

Head, Face, and Eye Injuries in Scholastic and Collegiate Lacrosse

A 4-Year Prospective Study

Andrew E. Lincoln,^{*†} ScD, MS, Richard Y. Hinton,[‡] MD, MPH, Jon L. Almquist,[§] ATC, Sean L. Lager,[‡] MD, and Randall W. Dick,^{||} MS

From the [†]Medstar Research Institute, Hyattsville, Maryland, and Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, [‡]Department of Orthopaedic Surgery, Union Memorial Hospital, Baltimore, Maryland, [§]Fairfax County Public Schools, Athletic Training Program, Fairfax, Virginia, and ^{||}National Collegiate Athletic Association, Indianapolis, Indiana

Background: Risks and mechanisms of head, face, and eye injuries in high school and college lacrosse are not well documented.

Purpose: To identify (1) primary mechanisms of head, face, and eye injuries in lacrosse and (2) differences in injury risk between the men's and women's game and between high school and collegiate levels.

Study Design: Descriptive epidemiological study.

Methods: The authors gathered data on 507 000 girls' and boys' high school and 649 573 women's and men's college lacrosse athletic exposures using sport-specific injury surveillance systems over 4 seasons. They identified the most common scenarios for head, face, and eye injuries.

Results: The high school girls' head, face, and eye injury rate (0.54 per 1000 athletic exposures) was significantly higher (incident rate ratio, 1.42; 95% confidence interval, 1.09-1.86) than that for boys (0.38 per 1000 athletic exposures); college women (0.77 per 1000 athletic exposures) sustained a higher rate of injuries (incident rate ratio, 1.76; 95% confidence interval, 1.42-2.19) than did men (0.44 per 1000 athletic exposures). Concussions constituted a higher percentage of injuries among boys (73%) and men (85%) than among girls (40%) and women (41%). Men sustained few facial injuries, whereas a substantial proportion of women's injuries involved the face and orbital area.

Conclusion: Although permitting only incidental contact, women's lacrosse had higher rates of head, face, and eye injuries at both the high school and collegiate levels. Concussion was the most common injury. For men, the primary injury mechanism was player-to-player contact; women's injuries primarily resulted from stick or ball contact. High school injury rates were lower than were college rates, but the nature of injuries, body parts affected, and mechanisms were similar.

Keywords: sports; injury; lacrosse; epidemiology

Lacrosse is a fast-paced team sport in which players use sticks to pass, catch, and run with a ball to score goals. The men's and women's games are among the fastest growing

sports in the United States. A US Lacrosse 2003 participation survey estimate cited approximately 115 000 players at the youth level, 119 000 at the high school level, and 24 000 at the college level.¹⁶ National Collegiate Athletic Association (NCAA) data show that the number of NCAA teams sponsoring men's lacrosse increased 24%, from 170 to 211, between 1993-1994 and 2003-2004. The increase is even more noteworthy in the women's game, in which the number of teams almost doubled, from 133 to 258, over the same 11-year time period.¹³

The men's game is a high-speed, high-collision sport with mandatory helmets, face masks, mouth guards, gloves, and upper body padding required for all field players (Figure 1). The stick, or crosse, is made of wood or synthetic material

*Address correspondence to Andrew E. Lincoln, ScD, MS, c/o Lyn Camire, Union Memorial Orthopaedics, The Johnston Professional Building, #400, 3333 North Calvert Street, Baltimore, MD 21218 (e-mail: lyn.camire@medstar.net).

One or more of these authors have declared a potential conflict of interest: some authors serve on the Sports Science Safety Subcommittee of United States Lacrosse.



Figure 1. Male lacrosse players in protective gear. Courtesy of US Lacrosse; reprinted with permission from Hinton et al.⁸

and has a shaped netted pocket at the end. The crosse dimensions vary by position, with attackmen and midfielders using shorter sticks than those used by defensive players. The solid rubber ball may travel at speeds up to 90 mph in the men's game.¹⁹

The women's game is also high speed but permits only incidental player-to-player contact. Helmets, face masks, and gloves have never been mandatory and are rarely used in the women's game (Figure 2). Until recently, mandatory protective equipment for field players included only mouth guards. However, US Lacrosse recommended protective eyewear in the women's game for 2004 and made it mandatory for women at all levels of play in 2005.¹⁷ The women's crosse is made of the same materials used for the men's stick and must be an overall length of 35.5 to 43.25 in. The goalie's crosse may be 48 in long. The ball is like that used in the men's game and may travel at speeds up to 60 mph in high school and adult play.¹⁷

