The First Decade of Web-Based Sports Injury Surveillance: Descriptive Epidemiology of Injuries in US High School Boys’ Ice Hockey (2008–2009 Through 2013–2014) and National Collegiate Athletic Association Men’s and Women’s Ice Hockey (2004–2005 Through 2013–2014)

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Context: Web-based sports injury surveillance via programs such as the High School Reporting Information Online system and the National Collegiate Athletic Association Injury Surveillance Program has aided efforts to collect data on ice hockey injuries.

Objective: To describe the epidemiology of injuries sustained in high school boy’s ice hockey in the 2008–2009 through 2013–2014 academic years and collegiate men’s and women’s ice hockey in the 2004–2005 through 2013–2014 academic years using Web-based surveillance.

Design: Descriptive epidemiology study.

Setting: Online injury surveillance of ice hockey teams of high school boys (annual average = 34), collegiate men (annual average = 20), and collegiate women (annual average = 11).

Patients or Other Participants: Boys’, men’s, and women’s ice hockey players who participated in practices and competitions during the 2008–2009 through 2013–2014 high school academic years or the 2004–2005 through 2013–2014 collegiate academic years.

Main Outcome Measure(s): Athletic trainers collected time-loss (>24 hours) injury and exposure data. We calculated injury rates per 1000 athlete-exposures (AEs), injury rate ratios (IRR) with 95% confidence intervals (CIs), and injury proportions by body site and diagnosis.

Results: The High School Reporting Information Online system documented 831 boys’ ice hockey time-loss injuries during 356,997 AEs; the National Collegiate Athletic Association Injury Surveillance Program documented 2611 men’s ice hockey time-loss injuries during 552,642 AEs and 752 women’s ice hockey injuries during 232,051 AEs. Injury rates were higher in collegiate men than in high school boys during 2008–2009 through 2013–2014 (4.38 versus 2.33/1000 AEs; IRR = 1.88; 95% CI = 1.73, 2.05) and collegiate women during 2004–2005 through 2013–2014 (IRR = 1.46; 95% CI = 1.34, 1.58). Most injuries occurred during competitions (boys = 80.0%, men = 66.9%, women = 55.3%); injury rates were higher in competitions than in practices for boys (IRR = 8.14; 95% CI = 6.87, 9.65), men (IRR = 6.58; 95% CI = 6.06, 7.13), and women (IRR = 3.63; 95% CI = 3.14, 4.19). At all levels, most injuries occurred to the head/face and shoulder/clavicle and resulted in concussions, contusions, or ligament sprains.

Conclusions: Injury rates varied across sports but were consistently higher in competitions than in practices. In competitions, concussions were common injuries, highlighting the need for continued development of injury-prevention strategies.

Key Words: musculoskeletal injuries, concussions, ligament sprains, injury rate

Key Points
- Men’s ice hockey had the highest overall injury rate among the cohorts investigated.
- Checking may have led to higher injury rates in boys’ ice hockey compared with men’s ice hockey.
- Of all women’s ice hockey competition injuries, 38% resulted from contact with another person, even though body checking was illegal.
Participation in collegiate men’s and women’s ice hockey has steadily increased over the last 3 decades. The growth in women’s collegiate ice hockey has been tremendous, with a nearly 7-fold increase in participation. At the high school level, almost 36,000 boys currently participate in ice hockey. The growth in participation may be associated with an increase in the number of injuries related to the sport. Thus, in order to develop injury-prevention interventions, we need data on the incidence of ice hockey injuries.

Even though ice hockey is a full-contact activity in the boys’ and men’s sports and unintentional contact can occur in the women’s sport, recent epidemiologic data from the high school and collegiate settings are lacking, with most researchers focusing on these age groups in international samples. Previous reports examining ice hockey injury data from the National Collegiate Athletic Association (NCAA) showed injury rates of 16.27/1000 athlete-exposures (AEs) in men’s ice hockey in the 1988–1999 through 2003–2004 academic years and 12.60/1000 AEs in women’s ice hockey in the 2001–2002 through 2003–2004 academic years. As denoted in the van Mechelen et al framework, injury prevention benefits from ongoing monitoring of injury incidence, and updated descriptive epidemiologic data are needed. Further, few comparisons exist on the injury epidemiology of ice hockey injuries across levels. Such differences in age and sex must also be considered when developing targeted and effective injury-prevention strategies.

