

Epidemiology and Outcomes of Maxillofacial Injuries in NCAA Division I Athletes Participating in 13 Sports

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Background: Maxillofacial injuries account for an estimated 11% of National Collegiate Athletic Association (NCAA) sport-related injuries and occur at a rate of 0.2-1.5 injuries per 1000 athletic events/exposures.

Purpose: The purpose of this study was to report the epidemiology, treatment, and outcomes of maxillofacial injuries in NCAA Division I athletes participating in 13 sports. It was hypothesized that the rate of maxillofacial injuries would be greater than previously reported in national registry studies.

Study Design: Descriptive epidemiology study.

Methods: A single-institution registry was utilized to retrieve the maxillofacial injuries and surgical procedures recorded over 4 athletic seasons, for the years 2015 through 2019, across 13 NCAA Division I sports. The incidence of injuries per sport was reported as the number per 1000 athlete-exposure (AE) hours. The time lost from participation and time to complete injury resolution per sport were reported as the mean and range.

Results: A total of 193 maxillofacial injuries occurred over 4 seasons. The overall incidence of maxillofacial injuries was 2.06 injuries per 1000 AE hours. The injury incidence for male and female athletes was 1.92 and 2.43 injuries per 1000 AE hours, respectively. Men's basketball (8.30 injuries per 1000 AE hours) and men's water polo (8.15 injuries per 1000 AE hours) had the highest rates of all sports. Overall, 20 athletes (10.4%) required surgery. The mean time to resolution across all sports was 33.3 days (range, 0-336 days) per injury. The mean time lost across all sports was 17.1 days (range, 0-336 days) per injury.

Conclusion: At a single NCAA Division I institution, maxillofacial injuries occurred at a higher rate than previously thought and could lead to significant time lost from sport participation. Basketball players were at the highest risk of this injury. Across all sports, male athletes took longer to return to sport after a maxillofacial injury compared to female athletes, but the latter required more time to fully recover. Maxillofacial injuries may require surgical treatment, and their prevention is critical.

Keywords: maxillofacial; collegiate; NCAA; Division I; time lost; epidemiology

Maxillofacial injuries account for an estimated 11% of National Collegiate Athletic Association (NCAA) sport-related injuries and occur at a rate of 0.2-1.5 injuries per 1000 athletic events/exposures.^{6,21} This rate increases in certain high-risk contact sports such as basketball, field hockey, and lacrosse.^{7,10,16-18,27} The frequency of maxillofacial injuries has been on the rise for several decades.^{8,9} Male athletes experience maxillofacial injuries at slightly higher rates than female athletes, although large

discrepancies lie between different sports.^{6,16,33} Maxillofacial injuries can often be catastrophic, requiring emergency transport, acute management, and leading to delayed return-to-play times.^{4,20-22,28}

Face masks, face shields, and mouth guards are considered the primary methods of maxillofacial injury prevention.¹³ Multiple authors have emphasized the importance of mandates for face shields by governing sports bodies.^{3,12} The use of these devices has been associated with a decreased incidence of maxillofacial injuries in ice hockey and basketball.^{12,24,25} However, athletes in sports that do mandate face shields (eg, men's ice hockey and lacrosse) experience some of the highest rates of maxillofacial

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injuries.^{1,10} Furthermore, other sports that do not require full face shields, such as half face shields that extend only to the tip of the nose, such as basketball, experience high rates of maxillofacial injuries.⁷

Previous investigators have conducted the majority of maxillofacial injury studies at the national level using data from the NCAA Injury Surveillance System (ISS) or another national database.^{4,6,8-11} Although these studies represent national trends and overall frequencies, they lack the specificity and accuracy found in a large institution-level study of prospectively collected data.²³ The literature lacks institutional studies, and those studies that are available are either outdated in terms of modern statistics or limited in the number of sports studied. Importantly, these studies fail to provide granular data points, such as days to resolution and return to play.^{7,18,28} Given the evidence of increasing rates of maxillofacial injuries in modern athletics, despite preventive considerations,^{8,9} an up-to-date institution-level study is warranted to better understand the impact that these injuries have on athletic careers in terms of lost playing time and to improve current prevention strategies among the different sports.