Until recently, there were little prospectively gathered injury surveillance data for scholastic-age lacrosse. The few epidemiologic studies in the literature were limited by low response rates, nonstandardized injury definitions, and insufficient exposure assessments.^{3,6,18,20} A 3-year prospective epidemiologic study of high school girls' and boys' lacrosse injuries⁸ concluded that the majority of lacrosse injuries in this age group involved strains, sprains, contusions, and abrasions. These investigators found that head,



Figure 2. Female lacrosse players. The data collection period of the study (2000-2003) predates the mandate for protective eyewear in the women's game. Courtesy of US Lacrosse; reprinted with permission from Hinton et al.⁸

face, and eye (HFE) injuries were gender dependent. For boys, the primary head/face injury was concussion, which most frequently resulted from body-to-body contact. For girls, the primary head/face injury was contusion, which most commonly resulted from incidental stick or ball impact.

Injury data from collegiate play indicate that men's lacrosse generally has a 30% to 40% higher game injury rate and similar practice injury rates as compared with the women's collegiate game,¹² although HFE injuries constitute a substantially larger percentage of injuries in women's games than in men's games. Most of the women's HFE injuries are minor in terms of days lost from play, but there is a real potential for significant damage to the unprotected face with a hard ball being thrown at eye level at speeds up to 60 mph. Incidents of sight-impairing injuries and orbital fractures have been noted.^{6,9,14,20} These initial findings, combined with concern by the sport's national governing bodies (US Lacrosse, NCAA), have led to the current study of lacrosse injuries specific to HFE.

The goals of this study were to document primary mechanisms of HFE injury, to demonstrate differences in injury

TABLE 1
Study Participation for Fairfax County, Virginia, High School and National Collegiate
Athletic Association Collegiate Lacrosse Play, 2000 to 2003 Seasons

Variable	High School		Collegiate	
	Boys	Girls	Men	Women
No. of games	2112	2112	1831	3556
No. of practices	9408	9408	7999	13 943
Game athletic exposures	54 565	38 385	41 503	58 631
Practice athletic exposures	243 060	170 990	260 156	289 283
Total athletic exposures	297 625	209 375	301 659	347 914
Total athletes	5072	3566	Not available	Not available

risk between the men's and women's game, and to identify differences in injury risk between high school and collegiate levels of participation.

MATERIALS AND METHODS

Data were prospectively gathered for HFE injuries during 4 seasons (2000-2003) of high school and college lacrosse. The data collection period precedes the mandate for protective eyewear in the women's game.

Data Collection

Data were prospectively gathered for each of the 23 high schools in the Fairfax County (Virginia) Public School System. Each high school participates in both girls' and boys' lacrosse, has 2 certified athletic trainers, and is part of a computerized injury surveillance system. As an official part of their job duties, the certified athletic trainers entered injury and illness data on a daily basis. A system-wide program supervisor monitored the program to enhance compliance and data quality. A certified athletic trainer was available daily and was on the field for all games.

Baseline demographic data were gathered on all high school players before the start of each season. These data enabled us to calculate athletic exposures (AEs) and injury rates per 1000 AEs. Injury data were collected for high school play using an instrument that allowed the collection of data on both major and less severe injuries, including those that did not result in lost playing time, using the Injury Tracking Treatment System (ITTS). The ITTS is based on Sports Injury Management Systems software (Med Sports Systems, Dimondale, Mich). It was supplemented with data provided by a lacrosse-specific injury information form developed by a committee of sports medicine specialists, injury epidemiologists, lacrosse coaches, and administrators working with US Lacrosse and its Sports Science and Safety Committee.⁸ This form focused on lacrosse-specific injury mechanisms, such as stick-to-body or ball-to-body injuries, and on team and player activities at the time of injury. The injury information form was completed at the time of injury and entered concurrently with standard Sports Injury Management Systems injury data by a certified athletic trainer.

