)
Illness/infection	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Inflammatory condition	7 (16.28)	452 (17.62)	0 (0.0)	0 (0.0)	7 (20.59)	452 (21.15)
Spasm	3 (6.98)	114 (4.44)	0 (0.0)	0 (0.0)	3 (8.82)	114 (5.33)
Sprain	4 (9.30)	141 (5.50)	1 (11.11)	30 (7.01)	3 (8.82)	110 (5.15)
Strain	8 (18.60)	523 (20.39)	1 (11.11)	126 (29.44)	7 (20.59)	397 (18.58)
Other	8 (18.60)	314 (12.24)	3 (33.33)	175 (40.89)	5 (14.71)	139 (6.50)

[a] Data presented in the order of reported number, followed by the proportion of all injuries attributable to a given category. Data pooled across event types are presented overall, and separately for practices and competitions. National estimates were produced using sampling weights estimated on the basis of sport, division, and year. A reportable injury was one that occurred due to participation in an organized intercollegiate practice or competition, and required medical attention by a team Certified Athletic Trainer or physician (regardless of time loss). Only scheduled team practices and competitions were retained in this analysis.

sports such as swimming. There were insufficient data to examine temporal patterns in competition injury incidence among swimmers in the present study. However, future researchers may examine more closely the trajectories of competition injury incidence in this population to determine whether the pattern is maintained and to identify temporal nuances. Such examinations will be critical in identifying rules and policy changes that have been effective in reducing the injury burden among NCAA men's swimming athletes.

The NTL injuries accounted for over half of all reported swimming injuries across the study period.[13] This may be unsurprising given the prevalence of overuse injuries, which often do not initially require missed participation.[14] The prevalence of NTL shoulder injuries in swimming may be of particular concern. In a previous study of actively competing competitive swimmers, 91% reported a history of shoulder pain and 80% reported pain during activity on a constant, daily, weekly, or monthly basis.[15] Given the observed prevalence of shoulder pain among actively training swimmers, the incidence of shoulder injury may even be greater than that observed in the present study. Because overuse injuries are often chronic and may be associated with cycles of remission and exacerbation, documenting only the cases that required medical attention and intervention by an AT may not fully capture the prevalence of shoulder pain in this population. When addressing overuse and chronic pain, clinicians and researchers alike may seek to identify cases of chronic shoulder pain as opposed to acute injury presentations.[16] Similarly, the observed distribution of swimming injuries across body parts may be expected when considering the dynamics of the sport. Given that swimmers use their upper extremities to propel themselves through the water, it is not surprising that injuries were mostly attributed to the shoulder, trunk, and hip and groin, as opposed to the extremities (eg, hand and wrist, elbow, foot, ankle, knee). Notably, most swimming injuries were attributed to noncontact or overuse mechanisms. These types of mechanisms have been known to lead to the development of inflammatory conditions such as bicep tendonitis, rotator cuff tendonitis, or bursitis.[13] Given the physical demands of

Table 4. Distribution of Injuries by Injury Activity; Stratified by Athlete Type and Event Type[a]

