Epidemiology of Foot and Ankle Injuries in National Collegiate Athletic Association Men’s and Women’s Ice Hockey

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Background: Ice hockey is a high-speed contact sport in which athletes are prone to many different injuries. While past studies have examined overall injury rates in ice hockey, foot and ankle injuries among collegiate ice hockey players have yet to be analyzed.

Purpose/Hypothesis: The purpose of this study was to elucidate the epidemiology of foot and ankle injuries among collegiate ice hockey players utilizing data from the National Collegiate Athletic Association (NCAA) Injury Surveillance Program. We hypothesized that male ice hockey players would sustain more injuries compared with female ice hockey players and that the injuries sustained would be more severe.

Study Design: Descriptive epidemiology study.

Methods: Data on all foot and ankle injuries sustained during the academic years 2004 through 2014 were obtained from the NCAA Injury Surveillance Program. Injury rates, rate ratios (RRs), and injury proportion ratios were reported with 95% CIs.

Results: Over the study period, the overall rate of foot and ankle injuries for men was higher than that for women (413 vs 103 injuries, respectively; RR, 4.01 [95% CI, 3.23-4.97]). Injury rates were highest during the regular season for both men (358 injuries; RR, 64.78 [95% CI, 58.07-71.49]) and women (89 injuries; RR, 38.37 [95% CI, 30.40-46.35]) compared with the preseason or postseason. The most common injury in men was a foot and/or toe contusion (22.5%), while women most commonly sustained a low ankle sprain (31.1%). For men, foot and/or toe contusions accounted for the most non–time loss (≤24 hours) and moderate time-loss (2-13 days) injuries, while high ankle sprains accounted for the most severe time-loss (>14 days) injuries. For women, foot and/or toe contusions accounted for the most non–time loss injuries, low ankle sprains accounted for the most moderate time-loss injuries, and high ankle sprains accounted for the most severe time-loss injuries.

Conclusion: Foot and ankle injuries were frequent among collegiate ice hockey players during the period studied. For men, contusions were the most commonly diagnosed injury, although high ankle sprains resulted in the most significant time lost. For women, low ankle sprains were the most common and resulted in the most moderate time lost. These findings may direct future injury prevention and guide improvements in ice skate design.

Keywords: ice hockey; foot and ankle injuries; high ankle sprain; low ankle sprain

Ice hockey is a fast-paced collision sport, played with aluminum sticks and razor-sharp ice skates on a sheet of ice, surrounded by high-density polyethylene boards.14 There are intrinsic hazards to playing this exciting sport, and it comes as no surprise that ice hockey has one of the highest injury rates in collegiate athletics.29 Despite the injury risk, the popularity of the sport continues to grow, as currently there are over 7000 National Collegiate Athletic Association (NCAA) varsity ice hockey athletes participating among 168 American colleges and universities.24 Lower extremity injuries are extremely common, with foot and ankle injuries being among the most prevalent.2,4,10 For example, prior epidemiology studies have noted that in men’s ice hockey, foot and ankle injuries represent approximately 12% of all injuries, with ankle sprains being the fourth most common injury overall.3,10,37 Similar studies of women’s ice hockey have found that foot and ankle injuries comprise 13% of all injuries, with ankle sprains being...
the third most common injury overall. Another investigation of ice hockey injuries noted that ankle sprains caused significant time loss away from the rink, the second most of all studied injuries.

While the above studies have highlighted both the prevalence of ankle sprains in ice hockey and their importance with regard to time lost from play and potential long-term side effects, they have failed to fully elucidate these injuries. Most importantly, these investigations did not differentiate between low and high ankle sprains, which is a key distinction given the increased severity associated with high ankle sprains. Although there have been prior epidemiological studies examining the overall injury rates in ice hockey, an in-depth analysis of foot and ankle injuries has yet to be performed. Such a comparison is necessary, as there are key differences between men’s and women’s hockey, namely that men are allowed to make physical contact with the trunk of their body to separate the opponent from the puck in the form of a body check. However, in women’s hockey, checking is illegal, resulting in a 2-minute penalty. Past studies have recognized that the overall lower rate of injuries in women’s hockey (9.19 per 1000 athlete-exposures [AEs] for men vs 7.77 per 1000 AEs for women) is partially because of the differences in body checking rules.

The goal of this study was to describe the epidemiology of foot and ankle injuries among male and female collegiate ice hockey players. We hypothesized that male ice hockey players would sustain a greater number and have more severe foot and ankle injuries than their female counterparts. The reasoning for this was 2-fold: as a result of differences in body-checking rules and the fact that male players are, on average, larger and may produce greater force. We also hypothesized that the most common foot and ankle injury sustained by ice hockey players would be a high ankle sprain due to the rigid skate boot, thought to be protective against low ankle sprains.

