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Gender-specific Injury Patterns in the Lacrosse Athlete

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ABSTRACT

Lacrosse is one of the fastest growing sports in the United States, increasing over 200% in the last two decades. With that increased participation, a corresponding rise in injury rates has also been identified, particularly impacting female lacrosse players. The most common injuries seen in female lacrosse players are sprains/strains, concussions, contusions, and lacerations. The lower extremities are the most commonly injured body site. Female lacrosse players sustain a
higher rate of sprains/strains, head, face, and eye (HFE) injuries, hand/wrist fractures, and contusions compared to male lacrosse players. The differences in the style of play and the mandatory equipment requirements between men’s and women’s lacrosse may explain the discrepancy in injury rates between the sports. These differences may provide an opportunity to implement preventative strategies to better protect players and reduce risk of injury.

INTRODUCTION

Over the past two decades, lacrosse has been one of the fastest growing sports in the United States of America. Since its inception in 2001, the United States (US) Lacrosse Participation Report has seen a growth of 226%. A total of 826,000 individuals participate in this sport, with youth (ages 14 and under) comprising the largest proportion of active players at 450,000 (1). With the sport expanding across all levels of play, new athletes from all ages begin to participate in the game each year. In particular, women’s lacrosse participation has grown steadily over time. There are currently more than 500 active women’s collegiate lacrosse programs across all NCAA divisions (2), contributing to the sport’s continued expansion and allowing many athletes to continue to play past the youth and high school level.

With the increase in total number of participants in the sport, the total number of lacrosse-related injuries has also increased. Bano et al(3) generated nationwide estimates of lacrosse-related injuries in youths aged 11 to 18 years based on 6406 actual cases treated in an Emergency Department (ED) setting from 2000 to 2016. The authors found that the overall rate of injury increased by 85.3% over the 17-year period. Another study investigating injury rates in women’s collegiate lacrosse also found an increased rate of injury over a 16-year period, with an average annual increase of 2.4% in game injury rate (4). For male and female lacrosse players the most common injuries were sprains/strains (3,5,6,7,8,9), contusions/abrasions (3,5,6,10), and concussions (3,7,8,9). These injuries are seen in male and female players of different ages and across all skill levels of play. While the injuries seen in male and female lacrosse players are similar, the manner in which the sport is played and the protective equipment requirements differ significantly across the sexes.
In this article, we review the most common injuries sustained by female lacrosse players, summarize the differences in gameplay and protective equipment between men’s and women’s lacrosse, and discuss preventative strategies that may lessen risk of injury in female players.

COMMON INJURIES IN WOMEN’S LACROSSE

A literature review conducted by Barber Foss et al (12), found that the injury rate for female lacrosse players ranged from 0.030 to 3.9 injuries/100 players in high school and ranged from 0.11 to 3.8 injuries/players in college. The most common injuries for female lacrosse players are sprains/strains (6,11,12), concussions (11,12), contusions, and lacerations (6,12). Incidence of total injuries increased with age and level of play, and was higher in games versus practices (6,12).

Head, Face, and Eye Injuries
The head, face and eye (HFE) region is a common location of injury in both male and female lacrosse players; however, females suffer injuries to this area at a disproportionate rate compared to males (13). A head injury is defined as an injury above the neck, excluding face or eye injury. Face injury specifically comprises damage to the face, nose, chin, jaw, mouth, teeth, and/or tongue. Eye injury is defined as an injury involving the eye orbit, eyebrow, eyelid, and all other structures of the eye proper (13). The majority of studies have concluded that concussions are the most common type of HFE injuries (9,11,13) across high school and collegiate levels; however, one study found that contusions were more common in adolescent female players than concussion (6). A concussion is a mild traumatic brain injury induced by biomechanical forces, a direct blow to the head or indirectly by a strike to the body that is transmitted to the head. It presents as rapid onset with short lived neurologic impairments, including confusion, disorientation, or change in consciousness, that resolves spontaneously (33). It should be noted that within the rate of total lacrosse-related injuries, male players experience more concussions than female players (6,7). Females most often sustain concussions from stick-to-body contact or ball-body-contact (7,13). In high school play, females were 5 times more likely to experience HFE fractures and 4 times more likely to experience contusions than males. At the high school and collegiate levels, males had a higher rate of injury to the head (84% and 89%, respectively)
and females had higher rates of injury to the nose (15% and 24%, respectively) and eyes (19% and 15%, respectively) (13). Regardless of level of play, the mechanism of HFE injuries differs between male and female players. At all levels of play, HFE injuries in females are caused most frequently by stick-to-body (3,7,13,14) and ball-to-body contact (3,14) while the most common mechanism of injury for male players is body-to-body contact (13).

