

Epidemiology of Lacrosse Injuries in High School–Aged Girls and Boys

A 3-Year Prospective Study

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Objective: To report the types, mechanisms, and circumstances of lacrosse injuries incurred by high school–aged girls and boys during organized interscholastic and summer camp games.

Study Design: Descriptive epidemiology study.

Methods: For 3 years, the authors gathered data on girls' and boys' lacrosse injuries for 359 040 high school and 28 318 summer camp athletic exposures using a lacrosse-specific computerized injury surveillance system. The most prevalent injuries were organized into multifactorial injury scenarios.

Results: In high school play, the injury rate for adolescent boys (2.89 per 1000 athletic exposures) was slightly higher than that for girls (2.54 per 1000 athletic exposures) (incidence rate ratio = 1.14; 95% confidence interval, 1.00-1.30). The most prevalent injuries for adolescent girls and boys were knee and ankle sprains resulting from noncontact mechanisms. Male players had significantly higher rates of shoulder, neck, trunk, and back injuries and higher game-to-practice injury ratios. In addition, they had higher rates of concussive events from player-to-player contact. Female players had higher rates of overall head injuries, many involving contusions and abrasions from stick and ball contact.

Conclusions: The overall injury rates for boys' and girls' high school lacrosse were significantly lower than those for collegiate play. Significant differences existed between adolescent boys and girls with respect to injury mechanisms, body parts injured, and player and team activity at the time of injury.

Keywords: sports; injury; lacrosse; high school–aged; epidemiology

With its roots in Native American cultures, lacrosse is not only the oldest team sport in North America but is also currently among its fastest growing sports. Today, more than 100 000 adolescent girls and boys play on organized high school teams, and another 150 000 are involved in recreational leagues and summer camps.²¹ Unfortunately, there are very little prospectively gathered injury surveillance data on lacrosse play at the high school level. Most published reports to date involve opinion state-

ments^{7,10,19,24} or limited case series.^{10,11,14} The few available epidemiologic studies have focused on limited injury types or have been hindered by low response rates, nonstandard injury definitions, and insufficient exposure parameters.^{5,6,22,25} As part of its injury surveillance program, the National Collegiate Athletic Association (NCAA) has gathered information on collegiate lacrosse injuries since the early 1980s.^{16,17} However, because of myriad differences in player attributes, equipment and facility conditions, coaching expertise, and other conditions of play, collegiate data cannot be reliably extrapolated to the high school level.

Basic descriptive, epidemiologic data are required to define the absolute and relative risks of high school–level lacrosse participation, mechanisms of injury, risk factors for injury, and injury prioritization for prevention programs. Our goals were to prospectively gather and report well-defined epidemiologic data on the types, mechanisms, and circumstances of lacrosse injuries in adolescents, incurred during both interscholastic and summer camp play.

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Lacrosse: An Overview

Both girls' and boys' lacrosse are free-flowing, fast-paced team sports played on fields similar in size to soccer or football fields. Players use a stringed, pocketed stick to pass, catch, and advance the ball upfield, with the aim of shooting the ball into the opponent's netted goal. There are offensive, defensive, and transitional field players, and each team's goal is guarded by a goalie. Although both boys' and girls' lacrosse matches share the qualities of high speed and quick change of direction, there are many procedural differences between them. To the sports medicine specialist, the most important differences are the greater amount of player-to-player and stick-to-player contact allowed in the boys' game and the mandatory protective equipment. Body contact, or body checking, is permitted in boys' lacrosse if contact is above the waist and below the shoulders of the opponent's front or side and as long as the player has possession of or is within 5 yd of the ball. A male player's gloved hands and padded arms are considered part of the stick and may be legally checked. In the girls' game, intentional body-to-body contact is not legal. Stick checking is allowed but must be directed toward the pocketed end. Sticks are to be kept away from an imaginary protective bubble around the opponent's head.

Mandatory protective gear for the boys' game includes a helmet with full face guard, a mouthpiece, lightweight noncantilevered shoulder pads, padded gloves, elbow pads, upper arm padding, and genital protective cups (Figure 1). The only mandatory protective gear for the girls' game has been a mouthpiece (Figure 2). Lightweight neoprene gloves, protective eyewear, and soft headgear are optional. Starting in 2005, the use of protective eyewear will be mandated at all levels of women's play (Figure 3).¹⁸ The combination of fast pace, change of direction, high ball velocity, and use of sticks in lacrosse results in a unique set of injury mechanisms and types.

MATERIALS AND METHODS

The study was approved by the departmental research committee and the institutional review board at the institution of the senior author (R.Y.H.). Data were collected for interscholastic and summer camp 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. We used the Injury Tracking Treatment System (ITTS), currently employed by Virginia's Fairfax County Public School System, to prospectively gather data over a consecutive 3-year period (1999-2001) on a large population of participants in both of these playing environments. The ITTS is based on Sports Injury Management System (SIMS) software (Med Sports Systems, Dimondale, Mich), a common data-collection instrument. It was supplemented with data provided by a lacrosse-specific injury information form (LSIIF) (Appendix, available in the online version of this article at [www.ajsm.org/cgi/content/33/9/\[PAGE\]/DC1](http://www.ajsm.org/cgi/content/33/9/[PAGE]/DC1)) developed by a committee of sports medicine specialists, injury epidemi-

ologists, lacrosse coaches, and administrators working with US Lacrosse, the national governing body for lacrosse, and its Sports Science and Safety Committee. 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 LSIIF was completed at the time of injury and entered concurrently with standard SIMS injury data by a certified athletic trainer. Baseline demographic data were gathered on all participants before the start of each season/camp for the generation of injury rates. Because high school and summer camp are such different playing environments, the nature of play and definition of injury were treated differently and are explained in the following sections.

