

Eye Injuries in High School and Collegiate Athletes

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Background: Although eye injuries constitute a small percentage of high school and college sports injuries, they have the potential to be permanently debilitating.

Hypothesis: Eye injury rates will vary by sport, sex, and between the high school and college age groups.

Study Design: Descriptive epidemiology study.

Level of Evidence: Level 3.

Methods: Data from eye injury reports in high school and college athletes were obtained from the National High School Sports-Related Injury Surveillance System, High School Reporting Information Online (HS RIO) database over a 10-year span (2005-2006 through 2014-2015 school years) and the National Collegiate Athletic Association (NCAA) Injury Surveillance Program (ISP) over an 11-year span (2004-2005 through 2014-2015 school years). Injury rates per 100,000 athlete-exposures (AEs), injury rate ratios (RRs), and 95% CIs were calculated. Distributions of eye injuries by diagnosis, mechanism, time loss, and surgery needs were also examined.

Results: A total of 237 and 273 eye injuries were reported in the HS RIO and the NCAA ISP databases, respectively. The sports with the highest eye injury rates (per 100,000 AEs) for combined high school and college athletes were women's basketball (2.36), women's field hockey (2.35), men's basketball (2.31), and men's wrestling (2.07). Overall eye injury rates at the high school and college levels were 0.68 and 1.84 per 100,000 AEs, respectively. Eye injury rates were higher in competition than practice in high school (RR, 3.47; 95% CI, 2.69-4.48) and college (RR, 3.13; 95% CI, 2.45-3.99). Most injuries were contusions (high school, 35.9%; college, 33.3%) and due to contact (high school, 89.9%; college, 86.4%). Only a small percentage of injuries resulted in time loss over 21 days (high school, 4.2%; college, 3.0%).

Conclusion: Eye injury rates and patterns vary by sport, sex, and between the high school and college age groups. Although severe injuries do occur, most eye injuries sustained by high school and college athletes are minor, with limited time loss and full recovery.

Clinical Relevance: Additional focus needs to be placed on preventing eye injuries at the collegiate level in women's and men's basketball, women's field hockey, and men's wrestling.

Keywords: eye injuries; epidemiology; high school; college; athletes

More than 42,000 sports- and recreation-related eye injuries were reported to emergency departments in 2000, with 72% occurring in individuals younger than 25 years.^{15,18} Eye injuries comprise approximately 1.5% of all sports injuries.¹⁷ Popular sports with a high risk for eye injuries

include basketball, baseball/softball, lacrosse, hockey, squash, racquetball, fencing, boxing, wrestling, and full-contact martial arts.^{2,5-7,15,21,25,26} Baseball and basketball were associated with the most eye injuries in 5- to 24-year-olds.¹ Although relatively rare, sports-related eye injuries are clinically important because

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ocular trauma is one of the most common causes of permanent visual impairment.¹⁹

The American Academy of Pediatrics (AAP) and the American Academy of Ophthalmology (AAO) strongly recommend protective eyewear for all participants in sports in which there is risk of eye injury.¹ However, various sports-governing bodies have different rules and guidelines regarding protective eyewear, which can vary by age group or competition level. For example, mandatory eye protection has been instituted at the high school and college levels for female lacrosse players. In field hockey, mandatory protective eyewear during competition was instituted before the 2011-2012 school year for high school athletes (National Federation of State High School Associations),¹⁶ but is not required at the collegiate level. In high school softball, a batting helmet with an attached facemask has been required since January 2006, but this is optional at the collegiate level.

Despite the existence of these AAP and AAO guidelines, little research has recently or directly examined eye injury rates and patterns across sports and competition levels. Large datasets rely on emergency department data, which may only collect the most severe injuries.¹⁵ This study utilized data from large national high school- and college-level sports injury surveillance systems to describe the epidemiology of eye injuries. Sport-specific eye injury rates are described, as well as the distributions of eye injuries by diagnosis, injury mechanism, and injury severity (based on time loss).