**Sprains and Strains**

Sprain and strains are other common injuries seen in female lacrosse players and typically affect the lower extremity. The vast majority of sprains and strains are caused by non-contact mechanisms (3,4). Females are 2.21 times (95% CI: 1.96–2.49) more likely than males to have non-contact injuries (3). A non-contact mechanism is defined as an injury sustained without extrinsic contact by another player or object. Since females sustain a higher proportion of sprains and strains than males, this helps explain the mechanism of these injuries (5). A systematic review conducted by Vincent et al(15) further elaborated on the incidence of non-contact injuries commonly seen in women’s lacrosse. Common mechanisms of injury seen in female lacrosse players during summer camp play were overuse (19% of total injuries), illegal stick/object hit (19%), ball contact with the body (15%), and falling to the ground with or without body contact (24%). The knee is a common site of injury in female lacrosse players. During regular season play, female players have higher rates of knee injuries than male players (15). A report of NCAA Surveillance System data analyzing 15 different sports found that anterior cruciate ligament (ACL) injuries comprised 4.3% of all injuries in women’s lacrosse (15). Another study analyzed 148 knee internal derangement (KID) injuries reported from 106 injury events that took place during high school women’s lacrosse games in the United States from 2008 to 2017. Among the 106 injury events, ACL injury (65.1%, n = 69) and meniscus injury (41.0%, n = 43) were reported the most frequently. One third of all injuries included two or more injuries occurring at once, with simultaneous injury to both the ACL and meniscus being the most frequent simultaneous injury reported throughout concurrent injury events (16). The ankle is another common site of injury in female lacrosse players. One study followed 18 women’s collegiate lacrosse teams over a two-year period and found that 15% of all injuries occurred to the ankle (17). An analysis of high school and collegiate female lacrosse players concluded that ankle injuries comprised 15% to 25.1% of total injuries (15). Upper extremity injuries are also
seen in both men’s and women’s lacrosse, as players largely depend on the upper extremities to cradle, pass, and shoot the ball. Upper extremity injuries, and specifically shoulder injuries, were found to occur at lower rates among female lacrosse players than male lacrosse players, both in practice as well as during games. Injuries to the shoulder and arm made up 1.6% to 4.1% of the total injuries reported in female lacrosse players, whereas shoulder injuries in male lacrosse players ranged from 5% to 12.4% of total injuries reported. Female lacrosse players were also found to experience shoulder injuries that required emergency room care 5 times less than male players (15).

Hand and Wrist Injuries

Injuries to the hand and wrist are also commonly seen among lacrosse players. An epidemiologic study followed male and female high school lacrosse players from 1999 to 2001 and concluded that hand and wrist injuries were the fourth most common injuries in adolescents participating in high school play (6). In this study, the specific types of injuries differed between the sexes. The most common injuries for male players were ligament sprains and fractures, while female players sustained more contusions as well as fractures. For both sexes, direct impact was the primary mechanism of injury (6). A separate study found that the hand and wrist region was the most commonly fractured site in female lacrosse players (15). It should be noted that male lacrosse players have demonstrated a higher rate of hand fractures than female players (9).

DIFFERENCES IN STYLES OF PLAY AND THE IMPACT ON INJURY RISK

Men’s and women’s lacrosse are fast-paced games played on turf or grass fields that involve quick movement of a ball between players with the ultimate objective of scoring a goal past the opponent’s goalie and into the net. Teammates work to move the ball up and down the field through strategic and well-timed passes using lacrosse sticks, while constantly moving and adjusting position. As soon as one team gains possession, the opposing team’s players quickly transition from an offensive style of play to a defensive style of play in hopes of preventing the opposing team from scoring a goal and subsequently regaining offensive possession. Although the two games may be similar at their core, there are vast differences between the rules of men’s and women’s lacrosse and the style in which the game is played.
The difference between the rules of women’s and men’s lacrosse may contribute to the unique pattern of injuries seen in both sports. The most obvious difference is that body checking between players is prohibited in women’s lacrosse whereas in men’s lacrosse it is permitted (18,19). As per the 2021 USA Lacrosse Equipment Guide (20), the only equipment required during a women’s lacrosse game are protective eyewear and a mouthguard. Gloves, arm pads, NOCSAE (National Operating Committee on Standards for Athletic Equipment) approved shoulder pads, a protective cup, cleats/athletic footwear, a mouth guard, and a NOCSAE-approved helmet are all required protective equipment that a male player must wear to participate (Table 1, Figures 1 and 2). Another notable difference between men’s and women’s lacrosse is that the head of a women’s lacrosse stick is flat and without a deep pocket, such that no more than half of the ball can be seen below the sidewall (19). The lack of a deep pocket further contributes to the fast pace and style of play, as a flat pocket eases the ability of a defender to knock the ball out of the head of the stick compared to men’s lacrosse sticks, which have deeper pockets. With flat pockets, female players carry the head of the stick close to their heads to increase ball control and prevent defenders from knocking the ball loose. Without helmets, this method of ball handling by female players puts them at a greater risk of sustaining injuries to the head and face (12). Along with body checking being illegal in women’s lacrosse, stick checking is limited and must occur below shoulder level and directed at the pocket of the stick without coming into contact with the opponent’s body (2). Conversely, in addition to checking the head of the stick, the rules of men’s lacrosse also allow for checking of the opponent’s hands and shaft of the stick as long as it is not deemed deliberately vicious or reckless by the referees. Furthermore, stick checks are allowed when the opponent has possession of the ball, when an opponent is within 5 yards of a loose ball or when the ball in flight is within 5 yards of the player (21).

