A Comprehensive Review of Men's and Women's Lacrosse Injuries

AT 715 Epidemiology
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ABSTRACT

Objective: The purpose of this literature review is to collect all available published data on injuries that occur in the sport of lacrosse. Of particular interest is the risk of injury based on level of play, gender, and position. Data Sources: A comprehensive literature search was performed in PubMed, High Wire Press, SPORTDiscus, Google Scholar, and Ovid using the keywords Lacrosse Injuries, Epidemiology Lacrosse Injuries, Lacrosse Injury, Lacrosse AND Injury. Years searched were from 1950 until 2008. Data Synthesis: Injury Rates; Injury Rates in games compared to practice; Injury Onset; Injury Site Location; Injury Type; Injury Severity; Injury by position; and Case Reports; Conclusions/Recommendations: Although there is such a large increase in participation, there is relatively little data on the injuries that do occur. There is no data at the professional level or the indoor game. Overall, the rate and severity of injuries per Athlete Exposure is relatively low compared to other collision sports like football and hockey. In females because the rules and equipment used are so drastically different then men, face and hand injuries are of most prevalence. Increased efforts to identify key factors on the most common cause of death in Lacrosse, Commodio Cordis, needs to be made so preventative measures can be made to reduce the incidence of catastrophic injuries. Medical professionals who cover lacrosse need to understand the injury types and injury rates. Knowledge of the types of injuries they should expect to encounter will better prepare them for injuries they will need to treat leading to better care for the athletes.

Key Words: Commodio Cordis, Epidemiology, Athlete Exposure Rate

INTRODUCTION

Lacrosse (LAX) has been one of the fastest-growing team sports in the Country. In the US Lacrosse 2007 participation survey, extensive growth has been displayed at all levels from youth to professional.[1]

Youth LAX has seen a 94 percent increase in participation over the past six years and in 2007 the youth movement rose over nine percent.[1] Over the last six years the high school segment has grown nearly 100 percent and shows no signs of slowing down. Only 18 state associations have sanctioned high school LAX.[1] Youth and high school participation are influencing increased opportunities at the collegiate level.

In a span of 10 years there have been 152 new programs added to college institutions. In 2008 there were 27 new varsity programs and 23 more teams are scheduled to begin play in the 2009 and 2010 seasons. The collegiate level has received some significant public attention from CSTV and ESPN with over sixty televised games both locally and nationally.[1] As expected, with an increase in participation at the collegiate level, the opportunities to be a male professional LAX player are growing as well.

In the 2005 there were only 150 participants and 21 teams at the professional level and in the 2007 season it has grown to 300 participants and 22 teams. An increase in participants is not as apparent as at the other levels but the popularity of the sport is becoming much more visible. Coverage of 60 Major League Lacrosse (MLL) games on ESPN and ESPN2 occurred in the 2008 season. The MLL is the professional outdoor league in the United States and Canada. According to the National Lacrosse League (NLL) website, this year NBC will have television coverage of over 30 games. The NLL is the Professional Indoor League of the United States and Canada.

There haven't been many reasons to explain why LAX is such a rapidly growing sport. Perhaps it is the US Lacrosse Association that has provided the infrastructure to support and nurture youth participants with exciting action, stylish equipment, and increased exposure. Both boys and girls are fueling the demand for additional playing opportunities.[1] It is exciting to see the oldest sport in the United States experiencing such a large growth. However, with additional participation in a contact (women's) and collision (men's) sport creates possibilities of more injuries.[2]

The purpose of this literature review is to collect all available data that provides information on injuries associated with playing lacrosse. Men's and Women's data will be collected at all levels of play. The characteristics and components from each study will be displayed in tables with a summary of those tables. Additionally, there will be suggestions for injury prevention and future research based upon the findings.

INJURY CHARACTERISTICS

Injury Rates

The data gathered on injury rates in men's and women's lacrosse are summarized in Table 1. Rates of injury are different based upon each of the researcher's interest (from .0000068 – 3.8 injuries/100 athletes). The disparity occurs because different researchers were looking at different types of injuries and different severities of injuries at different levels. Cantu, et al[3] looked at fatalities and catastrophic injuries in college and high school sports over a 15 year period. Cantu found that the relative incidence level of suffering a catastrophic injury or fatality in LAX is much lower than in other collision sports. Prodromos, et al[4] and Mihata[5] and Arendt[6] studied ACL injury rates in Men's and Women's Lacrosse and found correlation between each others findings and much lower incidence rates compared to soccer and basketball (.17men/.18 women versus .28/.32 in soccer and .13/.28 in basketball) Diamond and Gale[7] limited their research to head injuries in men's and women's lacrosse with much higher incidence in the women's game (.77/.44).

Yard[8] found almost a 4:1 boys to girls injury rate in youth players (4577/1250) with similar number of teams and players involved. Overall, the injury rates are higher in males at all levels and the rates increase with age and level of play.