METHODS

Data Collection

This study uses data from 2 large national sports injury surveillance systems. High school data originated from the National High School Sports-Related Injury Surveillance System, High School Reporting Information Online (HS RIO), and were captured during the 2005-2006 through 2014-2015 academic years.^{3,20} College data originated from the National Collegiate Athletic Association Injury Surveillance Program (NCAA ISP) during the 2004-2005 through 2014-2015 academic years.⁸ This study used injury and exposure data from 22 sports: boys'/men's football, wrestling, soccer, basketball, lacrosse, baseball, swimming and diving, ice hockey, track and field, cross country, and tennis, and girls'/women's volleyball, field hockey, soccer, basketball, lacrosse, softball, swimming and diving, gymnastics, track and field, cross country, and tennis.

High School Reporting Information Online

The HS RIO is an Internet-based sports-related injury surveillance system that has captured injury and exposure data from a sample of US high schools. The methodology of the HS RIO has been described previously.^{3,20} High schools eligible for the HS RIO must have at least 1 athletic trainer (AT) who is affiliated with the National Athletic Trainers' Association and has a valid email address. ATs from participating high schools reported injury incidence and athlete exposure information weekly throughout the academic year using a secure website.

National Estimates. In the HS RIO, national injury estimates are only calculated from the randomly selected national sample of 100 high schools reporting data on the original 9 sports of interest (boys' football, soccer, basketball, wrestling, and baseball and girls' soccer, volleyball, basketball, and softball). For those sports with available national estimates, a weighting algorithm based on the inverse probability of participant schools' selection into the study (based on US Census geographic location and high school size) was applied to individual case counts to calculate the national injury estimates.²³

National Collegiate Athletic Association Injury Surveillance Program

The NCAA ISP has been described previously in detail.⁸ Participation in the NCAA ISP, while voluntary, is available to all NCAA institutions.

National Estimates. To calculate national estimates of the number of collegiate injuries and athlete-exposures (AEs), poststratification sample weights, based on sport, division, and academic year, were applied to each reported injury and AE. Poststratification sample weights were calculated using the formula

$$\text{weight}_{ijk} = \left(\frac{\text{Number of sponsoring schools}_{ijk}}{\text{Number of ISP schools}_{ijk}} \right)$$

where weight_{ijk} is the weight for the i th sport of the j th division in the k th year. Weights were further adjusted to correct for underreporting, according to findings from Kucera et al,¹⁰ which estimated that the ISP captured 88.3% of all time-loss medical care injury events. Weighted counts were scaled up by a factor of 1.133 (or 0.883^{-1}).

Definitions

In this study, for both the HS RIO and the NCAA ISP, a reportable injury (1) occurred as a result of participation in a school-sanctioned practice or competition, (2) required attention from an AT or physician, and (3) resulted in participation restriction time of at least 24 hours. Eye injuries included in this dataset were those that were noted as such by an AT or physician and included injuries and infections to the globe, eyelids, and orbital bones. Severe injuries were those injuries resulting in participation restriction greater than 3 weeks or those with student-athletes ending their season prematurely (ie, season-ending injury).

Statistical Analysis

Eye injury rates were defined as the number of eye injuries divided by the number of AEs. The rates are reported per 100,000 AEs in high school and college overall, by sport, by event type (eg, competition and practice), and for severe injuries only. Rate ratios (RRs) compared rates by level of competition (high school or college) and event type. RRs were

also calculated per sport per level of competition. In addition, because high school field hockey mandated protective eyewear prior to the 2011-2012 academic year, RRs compared eye injury rates for 2005-2006 through 2010-2011 and 2011-2012 through 2014-2015. The following is an example of an RR comparing eye injury rates in college versus high school:

$$RR = \frac{\left[\frac{\sum \text{eye injuries in college}}{\sum \text{athlete-exposures in college}} \right]}{\left[\frac{\sum \text{eye injuries in high school}}{\sum \text{athlete-exposures in high school}} \right]}$$

Injury distributions were also examined for diagnosis, injury mechanism, and time loss. Injury proportion ratios (IPRs) compared differences in distributions of diagnosis, injury mechanism, and time loss between high school and college. The following is an example of an IPR comparing the proportion of eye injuries due to player contact in high school versus college:

$$IPR = \frac{\left[\frac{\sum \text{eye injuries due to player contact in high school}}{\sum \text{total eye injuries in high school}} \right]}{\left[\frac{\sum \text{eye injuries due to player contact in college}}{\sum \text{total eye injuries in college}} \right]}$$

All 95% CIs not including 1.00 were considered statistically significant. Data were analyzed using SAS-Enterprise Guide software (version 7.1; SAS Institute). The HS RIO was approved by Colorado Multiple Institutional Review Board. The NCAA ISP was approved by the NCAA Research Review Board.