Head, face, and eye injury was defined specifically in the study. Head injury was considered to be injury to areas above the neck other than eye or facial injury. Face injury was defined as injury to the face, nose, chin, jaw, mouth, teeth, and tongue. Eye injury was defined as injury involving the eye orbit, eyebrow, eyelid, and all other structures of the eye proper.⁶

A reportable high school injury was defined as one that required medical attention by the school athletic trainer and that resulted in the modification of participation for 1 or more days. This definition of reportable injury differed slightly from the NCAA definition in that it considered restricted play on the day of injury as lost playing time, whereas the NCAA counted lost playing time from the day after injury. An AE was defined as 1 athlete participating in 1 practice or game in which the high school or college participant was exposed to the possibility of injury, as defined by the NCAA.^{11,12} During the 4-year period, the total number of high school lacrosse AEs was 209 375 for girls and 297 625 for boys (Table 1).

At the college level, data were collected through the NCAA Injury Surveillance System (ISS). The ISS annually collected data from a voluntary representative sample of schools sponsoring lacrosse via athletic trainers. The target sample was 10% of the schools from each of the 3 divisions that sponsored lacrosse. Data were prospectively collected from an annual mean of 34 men's lacrosse programs (range, 26-41 programs; 17% of sponsoring schools) and an annual mean of 64 women's lacrosse programs (range, 49-83 programs; 27% of sponsoring schools) during the 2000 to 2003 seasons.

According to the ISS guidelines, a reportable injury is one that occurred as a result of participation in an organized intercollegiate practice or contest, required medical attention by a team certified athletic trainer or physician, and resulted in restriction of the student-athlete's participation or performance for 1 or more days beyond the day of injury, or was a dental injury occurring in an organized practice or game, regardless of time loss.^{11,12} An injury form submitted to the NCAA for each reportable injury includes information on basic injury mechanism, time and place of injury, body part injured, type of injury, and details specific to the sport. If more than 1 body part is injured in the same incident, a separate form is completed for each injury. As in high school play, a reportable exposure in college play is

1 athlete participating in 1 practice or game in which he or she was exposed to the possibility of athletic injury regardless of the time associated with that participation. Information was collected weekly from each participating school, including the number of practices and games.

Athletic trainers at selected schools were provided with data collection directions and a packet of injury and exposure forms. Forms returned to the NCAA were entered into a database via hand entry. There were no identifiers on the forms other than school and sport. Each school's data were reviewed to be sure they met defined minimum exposure levels. Participation incentives included a small honorarium and end-of-season reports for the individual school and aggregate divisional and national reports. During the 4-year period, the total number of AEs was 347 914 for college women and 301 659 for college men (Table 1).

Statistical Analysis

Injuries were analyzed in terms of (1) session type (practice or game), (2) nature of injury, (3) anatomical area injured, (4) mechanism of injury, (5) player activity at time of injury, and (6) most common scenarios for concussions, eye injuries, and face injuries. Results were reported in terms of the proportion of injuries for boys versus girls and men versus women and incidence density (number of injuries per 1000 AEs). Incidence rate ratios (IRRs) and 95% confidence intervals (CIs) were calculated using Stata 6.0 software (Stata Corp, College Station, Tex) to examine differences by gender, with girls and women as the reference groups. Differences in the proportions of injuries were analyzed with a χ^2 test, and a *P* value of .05 was used to denote statistical significance.

RESULTS

Game injury rates for high school boys and girls were 1.1 and 1.3 per 1000 AEs, respectively. Practice injury rates were 0.14 and 0.26 per 1000 AEs for high school boys and girls, respectively. Over the 4-year sample period, the 23 Fairfax County high schools reported 114 HFE injuries for high school girls and 114 for boys. This total results in a mean of 1.2 HFE injuries per team per year. High school girls experienced a significantly higher rate (0.54/1000 AE) of HFE injuries (IRR, 1.42; 95% CI, 1.09-1.86) than did boys (0.38/1000 AE) (Table 2).

For collegiate players, the game HFE injury rates were 1.81 per 1000 AEs for men and 1.98 per 1000 AEs for women, and the practice injury rates for men and women were 0.22 and 0.53 per 1000 AEs, respectively. Over the 4-year sample period, the 256 women's lacrosse schools reported 268 HFE injuries (1.0 per team per year), and the 136 men's programs reported 132 (1.0 per team per year). Collegiate women (0.77/1000 AE) sustained a higher rate of HFE injury (IRR, 1.76; 95% CI, 1.42-2.19) than did men (0.44/1000 AE) (Table 2).