Men's rate of injury should be higher because of the nature of the game is more physical and the rules allow for more body and stick contact.[9, 10] The studies also displayed higher numbers as the level increased, i.e., college displayed higher game and practice injury rates than high school, and the high school level had higher levels than the youth level.[11] The increase in age and level may be due to the intensity is higher and the athletes are bigger, faster, and stronger as the higher the level, less of the participation is for plain leisure as competition gets higher. In future research, time of injury should be included during assessment, i.e. first or second half of game or practice, or quarters, when applicable, to better understand the type of injury.

There was no data for those players who participate at the professional level or Indoor Lacrosse, known as Box Lacrosse.

I would tend to believe that indoor lacrosse, with much closer confines, would have a larger incident rate of head and face injuries in women who wear no helmet or facemask and hand injuries because no gloves are worn.[12] Further research to break down the differences in the games is necessary to further evaluate risk of injury.

Game vs. Practice Injury Rates

The game verses practice injury rates for both men's and women's lacrosse is typical of other sports that have participation by both genders as summarized in Table 2. The information provided by the literature showed that game injury rates appear higher across the board. Depending on what type of injuries the researchers were studying made the numbers appear much higher or lower when compared to one another. Yard, et al[8] did not differentiate between men/women and practice/game at the youth level. Lincoln, et al[13], Goldenberg, et al[14], Matz, et

al[15], Hootman et al, [16], Covasin, et al[17] all showed increased rate of injury during game activity. McCulloch, et al[18] did not study game injuries but showed a higher rate during games between men and women per 1000 AE (11.5/6.1). The reason for the disparity between the practice and game sessions could be attributed to the lack of intense competition during practice, as well as the types of activities and drills performed during practice. The decreased time spent during practice in high impact or scrimmage situations when the athletes are at greater risk.

Injury Onset

There wasn't an overwhelming amount of published studies involving injury onset. However, from the type of injury, the onset could be assumed. This data is summarized in Table 3. The majority of the information provided by Hinton, et al[19] (104/873 IPR/1000 AE), Mayer, et al[20] (0/2 IPR/1000 AE), Matz, et al[15] (0/104 IPR/1000AE), and Lincoln, et al[13] (16/348) listed acute, or sudden, injuries as the most common. Injuries occur most often in the men's game from player to player contact resulting in immediate injuries such as concussions, contusions, and lacerations. The nature of the women's game has injuries occurring most frequently from stick to player, or player to ball contact, rather than player-to-player contact.

Risk factors that contribute to injury onset in the women's game include the lack a head and hand protection, as well as lack of strict enforcement of the rules by the officials. Contusions, fractures, lacerations, concussions, sprains, and strains were the most common injuries recorded.[21] Injuries displaying as gradual onset included overuse injuries and stress fractures, but were seldom listed. Kang, et al[22] studied stress fractures which would account for a larger gradual onset than sudden onset (7/0 gradual versus sudden). In future research studies, documentation of the onset of injuries should be included.

Injury Site Location

There is an overwhelming amount of information provided in the literature on injury site location as listed in Table 4. The majority of data provided on the women centered on head and facial injuries. Women displayed a higher percent of head and facial injuries compared to anything else surveyed or observed, while male lacrosse players displayed a higher number of concussions, shoulder, and lower extremity injuries.[13, 23] Risk factors for these injuries can be attributed to lack of appropriate equipment or the incorrect use of equipment or lack of enforcement of the rules that are already in place.[7, 14, 24] Women only wear eye protection (mandated at all levels in 2004), but no helmet or face or hand protection.[25]

In the youth game, Yard[8] found the highest amount of injuries occur to females in the face (21%), hand (24%), and ankle (26%). Ankle injuries come in at the highest percentage of injury sites is also expected as ankle sprains are one of the most common injuries in running sports.[19] Yard[8] also found a high number of injuries in boys to the hand (23%) which is somewhat surprising considering the boys do wear gloves. The boys are able to strike the player that is carrying the ball with their own stick that may account for a lot of stick to hand contact that could lead to injury.

Lincoln [13] showed the exact number of head injuries at the high school level between boys and girls over a four year period involving 23 teams but this was the only study that showed similar rates of injury. The lack of a helmet in the women's game made up for the aggressive style and rules of the men's game. Goldenberg[14] showed a high rate of injury to the eye (1.4 IPR) but this study was done in 1995, before the mandatory use of eyewear in women in 2004. In the women's game, the majority of injuries occur to the head and facial area, which is left unprotected, except for the mandated protective eyewear. The eyewear does well to protect the eyes, but leaves the rest of the face vulnerable to being hit by the stick and ball.[25] Women tend to carry the head of the stick closer to their head and face because of a smaller basket to carry the ball compared to the men. Lack of protective glove-wear for females also increases their risk for injuries to the hands and fingers. Goldenberg[14] also showed largest number of injuries occur to the lower extremity (ankle 3.5, knee 1.9, thigh 1.7) in female high school lacrosse players.