The purpose of this study was to report the incidence of maxillofacial injuries among 13 sports from a single large university's athletic department and to provide novel data on the time lost from participation and time to complete injury resolution per sport because of these injuries. We hypothesized that in a single-institution analysis, the rate of maxillofacial injuries would be greater than previously reported in national registry studies.

METHODS

Data Collection

We conducted a retrospective review of athletic injury records from a single NCAA institution with dates from 2015 to 2019. The records reflected all athletics-related maxillofacial injuries that required an intervention by a physician or athletic trainer. Injury data were prospectively collected by athletic trainers using a standardized system, which has been used in previous epidemiological studies.^{18,28,34,35} This study was determined to be exempt from institutional review board approval.

Female and male athletes from 13 NCAA Division I teams were screened for inclusion. The included teams were football, baseball, men's and women's basketball, men's and women's water polo, men's and women's

tennis, men's and women's indoor volleyball, women's beach volleyball, women's lacrosse, and women's soccer. We included athletes from each sport if they had a recorded injury to their face that required immediate attention by a physician or athletic trainer. We excluded all patients who had an injury to a site other than the face. Additionally, we excluded any athletes who had a head injury that did not specify maxillofacial involvement.

We collected the following variables from the injury reports: sport, sex, injury type (ie, fracture, laceration, contusion), and injury site (eg, lip, eye, nose). Additionally, we gathered the number of days to resolution and the number of days of play lost. Time to resolution was defined as the number of days between the athlete's intake report and his or her last report for the maxillofacial injury. Time lost from participation was defined as the number of days that an athlete was unable to participate in competition because of a maxillofacial injury. Physicians were responsible for determining when athletes were clear to return to competition and when their injury resolved.

Statistical Analysis

The recorded maxillofacial injuries were classified by sport, sex, injury site, and injury type and were reported as the percentage (%). Days to resolution and days of participation lost for the overall cohort and for each sport were reported as the mean and range. The incidence of maxillofacial injuries per sport over 4 athletic seasons (2015-2019) was reported as the number of maxillofacial injuries per athlete-exposure (AE) hours.

We determined AE risk hours as the following: (number of players on a given team for a given year) \times (number of games played that year) \times (average length in hours of each game). For example, in 2015, the women's lacrosse team had 36 players on its roster and played 20 games. The average length of a lacrosse game is 1 hour. Therefore, there were 720 AE risk hours for the 2015 women's lacrosse team ($36 \times 20 \times 1$). The roster counts and number of games were found on the athletic department website.³⁰ The average time per game was found through a Google search. This method has been previously described by Phillips,³¹ although we adjusted our methodology to include roster size in our calculation to better account for practice sessions in which the whole team has a risk for injuries. We multiplied our incidence by 1000 to determine the number of maxillofacial injuries per 1000 AE hours.

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Ethical approval for this study was waived by the University of Southern California.

TABLE 1
Time to Complete Injury Resolution and Time Lost From Participation by Sport^a

	n (%)	Time to Resolution, d		Time Lost From Participation, d	
		Mean (Range)	Median (IQR)	Mean (Range)	Median (IQR)
Football	51 (26.4)	18.9 (0-135)	8 (4-15)	7.1 (0-118)	0 (0-4)
Men's basketball	31 (16.1)	46.6 (0-336)	15 (10-39)	23.8 (0-336)	0 (0-14)
Men's water polo	27 (14.0)	22.1 (0-136)	7 (1-23)	8.3 (0-73)	0 (0-6)
Women's basketball	19 (9.8)	25.6 (0-164)	12 (0-23)	3.9 (0-58)	0 (0-0)
Baseball	14 (7.3)	43.3 (5-184)	24 (10-38)	19.7 (0-184)	0 (0-10)
Men's volleyball	12 (6.2)	5.5 (0-12)	0 (0-8)	1.3 (0-7)	0 (0-0)
Women's lacrosse	11 (5.7)	24.1 (0-118)	0 (0-34)	1.3 (0-11)	0 (0-0)
Women's soccer	10 (5.2)	46.6 (0-132)	21 (4-94)	15.3 (0-71)	0 (0-5)
Women's water polo	7 (3.6)	28.7 (0-115)	18 (6-29)	20.1 (0-115)	0 (0-13)
Women's volleyball	7 (3.6)	46.8 (0-127)	4 (0-77)	2.3 (0-14)	0 (0-0)
Women's beach volleyball	2 (1.0)	5.5 (0-8)	6 (4-7)	0 (0-0)	0 (0-0)
Women's tennis	1 (0.5)	99.0	—	99.0	—
Men's tennis	1 (0.5)	20.0	—	20.0	—
Total	193 (100.0)	33.3 (0-336)	10 (3-34)	17.1 (0-336)	0 (0-4)
Women	57 (29.5)	32.3 (0-164)	9 (0-41)	8.9 (0-115)	0 (0-0)
Men	136 (70.5)	27.0 (0-336)	10 (4-26)	12.1 (0-336)	0 (0-6)