High School Play

Data were prospectively gathered during the 1999, 2000, and 2001 lacrosse seasons for each of the 23 high schools in the Fairfax County Public School System. Each high school participates in both girls' and boys' lacrosse, has 2 certified athletic trainers, and is part of the ITTS computerized injury surveillance system. Data were entered daily by the certified athletic trainers as an official part of their job duties. A systemwide program supervisor (J.L.A.) monitored the program to enhance compliance and data quality. A certified athletic trainer was available daily for practices and was on the field for all games. High school games took place on grass playing fields.

An athletic exposure (AE) was defined as 1 athlete participating in 1 practice or game in which the participant is exposed to the possibility of injury, as defined by the NCAA injury surveillance system.^{16,17} A reportable 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.^{16,17} 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 definition counts lost playing time from the day after injury. However, this difference in definition between high school- and collegiate-level play was considered relatively minor in terms of the general comparisons made with NCAA data.

During the 3-year study period, there were 3870 male and 2658 female lacrosse player-seasons, for total AEs of 212 850 for the boys and 146 190 for the girls.

Summer Camp Play

Data were prospectively gathered during the 1999, 2000, and 2001 Elite 300 Girls' and 205 Boys' Summer Lacrosse Camps in Baltimore, Maryland. These camps were held during June or July and followed the same format and structure each year. Most participants were upper-level high school players aged 15 to 18 years who aspired to play collegiate lacrosse. During the 3 years of the study, there were 2259 male and 1141 female participants. Activity in the summer camps was divided into game and practice sit-



Figure 1. Male lacrosse players in protective gear. Photograph courtesy of US Lacrosse.

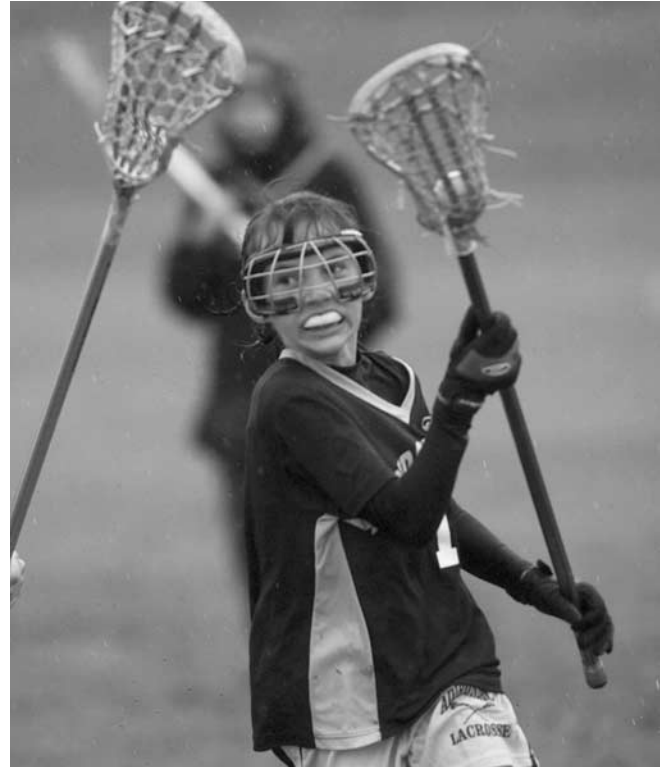


Figure 3. Protective eyewear and optional gloves on a female lacrosse player. Photograph courtesy of US Lacrosse.



Figure 2. Female lacrosse players wearing mouthguards. Photograph courtesy of US Lacrosse.

uations. An AE in this case was defined as 1 hour of game time or 2 hours of practice time, to correspond with a typical high school game or practice session. The 4.5-day boys' camps (2 sessions each summer) were broken into 5 hours of practice (2.5 AEs) and 6.5 hours of game time (6.5 AEs) for each participant, resulting in a total of 9 AEs for each participant during the camp. During the 3-day girls' camps (1 session each summer), there were 4 hours of practice (2 AEs) and 5 hours of game time (5 AEs) for each participant, giving a total of 7 AEs per participant. During the 3 summers, there were total AEs of 20 331 for the boys and 7987 for the girls. A certified athletic trainer was present at all practice and game sessions at the camps. Summer camp games took place on artificial turf.

For summer camp play, a reportable injury was defined as one that occurred as a result of participation in an organized practice or game and that required attention by the athletic trainer regardless of whether any participation time was lost. This definition differed from that used for high school play and limited the ability to compare between the groups, but it allowed the collection of data on all injuries for the summer camps, even those for which there was no lost participation time. Data were collected via the ITTS, supplemented with the LSIIF data, and entered the same day by a certified athletic trainer who had covered the event. The trainers were educated concerning use of the forms for data collection and entry to standardize data input and maximize consistent reporting.

Statistical Analysis

Injuries were analyzed in terms of anatomical area, nature of injury, session type, severity (using the surrogate measure of days lost), mechanisms, and player/team activity at the time of injury. Results are reported for the proportion of injuries between boys and girls and incidence density (number of injuries per 1000 AEs). Incidence rate ratios (IRR) and 95% confidence intervals (95% CI) were calculated using Stata 6.0 software (Stata Corp, College Station, Tex) to examine differences by gender, with girls as the reference group. Differences in the proportion of injuries between boys and girls were analyzed with a χ^2 test, and a *P* value of .05 was used to denote statistical significance.