In the men's game the protective helmet they wear does well to protect against eye injuries, lacerations, and other injuries in like nature, however when tested for protection against concussions, lacrosse helmets did not provide consistent protection.[16] Lincolns[13] data provides a clear pattern of occurrence in the men's game (84.2% HS and 88.6% College aged men of injuries to the head area) compared to females (58% HS and 49% College) respectively, as well as a need for further research on protective equipment. The high incidence of facial injuries displayed at all levels of women's plays needs some sort of alterations, whether it is the addition of protective equipment or changes in rules or enforcement.

Injury Type

The current research has information on several different types of injuries, concussions, sprains, contusions, and lacerations seemed to occur most frequently. These injuries are summarized in Table 5. Males experienced more concussions (nearly 2:1) in all studies, while females experienced contusions, abrasions, sprain/strains. Risk factors for these injuries are virtually the same throughout each table. For women, their lack of protective equipment is perhaps the number one cause of their contusions and lacerations. Since the majority of the articles covered head and facial injuries in women, had these players been wearing helmets, they would have been protected from such forces. In future research, more detailed injury tracking would be useful. Current research lists the number of sprains, but future research could include the area of the body the sprain occurred, i.e. ACL, MCL, ATF, or even just ankle or knee. Another detail that should be included is concussion severity. Current research provided the overall number of concussions occurring throughout the study, but the majority of the studies fail to list the severity or time lost from each concussion.[26]

Injury Severity

Injury severity in the current lacrosse literature has over 50 percent of injuries caused the participants to be out of game or practice between one and seven days. Table 6 summarizes the data on injury severity. The most common injuries that were in the mild category were contusions and lacerations.[27] The moderate category was anywhere from eight to 21 days, with the primary injuries being mild ankle sprains and muscle strains. 22+ days lost were attributed to ACL reconstructions and were documented by Hinton[19] and Matz.[15] Catastrophic injuries are

very rare and they only occurred in the men's game at the collegiate level and high school levels.[3, 15, 27]

The literature wasn't specific in regards to the type of catastrophic injuries. A search in Google on the World Wide Web provided some insight. There have been eight documented cases of death by Commotio Cordis in Lacrosse at the Men's college level. Commotio Cordis, sudden cardiac death secondary to blunt non-penetrating chest blows in sports, does not appear to have any type of treatment or prevention.[28-30] There have been incidences of Commotio Cordis in baseball, hockey, and lacrosse with and without protective equipment over the heart.[8, 30] Treatment by onsite emergency responders with AED's did not have any ability to prevent death in the four cases in lacrosse.[27-29] Future research in injury severity requires additional information regarding catastrophic injuries should be provided, i.e. type of catastrophic injury that occurred and the exact definition of a catastrophic injury. Commotio Cordis needs further study for prevention and treatment. The type and severity varied within the current literature. A catastrophic injury may be defined as the loss of vital functions or complete loss of life, that definition wasn't always clear.[15, 18] Injury severity needs to be included in more studies; the current research didn't include it as one of the criterion for injury tracking.

Injury by Position

There hasn't been much information on injury by position in any sport and that includes lacrosse. The data that is available is summarized in Table 7. Offensive players had the most injuries, followed by defensive players, and then midfielders.[12, 22, 31] Goalies had a low rate of injury which may be due to the amount of protective equipment that they wear and the rules that do not allow any contact by other players.[14] Risk appears to be greater in those players that may do more ball handling (more exposure to body and stick contact) and who do more running, cutting, stopping. Further research should include player position when documenting injuries to better track what type of injuries occur per position. This data can help rules officials develop requirements for different protective equipment and rules preventing certain activities to reduce the risk of injury.

Risk Factors

Risk factor data is displayed in Table 8 and is divided into intrinsic and extrinsic risk factors. Intrinsic risk factors for youth and collegiate are displayed and include hypermobility of joints, age, and skill level, and gender. [32, 33]

Extrinsic risk factors includes rules of the game (body/stick contact)[17, 26], equipment or lack of equipment in females[5, 10, 23, 31], possibly position played,[14] and game versus practice participation0.[16]

Further research needs to address indoor versus outdoor playing environments, fields (field turf versus grass), and possibly game times or tournament play. A risk may be that after a one or two day tournament, an increase in injury will occur in the latter games due to fatigue. Night games may pose a larger risk because of limited visibility of the ball. Information like this would allow

tournament directors to design the games to be played with longer or shorter times between games, less games (i.e. wrestler's are limited to 5 matches in day) to be played, or possibly no night games.

There was no data to compare grass fields versus field turf (artificial turf). An interesting comparison would be the indoor game on field turf versus outdoor on field turf. Comparing the two environments may decipher if it is the inside or outside game that may produce more injuries or the type of field the game is played on.

Injury Prevention:

I have provided a summary table of recommended injury prevention from the researchers and the supporting evidence in Table 9.

Suggestions For Further Research:

In addition to further research per subsection, I have provided a summary of suggestions in Table 10.