RESULTS

Eye Injury Counts and Rates

A total of 237 and 273 eye injuries were reported, respectively, in the HS RIO and NCAA ISP (Table 1). In the 9 sports in which the HS RIO provided national estimates, the reported injuries equated to an estimated 58,303 eye injuries sustained by high school student-athletes (or 5830 annually [58,303/10 academic years of data]). In the 22 sports in which the NCAA ISP provided national estimates, the reported eye injuries equated to an estimated 5753 eye injuries sustained by college student-athletes (or 523 annually [5723/11 academic years of data]).

Overall eye injury rates at the high school and college levels were 0.68 and 1.84 per 100,000 AEs, respectively (Table 1). At the high school level, sports with the highest eye injury rates included boys' baseball (1.68), boys' basketball (1.46), girls' field hockey (1.38), and boys' wrestling (1.07). At the college level, sports with the highest eye injury rates included men's wrestling (10.06), women's basketball (7.24), women's field hockey (5.61), and men's basketball (5.13). No eye injuries were reported in women's/girls' gymnastics, women's lacrosse, men's/boys' swimming and diving, men's/boys' ice hockey, men's/boys'/

women's/girls' indoor track, men's/boys'/women's/girls' outdoor track, men's/boys'/women's/girls' cross country, or men's/boys'/women's/girls' tennis.

Eye injury rates were significantly higher in college than in high school (RR, 2.65; 95% CI, 2.23-3.16) (Table 1). In nearly all sports, college athletes had significantly higher injury rates than high school athletes. The sole exceptions were baseball (RR, 0.98; 95% CI, 0.53-1.81) and men's/boys' lacrosse (RR, 1.40; 95% CI, 0.31-6.25).

Eye Injuries by Event Type

Among high school athletes, 55.3% of eye injuries occurred in competition, whereas among collegiate athletes, 60.8% occurred in practice (see the Appendix, available in the online version of this article). However, injury rates were significantly higher in competition than practice in both high school (RR, 3.47; 95% CI, 2.69-4.48) and college (RR, 3.13; 95% CI, 2.45-3.99). The direction and magnitude of RRs varied by sport and level.

Diagnosis

The distribution of eye injuries by diagnosis varied by sport and level. Contusions made up the largest proportion of eye injuries in high school (35.9%) and college (33.3%) athletics. Large proportions of eye injuries were also diagnosed as abrasions (high school, 16.0%; college, 20.5%) and lacerations (high school, 28.7%; college, 17.2%). Eye infections comprised 3.4% and 9.9% of diagnoses in high school and college sports, respectively. Most eye infections occurred in wrestling in high school ($n = 3$) and college ($n = 7$), with football also contributing 6 eye infections in college.

Injury Mechanism

Most eye injuries were due to contact in high school (89.9%) and college (86.4%). In particular, the most common contact mechanism was player contact (high school, 47.3%; college, 64.5%), followed by contact with the ball (high school, 37.1%; college, 18.3%). Men's basketball had the highest proportion of injuries due to player contact (high school, 93.3%; college, 95.8%). Sports with the largest proportion of eye injuries due to ball contact were baseball (high school, 92.3%; college, 85.7%), softball (high school, 95.2%; college, 62.5%), and volleyball (high school, 75.0%; college, 75.0%). A large proportion of eye injuries in college field hockey were also due to ball contact (72.7%), although only 33.3% of high school field hockey injuries were due to ball contact. The proportion of eye injuries due to player contact was greater in college than in high school (IPR, 1.36; 95% CI, 1.16-1.60); however, the proportion of eye injuries due to ball contact was greater in high school than in college (IPR, 2.07; 95% CI, 1.54-2.80).

