

A 7-year review of men's and women's ice hockey injuries in the NCAA

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Background: Ice hockey is a high-speed collision sport with recognized injury potential. Body checking, identified as a primary cause of injury, is allowed in men's hockey but is not allowed at any level for female players. The injury patterns in collegiate hockey should reflect this fundamental difference in how the game is played. In this study, we reviewed the injuries sustained by National Collegiate Athletic Association (NCAA) hockey players over a 7-year period.

Methods: We conducted a retrospective database review of injuries and exposures reported to the Injury Surveillance System to determine rates of injury or differences in the pattern of injury between the sexes.

Results: The rate of injury during games for men (18.69/1000 athlete-exposures [AEs]) and women (12.10/1000 AEs) was significantly higher than the rate of injury during practice. The rate of concussion was 0.72/1000 AEs for men and 0.82/1000 AEs for women, and the rate remained stable over the study period. Player contact was the cause of concussions in game situations for 41% of women and 72% of men.

Conclusion: Both men and women had increased rates of practice-related injuries that resulted in time loss during the study period. In addition, there were high rates of concussions from player contact. The concussion rate in women was higher than expected. A more detailed examination with focused data collection may impact these findings.

Contexte : Le hockey sur glace est un sport où les collisions à grande vitesse peuvent causer des blessures. Les mises en échec, qui constituent la principale cause de blessures, sont permises dans le hockey masculin, mais interdites à tous les niveaux chez les femmes. Les tendances des blessures au hockey collégial devraient refléter cette différence fondamentale de la façon de jouer. Au cours de cette étude, nous avons analysé les blessures subies par les joueurs de hockey de la National Collegiate Athletic Association (NCAA) au cours d'une période de 7 ans.

Méthodes : Nous avons effectué un examen rétrospectif de bases de données portant sur les blessures et les expositions déclarées au système de surveillance des blessures afin de déterminer les taux de blessures et les différences au niveau des tendances des blessures entre les sexes.

Résultats : Les taux de blessures subies au cours des parties chez les hommes (18,69 pour 1000 expositions-athlètes [EA]) et chez les femmes (12,10 pour 1000 EA) étaient beaucoup plus élevés que le taux de blessures subies au cours des pratiques. Le taux de commotions cérébrales s'est établi à 0,72 pour 1000 EA chez les hommes et à 0,82 pour 1000 EA chez les femmes, et il est demeuré stable au cours de la période à l'étude. Le contact entre les joueurs a été la cause de commotions cérébrales subies au cours d'une partie chez 41 % des femmes et 72 % des hommes.

Conclusion : Les hommes et les femmes présentaient des taux plus élevés de blessures entraînant une perte de temps et subies au cours d'une pratique durant la période à l'étude. En outre, on a constaté des taux élevés de commotions cérébrales causées par les contacts entre les joueurs. Le taux de commotions cérébrales chez les femmes était plus élevé qu'on ne s'y attendait. Une analyse plus détaillée et la collecte de données spécialisées pourraient avoir des répercussions sur ces constatations.

Men have been playing ice hockey since the mid-1800s, with the first rules laid down in 1879. Although women started playing in the late 1800s, there was a long period in the mid-1900s when the sport was dormant for women. It was not until the 1960s that the women's hockey made

a reasonably strong comeback. Hockey was introduced competitively at the American collegiate level in 1948 for men but not until 2001 for women.

Hockey is considered a high-speed collision sport. This implies that there will be contact between players and with other objects, such as the boards. Men's collegiate hockey permits deliberate contact (checking) between players, whereas women's collegiate hockey does not. All other rules and equipment are the same for both sexes, including the size of the rink and the length of the game.

In youth hockey, the sexes are often combined because player size and skill are equivalent and no checking is allowed. Checking is never allowed in girl's hockey at any age. Girls who play in boy's hockey divisions participate in checking as per the league's rules. A concern has been raised that in some places, girls skate with boys where checking is allowed and, thus, they incorporate those skills into their game. Because many girls do not learn checking skills, they are not prepared to absorb the contact when they are subject to collisions, even if the collision is incidental.¹⁻⁴

In North America, checking is allowed for boys at different ages, depending on the region. In Canada, checking is allowed for boys in Ontario and Saskatchewan from age 9, and it is allowed in Quebec from age 14. The other provinces allow checking from age 12. Although it is seen as a useful manoeuvre in hockey, checking is also the most common cause of injury in the sport. In response to this correlation between injury and the mechanism of injury, the Canadian Academy of Sports Medicine⁵ recommends that checking not be attempted until age 14, and the American Academy of Pediatrics⁶ recommends not allowing checking until age 15. These recommendations were based on reviews of previous studies and expert panels. Concerns in the popular press and the overall questioned veracity of some of the published research have made it difficult to interpret what age would be appropriate to start body checking. As such, it is important to have a better understanding of the injury pattern in collegiate or so-called elite athletes who have graduated from this program of checking regulation.