Since the 1980s, the NCAA has used injury surveillance to acquire collegiate sports injury data to assist in the development of evidence-based injury-prevention strategies. Although this NCAA-based surveillance system has had several names, we herein denote it as the NCAA Injury Surveillance Program (ISP). Since the 2004–2005 academic year, the NCAA has used a Web-based platform to collect collegiate sports injury and exposure data via athletic trainers (ATs). A year later, High School Reporting Information Online (HS RIO), a similar Web-based sports injury-surveillance system, was launched. The purpose of this article is to summarize the descriptive epidemiology of injuries sustained in boys’ high school ice hockey and men’s and women’s collegiate ice hockey during the first decade of Web-based sports injury surveillance (2004–2005 through 2013–2014 academic years).

METHODS

Data Sources and Study Period

This study used data collected by HS RIO and NCAA-ISP, sports injury-surveillance programs for the high school and collegiate levels, respectively. Use of HS RIO data was approved by the Nationwide Children’s Hospital Subjects Review Board (Columbus, OH). Use of the NCAA-ISP data was approved by the Research Review Board at the NCAA.

An average of 34 high schools sponsoring boys’ ice hockey participated in HS RIO during the 2008–2009 through 2013–2014 academic years (2008–2009 was the first year HS RIO collected data for the sport). During the 2004–2005 through 2013–2014 academic years, an average of 20 NCAA member institutions (Division I = 9, Division II = 2, Division III = 9) sponsoring men’s ice hockey and an average of 11 NCAA member institutions (Division I = 4, Division II = 1, Division III = 6) sponsoring women’s ice hockey participated in the NCAA-ISP. The methods of HS RIO and the NCAA-ISP are summarized in the following paragraphs. In-depth information on the methods and analyses for this special series of articles on Web-based sports injury surveillance can be found in a previously published methodologic article. In addition, previous publications have described the sampling and data collection of HS RIO and the NCAA-ISP in depth.

High School RIO

High School RIO consists of a sample of high schools with 1 or more National Athletic Trainers’ Association-affiliated ATs with valid e-mail addresses. The ATs from participating high schools reported injury incidence and AE information weekly throughout the academic year using a secure Web site. For each injury, the AT completed a detailed report on the athlete (age, height, weight, etc), the injury (site, diagnosis, severity, etc), and the injury event (activity, mechanism, etc). Throughout each academic year, participating ATs were able to view and update previously submitted reports with new information (eg, time loss) as needed.

High School RIO has 2 data-collection panels; a random sample of 100 schools recruited annually since 2005–2006 that report data for the 9 original sports of interest (boys’ baseball, basketball, football, soccer, and wrestling and girls’ basketball, soccer, softball, and volleyball) and an additional convenience sample of schools recruited annually since 2008–2009 that report data for the additional sports of interest (eg, boys’ ice hockey, lacrosse; girls’ field hockey, lacrosse). For the first panel, high schools were recruited into 8 strata based on school population (enrollment ≤1000 or >1000) and US Census geographic region. If a school dropped out of the system, a replacement from the same stratum was selected. For the second panel, it was impossible to approximate a nationally representative random sample due to strong regional variations in sport sponsorship (eg, ice hockey). As a result, exposure and injury data for the schools in the second panel represent a convenience sample of US high schools. The ATs at some schools from the first panel, those enrolled in the original random sample, chose to report for more than the original 9 sports of interest, and ATs at some of the schools from the second panel reported for some of the original 9 sports as well as the additional sports of interest. Those schools’ data represented the original and convenience samples that had collected data from boys’ ice hockey.

National Estimates. National injury estimate weights were not created for boys’ ice hockey and thus national estimates could not be computed.

The NCAA-ISP

The NCAA-ISP depends on a convenience sample of teams, with ATs voluntarily reporting injury and exposure data. Participation in the NCAA-ISP, while voluntary, is available to all NCAA institutions. For each injury event, the AT completes a detailed report on the injury or condition (eg, site, diagnosis) and the circumstances (eg,
activity, mechanism, event type [ie, competition or practice]). The ATs are able to view and update previously submitted information as needed during the course of a season. In addition, ATs also provide the number of student-athletes participating in each practice and competition. A description of the data collection for the 2004–2005 through 2013–2014 academic years follows.

During the 2004–2005 through 2008–2009 academic years, ATs used a Web-based platform launched by the NCAA to track injury and exposure data. This platform integrated some of the functional components of an electronic medical record, such as athlete demographic information and preseason injury information. During the 2009–2010 through 2013–2014 academic years, the Datalsys Center for Sports Injury Research and Prevention, Inc (Datalsys Center, Indianapolis, IN) introduced a common data element (CDE) standard to improve process flow. The CDE standard allowed data to be gathered from different electronic medical record and injury-documentation applications, including the Athletic Trainer System (Keffer Development, Grove City, PA), Injury Surveillance Tool (Datalsys Center), and the Sports Injury Monitoring System (FlanTech, Iowa City, IA). The CDE export standard allowed ATs to document injuries as they normally would during their daily clinical practice, as opposed to asking them to report injuries solely for purposes of participation in an injury-surveillance program. Data were deidentified and sent to the Datalsys Center, where they were examined by data quality-control staff and a verification engine.