We organized the most common combinations of body part, nature of injury, and specific mechanism into injury scenarios. This approach has been used in preventive and occupational health studies to better understand injury circumstances and to more effectively direct injury prevention programs.⁴

RESULTS

High School Play

Overall, 615 and 371 injuries were reported for adolescent boys and girls, respectively. The incidence rate for boys (2.89 per 1000 AEs) was slightly higher than that for girls (2.54 per 1000 AEs) (IRR = 1.14; 95% CI, 1.00-1.30) (Table 1). Boys were more often injured during games, whereas girls were more often injured during practices (Table 2). Also, boys were 3 times more likely than girls to sustain an injury during a game (IRR = 3.00; 95% CI, 2.26-4.05) (Table 2). In 20% of the records, the trainer did not report whether the injury occurred during a practice or game.

The most frequently injured body parts in high school play were the ankle, knee, head/face, and wrist/hand for both adolescent boys and girls (Table 3). Boys were less likely than girls to injure their ankles (IRR = 0.73; 95% CI, 0.55-0.98) but more likely to sustain injuries to the neck (IRR = 3.89; 95% CI, 1.13-20.73), shoulder (IRR = 2.38; 95% CI, 1.32-4.55), upper leg (IRR = 2.15; 95% CI, 1.18-4.14), and back/trunk (IRR = 2.11; 95% CI, 1.15-4.06).

The most common natures of injury for boys and girls were sprains/strains (42% and 46%, respectively) and contusions (23% and 18%, respectively) (Table 4). Fractures represented 9% of injuries for both adolescent boys and girls. Boys were 3 times more likely to sustain a concussion (IRR = 2.99; 95% CI, 1.65-5.79). Although boys tended to have fewer overuse injuries than girls (IRR = 0.69; 95% CI, 0.46-1.03), the difference did not reach statistical significance at the *P* = .05 level.

Among adolescent boys, the most prevalent injury scenario was an ankle ligament sprain related to indirect force (ie, noncontact mechanisms such as cutting, dodging, and torsion) (Table 5). These injuries accounted for 82 cases and 557 total days lost. The second most prevalent scenario was a concussive event (*n* = 61; 520 total days

TABLE 1
Study Participation and Injury Rates for High School and Summer Camp Lacrosse Play

Variable ^a	Fairfax County		Summer Camp	
	Boys	Girls	Boys	Girls
Player-seasons	3870	2658	2259	1141
Athletic exposures	212 850	146 190	20 331	7987
Reported injuries	615	371	299	106
Injury rate per 1000 athletic exposures	2.89	2.54	14.71	13.27
Exact 95% CI of injury rate IRR, boys to girls	2.67-3.13	2.29-2.81	13.09-16.47	10.87-16.05
95% CI for IRR	1.14	Reference	1.11	Reference
	1.00-1.30		0.89-1.40	

^a95% CI, 95% confidence interval; IRR, incidence rate ratio.

lost), with the most common mechanisms being legal body-to-body or object-to-body contact (44%). The most severe scenarios in terms of median days lost were ligament sprains of the knee related to indirect force (*n* = 34; 29 median days lost) and fractures of the hand/wrist related to direct impact or stick-to-body contact (*n* = 21; 19.5 median days lost) (Table 5). The 10 most common scenarios among adolescent boys accounted for 52% of all injuries. The seriousness of injury can be judged by the time lost (Table 5). Knee sprains led to a relatively high number of lost days, suggesting that they are a significant injury type.

Among adolescent girls, the 10 most common scenarios accounted for 225 injuries, or 61% of the total. Consistent with the results among boys, the single most common injury combination was ligament sprain of the ankle from indirect force, which accounted for 79 cases and 972 total days lost. The head/face was also a priority injury area for girls, but contusions (*n* = 23) rather than concussive events (*n* = 14) were the more common injury type. Head/face contusions for both adolescent girls and boys appeared to be relatively minor, resulting in a few lost days of participation. As was the case for boys, the girls' most severe injuries were fractures of the wrist/hand (*n* = 11; 31 median days lost) and ligament sprains of the knee (*n* = 21; 16 median days lost) (Table 5).

Summer Camp Play

At the summer camps, 299 and 106 injuries were reported for adolescent boys and girls, respectively. The documented injury rate for camps was dramatically higher than that for high school play (14.71 injuries per 1000 AEs for boys, 13.27 injuries per 1000 AEs for girls), primarily because of

TABLE 2
Injury by Session Type^a

Session	Fairfax County						Summer Camp					
	Frequency, n (%)		Incidence Rate ^b		IRR, Boys to Girls	95% CI	Frequency, n (%)		Incidence Rate ^b		IRR, Boys to Girls	95% CI
	Boys	Girls	Boys	Girls			Boys	Girls	Boys	Girls		
Game	258 (42.0)	59 (15.9)	4.44	1.48	3.00	2.26-4.05	195 (65.2)	65 (61.3)	13.28	11.39	1.18	0.89-1.59
Practice	217 (35.3)	242 (65.2)	1.40	2.28	0.61	0.51-0.74	84 (28.1)	33 (31.1)	14.87	14.46	1.00	0.66-1.54
Other ^c	11 (1.8)	9 (2.4)					0 (0.0)	0 (0.0)				
Missing	129 (21.0)	61 (16.4)					20 (6.7)	8 (7.6)				
Total	615 (100)	371 (100)	2.89	2.54	1.14	1.00-1.30	299 (100)	106 (100)	14.71	13.27	1.11	0.89-1.40

^aIRR, incidence rate ratio; 95% CI, 95% confidence interval.

^bIncidence rates represent the number of injury cases per 1000 athletic exposures.

^cIncludes conditioning, endurance training, sprint training, and unsupervised playing.