Other reviews of hockey injuries have occurred, particularly among European, youth and men's collegiate hockey players.⁷⁻⁹ All of these reviews found increased rates of game injuries compared with practice injuries and increased rates of concussion. Women's hockey injuries have not been reviewed along with men's hockey to compare and contrast the differences in anticipated and actual injuries. Thus, we compared the injuries sustained by male and female hockey players in the NCAA over a 7-year period (2000/01 through 2006/07).

METHODS

Data collection

The NCAA maintains a voluntary reporting injury surveil-

lance database (NCAA Injury Surveillance System [ISS]). The methodology behind this database for data collected from the 1988/89 to the 2003/04 season has been well documented.¹⁰ Starting with the 2004/05 season, data have been collected via a web-based system using the same voluntary input from schools. This project combines the data from both collection methods using the sampling criteria established for the original data.

In brief, in order to be eligible for analysis, schools had to report a minimum of 24 games and 63 practices for Division I (DI) and 17 games and 46 practices for Division III (DIII) for men and 22 game and 58 practices for DI and 15 games and 42 practices for DIII for women. There is currently no Division II hockey program in the NCAA. This had to be represented by a minimum reporting of 70% of the maximum number of weeks allowed for any sanctioned activity. Time loss of a minimum of 1 day was required for an injury to be counted. Exposure rates are calculated per 1000 athlete-exposures (AEs). An average of 24% of the NCAA schools with men's hockey teams and 15% of the NCAA schools with women's hockey teams are represented in this data set.

To have a comparable data set for both sexes, we limited our analysis to the 2000/01 to 2006/07 seasons. This included the first year that women's hockey was included in ISS. An average of 24% of DI and 22% of DIII schools for men and 21% of DI and 19% of DIII schools for women are represented in this data set.

Definitions

The following definitions are standard for the NCAA database and are defined here for clarity.

Athlete-exposure is the number of athletes participating in a game or practice regardless of duration or type of exposure. For ease of reporting, the data are presented per 1000 AEs. Any injury sustained to a knee ligament was grouped under the category of internal knee derangement. Any player who sustained multiple knee ligament injuries at one time had the overall knee injury counted only once. The specific structures injured were identified separately. The NCAA database does not have a specific definition of concussion. Grading concussion as grade I, II or III was available as an option in the NCAA ISS; however, these data were not originally accompanied by specific definitions and were thus felt to perhaps be unreliable for analysis. For this study, we grouped all concussions regardless of severity or symptoms identified by the reporting source. Preseason games are those that occurred before the start of the official schedule, such as early season tournaments.

Statistical analyses

We performed all data analysis using Excel 2000 and SAS v. 9.1. We calculated injury rates as the number of injuries

over the number of exposures. All rates are reported by 1000 AEs. We calculated 95% confidence intervals (CIs) using large sample formulas. Significance was defined as nonoverlapping CIs or $p \leq 0.05$. We calculated trends in injury rates over time using negative binominal regression. More detail about the analysis is available elsewhere.¹⁰

RESULTS

During the 7-year study period, men sustained a total of 2828 injuries and 475 687 exposures (5.95/1000 AEs), and women sustained 767 injuries and 149 137 exposures (5.12/1000 AEs). The rate ratio of overall men's to women's hockey injuries was 1.5 (95% CI 1.07–1.25, $p < 0.001$). The average yearly injury rates were 2.23/1000 AEs (95% CI 2.0–2.3) for men during practice and 18.69/1000 AEs (95% CI 17.8–19.4) during games. Women had an average injury rate of 2.90/1000 AEs (95% CI 2.6–3.2) during practice and 12.10/1000 AEs (95% CI 11.1–13.3) during games. All between-sex and within-sex differences were significantly different, as shown by the nonoverlapping CIs. These data also demonstrate a nonsignificant average annual increase in game injury rates for men's hockey (1.8%) and decrease (2.9%) for women's hockey. The practice injury rate for men had a 7.8% average annual increase ($p = 0.005$) and a 7.2% nonsignificant increase for women.