Given the absence of body checking and the limitations placed on stick checking in the women’s game, the style of play is focused on quick ball movement and strategically gaining open field space using the feet without the use of the body as a means of gaining separation against a defender. With limitations placed on stick checking and no allowance of body checking against an opponent, defenders must rely on footwork and body positioning to strategically guard their opponent and control the direction in which they move. This style of defense is known as “marking”, where female players must closely guard an opponent within a stick’s length (2).
Combining the offensive and defensive style of play in women’s lacrosse, the game ultimately relies on footwork, quick movement, and a reliance on the lower extremities for proper positioning, which may put female players at an increased risk for lower extremity injuries.

Compared to competitive male lacrosse players, female lacrosse players have been found to travel further absolute distances during games. With larger distances traveled during women’s games, excess strain may be placed on the lower extremities of female lacrosse players. When studied at a positional level, midfielders were found to run the furthest total distance and the furthest distance at high intensity speed, followed by attackers and then defenders (22). Therefore, there may be a correlation between one’s position on the field and physical strain leading to injuries as well.

By evaluating injury by position in female high school lacrosse players, it was found that offensive players had the most injuries, followed by defensive players and then midfielders (12). Goalies sustained far fewer injuries than all other positions. Given that goalies remain mostly stationary during games and that the game rules protect them from physical contact (19), the differences in injury rates by position may be explained not only by the amount one is exposed to body and stick contact but also by the amount of time a player spends running and actively moving. When comparing different age-group and levels of play, it was found that injury rates increased with age and that the highest number of injuries were seen at the collegiate level, suggesting that there may be a direct correlation with skill and pace of play to injury rates (12). Therefore, preventative strategies should be more focused on female players at higher levels of play.

The rules and style of play that exist in women’s lacrosse may contribute to the prevalence and types of injuries that are consistently seen amongst female lacrosse players. By evaluating lacrosse related injuries in females that were treated in United States Emergency Departments from 2000 to 2016, it was found that the most common causes of injury amongst players were by contact with a stick (24.7%), contact with a ball (19.9%), and non-contact injuries (19.8%). When compared to injuries amongst male players, female players were more than two times as likely to sustain a non-contact injury (3). The high incidence of injuries caused by contact with a stick or ball as well as the high rate of head injuries amongst female lacrosse players can be attributed to their lack of protective equipment. Although prohibiting body checking and most physical contact are protective measures to the players in some capacity and
reduce person-to-person contact injuries, the lack of equipment allows for other injury mechanisms to persist in the game.

PREVENTION STRATEGIES

Helmets

The use of helmets in women’s lacrosse is a hotly debated topic. A common argument against helmet use focuses on questionable effectiveness for concussion prevention. Men’s lacrosse mandates the use of helmets, and yet men’s lacrosse players consistently have higher rates of concussion than female players (6,7). While this is valid, the mechanisms by which female and male players sustain head injuries may help explain this. As noted previously, males are more likely to receive concussions from player-to-player contact (13), whereas stick-to-body and ball-to-body mechanisms are much more common in female players (3,7,14). Male lacrosse players were also found to have head or facial fractures at a frequency of 3% to 3.5% of all head injuries, whereas female players had much higher fracture rate of 14.0% to 20.9% of all head injuries (15). With limited protective equipment required in women’s lacrosse, injury to a player’s head from an opponent’s stick or an erratic ball can occur during regular gameplay.