TABLE 3
Injured Body Part by Frequency, Incidence Rate, and Relative Rate, Grouped by Playing Environment and Gender^a

Injured Body Part	Fairfax County						Summer Camp					
	Frequency, n (%)		Incidence Rate ^b		IRR, Boys to Girls	95% CI	Frequency, n (%)		Incidence Rate ^b		IRR, Boys to Girls	95% CI
	Boys	Girls	Boys	Girls			Boys	Girls	Boys	Girls		
Knee	95 (15.5)	79 (21.4)	0.45	0.54	0.83	0.61-1.13	76 (25.4)	31 (29.3)	3.74	3.88	0.96	0.63-1.51
Ankle	99 (16.1)	93 (25.1)	0.47	0.64	0.73	0.55-0.98	54 (18.1)	11 (10.4)	2.66	1.38	1.93	1.00-4.09
Head/face ^c	97 (15.8)	52 (14.1)	0.46	0.36	1.28	0.91-1.83	14 (4.7)	27 (25.5)	0.69	3.38	0.20	0.10-0.40
Wrist/hand	66 (10.7)	35 (9.5)	0.31	0.24	1.30	0.85-2.01	29 (9.7)	8 (7.6)	1.43	1.00	1.42	0.64-3.61
Arm	18 (2.9)	6 (1.6)	0.08	0.04	2.06	0.78-6.34	29 (9.7)	2 (1.9)	1.43	0.25	5.70	1.44-49.27
Foot	17 (2.8)	11 (3.0)	0.08	0.08	1.06	0.47-2.51	19 (6.4)	4 (3.8)	0.93	0.50	1.87	0.62-7.54
Back/trunk	46 (7.6)	15 (4.0)	0.22	0.10	2.11	1.15-4.06	15 (5.0)	3 (2.8)	0.74	0.38	1.96	0.55-10.58
Shoulder	52 (8.5)	15 (4.1)	0.24	0.10	2.38	1.32-4.55	15 (5.0)	2 (1.9)	0.74	0.25	2.95	0.68-26.56
Upper leg	47 (7.7)	15 (4.1)	0.22	0.10	2.15	1.18-4.14	14 (4.7)	1 (0.9)	0.69	0.13	5.50	0.84-232.5
Lower leg	32 (5.2)	24 (6.5)	0.15	0.16	0.92	0.52-1.62	13 (4.4)	5 (4.7)	0.64	0.63	1.02	0.34-3.66
Hip	16 (2.6)	15 (4.1)	0.08	0.10	0.73	0.34-1.59	7 (2.3)	2 (1.9)	0.34	0.25	1.37	0.26-13.56
Systemic ^d	11 (1.8)	7 (1.9)	0.05	0.05	1.08	0.38-3.28	6 (2.0)	9 (8.5)	0.30	1.13	0.26	0.08-0.82
Neck	17 (2.8)	3 (0.8)	0.08	0.02	3.89	1.13-20.73	5 (1.7)	1 (0.9)	0.25	0.13	1.96	0.22-92.89
Abdomen	0 (0.0)	0 (0.0)	0.00	0.00	–	–	2 (0.7)	0 (0.0)	0.10	0.00	–	–
Genitalia	1 (0.2)	0 (0.0)	0.00	0.00	–	–	1 (0.3)	0 (0.0)	0.05	0.00	–	–
Total	615 (100)	370 (100)	2.88	2.53	1.14	1.00-1.30	299 (100)	106 (100)	14.71	13.27	1.11	0.89-1.40

^aIRR, incidence rate ratio; 95% CI, 95% confidence interval.

^bIncidence rates represent the number of injury cases per 1000 athletic exposures.

^cIncludes injuries to the head, eye, ear, nose, face, chin, mouth, jaw, teeth, or tongue.

^dIncludes conditions such as heat exhaustion and infection.

the broader definition of reportable injury used in the camps. However, the IRR for boys relative to girls in the camps was similar to that in high school play (IRR = 1.11; 95% CI, 0.89-1.40) (Table 1). For both adolescent boys and girls, approximately two thirds of injuries occurred during games and one third occurred during practice sessions (Table 2).

During summer camp play, the most common area of injury for both boys and girls was the knee (Table 3). A large proportion of these injuries were abrasions, possibly associated with the synthetic surface used at the camps (Table 6). Boys were more likely than girls to sustain arm

injuries (IRR = 5.70; 95% CI, 1.44-49.27) and ankle injuries (IRR = 1.93; 95% CI, 1.00-4.09), but they were only one-fifth as likely as girls to experience an injury to the head/face (IRR = 0.20; 95% CI, 0.10-0.40) (Table 3). The most common natures of injury for both adolescent boys and girls were contusions (33% and 36%, respectively), sprains/strains (37% and 25%, respectively), and abrasions (19% and 20%, respectively) (Table 4). Boys had a higher risk for sprains/strains than girls (IRR = 1.65; 95% CI, 1.07-2.63), but they were less likely to experience heat exhaustion (IRR = 0.25; 95% CI, 0.06-0.85). The primary injury mechanisms were different for adolescent boys and

TABLE 4
Nature of Injury by Frequency, Incidence Rate, and Relative Rate, Grouped by Playing Environment and Gender^a