Case Reports:

As a courtesy for the reader, I have included a summary of the case reports available in regards to LAX injuries in Table 11. Case reports included clavicle fractures[34, 35], isolated rib fracture[36], eye/orbit injuries [23], hand injuries[24, 31, 37], stress fracture of the femoral shaft[22], and internal organ derangement. [38]

DISCUSSION

As expected, this review of the literature provided insight into the types of injuries to expect when covering lacrosse events as a medical provider. Not surprisingly, men have an increased incidence to all injuries and catastrophic injury. Women tend to have injuries to the lower extremity and exposed body parts of the hand and face because of their lack of protective equipment and incidental stick and body contact.

Overall, in the men's game, Lacrosse players have a decreased likelihood of injuries of all severities when compared to other collision sports like football and hockey. Women's injury rate in Lacrosse is also low compared to other contact sports like soccer but is higher than in basketball.

Although there are quality studies to fall back on when preparing for coverage of a LAX season, further research is needed. There is no available research in regards to the professional game that occurs both indoors and outdoors. Considering that each successive level of play induces higher injury rates, I would expect that the professional level would have the highest rate of injury compared to the youth, high school, and collegiate. In addition, the indoor game because of the aggressive nature, ability to cross check using one's stick, and fighting that is permissible by the rules, would lead to higher injury rates as well.

Coaches, referees, athletes, protective equipment manufactures, researchers, rules makers, and medical professionals can use this literature review when preparing for LAX practices and games. For example, knowing that the men's game involves the use of helmets, it would be appropriate to have a electric screw driver in both the coaches and athletic training bag so that one is prepared to remove a face mask for airway access in case of emergency. Training of coaches and medical personnel is also paramount prior to the season. A high rate of lacerations and abrasions would clue the athletic trainer to have the most evidence based approach to debridement and cleaning of these wounds with proper wound coverage to reduce the chance of infection. The strength and conditioning coach should use the high rate of lower extremity injuries in females as a clue to include neuromuscular training in warm-up to help prevent non-contact injuries to the knee and ankle. Referees can be clued to have strict adherence to the rules for not only proper outcome of the game but referees play a vital role in limiting injury exposure by not allowing stick and body contact during a women's game. Equipment manufacturers can continue to increase the safety of the game by enhancing the helmet for reduction in concussions. Facemasks must limit the exposure of the face to the stick and ball to reduce injuries to the eyes, nose, and mouth. Rules makers must continue to enhance the game by enforcing rules to limit the exposure of injury to the players. Researchers can look at the void that needs to be filled by continuing research on Commotio Cordis to reduce the chances of catastrophic injury to the players of Lacrosse and other sports that blunt trauma to the chest can occur.

With large increases in participation at all levels, efforts need to be made to enhance the safety and decrease the injuries that can have long term consequences on the players' health, our health care system, and future generations of Lacrosse players.

Table 1 Injury Rates

Study	# of inj	Dura-tion	Design	Participants		# of Teams		# of Injuries		I. P. R.	Mens C.R. /100 Athletes Total # injuries/100 athletes	Mens C. R./1000 AE Tot. Inj/1000 AEs	Women's C.R./100 Athletes Total # injuries/100 athletes	Women's C.R./1000 AE Total Inj/1000 AEs
				M	F	M	F	M	F					
Youth														
Yard, et al (2006)	5827	13 yrs	Retro	85,039		~~	~~	4577	1250	0.0685215				
High School														
Hinton, et al (2005)	986	3 yrs	Prosp			23	23	615	371	1.14		2.89		2.54
Lincoln, et al (2007)	228	4 yrs	Prosp	5072	3566	23	23	114	114	1.42		0.38		
Cantu, et al* (1999)	3	15 yrs	Retro	292,238	150,547	~~	~~	3	0	0.0000068	0.001	n/a	0	n/a
Goldenberg, et al (1995)	1383	3 yrs	Prosp	Zero	7263	Zero	~~	Zero	1383		Zero	Zero	19	3.9
College														
Diamond, et al (2001)	1727	10 yrs	Retro	1391	336							0.44		0.77
Lincoln,et al (2007)	400	4 yrs	Prosp	~~	~~	34	64	132	268	1.76				
Matz, et al (2004)	104	2 Sns	Prosp	~~	~~	~~	18	~~	104	3.8	~~	~~	~~	3.8
Waicus (2002)	125	2 Dys	Retro	~~	667	~~	34	~~	125	~~	~~	~~	~~	~~
Decoster, et al (1999)	134	1 sn	Prosp	147	163	7	10	154	111	2.29		4.67		1.76
Covassin, et al (2003)	128	3 yrs	Prosp	~~	~~	119	112	80	48					
Mihata, et al (2006)		15 yrs	Retro	~~	~~	453	552	169	146			0.17		.18*
Cantu*, et al (1999)	5	15 yrs	Retro	73,879	47,235	~~	~~	5	~~	0.00004	0.0068	n/a	0	n/a
Prodromos, et al (2007)	~~	~~	Retro	~~	~~	~~	~~	~~	~~	1.06		0.17		0.18