Arguments against the use of helmets claim that female players will become more aggressive, termed the gladiator effect, as wearing the helmets will give players a sense of invincibility and motivate them to participate in more risk taking (23). Additionally, one study showed that the implementation of padded helmets in rugby players did not decrease the rate of concussions (24). The different material composition of the helmets used in rugby can help explain this. The padded helmets in this study were made from fabric or leather that contain thin strips of impact-absorbing material but contain no hard outer shell or face mask. This is compared to the ASTM standard F3137 headgear that is currently recommended for female lacrosse players. The new ASTM standard is the first ever performance standard for women’s lacrosse headgear. These helmets have a flexible shell to avoid injuring players not wearing helmets and have been developed to help reduce impact forces associated with stick and ball contact (23). A recent study revealed that the use of headgear that meets the ASTM standard F3137 significantly reduced concussion rates (25). Overall, the researchers reported a 59% greater incidence of concussion in players not wearing headgear. The incidence increased to 74%
when evaluating concussion incidence during games only, but was lower (42%) when solely focused on practices. The researchers observed that headgear use among high school varsity female lacrosse players did not result in more impacts or changes in game-play behaviors. Furthermore, the addition of headgear was not associated with any change in frequency of penalties administered for illegal game play by officials. This study provides evidence that weakens the argument against helmet use.

In addition to concussion injuries, headwear can prevent other injuries to the HFE region, which also disproportionately affect female players compared to males (13). The use of protective headgear can decrease the risk of HFE contusions, lacerations and fractures (6,13). Baron et al (26) followed eight high school women’s lacrosse teams over two seasons and concluded that the players who wore headgear demonstrated significantly lower rates of in-game head and face injury, as well as in-game concussions. Another study analyzed the effects of mandating eyewear in women’s lacrosse. Eyewear was mandated in women’s lacrosse starting in the 2004-2005 season, which significantly reduced the rate of eye injuries and head/face injuries excluding concussions. The rate of eye injuries was reduced from 0.10 injuries per 1000 athlete exposures from 2000 to 2003 before the use of protective eyewear to 0.016 injuries per 1000 athlete exposures from 2004 to 2009 following the introduction of protective eyewear (27).

**Neuromuscular Training**

The goal of neuromuscular and proprioceptive training programs is to identify and correct the underlying biomechanical dysfunction in the lower extremity kinematic chain that predisposes an athlete to certain musculoskeletal injuries. While these preventative training programs have been described for numerous acute and chronic sports-related injuries, the vast majority of the literature focuses on integrative neuromuscular training to decrease the risk of non-contact ACL injuries (28, 30, 31). There is little data on the effects of neuromuscular training on other non-contact injuries, such as meniscal injury, that are more commonly seen in women’s lacrosse. More studies are needed to explore the potential benefits of this intervention on non-contact injuries as a whole.

Neuromuscular training programs for ACL injury prevention aim to prevent dynamic knee valgus, which increases strain on the ACL and subsequently increases risk of ACL tear. Numerous programs have been developed over the past two decades and all differ slightly in
terms of specific exercises performed, duration and sequence of exercises (28). Yet, the goal remains the same throughout all programs – to correct dangerous neuromuscular movement patterns by strengthening deficit muscular groups and shifting the balance to favor protective muscular recruitment. Strengthening the hip abductors and external rotators lessens hip adduction and internal rotation. Strengthening the medial hamstrings, the semitendinosus and gracilis, lessens tibia external rotation. Strengthening the posterior tibialis and gastrocnemius allows for balanced landing and decreases medial arch collapse. Recently, strengthening the core musculature to decrease trunk extension has also been proposed (29). All of these neuromuscular corrections lead to less dynamic knee valgus. Huang et al(28) performed a meta-analysis of randomized controlled trials evaluating the efficacy of ACL injury prevention programs and concluded that these programs had a significant protective effect and reduced ACL injury rates by 53%. These ACL injury prevention programs benefit female athletes in particular, given the high percentage of ACL injuries that occur through a non-contact mechanism. Mendelbaum et al (30) prospectively evaluated the efficacy of a neuromuscular and proprioceptive training program for reducing ACL injuries in female soccer players and also found a decreased rate of ACL injury in the experimental group. When female lacrosse player workloads are compared to those of female soccer players it is noted that lacrosse players travel less total distance during a game but spend a greater percentage of time at high intensity speed (22). With high strain placed on the lower extremities during women's soccer and lacrosse games and the rising incidence of sprain and strain injuries in both sports, neuromuscular training should be expanded to women’s lacrosse as a means of reducing injuries and protecting players from lower extremity injuries.