**METHODS**

This study analyzed foot and ankle injury data from the NCAA Injury Surveillance Program (NCAA-ISP) collected between 2004 and 2014 for men’s and women’s ice hockey. In-depth information describing the methods of the NCAA-ISP has been previously described and is noted below. The data were based on participating teams in the NCAA-ISP and were not expanded to include all programs.

Data Collection

The NCAA-ISP is an independent, nonprofit research organization that collects athlete injury information. Data were collected by athletic trainers (ATs) who completed standardized electronic forms for all athletes injured during official intercollegiate practices and games. This form includes detailed information regarding the injury (diagnosis, location, type, time loss) and how it occurred (practice/game, mechanism, activity). ATs also submitted weekly exposure reports describing participation information such as the number of participating athletes and the number of practices and games. ATs were able to review and update their surveys throughout the season. Information submitted to the NCAA-ISP was evaluated by quality control staff who either verified valid data or identified invalid data.

Between 2004 and 2009, an average of 14.1% of qualified men’s ice hockey teams (19/135 programs) and 12.7% of qualified women’s ice hockey teams (10/79 programs) participated in data collection. In 2009 and 2014, an average of 13.2% of qualified men’s ice hockey teams (18/136 programs) and 10.6% of qualified women’s ice hockey teams (9/85 programs) participated in data collection.

Definitions used in this study are as follows. A reportable injury was defined as an injury sustained during either a practice or a competition and required an examination from a medical professional. An AE was defined as 1 student-athlete being exposed to the opportunity of an injury while participating in an official practice or competition. Time loss was defined as the time from when the injury was sustained to when the athlete returned to participation. In line with previous studies, an injury necessitating ≤24 hours of restricted activity was defined as a non–time loss (NTL) injury, with a moderate time-loss injury requiring between 2 and 13 days lost from athletic participation and a severe injury defined as restriction of participation for ≥14 days or an injury requiring surgery.

**RESULTS**

**Overall Injury Frequency and Rates**

**Men’s Ice Hockey.** In total, 413 foot and ankle injuries were sustained among 552,623 AEs for men’s ice hockey between the academic years 2004-2005 through 2013-2014. Practice AEs accounted for 76.5% of the overall AEs (n = 422,794), but 55.4% of foot and ankle injuries were sustained during a competition (n = 229). The competition injury rate was 176.4 per 100,000 AEs compared with the practice injury rate.
rate of 43.5 per 100,000 AEs. Division III athletes sustained the greatest total number of foot and ankle injuries, accounting for 44.8% of all foot and ankle injuries, and had the greatest overall injury rate of 33.5 per 100,000 AEs. Additionally, 86.7% of foot and ankle injuries occurred during the regular season (n = 358), with the majority occurring during a competition (167.1 per 100,000 AEs) (Table 1).

Male forwards sustained the highest frequency of foot and ankle injuries (48.7%), followed by defensemen (28.1%). As hockey is played with 6 players on the ice per team with 3 forwards, 2 defensemen, and 1 goalie, these injury rates are proportionate to the number of players on the ice. Of note, 20.1% of injuries by position were reported as unknown/not available (Figure 1).

Women’s Ice Hockey. In total, 103 foot and ankle injuries were sustained among 231,928 AEs for women’s ice hockey. Practice AEs comprised 74.6% of the overall AEs (n = 172,910), but 53.4% of foot and ankle injuries were sustained during a competition (n = 55). The competition injury rate was 93.2 per 100,000 AEs, which was significantly greater than the practice injury rate of 27.8 per 100,000 AEs. Division III athletes sustained the greatest total number of foot and ankle injuries, accounting for 66.0% of all foot and ankle injuries, and had the greatest overall injury rate (29.3 per 100,000 AEs). Additionally, 86.4% of foot and ankle injuries occurred during the regular season (n = 89), with the majority occurring during a competition (91.5 per 100,000 AEs) (Table 1).

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**TABLE 1**

| Foot and Ankle Injuries by Division, Type of AE, and Time of Season for Men’s and Women’s Ice Hockey |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Men’s                                                                                                                         |
| **Foot and Ankle Injuries, n** | **Injury Rate per 100,000 AEs (95% CI)** |
| Overall | Competition | Practice | Overall | Competition | Practice |
| Total | 413 | 229 | 184 | 74.73 (67.53-81.94) | 176.39 (153.56-199.21) | 43.52 (37.23-49.81) |
| Division I | 164 | 94 | 70 | 29.68 (25.14-34.22) | 72.40 (57.77-87.03) | 16.56 (12.68-20.43) |
| Division II | 64 | 40 | 24 | 11.58 (8.74-14.42) | 30.81 (21.26-40.36) | 5.68 (3.41-7.95) |
| Division III | 185 | 95 | 90 | 33.48 (28.65-38.30) | 73.17 (58.46-87.88) | 21.29 (16.89-25.68) |
| Regular season | 358 | 217 | 141 | 64.78 (58.07-71.49) | 167.14 (144.92-189.36) | 33.35 (27.85-38.85) |
| Postseason | 16 | 8 | 8 | 2.90 (1.48-4.31) | 6.16 (1.89-10.43) | 1.89 (0.58-3.20) |
| Preseason | 39 | 4 | 35 | 7.06 (4.84-9.27) | 3.98 (0.06-6.10) | 8.28 (5.54-11.02) |