Over the course of the season, injury rates varied (Table 1). The injury rates during practice went down over the course of the season regardless of sex, and the highest game injury rates occurred during the preseason for men and during the regular season for women. The most common injury among men was concussion ($n = 333$) followed by shoulder ($n = 292$) and knee ($n = 284$) ligamentous injuries. For women, concussions were also the most common injury ($n = 121$). The next most common injuries were hip/groin ($n = 54$) and ankle ($n = 28$) ligamentous injuries.

The average rate of concussion over 7-year period was 0.72/1000 AEs among men and 0.82/1000 AEs among women. There was no significant change in the average annual rate of concussion for either sex over the study period. In total, 80% of the reported concussions in

women and 73% of the reported concussions in men required fewer than 10 days of lost activity; 77% of those concussions occurred during a game. For concussions severe enough to keep an athlete out of scheduled practices or games for 10 or more days, 79% of these severe concussions sustained by men and 75% of these severe concussions sustained by women occurred during games. In women, 41% of the concussions sustained in games resulted from player contact, whereas 72% of those sustained by men were the result of player contact. Overall, 48% of injuries sustained by men and 35% of the injuries sustained by women were the result of player contact.

DISCUSSION

The number of schools that sponsor collegiate hockey continues to grow. In 1981/82, the first year for which numbers are available, there were 130 schools with men's hockey. Today, there are 134 men's NCAA collegiate ice hockey teams. Women's hockey began with 63 teams in 2000/01 and has grown to 73 teams. As with all injury reporting, it is difficult to determine if the changes in injury rates and patterns are the result of better reporting and data collection methods over time. Also the changes in rates may be the result of faster, stronger, better-conditioned athletes or more athletes with less experience. This surveillance data system does not allow us to directly attribute cause to any of the injury patterns or trends that we have described. However, it does allow us to highlight concerning findings and make recommendations for future focused research. A documented strength⁷ of the NCAA database has been the overall stability of the trends over time, indicating that, although the schools reporting and the percentage of participating schools changes, the data appear to be representative across schools even though specific injuries may fluctuate in frequency. Whereas the data represent only a sample of participating schools, the data have proven to be a good indicator of injury patterns or injury events that require further specific exploration. As mentioned in the methods section, the epidemiologic data from a smaller study group from earlier years has previously been reported.¹¹

Overall, there was a 1.8% annual increase among men in game injury rates over the 7-year period and a 7.8% increase in practice injury rates. The women had a 2.9% decrease in game injury rates and a 7.2% increase in practice injury rates. In both cases, further evaluation needs to occur to determine if practice intensity or frequency has changed over the years.

The pattern of groin injuries and concussions as the most frequent injury to lead to at least 1 missed practice or game varied little over the 7-year study period for men. This is in contrast to an earlier review of 16 years of men's hockey data in which knee ligament injuries were the most frequent injury during games and the second most frequent

Table 1. Incidence of injuries in men's and women's NCAA hockey players, from 2000/01 to 2006/07

Time and setting of injury	Group; incidence per 1000 athlete-exposures	
	Men	Women
Preseason practice	4.13	3.68
In-season practice	1.66	4.36
Postseason practice	0.80	1.07
Preseason game	21.03	8.35
In-season game	18.22	11.01
Postseason game	10.34	7.71

NCAA = National Collegiate Athletic Association.

injury during practices.⁷ Women had more variation in the types of injuries, with the most frequently occurring injuries varying from concussions and groin injuries to low back pain and foot contusions. Concussions were one of the top 3 injuries in each year for both sexes, except in 2005 for women and in 2003 for men. This finding is consistent with the earlier published epidemiologic data.¹¹

There was a statistically significant difference in injury rates between games and practices for both sexes, as shown by the nonoverlapping CIs. Women's hockey is meant to be no contact, so the magnitude of this difference is even more concerning. Some of the difference between men's game and practice rates could be explained by inferring that a game, unlike a practice, is all contact exposure, whereas the same cannot be said for women.