I.P.R. = Incidence porportion rate- (# of injured athletes/ total number of athletes)

All data was taken directly from the references, unless otherwise noted

* Cantu only studied Catastrophic Injuries

* Prodromos, et al and Mihata only studied ACL injuries

Goldenberg only studied head a face injuries

Table 2 Game vs Practice Injury Rates

Study	# of inj	Dura-tion	Design	Subjects		# of Teams		# of Injuries		Rate (Combo M & F)		Mens		Women's	
				M	F	M	F	M	F	Practice Inj/1000 AE	Game Inj/1000 AE	P/1000 AE	G/1000 AE	P/1000AE	G/1000 AE
Youth															
Yard, et al (2006)	5827	13 yrs	Retro	85,039		~~	~~	2002*			n/a				
High School															
Lincoln, et al (2007)	228	4 yrs	Prosp	5072	3566	23	23	114	114	1.83	1.21	0.14	1.1	0.26	1.33
Mayer, et al (1987)	2	~~	Retro	~~	2	~~	~~	~~	2					2**	
Lapidus, et al (1992)	2	~~	Retro	~~	1	~~	1	~~	2					2**	
Goldenberget al (1995)	1383	3 yrs	Prosp	Zero	7263	Zero	~~	Zero	1383		3.5 `			1.8`	3.5 `
College															
Lincoln, et al (2007)	400	4 yrs	Prosp	~~	~~	34	64	132	268	2.4	1.09	0.22	1.81	0.53	1.98
Matz, et al (2004)	104	2 Sns	Prosp	~~	~~	~~	18	~~	104		8.65	~~	~~	2.75	8.65
Hootman, et al (2007)	2060	16 yrs	Retro	~~	~~	~~	~~	1100	960			3.2	12.6	3.3	7.2
Waicus, et al (2002)	125	2 dys	Retro	~~	667	~~	34	~~	125			~~	~~	41**	38 **
Covassin, et al (2003)	128	3 yrs	Prosp	~~	~~	119	112	80	48			.13^	1.46^	.22^	1.06^
Livingston, et al (2003)	1	~~	Retro	~~	1	~~	1	~~	1		1**			1**	
Lapidus, et al (1992)	6	~~	Retro	~~	3	~~	~~	~~	6		6**			6**	
McCulloch, et al (2007)	534	~~	Retro	~~	Zero	~~	~~	572	Zero		8.8	~~	11.5		6.1

*combined data was only given

** Not given sufficient data to calculate, athletes self reported injuries on survey, no athletic exposure data reported

^ numbers are calculated averages for the three individual years

` numbers are per 100 not per 1000 AEs

All data was taken directly from the references, unless otherwise noted

Table 3 Injury Onset

Study	# of injuries	Duration	Design	# of Subjects M	# of Subjects F	# of Teams M	# of Teams F	# of Injuries M	# of Injuries F	# of season	Injury Onset Gradual I. P.R.	Injury Onset Gradual /1000 AE	Injury Onset Sudden I. P.R.	Injury Onset Sudden /1,000 AE
Youth														
Yard, et al (2006)	85039	13 yrs	Retro	85039				2002*		~~				
High School														
Hinton, et al (2005)	977	3 yrs	Prosp	~~	~~	23	23	609	368	3	104*		873*	
Kang, et al (2005)	7	6 yrs	Retro	~~	7	~~	1	~~	7	6	7*			
Mayer et al (1987)	2	~~	Retro	~~	2	~~	~~		2		Zero		2*	
Lincoln et al (2007)	228	4 yrs	Prosp	5072	3566	23	23	114	114	4	7*		221*	
College														
Livingston, et al (2003)	1	~~	Retro	~~	1	~~	1	~~	1	1	~~		1*	
Lincoln, et al (2007)	400	4 yrs	Prosp	~~	~~	34	64	132	268	4	16*		348*	
Matz, et al (2004)	104	2 sns	Prosp	Zero	~~	~~	18	Zero	104	2	Zero		104*	