Women’s

| **Foot and Ankle Injuries, n** | **Injury Rate per 100,000 AEs (95% CI)** |
| Overall | Competition | Practice |
| Total | 103 | 55 | 48 | 44.41 (35.84-52.99) | 93.19 (68.57-117.81) | 27.76 (19.91-35.61) |
| Division I | 29 | 20 | 9 | 12.50 (7.95-17.05) | 33.89 (19.04-48.74) | 5.21 (1.80-8.61) |
| Division II | 6 | 5 | 1 | 2.59 (0.52-4.66) | 8.47 (1.05-15.90) | 0.58 (0.00-1.71) |
| Division III | 68 | 30 | 38 | 29.32 (22.35-36.29) | 50.83 (32.65-69.02) | 21.98 (14.99-28.96) |
| Regular season | 89 | 54 | 35 | 38.37 (30.40-46.35) | 91.50 (67.10-115.89) | 20.24 (13.54-26.95) |
| Postseason | 4 | 1 | 3 | 1.72 (0.03-3.41) | 1.69 (1.63-5.02) | 1.74 (0.00-3.70) |
| Preseason | 10 | 0 | 10 | 4.31 (1.64-6.98) | 0.00 (—) | 5.78 (2.20-9.37) |

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**Figure 1.** Injury by position for men’s and women’s ice hockey.

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**TABLE 2**

| Foot and Ankle Injuries by Division and Time of Season for Men’s and Women’s Ice Hockey |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Men’s, n | Women’s, n | Rate Ratio (95% CI) |
| Overall | 413 | 103 | 4.01 (3.23-4.97) |
| Division I | 164 | 29 | 5.66 (3.81-8.39) |
| Division II | 64 | 6 | 10.67 (4.61-24.60) |
| Division III | 185 | 68 | 2.72 (2.06-3.59) |
| Regular season | 358 | 89 | 4.02 (3.19-5.07) |
| Postseason | 16 | 4 | 4.00 (1.33-12.00) |
| Preseason | 39 | 10 | 3.90 (1.95-7.81) |
Similar to men’s hockey, forwards sustained the highest frequency of foot and ankle injuries (49.5%), followed by defensemen (21.4%) and then goaltenders (2.0%). Of note, 27.2% of injuries by position were reported as unknown/not available (Figure 1).

Sex-Based Differences. The overall rate of foot and ankle injuries in men’s ice hockey was noted to be significantly higher than that in women’s ice hockey (Table 2). This included injuries sustained during the preseason, regular season, and postseason. Compared with women, men had approximately twice the probability of sustaining foot and ankle injuries during the preseason or postseason. There were no differences between men’s and women’s ice hockey with regard to foot and ankle injuries by laterality of injury or player position.

Injury Type and Specific Injuries

The most common foot and ankle injury type sustained for both men and women was a sprain (men, 41.2%; women, 48.5%), followed by a contusion (men, 38.7%; women, 34.0%). The third most common injury was a fracture for men (6.1%), while a fracture and inflammation (lace bite) were equally common for women (5.8% for each) (Table 3).

The most common specific foot and ankle injury overall for men was a foot/toe contusion (22.5%), which occurred most often during a practice (Table 4). The second most common injury overall was a low ankle sprain (19.1%), which was the most common injury sustained during a competition, followed closely by a high ankle sprain (17.2%). The most common specific foot and ankle injury overall for women was a low ankle sprain (31.1%), which occurred most often during both competitions and practices (Table 4). The second most common injury sustained during competitions and practices for women was a foot/toe contusion (26.2%).

Injury Mechanism

For men and women, the most frequent mechanism of injury was contact with an apparatus (men, 51.8%; women, 44.7%), which may have included contact with the boards or glass, the goal, or another player’s stick. The second most common mechanism of injury included contact with a player for men (18.6%) and acute noncontact for women (22.3%) (Table 5).