^ad, days; IQR, interquartile range. Dashes indicate no ranges as there was only one athlete.

RESULTS

A total of 193 NCAA Division I athletes across 13 sports sustained at least 1 maxillofacial injury over 4 athletic seasons. Football had the most injuries with 51 (26.4%), followed by men's basketball and men's water polo with 31 (16.1%) and 27 (14.0%), respectively (Table 1). Women's sports with the most injuries were basketball (n = 19 [9.8%]), lacrosse (n = 11 [5.7%]), and soccer (n = 10 [5.2%]). Across all sports, male athletes experienced 136 (70.5%) maxillofacial injuries, while female athletes experienced 57 (29.5%) injuries.

The overall incidence of maxillofacial injuries was 2.06 injuries per 1000 AE hours. The injury incidence for male and female athletes was 1.92 and 2.43 injuries per 1000 AE hours, respectively (Table 2). Men's basketball (8.30 injuries per 1000 AE hours) and men's water polo (8.15 injuries per 1000 AE hours) had the highest rates of all sports. Women's basketball had the highest incidence of women's sports (5.79 injuries per 1000 AE hours). Men's and women's tennis and baseball had the lowest rates, all with fewer than 1 injury per 1000 AE hours.

The majority of maxillofacial injuries were to the eye (29%), followed by the nose (24%), tooth (13%), jaw (9%), and lip/mouth (8%). The remaining injury sites included the ear, forehead, and cheek (all <5% each). Lacerations (40%), fractures (30%), and contusions/hematomas (23%) consisted of the majority of injury types. Over two-thirds of all fractures were seen in male athletes (69%), and 44% were seen in football players. There were 93 (48.2%) reports that had a record of the time of the injury. Of these injuries, 65 (69.9%) of injuries occurred during practice, and 28 (30.1%) occurred during competition.

The mean time to resolution across all sports was 33.3 days (range, 0-336 days) per injury (Table 1). The

TABLE 2
Injury Incidence by Sport

Sport	Injuries per 1000 Athlete-Exposure Hours		Rate Ratio (Male:Female)
	Men	Women	
Basketball	8.30	5.79	1.43
Water polo	8.15	2.15	3.79
Volleyball	3.46	2.16	1.60
Football	2.34	—	—
Baseball	0.41	—	—
Lacrosse	—	3.48	—
Soccer	—	2.07	—
Beach volleyball	—	1.08	—
Tennis	0.18	0.26	0.69
Total	1.92	2.43	0.79

mean time lost across all sports was 17.1 days (range, 0-336 days) per injury. Women's volleyball, men's basketball, and women's soccer players experienced the most days to resolution with 46.8 (range, 0-127), 46.6 (range, 0-336), and 46.6 (range, 0-132) days, respectively (excluding women's tennis, which had only 1 injury that resolved after 99.0 days). Men's basketball and women's water polo players experienced the most days of participation lost with 23.8 (range, 0-336) and 20.1 (range, 0-115) days, respectively. Across all sports, female athletes had more days to resolution (32.3 vs 27.0 days, respectively; $P = .45$), and male athletes took longer to return to play (12.1 vs 8.9 days of participation lost, respectively; $P = .49$), although both results were nonsignificant.