Nature of Injury	Fairfax County						Summer Camp					
	Frequency, n (%)		Incidence Rate ^b		IRR, Boys to Girls	95% CI	Frequency, n (%)		Incidence Rate ^b		IRR, Boys to Girls	95% CI
	Boys	Girls	Boys	Girls			Boys	Girls	Boys	Girls		
Sprain/strain	258 (42.4)	170 (46.2)	1.21	1.16	1.04	0.86-1.27	109 (36.5)	26 (24.5)	5.36	3.26	1.65	1.07-2.63
Contusion	138 (22.7)	66 (17.9)	0.65	0.45	1.44	1.06-1.96	99 (33.1)	38 (35.9)	4.87	4.76	1.02	0.70-1.53
Abrasion	2 (0.3)	3 (0.8)	0.01	0.02	0.46	0.04-4.00	57 (19.1)	21 (19.8)	2.80	2.63	1.07	0.64-1.85
Laceration	11 (1.8)	5 (1.4)	0.05	0.03	1.51	0.48-5.55	7 (2.3)	4 (3.8)	0.34	0.50	0.69	0.17-3.20
Blister	0 (0.0)	0 (0.0)	0.00	0.00	—	—	7 (2.3)	2 (1.9)	0.34	0.25	1.37	0.26-13.56
Concussion	61 (10.0)	14 (3.8)	0.29	0.10	2.99	1.65-5.79	7 (2.3)	1 (0.9)	0.34	0.13	2.75	0.35-124.0
Heat exhaustion	2 (0.3)	3 (0.8)	0.01	0.02	0.46	0.04-4.00	5 (1.7)	8 (7.6)	0.25	1.00	0.25	0.06-0.85
Fracture	57 (9.4)	33 (9.0)	0.27	0.23	1.19	0.76-1.88	4 (1.3)	0 (0.0)	0.20	0.00	—	—
Chronic/overuse	52 (8.5)	52 (14.1)	0.24	0.36	0.69	0.46-1.03	3 (1.0)	3 (2.8)	0.15	0.38	0.39	0.05-2.93
Illness/infection	12 (2.0)	9 (2.5)	0.06	0.06	0.92	0.35-2.46	1 (0.3)	3 (2.8)	0.05	0.38	0.13	0.01-1.63
Torn cartilage	6 (1.0)	3 (0.8)	0.03	0.02	1.37	0.29-8.49	0 (0.0)	0 (0.0)	0.00	0.00	—	—
Dislocation	10 (1.6)	10 (2.7)	0.05	0.07	0.69	0.26-1.84	0 (0.0)	0 (0.0)	0.00	0.00	—	—
Total	609 (100)	368 (100)	2.86	2.52	1.14	1.00-1.30	299 (100)	106 (100)	14.71	13.27	1.11	0.89-1.40

^aIRR, incidence rate ratio; 95% CI, 95% confidence interval.

^bIncidence rates represent the number of injury cases per 1000 athletic exposures.

TABLE 5
Ten Most Common Injury Scenarios in Fairfax County Public Schools, 1999-2001

Gender	Rank Order	Body Part	Nature of Injury	Number of Cases	Incidence Rate ^a	Median Days Lost	Total Days Lost	Primary Mechanisms
Boys	1	Ankle	Ligament sprain	82	0.39	4.0	557	Indirect force (78%)
	2	Head/face	Concussion	61	0.29	6.0	520	Legal body/object to body (44%); illegal body/object to body (23%)
	3	Knee	Ligament sprain	34	0.16	29.0	1880	Indirect force (59%)
	4	Upper leg	Muscle-tendon strain	26	0.12	7.0	357	Indirect force (73%)
	5	Head/face	Contusion	21	0.10	1.0	52	Legal object to body (43%)
	5	Wrist/hand	Fracture	21	0.10	19.5	379	Direct impact (38%); legal object/stick to body (33%)
	7	Wrist/hand	Ligament sprain	20	0.09	3.0	127	Direct impact (25%); fall to ground by body contact (25%)
	8	Upper leg	Contusion	18	0.08	3.0	75	Direct impact (50%)
	8	Back	Muscle-tendon strain	18	0.08	5.0	120	Indirect force (44%)
	8	Knee	Inflammation	18	0.08	6.5	316	Indirect force (22%)
Girls	1	Ankle	Ligament sprain	79	0.54	7.0	972	Indirect force (80%)
	2	Knee	Inflammation	30	0.21	2.5	619 ^b	Indirect force (33%); overuse (30%)
	3	Head/face	Contusion	23	0.16	1.0	55	Direct impact (35%); legal object to body (26%)
	4	Knee	Ligament sprain	21	0.14	16.0	581	Indirect force (62%)
	5	Head/face	Concussion	14	0.10	4.0	83	Direct impact (43%)
	6	Wrist/hand	Contusion	13	0.09	2.0	38	Direct impact (46%); legal object to body (39%)
	6	Hips	Muscle-tendon strain	13	0.09	7.0	107	Indirect force (46%)
	8	Upper leg	Muscle-tendon strain	12	0.08	2.5	72	Indirect force (50%)
	9	Wrist/hand	Fracture	11	0.08	31.0	439	Direct impact (46%)
	10	Back	Muscle-tendon strain	9	0.06	2.0	39	Indirect force (33%)

^aIncidence rates represent the number of injury cases per 1000 athletic exposures.

^bOne case accounted for 365 days.

TABLE 6
Five Most Common Injury Scenarios in Summer Camp Play, 1999-2001

Gender	Rank Order	Body Part	Nature of Injury	Number of Cases	Incidence Rate ^a	Primary Mechanisms
Boys	1	Ankle	Ligament sprain	52	2.56	Indirect force (87%)
	2	Knee	Abrasion	47	2.31	Fall to ground, no body contact (47%); fall to ground by body contact (40%)
	3	Arm	Contusion	19	0.93	Legal object to body (42%); illegal object to body (26%)
	4	Wrist/hand	Contusion	18	0.89	Legal object to body (56%)
	5	Knee	Ligament sprain	14	0.69	Indirect force (50%)
Girls	1	Head/face	Contusion	22	2.75	Illegal object to body (64%); ball to body (36%)
	2	Knee	Abrasion	19	2.38	Fall to ground, no body contact (58%); fall to ground by body contact (32%)
	3	Ankle	Ligament sprain	11	1.38	Indirect force (73%)
	4	Systemic ^b	Heat illness	8	1.00	Environmental (100%)
	5	Knee	Ligament sprain	6	0.75	Indirect force (50%)

^aIncidence rates represent the number of injury cases per 1000 athletic exposures.

^bIncludes conditions such as heat exhaustion and infection.