Time Loss and Surgery

NTL injuries (<24 hours) accounted for the majority of foot and ankle injuries for men (41.4%) and women (49.5%) (Figure 2). The overall rate of NTL injuries was 31.0 per 100,000 AEs for men versus 22.0 for women. Injuries requiring surgery, NTL injuries, moderate injuries, and severe injuries occurred most often during the regular season for men and women (NTL: men n = 171 for men vs 51 for women). The most common NTL injury diagnoses for men

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### TABLE 3

| Injury Type | Men’s, n (%) | Women’s, n (%) | Injury Proportion Ratio (95% CI) |
|-------------|--------------|----------------|----------------------------------|
| Abrasion    | 5 (1.21)     | 0 (0.00)       | —                                |
| Bursitis    | 7 (1.69)     | 0 (0.00)       | —                                |
| Contusion (hematoma) | 160 (38.74) | 35 (33.98) | 1.14 (0.85-1.53) |
| Effusion    | 1 (0.24)     | 0 (0.00)       | —                                |
| Exostosis   | 2 (0.48)     | 0 (0.00)       | —                                |
| Fracture    | 25 (6.05)    | 6 (5.83)       | 1.04 (0.44-2.47)                 |
| Impingement | 1 (0.24)     | 0 (0.00)       | —                                |
| Infection   | 3 (0.73)     | 0 (0.00)       | —                                |
| Inflammation| 2 (0.48)     | 6 (5.83)       | 0.08 (0.02-0.41)                 |
| Miscellaneous| 12 (2.91)    | 3 (2.91)       | 0.98 (0.29-3.47)                 |
| Strain      | 170 (41.16)  | 50 (48.54)     | 0.85 (0.67-1.07)                 |
| Synovitis   | 16 (3.87)    | 3 (3.87)       | 0.75 (0.08-7.12)                 |
| Tendinitis  | 0 (0.00)     | 1 (0.97)       | 1.00 (0.29-3.47)                 |

### TABLE 4

| Injury Type | Men’s, n (%) | Women’s, n (%) |
|-------------|--------------|----------------|
| Overall     |              |                |
| Foot/toe contusion | 93 (22.5) ATFL/CFL/PTFL tear (partial or complete) | 32 (31.1) |
| ATFL/CFL/PTFL tear (partial or complete) | 79 (19.1) Foot/toe contusion (partial or complete) | 27 (26.2) |
| High ankle sprain (partial or complete) | 71 (17.2) High ankle sprain (partial or complete) | 11 (10.7) |
| Ankle contusion | 67 (16.2) Ankle contusion | 8 (7.8) |
| Ankle synovitis | 16 (3.9) Plantar fasciitis | 5 (4.9) |
| Inflammation | 2 (0.48) | 6 (5.83) | 0.08 (0.02-0.41) |
| Infection | 3 (0.73) | 0 (0.00) | — |
| Laceration | 6 (1.45) | 1 (0.97) | 1.50 (0.18-12.29) |
| Miscellaneous | 12 (2.91) | 3 (2.91) | 1.00 (0.29-3.47) |
| Strain | 170 (41.16) | 50 (48.54) | 0.85 (0.67-1.07) |
| Synovitis | 16 (3.87) | 3 (3.87) | 0.75 (0.08-7.12) |
| Tendinitis | 0 (0.00) | 1 (0.97) | 1.00 (0.29-3.47) |

*Foot/toe contusion, ATFL, anterior talofibular ligament; CFL, calcaneofibular ligament; PTFL, posterior talofibular ligament.*
Injuries between men's and women's ice hockey and has a few key findings worth discussing.

First, the overall rate of foot and ankle injuries was higher for men than for women over the 10-year period examined, with men sustaining approximately 4 times as many injuries as women. While men (51.8%) and women (44.7%) both sustained most lower extremity injuries from contact with an apparatus (boards, a player's stick, and the goal), men sustained a greater proportion of injuries from contact with another player (18.6% vs 13.6%, respectively), while women had a higher proportion of acute noncontact injuries (22.3% vs 12.1%, respectively). Interestingly, a study by Melvin et al[24] found that the most common cause of injury to the upper extremity among hockey players was also contact with an apparatus (41.6%). However, a much greater proportion of upper extremity injuries were caused by contact with a player for both men and women, 38.3% and 24.9%, respectively, compared with lower extremity injuries. A 2018 epidemiological study of ankle injuries in male and female collegiate basketball athletes noted similar results to our study.[36] Men were found to sustain a higher rate of ankle injuries compared with women, and women were also found to sustain a higher rate of injuries from acute noncontact mechanisms and a lower rate of contact injuries compared with men, which the authors postulated was caused by differences in playing styles and physical attributes.[36] In contrast, they found the most common mechanism for an ankle injury to be contact with another player, with 57.6% and 50.4% of ankle injuries in men and women, respectively, being caused by player contact.[36]

As was initially hypothesized, the differences in the frequency and mechanisms of lower extremity injuries identified between sexes were likely because of a combination of rule differences (body checking) as well as intrinsic sex-based differences such as height, weight, and strength that would have resulted in greater momentum and force during collisions with other players, the ice, or the boards.[36,41] However, it is important to note that contact with a person still resulted in 13.6% of female lower extremity injuries. Thus, although checking is illegal in women's ice hockey, incidental contact does occur and can be a significant source of injuries.[6]

The differences noted in these mechanisms of injury, as well as the more aggressive playing style inherent in men's hockey, likely influenced the types and severity of injuries. Overall, male collegiate ice hockey players were found to have greater rates of NTL injuries, severe injuries, and surgery for foot and ankle injuries compared with female collegiate ice hockey players.