A total of 20 athletes (10.4%) required surgical treatment for their maxillofacial injuries. One athlete required a

TABLE 3
Injuries That Required Surgical Treatment (n = 20)

Sport	Injuries, n (%)	Injury Type
Football	11 (55.0)	Nasal fracture (n = 2), orbital fracture (n = 3), tooth fracture (n = 6)
Men's volleyball	2 (10.0)	Nasal fracture (n = 1), orbital fracture (n = 1)
Men's basketball	2 (10.0)	Nasal fracture (n = 1), tooth fracture (n = 1)
Women's basketball	1 (5.0)	Tooth fracture
Women's tennis	1 (5.0)	Tooth fracture
Women's soccer	1 (5.0)	Orbital fracture
Men's water polo	1 (5.0)	Nasal fracture
Baseball	1 (5.0)	Orbital fracture

reoperation. Football players underwent over half of all surgical procedures (n = 11 [55.0%]). Men's and women's basketball, men's volleyball, men's water polo, women's soccer, women's tennis, and baseball athletes underwent the remainder of the surgical procedures (Table 3). Male athletes underwent the majority of surgical procedures (17 [85.0%] vs 3 [15.0%], respectively). Athletes underwent surgery for 1 of 3 injuries: tooth fracture (n = 9 [45.0%]), orbital fracture (n = 6 [30.0%]), or nasal fracture (n = 5 [25.0%]).

DISCUSSION

In this study, we found an overall incidence of 2.06 maxillofacial injuries per 1000 AE hours in NCAA Division I athletes competing at a single institution over a period of 4 athletic seasons. Football had the most injuries with 51 (26.4%), followed by men's basketball and men's water polo with 31 (16.1%) and 27 (14.0%), respectively. Men's basketball (8.30 injuries per 1000 AE hours) and men's water polo (8.15 injuries per 1000 AE hours) had the highest rates among the sports. Maxillofacial injuries led to athletes missing a mean of 17.1 days (range, 0-336 days) of playing time and took 33.3 days (range, 0-336 days) to resolve. Across all sports, female athletes had more days to resolution (32.3 vs 27.0 days, respectively; $P = .45$), and male athletes took longer to return to play (12.1 vs 8.9 days of participation lost, respectively; $P = .49$), although both results were nonsignificant. There were 20 athletes (10.4%) who required surgery for their injuries. Football players underwent the most surgical procedures (n = 11 [55.0%]). Male athletes underwent more surgical procedures than female athletes (17 [85.0%] vs 3 [15.0%], respectively).

Recent epidemiological data from the NCAA ISS reported an overall incidence of 2.04 maxillofacial injuries per 10,000 athletic events, which is a lower rate than the 2.06 injuries per 1000 AE hours found in our study.⁶ The prior data, however, were collected through voluntary reporting of both exposures and injuries by athletic trainers.⁶ Although limited by a smaller population size compared to other studies using national registries, our

analysis may portray a more complete picture of maxillofacial injuries, as our institution's physicians and trainers are required to report all injuries in a standardized method, thus decreasing the opportunity for an injury to go unreported. Additionally, by using the standardized measure of "injuries per hour of athletic-exposure" rather than "per athletic event," our rates can be compared between sports of different durations. In terms of sex differences in injury rates, our results show that female athletes had a higher incidence of maxillofacial injuries compared to male athletes (2.43 vs 1.92, respectively). This aligns with prior NCAA ISS data (female: 2.06; male: 2.03; $P < .01$).⁶ Further research can determine whether specific aspects of different sports contribute to these slight differences.

In our study, basketball players had the highest rate of maxillofacial injuries for both male and female athletes (8.30 and 5.79 injuries per 1000 AE hours, respectively). This is in agreement with prior NCAA ISS data, despite the smaller population size of our study.⁶ Maxillofacial injuries comprise a substantial proportion of total injuries in basketball and have increased in prevalence within the sport.⁸ A study of dental injuries by Cohenca et al⁷ highlighted that basketball players had an incidence that was 5 times greater than football players, which is similar to our study (men's basketball: 8.30; football: 2.34). The authors suggested that this difference may be because of the mandatory use of mouth guards in football, which was implemented in the mid-1900s to prevent head and face injuries, and not in basketball.^{7,26} This further supports the idea that protective equipment should be increasingly used in basketball. It should be noted that the mandatory use of face masks in football has not fully prevented facial injuries from occurring in the sport. Interestingly, men's water polo had the second highest incidence (8.15 injuries per 1000 AE hours) of all sports in our study. There is limited literature on maxillofacial injuries in water polo; however, in a survey of active European professional players, 21% reported having a dental injury during their career.¹⁹ The high rate may be the result of the inherent difficulties of wearing protective equipment in an aquatic sport. However, our results may encourage further research into methods of prevention to reduce the burden of these injuries in water polo.