Boys, girls, and collegiate men sustained a majority of HFE injury during games, whereas collegiate women sustained a majority of such injuries during practice (Table 2). The overall elevated rates among women and girls are largely attributed to injury incidence during practices rather than games.

The most common type of HFE injuries were concussions, contusions, and fractures (Table 3). High school boys sustained 83 concussions (73% of all HFE injuries), whereas girls sustained 45 concussions (40%). Concussions constituted a higher percentage of HFE injuries at the college level, representing 112 of 132 HFE injuries (85%) for men and 111 of 268 HFE injuries (41%) for women. The HFE contusions were dramatically lower for high school boys ($n = 14$, 12%) and college men ($n = 4$, 3%) than for their female counterparts ($n = 38$, 33%; $n = 64$, 24%, respectively). For high school play, girls were more than 5 times as likely to experience an HFE fracture and nearly 4 times as likely to experience an HFE contusion as were their male counterparts (Table 3). Incident rate ratios for female collegiate players were even higher for contusions (13.9) and fractures (12.1).

The preponderance of HFE injuries in high school boys (84%) and college men (89%) were to the head. In contrast, high school girls and college women experienced significantly higher proportions of HFE injuries to the nose (15% and 24%, respectively) and eyes (19% and 15%, respectively) than did their male counterparts (Table 4).

Further investigation of concussion mechanisms during games and practices combined revealed that the male HFE injuries resulted most often from direct contact with another player, whereas female concussions were owing to incidental contact with the stick, ground, or ball. Of 83 total concussions, high school boys sustained 33 (34%; 0.11/1000 AE) from body-to-body contact with another player. An additional 16 cases were coded as "direct impact," many of which may actually be body-to-body contact. Of 45 total concussions, girls sustained 22 (49%) from stick contact (0.11/1000 AE). College men sustained 83% of their concussions ($n = 93$, 0.31/1000 AE) from contact with another player, whereas 7 were owing to contact with a stick (0.02/1000 AE), and 6 resulted from contact with the ball (0.02/1000 AE). For college women, 39% ($n = 43$) of reported concussions were related to stick contact (0.12/1000 AE), 37% ($n = 41$) owing to contact with the ball (0.12/1000 AE), and 14% ($n = 16$) owing to contact with another player (0.05/1000 AE) (see Appendix 1, available in the online version of this article at <http://ajsm.sagepub.com/cgi/content/full/X/X/X/DC1/>).

High school boys sustained a total of 9 facial injuries exclusive of the eye (contusions and lacerations) associated with ball-to-body or stick-to-body contact. High school girls sustained 14 facial contusions from stick contact, 11 HFE contusions from ball-to-body contact, and 7 fractures to these areas from ball-to-body contact. College men had 4 HFE lacerations and 3 HFE fractures as a result of body-to-body contact and 2 lacerations from stick-to-body contact. College women sustained 32 facial fractures from ball contact, 18 fractures from stick contact, and 10 lacerations from stick contact (see Appendix 2 online).

The pattern of gender-based injury mechanisms continued for the most common eye injury scenarios. Men and boys sustained only 1 and 2 eye injuries, respectively. College women sustained 24 contusions from contact with the ball, 4 lacerations from stick contact, and 4 contusions from stick contact (see Appendix 3 online). High school girls sustained 6 contusions from ball-to-body contact, 5 contusions from stick-to-body contact, and 3 orbital fractures from ball contact.

TABLE 2
Head, Face, and Eye Injuries by Session Type^a

Session	High School						Collegiate								
	Boys			Girls			Men			Women					
	Frequency, n	Percentage	Incidence Rate	Frequency, n	Percentage	Incidence Rate	Incident Rate Ratio, Girls/Boys	Frequency, n	Percentage	Incidence Rate	Frequency, n	Percentage	Incidence Rate	Incident Rate Ratio, Women/Men	95% CI
Game	60	52.6	1.10	51	44.7	1.33	1.21	75	56.8	1.81	116	43.3	1.98	1.09	0.81-1.48
Practice	35	30.7	0.14	45	39.5	0.26	1.83	57	43.2	0.22	152	56.7	0.53	2.40	1.75-3.31
Other	10	8.8		7	6.1			0			0				
Missing	9	7.9		11	9.7			0			0				
Total	114	100	0.38	114	100	0.54	1.42	132	100	0.44	268	100	0.77	1.76	1.42-2.19

^aThe incident rate is injuries per 1000 athletic exposures. CI, confidence interval.