The majority of foot and ankle injuries diagnosed in this investigation were classified as NTL injuries. The most common NTL injury diagnosed for both men and women was a contusion, comprising 38.7% and 34.0%, respectively, of all injuries. Foot/toe contusions were most common for both sexes, representing 22.5% of male injuries and 26.2% of female injuries. Ankle contusions were less common. Sprains accounted for the second most common types of injury in both men and women. When comparing low with high ankle sprains in women,

| Table 5: Injury Proportion Ratios by Mechanism of Injury for Men's and Women's Ice Hockey |
|----------------------------------------|----------------------------------------|-------------------|
| Mechanism of Injury | Men's, n (%) | Women's, n (%) | Injury Proportion Ratio (95% CI) |
| Acute noncontact | 50 (12.1) | 23 (22.3) | 0.54 (0.35-0.85) |
| Contact with apparatus | 214 (51.8) | 46 (44.7) | 1.16 (0.92-1.47) |
| Contact with out-of-bounds object | 1 (0.2) | 0 (0.0) | — |
| Contact with person | 77 (18.6) | 14 (13.6) | 1.37 (0.81-2.32) |
| Contact with surface | 27 (6.5) | 9 (8.7) | 0.75 (0.36-1.54) |
| Illness | 4 (1.0) | 0 (0.0) | — |
| Overuse/gradual | 29 (7.0) | 6 (5.8) | 1.21 (0.51-2.83) |
| Other/unknown | 11 (2.7) | 5 (4.9) | 0.55 (0.19-1.54) |

DISCUSSION

Contact athletes are prone to injuries of the lower extremities.[14] For example, in an epidemiological study of collegiate injuries across 15 sports, Hootman et al[12] found that 58% of game injuries and 41.6% of practice injuries were contact related, with more than half of all injuries being to the lower extremity. Of these injuries, the authors found that ankle ligament sprains were among the most common injuries across all sports (14.8%).[12] Hockey, in particular, is a collision sport that has recently garnered significant attention among injury epidemiology investigations. Past studies have specifically examined sex-based differences in head injuries, inclusive of concussions, as well as injuries of the upper extremity among collegiate ice hockey athletes.[6,7,24,40] A study looking at the same data of NCAA hockey players, but focusing on hip and groin injuries, found that these injury rates were greater in men’s than in women’s ice hockey.[8] The current investigation analyzed the rates of foot and ankle
there was a near 3:1 ratio versus a near 1:1 ratio in men. Additionally, high ankle sprains accounted for the majority of injuries that resulted in time loss of 2 to 13 days or ≥14 days. For women, low ankle sprains accounted for most of the women's injuries that resulted in time loss of 2 to 13 days. High ankle sprains in women resulted in the majority of severe time loss injuries.

Our study noted that 49.3% and 36.3% of high ankle sprains in men and women, respectively, resulted in time loss of ≥14 days. In comparison, a recent NCAA basketball
study found that 22.0% and 16.4% of high ankle sprains in men and women, respectively, resulted in time loss of greater than 14 days. Possible long-term sequelae of high ankle sprains include recurrent injuries, persistent ankle instability, heterotopic bone formation, and posttraumatic osteoarthritis. A 2017 study by Mauntel et al examined high ankle sprains across all NCAA sports and found ice hockey to have the highest rate of high ankle sprains (7.3%) of all reported injuries. These authors also found that 3.6% of sprains required >21 days to return to play. Our study noted that 17.7% and 15.6% of low ankle sprains in men and women, respectively, resulted in time loss of >14 days; in comparison, a recent NCAA basketball study found that 16.4% and 15.5% of low ankle sprains in men and women, respectively, resulted in time loss of greater than 14 days. In ice hockey, minor and moderate low sprains are commonly managed with rehabilitation, allowing athletes to return to play within a few days to a week, as ice hockey skates provide some intrinsic support and protection. Past studies have demonstrated that sports associated with player contact have a dramatic difference in the practice and game injury rate. Despite practices and games containing the same common apparatus risk factors for an injury, sharp skates, hockey sticks, and high-speed pucks, the increased injury rate in competitions is likely due to the increased player contact compared with practices and due to game intensity. Other authors have noted ankle injuries to be highest in the preseason because of poor athlete conditioning at the start of the season and vigorous training. However, this study found the injury rate for both men and women to be significantly higher during the regular season compared with the preseason.

Ankle contusions and sprains as common foot and ankle injuries in ice hockey may direct design changes to the construct of the ice skate to help minimize these injuries moving forward. Interestingly, Agel and Harvey noted that for the past decade, equipment manufacturers have been strongly marketing lighter equipment, most notably skates. Skates are frequently made lighter by decreasing the amount of material in the front (tongue area) and in the sidewall of the skate, rendering the foot and ankle vulnerable to impact, particularly from a high-speed puck. There were 6 lacerations involving the ankle area in men and 1 laceration in a female player during the study period. Currently, Kevlar socks can be worn, which have been shown in biomechanical studies to diminish the severity of injuries from a skate blade.