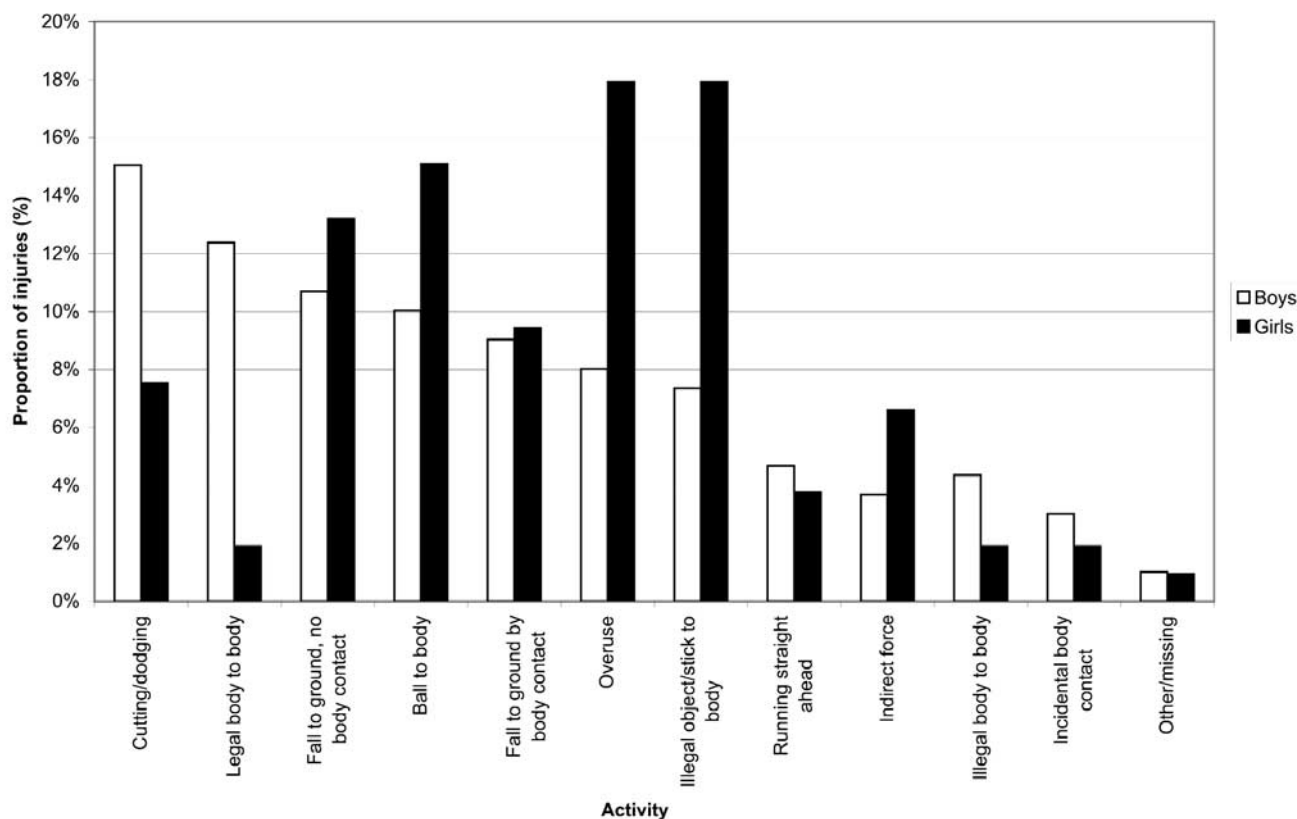


Figure 4. Primary injury mechanisms in summer camp play, 1999-2001.

girls (Figure 4). The top 3 injury mechanisms for boys were cutting/dodging (15%), legal body-to-body contact (12%), and fall to the ground with no contact (11%), whereas the top 3 injury mechanisms in the girls' games were overuse (18%), illegal stick-to-body contact (18%), and ball-to-body contact (15%).

The smaller number of summer camp AEs enabled us to reliably calculate the 5 most common injury scenarios for male and female players (Table 6). Total days lost as an

indicator of severity was not measurable because players were in camp for only a few days. Among adolescent boys, knee abrasions (n = 47; 2.31 per 1000 AEs) and arm contusions (n = 19; 0.93 per 1000 AEs) were more common in summer camp play than in high school play. Heat-related conditions were a common injury scenario in adolescent girls' summer camp play.

Specific player and team activity at the time of injury were reliably captured for summer camp play. Defenders