Time Loss

Most eye injuries resulted in time loss of 1 to 6 days (high school, 65.8%; college, 78.8%). Few eye injuries were severe (ie, time loss >21 days; high school, 4.2%; college, 3.0%). Of the 10 severe eye injuries in high school, 2 occurred in boys' soccer, 1

Table 1. Eye injury counts, rates, and annual national estimates in high school and college sports

	Overall		HS RIO, 2005-2006 Through 2014-2015		NCAA ISP, 2004-2005 Through 2014-2015		College vs HS, Rate Ratio (95% CI) ^b		
	N	Rate per 100,000 AEs	n	Rate per 100,000 AEs	National Estimate ^a	n		Rate per 100,000 AEs	National Estimate
Boys'/men's football	72	0.58 (0.45-0.71)	26	0.38 (0.23-0.53)	4558	46	0.83 (0.59-1.07)	615	2.18 (1.35-3.52) ^c
Boys'/men's wrestling	52	2.07 (1.51-2.63)	24	1.07 (0.64-1.50)	6352	28	10.06 (6.33-13.79)	656	9.37 (5.43-16.17) ^c
Girls'/women's volleyball	12	0.41 (0.18-0.65)	4	0.17 (0.00-0.35)	467	8	1.32 (0.41-2.24)	158	7.58 (2.28-25.17) ^c
Girls'/women's field hockey	20	2.35 (1.32-3.39)	9	1.38 (0.48-2.28)	—	11	5.61 (2.29-8.92)	134	4.06 (1.68-9.81) ^c
Boys'/men's soccer	41	1.25 (0.87-1.64)	26	1.02 (0.63-1.41)	9297	15	2.09 (1.03-3.15)	455	2.05 (1.09-3.88) ^c
Girls'/women's soccer	39	1.29 (0.88-1.69)	18	0.81 (0.44-1.19)	6945	21	2.55 (1.46-3.64)	488	3.13 (1.67-5.87) ^c
Boys'/men's basketball	93	2.31 (1.84-2.78)	45	1.46 (1.03-1.88)	9180	48	5.13 (3.68-6.58)	827	3.52 (2.35-5.29) ^c
Girls'/women's basketball	78	2.36 (1.83-2.88)	18	0.73 (0.39-1.06)	4400	60	7.24 (5.41-9.07)	1008	9.95 (5.88-16.85) ^c
Boys'/men's lacrosse	7	0.57 (0.15-0.99)	4	0.50 (0.01-0.99)	—	3	0.70 (0.09-1.49)	53	1.40 (0.31-6.25)
Girls'/women's lacrosse	2	0.22 (0.00-0.53)	2	0.34 (0.00-0.82)	—	0	0	0	n/a
Boys'/men's baseball	53	1.67 (1.22-2.12)	39	1.68 (1.15-2.20)	9927	14	1.64 (0.78-2.51)	491	0.98 (0.53-1.81)
Girls'/women's softball	36	1.53 (1.03-2.02)	21	1.21 (0.69-1.73)	7178	15	2.39 (1.18-3.60)	349	1.97 (1.02-3.82) ^c
Girls'/women's swimming and diving	5	0.49 (0.06-0.92)	1	0.13 (0.00-0.40)	—	4	1.46 (0.03-2.88)	520	10.78 (1.21-96.48) ^c
Total ^d	510	1.04 (0.95-1.13)	237	0.68 (0.60-0.77)	58,303	273	1.84 (1.62-2.06)	5753	2.65 (2.23-3.16) ^c

AE, athlete-exposure; HS RIO, High School Reporting Information Online; n/a, not applicable; NCAA ISP, National Collegiate Athletic Association Injury Surveillance Program.

^aNational estimates from HS RIO were not available for girls' field hockey, boys' lacrosse, girls' lacrosse, or girls' swimming and diving.

^bRate ratio compares the college rate to the high school rate.

^cDenotes statistical significance, as 95% CI does not include 1.00.

^dNo cases of eye injuries were reported in women's/girls' gymnastics, men's/boys' ice hockey, women's lacrosse, men's/boys' track and field, women's/girls' track and field, men's/boys' cross country, women's/girls' cross country, men's/boys' swimming and diving, men's/boys' tennis, and women's/girls' tennis. However, AEs from these sports contribute to the total eye injury rates.

in girls' soccer, 2 in girls' basketball, 1 in boys' wrestling, 3 in boys' baseball, and 1 in girls' softball. Most were diagnosed as contusion ($n = 4$) or fracture ($n = 3$) and occurred from player contact ($n = 5$) or ball contact ($n = 3$). Of the 14 severe eye injuries in college, 4 occurred in men's baseball, 3 in men's basketball, 3 in women's field hockey, 2 in women's basketball, 1 in men's football, and 1 in women's softball. Most were diagnosed as fracture ($n = 5$) or abrasion ($n = 3$), and all occurred from player contact ($n = 6$) or ball contact ($n = 8$). The reported severe eye injuries equated to an estimated 1935 high school and 191 college severe eye injuries nationally during the study period (194 and 17 annually, respectively). The severe eye injury rate was higher in college (0.09) than in high school (0.03) (RR, 3.22; 95% CI, 1.43-7.26).