		Overall		Competitions		Practices	
Athlete Type	Activity	Injuries Reported (%)	National Estimate (%)	Injuries Reported (%)	National Estimate (%)	Injuries Reported (%)	National Estimate (%)
Swimmers	Swim–backstroke	14 (4.73)	366 (3.34)	1 (4.55)	34 (3.71)	13 (4.74)	332 (3.31)
	Swim–breast	32 (10.81)	1117 (10.20)	5 (22.73)	155 (16.90)	27 (9.85)	962 (9.58)
	Swim–butterfly	15 (5.07)	652 (5.95)	3 (13.64)	325 (35.44)	12 (4.38)	328 (3.27)
	Swim–freestyle	101 (34.12)	3663 (33.43)	12 (54.55)	365 (39.80)	89 (32.48)	3298 (32.85)
	Swim–medley	7 (2.36)	236 (2.15)	0 (0.0)	0 (0.0)	7 (2.55)	236 (2.35)
	Diving–not specified	1 (0.34)	34 (0.31)	0 (0.0)	0 (0.0)	1 (0.36)	34 (0.34)
	Conditioning	50 (16.89)	2606 (23.79)	0 (0.0)	0 (0.0)	50 (18.25)	2606 (25.96)
	Weights	9 (3.04)	253 (2.31)	0 (0.0)	0 (0.0)	9 (3.28)	253 (2.52)
	Other or unknown	67 (22.64)	2030 (18.53)	1 (4.55)	38 (4.14)	66 (24.09)	1992 (19.84)
Divers	Dive–1.0-m board	8 (18.60)	547 (21.33)	3 (33.33)	186 (43.46)	5 (14.71)	361 (16.89)
	Dive–1.0-m platform	1 (2.33)	19 (0.74)	1 (11.11)	19 (4.44)	0 (0.0)	0 (0.0)
	Dive–3.0-m board	5 (11.63)	128 (4.99)	1 (11.11)	19 (4.44)	4 (11.76)	110 (5.15)
	Dive–3.0-m platform	1 (2.33)	30 (1.17)	0 (0.0)	0 (0.0)	1 (2.94)	30 (1.40)
	Dive–5.0-m platform	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	Dive–7.5-m platform	1 (2.33)	19 (0.74)	0 (0.0)	0 (0.0)	1 (2.94)	19 (0.89)
	Dive–10.0-m platform	1 (2.33)	30 (1.17)	1 (11.11)	30 (7.01)	0 (0.0)	0 (0.0)
	Diving–not specified	19 (44.19)	1615 (62.96)	2 (22.22)	156 (36.45)	17 (50.00)	1459 (68.27)
	Weights	2 (4.65)	37 (1.44)	0 (0.0)	0 (0.0)	2 (5.88)	37 (1.73)
	Other or unknown	5 (11.63)	140 (5.46)	1 (11.11)	19 (4.44)	4 (11.76)	121 (5.66)

[a] Data presented in the order of reported number, followed by the proportion of all injuries attributable to a given category. Data pooled across event types are presented overall, and separately for practices and competitions. National estimates were produced using sampling weights estimated on the basis of sport, division, and year. A reportable injury was one that occurred due to participation in an organized intercollegiate practice or competition, and required medical attention by a team Certified Athletic Trainer or physician (regardless of time loss). Only scheduled team practices and competitions were retained in this analysis.

competitive swimming and the typical nature of injuries reported in men's swimming, it is unsurprising that the 3 most reported specific injuries were in fact biceps tendonitis (shoulder), shoulder impingement, and rotator cuff tendinitis.[17,18] It is important to note that swimming athletes may also experience concomitant shoulder injuries due to the multifactorial etiology (strength imbalances, glenohumeral joint laxity, scapular dyskinesia) of overuse shoulder pain.[18–20] On the basis of the existing literature surrounding the prevalence of shoulder injury,[13] the necessary stress and strain on the shoulder to be competitive—and the difficulty in implementing injury prevention programs for a multifactorial injury that is often overuse—may involve multiple anatomical structures and involve individualized muscular imbalances and form variations. It may be reasonable to suggest that in addition to screening for risk factors such as range of motion deficits, muscular imbalances, and history of injury, clinician and research focus should be aimed towards secondary injury prevention strategies. This may include monitoring fatigue and recovery as well as addressing the cycle of remission and exacerbation within overuse injuries. Previous studies have indicated that a repetitive strain on the shoulder and a high prevalence of shoulder injury are associated with competitive swimming.[15,21] Coupled with the multifactorial pathology of shoulder injury in swimming (which may involve multiple anatomical structures,[22] muscular imbalances,[23] and form variations[24]), it may be reasonable to suggest that in addition to screening for risk factors (such as excessive and/or limited range of motion,[24,25] muscular imbalances,[23] and history of injury), clinicians and researchers should also focus on secondary injury prevention strategies. Such strategies may include monitoring workload[26,27] as well as addressing the cycle of remission and exacerbation within overuse injuries.[16]