From a foot and ankle injury prevention perspective, the results of this study call into question the role of a preseason strengthening program to minimize the incidence of low ankle sprains and screening to identify athletes at risk. Poor proprioceptive control, decreased single-leg balance, and a

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**TABLE 6**

| Injury | Rate per 100,000 AE | Non–Time Loss | Severe Injury | Requiring Surgery |
|--------|------------------|---------------|--------------|------------------|
| Men's  |                 |               |              |                  |
| 413    | 74.73            |               |              |                  |
| Abrasion | 5     | 0.90          | 100.0        | 0.0              | 0.0              |
| Bursitis | 7     | 1.27          | 100.0        | 0.0              | 0.0              |
| Contusion (hematoma) | 160 | 28.95        | 53.1         | 3.1              | 0.0              |
| Effusion | 1     | 0.18          | 100.0        | 0.0              | 0.0              |
| Exostosis | 2     | 0.36          | 50.0         | 0.0              | 0.0              |
| Fracture | 25    | 4.52          | 16.0         | 76.0             | 4.0              |
| Impingement | 1 | 0.18          | 0.0          | 0.0              | 0.0              |
| Infection | 3     | 0.54          | 33.3         | 33.3             | 0.0              |
| Inflammation | 2 | 0.36          | 0.0          | 0.0              | 50.0             |
| Laceration | 6    | 1.09          | 33.3         | 16.7             | 33.3             |
| Miscellaneous | 12 | 2.17          | 50.0         | 8.3              | 8.3              |
| Sprain | 170     | 30.76      | 24.7         | 31.8             | 0.6              |
| Strain | 3       | 0.54          | 66.6         | 0.0              | 0.0              |
| Synovitis | 16    | 2.90          | 93.8         | 0.0              | 0.0              |
| Women's | 103    | 44.41        |              |                  |
| Contusion (hematoma) | 35  | 15.09        | 62.9         | 5.7              | 0.0              |
| Fracture | 6      | 2.59          | 16.7         | 33.3             | 0.0              |
| Inflammation | 6 | 2.59          | 100.0        | 0.0              | 0.0              |
| Laceration | 1    | 0.43          | 100.0        | 0.0              | 0.0              |
| Miscellaneous | 3 | 1.29          | 66.7         | 33.3             | 0.0              |
| Sprain | 50      | 21.56        | 36.0         | 18.0             | 0.0              |
| Strain | 1       | 0.43          | 0.0          | 0.0              | 0.0              |
| Tendinitis | 1     | 0.43         | 100.0        | 0.0              | 0.0              |

AE, athlete-exposure.
history of ankle sprains have been noted as risk factors for an injury in basketball, the sport with the highest rate of ankle sprains. Prophylactic injury prevention programs that focus on improving neuromuscular performance for as little as once per week have been noted to be effective in decreasing ankle sprains. A recent meta-analysis of ankle injury prevention programs in soccer demonstrated a significant reduction in these injuries. Further research is warranted to develop an off-season ice hockey–specific ankle injury prevention program focusing on balance board, proprioceptive training, dynamic stability, and plyometrics.

This study provides a general overview of foot and ankle injuries of NCAA ice hockey athletes. However, there are several limitations. First, this study sample consists only of NCAA athletes, making the findings less applicable to younger, older, or less skilled players. Second, data collection relied on reporting from multiple different ATs, leading to less standardization and more subjective diagnoses of foot and ankle injuries. Third, the number of foot and ankle injuries analyzed in this study was relatively low, limiting the statistical power in analysis. Fourth, clinical tests for high and low ankle sprains are not very sensitive or specific and often require imaging for a proper diagnosis. Some injuries may have been missed or misdiagnosed. Last, sprain grading was not reported in the database. This information could provide insight into the connection between injury severity, time loss, and the need for surgery.

**Figure 3.** Time loss by specific injury for men’s ice hockey. ATF, anterior talofibular; CF, calcaneofibular; PTF, posterior talofibular.

**Figure 4.** Time loss by specific injury for women’s ice hockey. ATF, anterior talofibular; CF, calcaneofibular; PTF, posterior talofibular.
CONCLUSION

The data in our study supported our hypotheses that male ice hockey players would sustain more foot and ankle injuries and more severe injuries than female ice hockey players. The data did not support our hypothesis that the most common foot and ankle injury overall is a high ankle sprain, as foot and toe contusions were the most prevalent, followed by low ankle sprains. The overall rate of foot and ankle injuries was much greater in men compared with women. These data may provide insight for future injury prevention programs and offer suggestions of where to focus improvements in the construction and design of ice hockey skates.