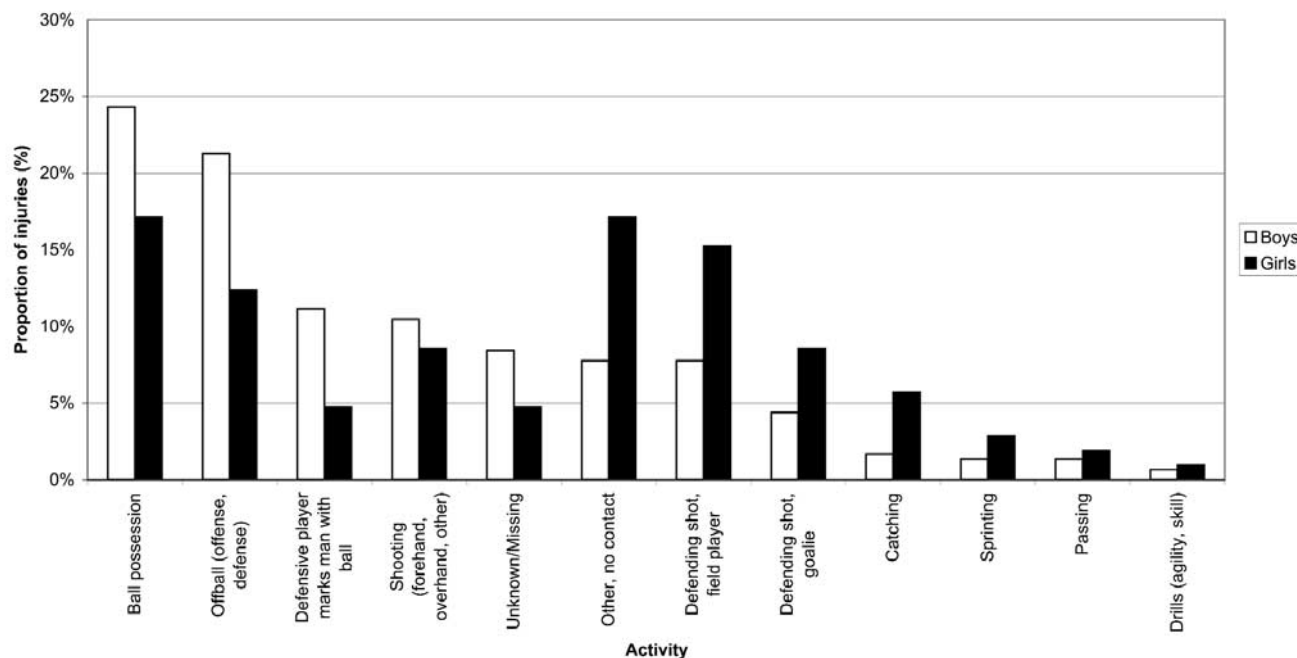


Figure 5. Player activity at time of injury in summer camp play, 1999-2001.

had the highest injury prevalence (0.14 injuries per camp registrant in playing position) among girls, whereas attackmen had the highest injury prevalence (0.17 injuries per athlete in playing position) among boys. Gender differences were most noticeable among attackmen ($P = .001$) and midfielders ($P = .004$), among which boys (0.17 and 0.12, respectively) had a higher injury prevalence rate than girls (0.10 and 0.07, respectively). Goalies had relatively low injury prevalence for both adolescent girls and boys. Boys were injured more often than girls during ball possession (24% and 17%, respectively; $P = .17$) and offball activity (21% and 13%, respectively; $P = .06$), although the differences were not statistically significant. Girls sustained a higher percentage of their injuries while defending a shot to the goal as compared with boys (24% vs 12%; $P = .007$). Girls also sustained a greater proportion of their injuries from stick and ball contact ($P = .001$) rather than body-to-body contact ($P = .003$) (Figure 5). Boys were more likely to be injured during settled play (half-field situation with predesigned plays) than during unsettled play (full-field, loose ball, or transition play) (55% and 26%, respectively; $P = .001$). Girls were also more likely to be injured in settled play versus unsettled play (62% and 12%, respectively; $P = .001$).

DISCUSSION

Our investigation found lacrosse played at the high school level to be a relatively safe sport, in that the vast majority of injuries for both adolescent boys and girls involved strains, sprains, contusions, and abrasions. No fatal or catastrophic neurologic injuries occurred during the 3 years of prospectively gathered data involving more than 385 000

AEs. Data from summer camp play, in which a more inclusive definition of injury was used, reflected the finding that most lacrosse injuries are minor and that many may not restrict participation time.

In the current study, the most prevalent injuries were ankle and knee ligament sprain/strain, head/face injury, and wrist/hand injury. Boys' and girls' lacrosse generally shared priority injuries and basic injury types. The primary injury scenarios for both adolescent boys and girls involved ankle and knee ligament sprains occurring in noncontact situations, which reflect the high speed and quick direction change inherent in the game. These injuries are not only the most frequent, but they also result in the greatest injury burden of restricted playing time. Injury prevention programs should directly target these areas,^{1,3,15,20,23,26,27} and preexisting ankle and knee injuries must be fully rehabilitated before they become chronic conditions.

The current data show that injuries to the head and face are concerns in both boys' and girls' lacrosse, but the nature of head/face injuries varies dramatically based on gender. For adolescent boys, the primary head/face injuries were concussions that most commonly resulted from body-to-body contact. Previous findings have noted that boys sustain higher rates of concussive events and major head injuries than do girls while playing lacrosse.⁵ For adolescent girls, the primary head/face injuries were contusions most frequently related to impact from the stick or ball.

Hand/wrist injuries were the fourth most common injury for both adolescent boys and girls, and many of these injuries may be preventable. For boys, the player's gloved hands are considered part of the stick and may be legally checked. Girls are not required to wear protective gloves because the rules in the girls' games allow checking

only at the pocketed end of the stick. The high incidence of hand/wrist injuries suggests a need to evaluate the effectiveness of protective gear in the boys' and girls' games and to better enforce the rule of stick-only checking in the girls' games.

Injury mechanism data from the summer camps show some differences in terms of gender. Boys had a higher rate of injury from player-to-player contact, whereas girls had a higher rate of injury related to ball-to-body contact, stick-to-body contact, and overuse. Female players were significantly more likely to be injured while defending a shot or catching a pass than their male counterparts. These data reflect differences in the nature of the boys' and girls' games, the protective equipment involved, and different levels of stick skills between boys and girls.

The injury rates in high school-level lacrosse in the current study were approximately one third of those seen at the collegiate level during the same time period.^{16,17} However, the most common types of injuries to players, the primary anatomical areas of the injuries, and the mechanisms of injuries were very similar between these levels. We also found that the game-to-practice injury ratio was similar for male players at the high school and collegiate levels, but female players at the high school level had a dramatically lower game-to-practice injury ratio than did their collegiate counterparts. Perhaps as a reflection of these changes and of the more physical play associated with the boys' games, adolescent boys sustained a significantly higher rate of injuries to the neck, shoulder, arm, and trunk than did their female counterparts. Purposeful body contact against opponents in game situations may also underlie the significantly higher ratio of game-to-practice injury rates for boys as compared with girls. The data in the current study suggest a need to reevaluate the ability of protective equipment to absorb enough energy to reduce injury risk.