I.P.R= Incidence Porportion Rate

* Numbers are totals, not in rate per 1000 AE or Incidence Porportions

All data was taken directly from the references, unless otherwise noted

Table 4 Injury Site Location

	Youth		High school					Collegiate										
	Yard('06)		Lincoln, et al ('07)		Hinton ('05)		Goldenberg ('95)	Diamond ('01)		Covassin('05)		Hootman ('07)		Waicus ('02)	Lincoln ('07)		Matz ('04)	McCulloch ('07)
Duration	13 years		4 years		3 years		3 Years	10 years		3 years		16 years		2 days	4 years		2 seasons	~~
Design Type	Retro		Prosp		Prosp		Prosp	Retro		Prosp		Retro		Retro	Prosp		Prosp	Retro
	M	**F**	**M**	**F**	**M**	**F**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**F**	**M**	**F**	**F**	**M**
# of subjects			5072	3566	~~	na	7263			~~	~~	~~	~~	667	~~	~~	~~	~~
# of injuries	4577	1250	114	114	615	371	1383	1391	336	80	48	1100	960	125	132	268	104	572
# of Teams			23	23	23	23				119	112			34	34	64	18	
Site of injury																		
Head	320.4 (7%)	100 (8%)	96 (84.2%)	66 (57.9%)	97^^	52^^	5.4	250.9	101	80*^	48*^	271*^	213^*		117 (88.6%)	130 (48.5%)	40 (38.5%)	63 (11%)^
Nose			3 (2.6%)	17 (14.9%)	~~	~~	1	~~	~~						0	65 (24.3%)	14 (13%)	~~
Face	457.7 (10%)	262.5 (21%)	7 (6.1%)	7 (6.1%)	~~	~~	~~	~~	~~						2 (1.5%)	11 (4.1%)	1 (.7%)	~~
Jaw/Chin			3 (2.6%)	1 (.9%)	~~	~~	0.18	~~	~~						12 (9.1%)	12 (4.5%)	~~	~~
Mouth	63	16	3 (2.6%)	1 (.9%)	~~	~~	0.4	~~	~~						0	10 (3.7%)	~~	~~
Teeth					~~	~~	0.06	~~	~~								~~	~~
Ear					~~	~~	0.05	~~	~~								~~	~~
Eyes	52	30	2 (1.8%)	22 (19.3%)	~~	~~	1.3							125	1 (.8%)	40 (14.9%)	12 (11.5%)	~~
Other							~~	83.5	17.5									
Spine/Trunk							0.49	~~	~~								~~	~~
Neck	137.3 (3%)	25 (2%)			17	3	~~	38.95	2.02								~~	3 (<1%)
Upper Back					46	15	~~	101.5	3.02								~~	17 (3%)
Lower Back					~~	~~	0.22	~~	~~								~~	~~
Ribs					~~	~~	0.11	~~	~~								~~	11 (2%)
Stomach					~~	~~	0.12	~~	~~								~~	~~
Upper Ext							2.3										~~	~~
Shoulder	686.6 (15%)	37.5 (3%)			52	15	0.29	189.2	10.1								~~	56 (10%)
Arm					18	6	~~	~~	~~								~~	~~
Elbow	366.2 (8%)	50 (4%)			~~	~~	~~	58.4	5.04								~~	~~
Forearm					~~	~~	~~	51.47	8.1								~~	~~
Wrist					66	35	~~	83.46	11.1								~~	16 (3%)
Hand	1052.7 (23%) *	300 (24%)*			~~	~~	~~	55.64	19.2								9 (8.6%)	~~
Thumb					~~	~~	0.52										~~	24 (4%)
Finger					~~	~~	0.54	176.7	45								~~	~~
Lower Ext							14											
Pelvis, hip					16	15	~~	~~	~~								~~	38 (7%)
Thigh					47	15	1.7	~~	~~								7 (6.7%)	85 (15%)

Knee	457.7 (10%)**	87.5 (7%)**		95	79	1.9	28.8	117		131^*	145^*		14 (13%)	80 (14%)
Leg				32	24	1.4	37.6	6.05					5 (4.8%)	31 (5%)
Ankle	640.8 (14%)***	325 (26%)***		99	93	3.5	123.8	67.9		698	602		16 (15%)	101 (18%)
Heel/Achilles				~~	~~	~~	~~	~~					~~	6 (1%)
Foot				17	11	~~	23.65	11.1					~~	14 (2%)
other	457.7 (10%)	62.5 (5%)		11	7	5.5							13 (12.5%)	27 (5%)

* hand and wrist are combines into one group

^ Includes concussions

^* Only includes ACL injuries

** Knee and upper leg/thigh are combined into one group

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

` All inj. stress fx of femoral shaft

***Foot and ankle combined into one group

All data was taken directly from the references, unless otherwise noted

*^ Only includes concussion

Table 5 Injury Type

Study	Design	Duration		# of Subjects	# of Injuries	# of Teams	Contusions/ Abrasions	Concussions	Dislocations	Fx	Lacerations	Sprain	Strain	Other
Youth														
Yard (2006)	R	13 yrs	M		4577		1464	137.30	Na	961.2	366.2	1144.3		503.5
			F		1250		375	37.5	Na	175	87.5	400		162.5
High School														
Lincoln (2007)	P	4 yrs	M	5072	114	23	14	83		4	9			3
			F	3566	114	23	38	45		16	8			4
Hinton (2005)	P	3 yrs	M		371	23	140	61	10	57	11	258		
			F		615	23	69	14	10	33	5	170		
College														
Diamond (2001)	R	10 yrs	M/F	1727	1727	~~	84	84	~~	31	131			
Lincoln (2007)			M	~~	132	34	4	112		4	8			3
			F	~~	268	64	64	111		56	25			12
McCulloch (2007)	R		M	~~	534		81	62	9	40		166	136	
Hootman (2007)	R	16 yrs	M	~~	1100	~~		271				698		131
			F	~~	960	~~		213				602		145
Mihata (2006)	R	15 yrs	M	~~	169	453						169		
			F	~~	146	552						146		
Covassin (2003)	P	3 yrs	M	~~	80	119		80						
			F	~~	48	112		48						