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REFERENCES

1. Abbott K. Injuries in women’s ice hockey: special considerations. Curr Sports Med Rep. 2014;13(6):377-382.
2. Agel J, Dick R, Nelson B, Marshall SW, Dompier TP. Descriptive epidemiology of collegiate women’s ice hockey injuries: National Collegiate Athletic Association Injury Surveillance System, 2000-2001 through 2003-2004. J Athl Train. 2007;42(2):249-254.
3. Agel J, Dompier TP, Dick R, Marshall SW. Descriptive epidemiology of collegiate men’s ice hockey injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. J Athl Train. 2007;42(2):241-248.
4. Agel J, Harvey EJ. A 7-year review of men’s and women’s ice hockey injuries in the NCAA. Can J Surg. 2010;53(5):319-323.
5. Baker JC, Hoover EG, Hillen TJ, Smith MV, Wright RW, Rubin DA. Subradiographic foot and ankle fractures and bone contusions detected by MRI in elite ice hockey players. Am J Sports Med. 2016;44(5):1317-1323.
6. Brainard LL, Beckwith JG, Chu JJ, et al. Gender differences in head impacts sustained by collegiate ice hockey players. Med Sci Sports Exerc. 2012;44(2):297-304.
7. Covassin T, Swainik CB, Sachs ML. Sex differences and the incidence of concussions among collegiate athletes. J Athl Train. 2003;38(3):238-244.
8. Dalton SL, Zupon AB, Gardner EC, Djoko A, Dompier TP, Kerr ZY. The epidemiology of hip/groin injuries in National Collegiate Athletic Association men’s and women’s ice hockey: 2009-2010 through 2014-2015 academic years. Orthop J Sports Med. 2016;4(3):2325967116632692.
9. Els E, Schröter R, Schröder M, Gerss J, Rosenbaum D. Multistation proprioceptive exercise program prevents ankle injuries in basketball. Med Sci Sports Exerc. 2010;42(11):2098-2105.
10. Flik K, Lyman S, Marx RG. American collegiate men’s ice hockey: an analysis of injuries. Am J Sports Med. 2005;33(2):183-187.
11. Hermans JJ, Beumer A, de Jong TA, Kleinrensink GJ. Anatomy of the distal fibulotibial syndesmosis in adults: a pictorial essay with a multimodality approach. J Anat. 2010;217(6):633-645.
12. Hootman JM, Dick R, Agel J. Epidemiology of collegiate injuries for 15 sports: summary and recommendations for injury prevention initiatives. J Athl Train. 2007;42(2):311-319.
13. Hubbard TJ, Hicks-Little CA. Ankle ligament healing after an acute ankle sprain: an evidence-based approach. J Athl Train. 2008;43(5):523-529.
14. Irvine JN Jr, Lynch S, Hanypsiak BT, Popkin CA. Lower extremity injuries in ice hockey: current concepts. Am J Orthop (Belle Mead NJ). 2018;47(11).
15. Keightley M, Reed N, Green S, Taha T. Age and competition level on injuries in female ice hockey. Int J Sports Med. 2013;34(8):756-759.
16. Kerbel VE, Smith CM, Prodomo JP, Nzeogu MI, Mulcahey MK. Epidemiology of hip and groin injuries in collegiate athletes in the United States. Orthop J Sports Med. 2018;6(5):2325967118771676.
17. Kerr ZY, Dompier TP, Snook EM, et al. National Collegiate Athletic Association Injury Surveillance System: review of methods for 2004-2005 through 2013-2014 data collection. J Athl Train. 2014;49(4):552-560.
18. Kerr ZY, Marshall SW, Dompier TP, Corlette J, Klossner DA, Gilchrist J. College sports-related injuries: United States, 2009-10 through 2013-14 academic years. MMWR Morb Mortal Wkly Rep. 2015;64(48):1330-1336.
19. Kuzuhara K, Shimamoto H, Mase Y. Ice hockey injuries in a Japanese elite team: a 3-year prospective study. J Athl Train. 2009;44(2):208-214.
20. Laprade RF, Suwircik RW, Sochanska AN, et al. Epidemiology, identification, treatment and return to play of musculoskeletal-based ice hockey injuries. Br J Sports Med. 2014;48(1):4-10.
21. Leanderson J, Wykman A, Eriksson E. Ankle sprain and postural sway in basketball players. Knee Surg Sports Traumatol Arthrosc. 1993;1(3-4):203-205.
22. Maultel TC, Wikstrom EA, Roos KG, Djoko A, Dompier TP, Kerr ZY. The epidemiology of high ankle sprains in National Collegiate Athletic Association sports. Am J Sports Med. 2017;45(9):2156-2163.
23. McGuine TA, Greene JJ, Best T, LeVerson G. Balance as a predictor of ankle injuries in high school basketball players. Clin J Sport Med. 2000;10(4):239-244.
24. Melvin PR, Souza S, Mead RN, Smith C, Mulcahey MK. Epidemiology of upper extremity injuries in NCAA men’s and women’s ice hockey. Am J Sports Med. 2018;46(10):2521-2529.
25. Mosenthal W, Kim M, Holzshu R, Hanypsiak B, Athiviraham A. Common ice hockey injuries and treatment: a current concepts review. Curr Sports Med Rep. 2017;16(5):357-362.
26. Nelson AJ, Collins CL, Yard EE, Fields SK, Comstock RD. Ankle injuries among United States high school sports athletes, 2005-2006. J Athl Train. 2007;42(3):381-387.
27. Payne KA, Berg K, Latin RW. Ankle injuries and ankle strength, flexibility, and proprioception in college basketball players. J Athl Train. 1997;32(3):221-225.
28. Piotrowski S, Langseth K, Hapin T. 2016-17 and 2017-18 NCAA men’s and women’s ice hockey rules and interpretations. https://www.ncaapublications.com/p-4396-ice-hockey-2016-17-and-2017-18-rules-interpretations.aspx. Accessed February 2, 2019.
29. Popkin CA, Nelson BJ, Park CN, et al. Head, neck, and shoulder injuries in ice hockey: current concepts. Am J Orthop (Belle Mead NJ). 2017;46(3):123-134.
30. Porter DA, Jaggers RR, Barnes AF, Rund AM. Optimal management of ankle syndesmosis injuries. Knee Surg Sports Traumatol Arthrosc. 1997;32(3):221-225.
31. Riva D, Bianchi R, Rocca F, Mamo C. Proprioceptive training and balance, and proprioception in college basketball players. J Athl Train. 2007;42(3)-203-205.
32. Roos KG, Kerr ZY, Mauntel TC, Djoko A, Dompier TP. Knee ligament healing after an acute ankle sprain: an evidence-based approach. J Orthop (Belle Mead NJ). 2017;46(3):123-134.
33. Porter DA, Jaggers RR, Barnes AF, Rund AM. Optimal management of ankle syndesmosis injuries. Open Access J Sports Med. 2014;5:173-182.
34. Riva D, Bianchi R, Rocca F, Mamo C. Proprioceptive training and injury prevention in a professional men’s basketball team: a six-year prospective study. J Strength Cond Res. 2016;30(2):461-475.
35. Roos KG, Kerr ZY, Mauntel TC, Djoko A, Dompier TP, Wikstrom EA. The epidemiology of lateral ligament complex ankle sprains in National Collegiate Athletic Association sports. Am J Sports Med. 2017;45(1):201-209.
33. Schick DM, Meeuwisse WH. Injury rates and profiles in female ice hockey players. *Am J Sports Med.* 2003;31(1):47-52.