TABLE 3
Nature of Injury by Frequency, Rate, and Relative Rate by Gender for Fairfax County, Virginia, High School and National Collegiate Athletic Association Lacrosse Play^a

Nature of Injury	High School						Collegiate								
	Boys			Girls			Men			Women					
	Frequency, n	Percentage	Incidence Rate	Frequency, n	Percentage	Incidence Rate	Incident Rate Ratio, Girls/Boys	Frequency, n	Percentage	Incidence Rate	Frequency, n	Percentage	Incidence Rate	Incident Rate Ratio, Women/Men	95% CI
Concussion	83	72.8	0.28	45	39.5	0.21	0.77	112	84.8	0.37	111	41.4	0.32	0.86	0.65-1.13
Contusion	14	12.3	0.05	38	33.3	0.18	3.86	4	3.0	0.01	64	23.9	0.18	13.87	5.16-52.47
Fracture	4	3.5	0.01	16	14.0	0.08	5.69	4	3.0	0.01	56	20.9	0.16	12.14	4.49-46.03
Laceration	9	7.9	0.03	8	7.0	0.04	1.26	8	6.1	0.03	25	9.3	0.07	2.71	1.18-6.96
Other	3	2.6	0.01	4	3.5	0.02	1.90	4	3.0	0.01	12	4.5	0.03	2.60	0.79-11.05
Total	114	100	0.38	114	100	0.54	1.42	132	100	0.44	268	100	0.77	1.76	1.42-2.19

^aGame and practice injuries are combined. The incident rate is injuries per 1000 athletic exposures. CI, confidence interval.

TABLE 4
 Body Part Injured by Frequency, Rate, and Relative Rate by Gender for Fairfax County,
 Virginia, High School and National Collegiate Athletic Association Lacrosse Play^a

Body Part	High School						Collegiate					
	Boys			Girls			Men			Women		
	Frequency, n	Incidence Rate Percentage	Frequency, n	Incidence Rate Percentage	Incident Rate Ratio, Girls/Boys	95% CI	Frequency, n	Incidence Rate Percentage	Frequency, n	Incidence Rate Percentage	Incident Rate Ratio, Women/Men	95% CI
Head	96	0.32	66	0.32	0.98	0.70-1.35	117	0.39	130 ^b	0.37	0.96	0.74-1.25
Nose	3	0.01	17	0.08	8.06	2.33-42.90	0	0.00	65	0.18	56.36	9.77-2252.93
Eye/orbit	2	0.01	22	0.11	15.64	3.84-137.17	1	0.00	40	0.11	34.68	5.87-1399.22
Face	7	0.02	7	0.03	1.42	0.42-4.75	2	0.01	11	0.03	4.77	1.04-44.22
Jaw/chin	3	0.01	1	0.9	0.47	0.01-5.90	12	0.04	12	0.03	0.87	0.35-2.11
Mouth/teeth	3	0.01	1	0.9	0.47	0.01-5.90	0	0.00	10	0.03	8.67	1.24-374.77
Total	114	0.38	114	0.54	1.42	1.09-1.86	132	0.44	268	0.77	1.76	1.42-2.19

^aGame and practice injuries are combined. The incident rate is injuries per 1000 athletic exposures. CI, confidence interval.

^bIncludes 3 injuries to ear.