Whereas the men experienced a steady decrease in injury rates for both practices and games over the season, the women had higher injury rates for practices and games during the season than the preseason. This may be because of bias from the selection processes for team play in men's and women's hockey. The preseason may be used by coaches to better evaluate players and pick a team because the men's system has a larger pool of players to draw from. This may mean that the men's preseason contains more full-contact exercises than the women's league does, because the men's coaches use this time to run the players in full-contact drills and scrimmages. The type of practice drills changes over the season as the team is determined. The extremely high rate of injuries in men's games in the preseason reflects the use of these games as tryouts. The weaker players may be weeded out during full-contact games in the early season. Over the course of the season, the higher incidence of concussions in games compared with practice is probably because of the fact that, for men, the entire game is contact, compared with the practice which may be broken into skills training, conditioning and other non-concussion producing events. However, the amount of time spent in practices over the course of a season is significantly higher than the amount of time spent in games.

In all, concussions were the most common injury among both sexes. This potentially life-threatening injury has high rates of morbidity, mandating further evaluation. Athletes wear mouth guards and helmets, which are meant to provide some cushioning from impact to their heads. Even though most concussions did not have lengthy time loss, current research has shown that even concussions previously felt to be clinically insignificant leave some cognitive impairment.¹²⁻¹⁴

The high rate of concussions sustained by women during games as the result of player contact also merits specific attention, because a review of the penalties and types of play (deliberate v. out-of-control contact) may be amenable to prevention interventions. Comparisons of secondary contact with the ice versus player-to-player contact may also be important in the design of helmets. The overall

preparation for contact or anticipation response may be different in male and female players. An examination of paraspinal strength and response should be part of any examination of the mechanism of concussions in women. It is also important to keep in mind that the concussion rates reported here might be artificially low because time loss was a requisite for data reporting.

Another injury that may be subject to underreporting is laceration. Lacerations, particularly those that require stitches, may be underreported because they do not lead to time loss; however, these might be easily affected by injury-prevention efforts such as equipment changes. Inclusion criterion for the new NCAA web-based system does not mandate time loss as a requisite for injury reporting in an attempt to address this issue.

Women sustained fewer upper extremity, shoulder and knee injuries than men. These are typical contact injuries. Shoulder separations and knee sprains are seen in the higher-speed contact that occurs in men's league. The higher rates of groin and foot injuries seen in women than in men is probably a reflection of less contact-related injuries. Groin injuries, however, are directly related to off-ice and off-season conditioning programs. These injuries can be mostly prevented by off-ice programs enacted before the season starts. Most professional teams now implement some type of program to decrease these injuries. Foot injuries are also probably a reflection of the lack of other injuries, resulting in foot problems rising to the top of the list. However, there has been a marketing push over the last decade for lighter equipment, including skates. There is remarkably less material over the front of the skates, including the tongue area, as well as less, but more rigid, sidewall material to minimize weight. Foot injuries in both men's and women's hockey need to be examined to determine if there are direct contact or twisting injuries that are the result of changes to skate designs. Perhaps if we had this information, there could be more constructive proactive measures to aid in skate design.

This study reports on injury patterns resulting in loss of activity in a selection of schools with hockey programs. Concussions occurred commonly in both sexes. This is expected in men's hockey, a contact sport. Men's hockey also has high rates of shoulder and knee injuries, presumably from player-to-player contact. The unusually high rate of concussions in women's hockey is perplexing, especially in light of the noncontact designation. The definition of noncontact is, however, effectively left up to the referees and divisions. Open-ice spectacular hits do not occur as they do in men's hockey, but women's hockey allows for pinching attackers off along the boards and into the goal, which may result in secondary concussions from contact with the ice, boards or goals. There has not been any evaluation of single-person injuries resulting from loss of control. The sex differences in anticipatory muscle tensioning or paraspinal strength have not been examined. On first

glance, it appears that both leagues could benefit from new training programs. Less full-contact scrimmage in the early season for men could decrease the concussion rate. More off-ice training programs for women could decrease the groin injury rate. A more careful review of the injury patterns, especially those that do not cause a loss of activity, may result in more efficacious and safe designs for equipment for both men's and women's hockey. This review of injury patterns could be facilitated by a concerted effort from the NCAA and the men's and women's ice hockey collegiate committees to consider mandating data collection to improve on the current participation rates.

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Contributors: Both of the authors were involved in the conception and design of the study, interpretation of the data and the writing and review of the article. Both authors approved the final version submitted for publication.

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