34. Smith RW, Reischl SF. Treatment of ankle sprains in young athletes. *Am J Sports Med.* 1986;14(6):465-471.

35. Taylor JB, Ford KR, Nguyen AD, Terry LN, Hegedus EJ. Prevention of lower extremity injuries in basketball: a systematic review and meta-analysis. *Sports Health.* 2015;7(5):392-398.

36. Tummala SV, Hartigan DE, Makovicka JL, Patel KA, Chhabra A. 10-year epidemiology of ankle injuries in men’s and women’s collegiate basketball. *Orthop J Sports Med.* 2018;6(11):2325967118805400.

37. Tuominen M, Stuart MJ, Aubry M, Kannus P, Parkkari J. Injuries in men’s international ice hockey: a 7-year study of the International Ice Hockey Federation Adult World Championship Tournaments and Olympic Winter Games. *Br J Sports Med.* 2015;49(1):30-36.

38. Tuominen M, Stuart MJ, Aubry M, Kannus P, Tokola K, Parkkari J. Injuries in women’s international ice hockey: an 8-year study of the World Championship Tournaments and Olympic Winter Games. *Br J Sports Med.* 2016;50(22):1406-1412.

39. Wang HK, Chen CH, Shiang TY, Jan MH, Lin KH. Risk-factor analysis of high school basketball-player ankle injuries: a prospective controlled cohort study evaluating postural sway, ankle strength, and flexibility. *Arch Phys Med Rehabil.* 2006;87(6):821-825.

40. Wilcox BJ, Beckwith JG, Greenwald RM, et al. Head impact exposure in male and female collegiate ice hockey players. *J Biomech.* 2014;47(1):109-114.

41. Wilkerson RD, Mason MA. Differences in men’s and women’s mean ankle ligamentous laxity. *Iowa Orthop.* 2000;20:46-48.

42. Williams GN, Jones MH, Amendola A. Syndesmotic ankle sprains in athletes. *Am J Sports Med.* 2007;35(7):1197-1207.

43. Windt J, Zumbo BD, Sporer B, MacDonald K, Gabbett TJ. Why do workload spikes cause injuries, and which athletes are at higher risk? Mediators and moderators in workload–injury investigations. *Br J Sports Med.* 2017;51(13):993-994.