* All stress Fx of Femoral Shaft

All data was taken directly from the references, unless otherwise noted

Table 6 Injury Severity

Study	# of injuries	Dura-tion	Design	Participants		# of Teams	# of Injuries		Rate Inj/1000 AEs (1-7 days)		Inj/1000 AEs (8-21 days)		Inj/1000 AEs (22+ days lost)		Inj/1000 AEs Catastrophic	
				M	F		M	F	M	F	M	F	M	F	M	F
Youth																
Yard (2006)		13 yrs	Retro	~~	~~		2002*		~~	~~	~~	~~	~~	~~	zero	zero
High school																
Luckstead (2002)	91*	18 yrs	Retro	~~	~~				~~	~~	~~	~~	~~	~~	4	zero
Hinton (2005)	986	3 yrs	Retro	~~	~~	~~	615	371	264	193	21	21	34	11	zero	zero
Mayer (1987)	2	na	Retro	~~	2	~~	~~	2		~~		~~		2		~~
Cantu (1999)	3	14 yrs	Retro	292,238	150,547	~~	3								3	
College															3	Zero
Luckstead	37**	18 yrs	Retro	~~	~~				~~	~~	~~	~~	~~	~~		
Matz (20044)	104	2 sns	Retro	~~	~~	18	~~	104	~~	76.35	~~	18	~~	10	~~	Zero
Waicus (2002)	125	2 dys	Retro	~~	667	34	~~	125	~~	79	~~	9	~~	Zero	~~	Zero
Decoster (1999)	134	1 sn	Prosp	147	163	17	154	111			59					
Cantu (1999)	5	14 yrs	Retro	73,879	47,256	~~	5								5	

* Includes all catastrophic injuries for all HS spring sports

** Includes all catastrphic injuries for all College spring sports

All data was taken directly from the references, unless otherwise noted

Table 7 Injury by Position

Study		Duration	Design	# of Part.	# of Teams	# of Inj	Goalie	Point	Cover-point	3rd Man	L Def Wing	R Def Wing	Total Def	Center	R Attack Wing	L Attack Wing	3rd Home	2nd Home	1st Home	Total Off	Total Mid
Youth																					
High School																					
Goldenburg (1995)*	F	3 years	Prosp	7263	63	1383	5	19	26	28	26	21	125	35	48	30	29	26	21	189	
College																					
Waicus (2002)	F	2days	Retro	667	34	125	na	na	na	na	na	na	27	na	na	na	na	na	na	41	22
Kang (2005)	F	6 years	Retro	7	1	7							1							3	3
Livingston (2003)	F	1 year	Retro	1	1	1															1
	F																				
Pro																					
None																					

* Only covered head and facial injuries in HS Girls

All data was taken directly from the references, unless otherwise noted

All data was done on female athletes

Table 8 Injury Risk Factors

	Design	Duration	Description
Intrinsic Risk Factors			
Youth			
Yard et al (2006)	R	13 years	Children 2 through 9 years of age sustained more injuries to the head and face
McGuine (2006)	R	10 years	Sex, Age/Grade. Experience, Previous History, Body Size
College			
Brown et al	O	1 year	Gender differences (females more susceptible to injuries, concussion, ACL, etc.)
Decoster (1999)	P	1 season	Hypermobility of joints
Extrinsic Risk Factors			
Youth	**Design**		**Descrption**
Yard (2006)	R	13 years	Rules
High school			
Lapidus et al (1992)	R	~~	Lack of Eye Protection (women)
Hinton (2005)	P	3 years	Lack of Rule enforcement (girls), and effectivness of protective gear in M & F
Goldenberg (1995)	P	3 years	Field Position, Midfield play more prone to injury
College			
Caswell (2003)	P	~~	Player contact causes more than half of the reported injuries (men)
Covassin (2003)	P	3 years	Higher incidence of concussion because of style of play (men)
Hootman (2007)	R	16 years	Increase in Participation, higher rate of injury in game vs practice
Livingston (2003)	R	~~	Lack of Equipment Protection, Gloves (women)
Lapidus et al (1992)	R	~~	lack of Eye Protection (women)
Shermondy (2006)	R	1 year	Lack of Equipment.
Mihata (2006)	R	15 years	Rules and Style of Play, Gender