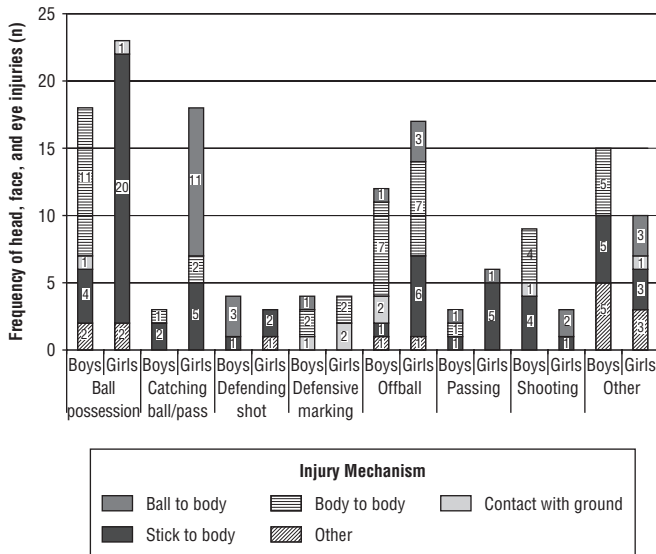


Figure 3. Head, face, and eye injuries in high school lacrosse: player activity and injury mechanism by gender; Fairfax County, Virginia, public schools, 2000-2003.

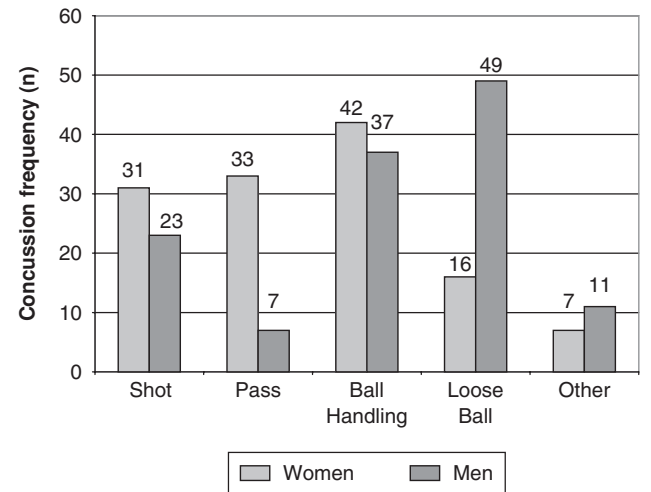


Figure 5. Concussions and player activity in collegiate lacrosse, National Collegiate Athletic Association, 2000-2003.

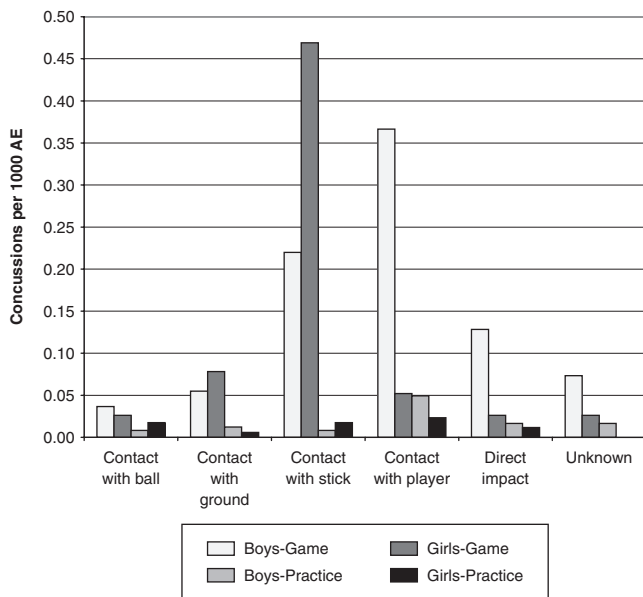


Figure 4. Mechanisms of concussion in high school play by setting. AE, athletic exposure.

In high school play, the distributions of HFE injuries by player activity were distinctly different by gender (Figure 3). Although ball possession was the most common player activity for both girls' and boys' injuries, 87% (n = 20) of HFE injuries to girls resulted from stick-to-body contact, whereas 61% (n = 11) of HFE injuries to boys resulted from body-to-body contact. For girls, the second most common activity associated with HFE injury was catching a ball or pass (n = 18). Offball activity was also prevalent, with 17 girls and 12 boys sustaining HFE injuries.

Mechanisms of concussion in high school play were dramatically different for game and practice settings (Figure 4). Virtually all concussions associated with stick contact for the girls occurred during games, whereas boys' concussions associated with both stick and player contact were elevated during games.

For concussions occurring at the college level, women (n = 33) were much more likely to be injured in passing activities than were men (n = 7). In contrast, men (n = 49) were more often injured pursuing a loose ball than were women (n = 16) (Figure 5).