We found, on average, that maxillofacial injuries led to players missing over 2 weeks of athletic activity and took over 4 weeks to resolve completely. In certain sports, such as men's basketball and women's soccer, athletes missed a mean of 3 to 4 weeks, and in several sports, athletes took multiple months to resolve their injury. To our knowledge, there are no published studies on the time to return to participation and the time to resolution for maxillofacial injuries. However, the duration of delay found in our study is comparable to other common sport-related injuries. For instance, in a study of concussed athletes, two-thirds had resolution of their symptoms and returned to participation within 2 weeks.³² Additionally, a review of sport-related tendinopathies found that 64% of athletes did not have to miss any time and that those who did missed a median of 7 days.¹⁵ Our data illuminate the detrimental impact that maxillofacial injuries can have on student-athletes, taking

away valuable practice and competition opportunities. Prior research on anterior cruciate ligament injuries has shown the negative impact that lost playing time due to an injury has on player confidence and the ability to return to preinjury levels of competition.^{2,14} Measures focused on preventing maxillofacial injuries may have a meaningful impact on student-athletes' quality of life and athletic success.

Overall, 10.4% (n = 20) of the athletes with a maxillofacial injury required a surgical intervention in our study. Football players (n = 11 [55.0%]) and male athletes (n = 17 [85.0%]) underwent the majority of surgical procedures. All of the surgical patients in our study had a fracture (45.0% tooth, 30.0% orbital, 25.0% nasal). The number of facial fractures found in this study may indicate that athletes would benefit from the services of a dedicated ear, nose, and throat surgeon at their institution. The overall rate of surgical procedures found in our study is substantially lower than that found in previous studies. For example, a study of trauma referrals to a single institution found that 70% of patients with maxillofacial injuries required surgery.²⁹ Their study, however, had a much higher percentage of fractures compared to ours (86% vs 30%, respectively), which is likely a factor of their trauma population.²⁹ Prior studies have found that male athletes with maxillofacial fractures are more likely to require surgery than female athletes, which is similar to our study.^{5,6} A thorough analysis of the mechanisms behind maxillofacial fractures may elucidate why male athletes experience more severe injuries and require operative treatment. We did not analyze the time and rate to return to sport because of differences among the performed procedures.

This study should be considered in light of its limitations. The retrospective nature of the study creates a potential for data loss, which is an inherent limitation of retrospective studies in general. Data loss was limited by strict reporting guidelines for team physicians and trainers. Furthermore, our study does not include some sports with high maxillofacial injury rates such as wrestling and women's field hockey. These sports are not played at our institution. We were, however, able to provide data on 13 sports, including those that have been previously underreported such as water polo, beach volleyball, and tennis. An additional limitation is that we did not report whether protective equipment was worn when the injury occurred and the effect of this intervention on the maxillofacial injury incidence or on time to return to play. This represents an area of future investigation.

At our institution, athletes suffered maxillofacial injuries at a substantially higher rate (2.06 injuries per 1000 AE hours) than previously reported in the literature (0.2-1.5 injuries per 1000 athletic events/exposures).^{6,17,33} These athletes experienced over 2 weeks of lost training and competition and did not have complete resolution of their injuries for a month. We recognize that the discrepancy in the results between our study and other studies using NCAA ISS data may be because of differences in the study population; however, future studies should examine the efficacy of protective equipment such as mouth guards and face shields in preventing maxillofacial injuries in

athletes. Additionally, because two-thirds of the injuries in this study occurred during practice, an investigation into compliance with protective equipment use outside of competition may be warranted.

CONCLUSION

In NCAA Division I athletes, maxillofacial injuries occurred at a higher rate than previously thought and could lead to significant time lost from sport participation. Basketball players were at the highest risk of these injuries. Across all sports, male athletes took longer to return to sport after a maxillofacial injury compared to female athletes, but the latter required more time to fully recover. Maxillofacial injuries may also require surgical treatment, and their prevention is critical. Future modification of current maxillofacial injury prevention strategies across different sports should take into consideration these updated epidemiological data.

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