Rule Change in High School Field Hockey

Beginning in the 2011-2012 school year, protective eyewear was mandated in high school field hockey. Prior to this rule change, 6 eye injuries were reported in high school field hockey; after the rule change, 3 eye injuries were reported. The eye injury rates were 1.88 prior to and 0.90 after the rule change. Although the rule change was associated with a 52% reduction in the injury rate, the difference was not statistically significant due to small counts (RR, 0.48; 95% CI, 0.12-1.92).

DISCUSSION

Although research has examined eye injuries presenting to emergency departments,¹⁵ such data do not include those potentially less severe injuries. Understanding the epidemiology of eye injuries is important if effective, sport-specific prevention programs are to be developed. Despite their relative rarity, eye injuries are of particular clinical concern given their potential to be permanently debilitating.

Prevention

A study by the Consumer Product Safety Commission reported that protective equipment may be capable of reducing the incidence or severity of approximately one-third of all baseball injuries and most facial and eye injuries in young athletes.¹¹ Both the AAP and the AAO strongly recommend protective eyewear in high-risk sports such as baseball/softball, basketball, field hockey, football, ice hockey, and lacrosse.¹ Although eye protection such as goggles and face shields cannot eliminate all eye injuries, they have been reported to reduce the risk of injury by 90% and thus are considered very effective.¹⁷

Policies related to protective eyewear vary by sport and competition level. During the time period of the current study, protective eyewear/facemasks were mandatory for male and female athletes in high school and college lacrosse and ice hockey. It is possible that the low incidence of eye injuries in these sports was attributable to such policies. The low incidence

in lacrosse concurs with previous research that found protective eyewear mandates in female players was effective in reducing eye injuries.^{13,14,24} Despite concerns that protective eyewear might promote rougher play, the reduced rate of eye injuries in girls' lacrosse has been achieved without an increase in head/face injuries.¹³ In ice hockey, full-face masks or face shields were required throughout the study period at the high school and college levels. Although ice hockey has been considered a high-risk sport for eye injuries,^{4,12} there were no eye injuries reported in this study. Wearing full facial protection, or even partial facial protection, was associated with a decreased risk of injury.²² Protective facemasks were also mandated for high school softball athletes during batting and running the bases, but not fielding, prior to the onset of this study. The mandated facemask rule for high school softball may partially explain the reduced rate of eye injuries in softball compared with baseball, although other characteristics of the game such as the size and speed of the ball in play may also be contributory.

Current NCAA field hockey rules do not mandate goggles or facemasks. However, beginning with the 2011-2012 academic year, US high school field hockey players have been required to wear protective eyewear. The eye injury rate in field hockey decreased 52% after the rule change, although findings were not statistically significant due to small sample size. The mandatory protective eyewear rule in high school field hockey reduced the rate of eye/orbital injuries more than 3-fold and the number of severe eye injuries with time loss greater than 21 days by 67%.⁹

Limitations

Both injury surveillance systems providing data to this study included a convenience sample of all schools, which may lead to results not being generalizable across the entire population of high school and college student-athletes. In particular, as eye injuries are relatively rare events, it is possible that these results may not accurately estimate the true national incidence of eye injuries. Census-level data would better account for incidence. This study only captured injuries associated with time loss and did not account for injuries that may have been seen by ATs but did not alter sports participation. Although this undoubtedly resulted in an underestimate of true eye injury incidence, those injuries that do not result in time loss are considered less clinically important.

CONCLUSION

Eye injury rates vary across sports but are highest in basketball, baseball, field hockey, and wrestling. Most eye injuries are minor with limited time loss. However, severe injuries do occur, highlighting the need to identify measures to reduce the incidence and severity of eye injuries. The low eye injury rates in ice hockey and lacrosse illustrate the benefits of mandating protective eyewear.

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