All data was taken directly from the references, unless otherwise noted

Table 9 Injury Prevention: Lacrosse

Area of Need	Suggestions from Literature	Supporting Evidence
Equipment	-Protective gear in boys and girls for hand and wrist injuries	Hinton et al (2005)
	-Protective gear (men), shoulder pads provide little protection from body to body or body to surface contact.	Casazza et al (1999)
	- Helmets currently designed to with stand stick contact not body to body contact	Casazza et al (1999)
	-Several areas regarding helmet performance, including fit, environmental conditions, shell composition, shape, face mask design, and types of padding	Caswell et al (2002)
	-Gloves, especially for goalkeepers, to protect the thumb against injury. Current gloves offer little protection of the thumb.	Elkousy et al (2000)
	-Prohibiting the use of molded plastic heads with openings large enough to allow entry of a finger or thumb (women's)	Livingston (2003)
	-Use of appropriate recommended polycarbonate eye wear in men's and women's Lax	Luckstead (2002)
	-Require goggles to prevent catastrophic ocular trauma	Matz (2004)
	-All female lax players wear protective helmets and face masks and gloves to prevent bony injuries	Mayer et al (1987)
	-Wearing protective eyewear	McGuine (2006), Sherman (2000), Lincoln (2007). Lapidus (1992), Waicus (2002), Yard (2006)
	-Additional equipment for men's lax players to protect should/upper arm.	Yard (2006)
	-Full head gear for women's lax to protect against the high incidence on facial injuries	Yard (2006)
	-Larger baskets for female sticks to avoid the need to cradle the stick next to their head as much	Waicus (2002)
Rule Enforcement	-Stricter enforcement of existing rules	Lincoln et al (2007)
	-Game officials must enforce rules strictly and coaches should support officials' efforts to conduct safe competitions.	Cantu et al (1999)
	-Prevention initiatives should focus on instituting and enforcing existing playing rules and policies developed for competition	Hootman (2007)

Injury reporting /Recording	-Increased awareness of sport-related concussions	Brown et al (2007)
	-Established protocols for return to play after concussions	Casazza et al (1999)
Conditioning	-Incorporate ACL Prevention and other Knee ligament prevention programs into training	Arendt et al (1999)
	-Better conditioning to reduce injuries resulting from fatigue, especially in midfielders	Casazza et al (1999)
	-Coaches should be well trained in physical conditioning, the skills of their sport, and the risks of injury and be able to teach them effectively.	Cantu et al (1999)
	-Coaches should develop drills that will enable players to control the stick on defense as well as develop their ability to control the ball in midfield and on goal play	Goldenburg (1995)
	-Injury prevention programs should be incorporated to strengthen knee and ankle ligaments and pre-existing conditions need to be fully rehabilitated before return to play is made.	Hinton (2005)
	-Strength training for shoulder and upper arms in men's lax.	Yard (2006)
	-Up to date warm up/conditioning for athletes needs to be implemented by coaches.	Herman (2008)
Playing Surface	-If possible play on natural surfaces.	Casazza et al (1999)
Awareness	-With growth of sport, sports med physicians and ATCs need to have an understanding of the game and its physical demands to help guide decisions regarding treatment and return to play.	McCulloch (2007)
	-Have an accurate understanding on biomechanical risk factors, followed by prospective identification and demonstrable changing on those factors presumed to be modifiable,	Mihata (2006)

Table 10 Suggestions for Further Research into Lacrosse Injuries

Element to be Studied	Suggestions
Injury definitions	Injuries should be classified by position, as well as age and classification type. Injuries should also include classification for severity
Data Collection	More complete and thorough data needed for both the men's and women's injuries that include all factors such as age, position, severity, risk factors, type of activity (catching ball, passing, ect.), and game vs. practice times (first half, second, half, OT)
Subjects	Injuries among both male and females at the post collegiate levels, including amateur, professional, and International play. Injuries should be distinguished by cause, either intrinsic or extrinsic factors. Injuries related to the growth of the sport for both males and females.
Research Design	Longitudinal research in areas where injury severity is documented at all levels of play in both men's and women's lacrosse. Meta-analysis for all lacrosse injuries at all levels
Researchers	More thorough statistical analysis More epidemiology studies done at all levels of play for both females and males

Case Reports Table 11

Study	Design	Subjects	# Injuries	Summary
High School				
Silloway (1985)	Case	3	3	Clavicular and AC Joint Fractures and Dislocations
O'Neill (2000)	Case	1	1	Double Clavicular Fracture
Attia (2000)	Case	1	1	Isolated First Rib Fracture
Lapidus (1992)	Case	1	1	Orbital Fracture and Mild Enophthalmos from being hit by a lacrosse ball
College				
Elkousy (2000)	Case	3	3	Case study for Lacrosse Gamekeepers thumb
Livingston (2003)	Case	1	1	Entrapment of the thumb
Kang (2005)	Case	7	7	Stress Fractures of the Femoral Shaft
Lapidus (1992)	Case	3	3	Different cases of Eye injuries from trauma by a lacrosse ball
Amateur/ Post collegiate				
Gangemi (1999)	Case	1	1	Splenic Rupture from a lacrosse ball
Ho (1985)	Case	2	2	True aneurysms of the hand resulting from vasculature of the hand after blunt athletic trauma

All data was taken directly from the references, unless otherwise noted

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