Differences in game-to-practice injury ratios for male versus female players are less substantial at the collegiate level than in the current study.^{6,16,17} This more similar injury ratio between men and women at the collegiate level suggests that the women's games may include more contact than is found in high school games. Women at the collegiate level had a higher rate of overuse injuries (particularly about the knee) as compared with men. This finding may reflect the greater predisposition to extensor mechanism problems in the female athlete in general.^{2,9}

Previous studies have discussed head and face injuries in women's games and the possible implications for added protective equipment.^{6,8,12,13,25} The decision to mandate the use of protective equipment is largely a value judgment based on what constitutes an excessive hazard. Women's lacrosse has a low overall injury rate compared with men's lacrosse, but head, face, and eye injuries make up a substantially larger percentage of injuries in women's games compared with men's games.¹⁷ Most of the women's head, face, and eye injuries reported in earlier studies are minor, but a few incidents of sight-impairing injuries and orbital fractures have been noted.^{6,10,18,25} In 2003, based on a review of data from the current study and other sources,

US Lacrosse recommended the use of effective protective eyewear at the youth, high school, and collegiate levels of women's lacrosse for the 2004 season and mandated the use of protective eyewear at all levels of play in 2005. US Lacrosse has also suggested the more careful enforcement of rules and coaching changes to help avoid the infrequent but catastrophic sight-loss injury caused primarily by stick or ball contact. Further study of the role of protective gear in women's lacrosse is warranted. A more detailed study of head, face, and eye injuries in women's lacrosse is the subject of a study currently in progress.

The substantially higher rate of injury in summer camp play in part reflects the purposefully broader definition of reportable injury in the data-collection methods used at the summer camps and provides a more inclusive view of injuries seen in interscholastic play. We found a large proportion of injuries, such as knee abrasions, contusions, and small lacerations, that were significant and reportable by the player but that did not result in lost participation time. Although playing time was not lost, the stick-to-body and ball-to-body contact mechanisms of these face/head injuries are worrisome in that the same mechanisms could potentially result in more severe injuries.

This study has several acknowledged limitations. High-priority data such as body area of injury, injury type, and injury occurrence were uniformly recorded, but data were not completely reported for some secondary variables for high school play and are therefore not presented here. The decision to use a different definition of injury for summer camp play limited the ability to compare between summer camp and high school play but allowed a useful view of the full range of injuries in the summer camp setting.

CONCLUSION

Both boys' and girls' lacrosse are relatively safe sports, with most injuries involving sprains, strains, contusions, and abrasions. Priority injuries for both female and male players involved ligament injuries about the knee and ankle sustained in noncontact situations. Head, face, and eye injuries are concerns for both the boys' and the girls' game. The overall injury rates for boys' and girls' high school lacrosse were significantly lower than those at the collegiate level. There are significant differences in boys' and girls' lacrosse with regard to mechanisms of injury, subclassification of areas of anatomical injury, and player and team activity at the time of injury.

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APPENDIX
Lacrosse-Specific Injury Information Form



Boys & Girls Lacrosse Injuries Only

Athlete: _____

Injury _____ Date _____

This information is to be filled out regarding the athletes location and action AT TIME OF INJURY

Please answer the following questions as **specific** as possible. Details relate to what happened and where you were at the **exact time the injury occurred.**

Place check where appropriate

CASE

NATURE OF INJURY

ACUTE

- Sudden w/contact
- Sudden w/o contact
- Gradual w/contact
- Gradual w/o contact

} Choose only one

PRIMARY MECHANISM

DIRECT IMPACT

- Legal object to body
- Illegal object to body
- Legal body to body
- Illegal body to body
- Ball to body
- Fall to ground pushed by body

INDIRECT IMPACT

- Running straight ahead
- Cutting/dodging
- Falling to ground
- Indirect with torsion/twisting motion
- Indirect with stretching motion
- Indirect with impingement
- Indirect OVERUSE
- Indirect SHEARING
- Indirect other

COLLISION

- Incidental body contact
- Contact with goal
- Contact with out of bounds object

} Choose Only one

SPORT

TEAM SESSION

- Practice
- Game PENALTY at time of injury
- Injury caused by penalty

PLAYER ACTIVITY

- SHOT ON GOAL**
- Taking a shot
 - Field player defending shot
 - Goalie defending shot

- BALL POSSESSION**
- Offensive player with ball
 - Defensive player marks man with ball

- PASSING**
- Delivering a pass
 - Catching a pass

- OFFBALL**
- Offball, offensive player
 - Offball, defensive player

- OTHER, NO CONTACT**
- Agility Drills
 - Skill drills
 - Sprinting
 - Endurance training
 - Strength training

} Choose only one

PLAYER POSITION

- ATTACKMAN
- MIDFIELDER
- DEFENSEMAN
- GOALIE
- NON-PARTICIPANT

} Choose one

- Playing offense in the midfield
- Playing defense in the midfield
- Playing offense at the offensive end of the field
- Playing defense at the offensive end of the field
- Playing offense at the defensive end of the field
- Playing defense at the defensive end of the field
- Playing offense in the crease
- Playing defense in the crease

} Choose one

TEAM ACTIVITY

SETTLED

- Half field offense
- Half field offensive shot
- Half field defense
- Half field defensive shot
- Clearing (Offense)
- Riding (Defense)

} Choose only one

UNSETTLED

- Ground or loose ball
- Fastbreak offense
- Fastbreak offensive shot
- Fastbreak defense
- Fastbreak defense defending shot
- Transition offensive
- Transition defense
- Face off or Draw (girls Lax)