DISCUSSION

Although women's lacrosse involves less physical contact than does the men's game, our findings illustrate that females experience higher rates of HFE injuries than do their male counterparts at both the high school and collegiate levels. In the current study, concussion was the most common injury sustained by male and female players in both high school and collegiate settings. For boys and men, the mechanism of concussions was most often player-to-player contact. In contrast, concussions in women primarily resulted from stick or ball contact. Although the injury rates for HFE injuries were similar for boys and men, college women had higher rates than did the girls. This result may be associated with the relative difference in aggressive play between the women's collegiate and high school levels.

One of the primary differences in protective equipment between men's and women's lacrosse is the use of a helmet and face mask, which is required of all players in the men's game and only the goalie in the women's game. The injury patterns largely reflect the protection offered by this

equipment in that high school boys and college men sustained few facial and eye injuries, whereas a significant proportion of girls' and women's injuries involved the face and eyes.

Our findings show a high incidence of concussion in the men's game, which may seem surprising given the use of a helmet. However, the use of padded headgear does not necessarily reduce the risk of concussion, as found by Marshall et al¹⁰ when investigating protective equipment used in rugby union play. Helmets are designed to reduce contusion, lacerations, fracture, cerebral hematomas, and facial injuries that result primarily from inadvertent contact with the ball or stick.² Based on the data reported in this study, helmets perform this role very well. No sport helmet standard claims to reduce the risk of concussion because of the lack of scientific data on the cause of concussion.² However, recent technological advances in helmet impact measurement have been implemented to better understand the biomechanics associated with concussion incidence.⁴

Skills improvement and rule enforcement could have an effect on injury rates. For example, high school girls were injured most commonly in the current study during ball possession from stick-to-body contact (20 injuries) and during catching the ball or passing (11 injuries). Focused training and education in stick handling may help in preventing some of these injuries.

Our findings regarding injury frequency and patterns of HFE injury offer support of US Lacrosse's mandate of protective eyewear for females at all levels of play. Protective eyewear, along with enforcement of existing rules and education/training to improve stick handling, may help prevent some of these HFE injuries. Further study of the data subsequent to the introduction of protective eyewear will provide evidence of the effectiveness of this change.

There is some concern that players who perceive themselves to be safer through the use of protective equipment will play more aggressively and/or recklessly to assume the previous (preintervention) level of risk,²¹ although the legitimacy of such a phenomenon has not been clearly established.^{1,5,15} Studies of the implementation of ice hockey helmets do not support concerns about occurrence of more aggressive or reckless play with the introduction of protective equipment.⁷ A prospective study currently underway at our institutions should provide further insight into the issue of risk compensation associated with protective eyewear.

The primary limitations of the current study relate to possible reporting errors. Injury diagnoses and mechanisms were reported for both high school and college surveillance systems by athletic trainers who treated but may not have actually witnessed the actual injury. Therefore, the accuracy of the reported mechanism of injury may be questioned. Further study is needed to investigate the accuracy of injury mechanism reporting.

Another limitation involves the use of 2 different surveillance systems used to capture injury data in the high

school and collegiate settings. The Fairfax County ITTS covers all athletes at all schools, whereas the NCAA ISS uses a sampling methodology to represent the collegiate injury experience. In addition, the NCAA ISS did not capture those cases in which an HFE injury occurred and limited participation for the remainder of that day's game or practice but did not affect play on the following day. This may have resulted in an undercount of collegiate injuries as compared with high school injuries, so that the true difference between collegiate and high school injury incidence may be even greater than what was reported here.

CONCLUSION

Lacrosse played at high school and collegiate levels is a relatively safe sport, although HFE injuries occur primarily in the form of concussions, contusions, and fractures. Such injuries have potentially catastrophic consequences and are of serious concern to players, parents, coaches, and officials. Although high school injury rates are lower than those of college, the distributions in terms of the nature of injuries, body parts affected, and mechanisms of injury are similar. The women's game, although not allowing physical contact, has higher rates of HFE injuries, most likely because of the lack of any required head/face protection other than a mouth guard. The use of mandatory protective eyewear in the women's game, enforcement of current rules of play, and improvement of players' skills may effectively reduce these injuries.

ACKNOWLEDGMENT

The authors thank Julie Agel, MA, University of Minnesota, for her contribution to this study. Nonrestrictive financial support was provided by the Union Memorial Hospital Orthopaedic Research Committee and US Lacrosse.

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