Given that whole-body movement and coordination is necessary in swimming, it is important to identify that injury to the shoulder may be a functional manifestation of underlying core weakness.[24,28–30] This observation in previous literature (in both swimming[24,28]and overhead[31,32] athletes) may be further supported by the finding that after the shoulder, the trunk and the hip and groin were also prevalently injured structures in the current study. Therefore, the observed distribution of injuries along the kinetic chain among NCAA men's swimming athletes in the present study point to the importance of the interaction among the shoulder, trunk, and hip and groin and may indicate a relationship between the inherent risks of injury within these structures.[28,30,33]

The overall men's diving injury rate in the present study was lower than previously reported in this population.[4] Given the observed frequencies of diving injuries reported across the study period, it is difficult to contextualize these findings. The most commonly reported injuries among men's diving occurred in the shoulder and trunk, which is consistent with previous reports within this population.[4] It is important that the biomechanics of diving during takeoff (contact with the surface of the diving board or platform), flight, and entry are inherent factors that contribute to injury.[34] During takeoff, flight, and entry, divers perform complex extension, flexion, and rotational movements within the trunk.[34] Just before entering the water, divers' shoulders are uniquely abducted and flexed in a vulnerable position whereby glenohumeral joint stability may be compromised.[34] During entry, divers' shoulders (abducted and flexed) and wrists (dorsiflexed, pronated, and radially deviated) bear significant gravitational force of impact, breaking the surface tension of the water while being placed in an unstable position.[34] The competitive nature of the sport demands that athletes consistently practice and develop complex aerial movements, putting them at risk of developing both strains through noncontact mechanisms and inflammatory conditions through overuse mechanism.[35] It may be noted that over half of all reported injuries in the present study were attributed to these mechanisms. Therefore, the findings of the present study are largely consistent with expectations given the biomechanical demands of diving activities.

In considering the results of the present study, there exist limitations applicable to both swimming and diving injuries that warrant targeted attention and discussion. First, NCAA ISP participation among men's swimming and diving programs was notably low throughout the study period. Despite the similarity in participation with previous surveillance-based investigations of NCAA men's swimming,[4] the limited participation among NCAA men's swimming programs in the current study not only limits the analytical flexibility of the data collected (as noted throughout the present study), but also the external validity of the findings. Whereas sports injury surveillance is an effective tool to examine temporal patterns in injury incidence, healthy participation in surveillance programs is needed to facilitate such investigations. As such, it is critical to continue efforts aimed at increasing ISP participation among men's swimming and diving programs. Second, in considering the injury rates reported in the present study, it is imperative to acknowledge that exposure-time ascertainment remains a challenge in sports injury surveillance, particularly for individualized sports with nontraditional athletic seasons, such as swimming and diving. Swimming and diving are unique sports, and therefore, swimmers and divers are subjected to inherently different degrees of injury risk. As one example, swimmers perform repetitive movements at varying intensities, whereas divers are tasked with performing highly technical aerial maneuvers at a comparatively lesser volume. These differences notwithstanding, swimming and diving are typically recognized as 1 team within member institutions. As such, computation of position-specific at-risk exposure time is particularly challenging, and although AEs may be estimated on the basis of roster sizes (as done herein), this practice remains far from ideal. Incorporating wearable health instruments to capture athletes' time spent practicing, distance and strokes swum, number and type of dives, or cardiovascular and muscular exertional indices may more precisely describe and quantify at-risk exposure time in this population.[36,37] The NCAA ISP in its current form is not well positioned to accommodate such measures, and such nuanced measurement may require adaptations in sports injury surveillance (separately capturing at-risk exposure time for swimmers and divers) or small-sample studies.

Routine surveillance of collegiate men's swimmers and divers allows researchers to describe and highlight injury patterns, which in turn are disseminated to provide the sports medicine community with current and practical information. As discussed above, this critical process will be more effective with more robust participation in sports injury surveillance programs. Our findings demonstrate unique injury characteristics in NCAA men's swimming and diving. The results observed in this study, coupled with the inferential limitations discussed above, highlight the need for further study of men's swimming and diving injuries yet also offer avenues for additional data collection and targeted examination.

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Address correspondence to Avinash Chandran, PhD, MS, Datalys Center for Sports Injury Research and Prevention, 6151 Central Avenue, Suite 117, Indianapolis, IN 46202. Address email to avinashc@datalyscenter.org.