Proprioceptive balance board training is another intervention that aims to prevent lower extremity injuries and has proven to be effective in reducing ankle injuries in athletes by improving muscle strength around the ankle. Verhagen et al(31) followed 116 male and female volleyball teams during the 2001-2002 season and found that players who participated in proprioceptive balance board training experienced significantly fewer ankle sprains compared to athletes who did not participate in this training program. Thus, balance board training may be an effective intervention to lessen the risk of ankle injuries in female lacrosse players.
The use of gloves could play a role in decreasing the risk of various hand and wrist injuries in female lacrosse players. In the youth game, hand and wrist injuries comprise nearly a quarter of all injuries sustained by female players, the vast majority being contusions and abrasions (32). At the present time, gloves are required for men’s lacrosse but not in the women’s game. While the efficacy of gloves for decreasing risk of hand fractures is questionable, given the higher rate of hand fractures in male players where gloves are mandated, requiring the use of gloves in the women’s game may lower risk of hand and wrist contusions and abrasions and should be considered. The addition of a glove mandate to women’s lacrosse may be more effective in reducing injuries to the hands and wrist compared to men’s lacrosse due to the rules that already prohibit body contact and stick checks to opponents hands in women’s lacrosse.

CONCLUSION

As women’s lacrosse participation continues to rise across all age groups, we can anticipate that injury rates will follow a similar trend. The style of play, required protective equipment and rules of women’s lacrosse all contribute to the different injury rates identified in female lacrosse players compared to their male counterparts. Injuries to the HFE region, lower extremity sprains and strains, as well as contact injuries to the hand and wrist are common in female lacrosse players. Injury risk may be lessened by mandating certain protective equipment and implementing neuromuscular and proprioceptive training programs. We propose that the addition of gloves and helmets to the list of required equipment for women’s lacrosse will better protect female players from injuries to the HFE region, hand and wrist. In addition to expanding protective equipment requirements, we also suggest that players actively participate in neuromuscular training programs in order to improve joint stability and further reduce risk of lower extremity sprains. Further research is needed to clarify injury risk factors by age and position, assess the impact of rule changes and protective equipment on rates of injury and help guide further recommendations for mitigating risk of injury at all levels of play.

Author contributor roles
MB conceived of the presented topic. Cassandra B and Conor B wrote the manuscript, with both authors having contributed equally. AB and MB provided critical feedback, and all authors contributed to the revisions. All authors read and approved the final manuscript.

Conflict of interest
The authors have no conflicts of interest to disclose.

Informed Patient Consent
The author(s) should confirm that written informed consent has been obtained from the involved patient(s) or if appropriate from the parent, guardian, power of attorney of the involved patient(s); and, they have given approval for this information to be published in this case report (series). Please refer to Elsevier’s policy regarding written patient consent requirements https://www.elsevier.com/about/policies/patient-consent#:~:text=That%20individual%2C%20legal%20guardian%20or%20writing%20of%20all%20such%20conditions

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REFERENCES

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Table 1. Equipment differences between men’s and women’s lacrosse

<table>
<thead>
<tr>
<th>Men’s Lacrosse</th>
<th>Women’s Lacrosse</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Helmet (Must meet NOSCAE Standard)</td>
<td>● Helmet (OPTIONAL)</td>
</tr>
<tr>
<td>● Crosse (Stick)</td>
<td>● Crosse (Stick)</td>
</tr>
<tr>
<td>● Gloves</td>
<td>● Gloves (OPTIONAL)</td>
</tr>
<tr>
<td>● Mouthguard</td>
<td>● Mouthguard</td>
</tr>
<tr>
<td>● Athletic Cleats or Athletic Shoes</td>
<td>● Goggles</td>
</tr>
<tr>
<td>● Arm Pads</td>
<td>- Must meet current ASTM standard for women’s lacrosse eyewear</td>
</tr>
<tr>
<td>- Elbow must be completely covered</td>
<td>- Must be SEI certified and bear the SEI mark</td>
</tr>
<tr>
<td>● Shoulder Pads</td>
<td></td>
</tr>
<tr>
<td>Must cover top of shoulder, collarbone &amp; sternum</td>
<td></td>
</tr>
</tbody>
</table>

*All requirements according to the 2021 USA LACROSSE EQUIPMENT GUIDE*

Figure 1. Women’s lacrosse equipment
Figure 2. Men’s lacrosse equipment

*Image courtesy of Q-Collar https://qcollar.com/
* Image courtesy of Premier Lacrosse League: Ty Warner of the PLL Whipsnakes LC defending Connor Fields of PLL Chaos LC