**National Estimates.** To calculate national estimates of the number of injuries and AEs, poststratification sample weights, based on sport, division, and academic year, were applied to each reported injury and AE. Weights for all data were further adjusted to correct for underreporting, according to the findings of Kucera et al, who estimated that the ISP captured 88.3% of all time-loss medical-care injury events. Weighted counts were scaled up by a factor of (0.883 ^1). In-depth information on the formula used to calculate national estimates can be found in the previously published methodologic article.

**Definitions**

**Injury.** A reportable injury in both HS RIO and the NCAA-ISP was defined as an injury that (1) occurred as a result of participation in an organized practice or competition; (2) required medical attention by a certified AT or physician; and (3) resulted in restriction of the student-athlete’s participation for 1 or more days beyond the day of injury. Since the 2007–2008 academic year, HS RIO has also captured all concussions, fractures, and dental injuries, regardless of time loss. In the NCAA-ISP, multiple injuries occurring from 1 injury event could be included, whereas in HS RIO, only the principal injury was captured. Beginning in the 2009–2010 academic year, the NCAA-ISP also began to monitor all non–time-loss injuries. A non–time-loss injury was defined as any injury that was evaluated or treated (or both) by an AT or physician but did not result in restriction from participation beyond the day of injury. However, because HS RIO captures only time-loss injuries (to reduce the burden on ATs), for this series of publications, only time-loss injuries (with the exception of concussions, fractures, and dental injuries as noted earlier) were included.

**Athlete-Exposures.** For both surveillance systems, a reportable AE was defined as 1 student-athlete participating in 1 school-sanctioned practice or competition in which he or she was exposed to the possibility of athletic injury, regardless of the time associated with that participation. Preseason scrimmages were considered practice exposures, not competition exposures.

**Statistical Analysis**

Data were analyzed using SAS Enterprise Guide software (version 5.4; SAS Institute, Inc, Cary, NC). Because the data collected from HS RIO and the NCAA-ISP were similar, we opted to recode data when necessary in order to increase the comparability between high school and collegiate student-athletes. We also opted to ensure that categorizations were consistent among all sport-specific articles within this special series. Because methodologic variations may lead to small differences in injury reporting between these surveillance systems, caution must be taken when interpreting these results.

We examined injury counts, national estimates (for college only), and distributions by event type (practice and competition), time in season (preseason, regular season, postseason), time loss (1–6 days; 7–21 days; more than 21 days, including injuries resulting in a premature end to the season), body part injured, diagnosis, mechanism of injury, activity during injury, and position. We also calculated injury rates per 1000 AEs and injury rate ratios (IRRs). The IRRs first focused on comparisons of high school boys’ versus collegiate men’s ice hockey and collegiate men’s versus women’s ice hockey. Comparisons within sport were then performed by event type (practice and competition), school size in high school (<1000 and >1000 students), division in college (Divisions I, II, and III), and time in season (preseason, regular season, and postseason). For the IRRs comparing high school boys and collegiate men, because HS RIO had data available only for 2008–2009 through 2013–2014, we analyzed the NCAA-ISP data only from that time period as well. All IRRs with 95% confidence intervals (CIs) not containing 1.0 were considered statistically significant.

Last, we used linear regression to analyze linear trends across time of injury rates and compute average annual changes (ie, mean differences). Because of the 2 data-collection methods for the NCAA-ISP during the 2004–2005 through 2008–2009 and 2009–2010 through 2013–2014 academic years, linear trends were conducted separately for each time period. All mean differences with 95% CIs not containing 0.0 were considered statistically significant.

**RESULTS**

**Total Injury Frequency and Injury Rates**

During the 2008–2009 through 2013–2014 academic years, ATs reported a total of 831 time-loss injuries in high school boys’ ice hockey (Table 1). During the 2004–2005 through 2013–2014 academic years, ATs reported a total of 2611 and 752 injuries in collegiate men’s and women’s ice hockey, respectively. The total injury rate for high school
boys’ ice hockey was 2.33/1000 AEs (95% CI = 2.17, 2.49). The total injury rates for collegiate men’s and women’s ice hockey were 4.72/1000 AEs (95% CI = 4.54, 4.91) and 3.24/1000 AEs (95% CI = 3.01, 3.47), respectively. The total injury rate during 2008–2009 through 2013–2014 was higher in collegiate men than in high school boys (4.38 versus 2.33/1000 AEs; IRR = 1.88; 95% CI = 1.73, 2.05). The total injury rate during 2004–2005 through 2013–2014 was higher in collegiate men than in collegiate women (IRR = 1.31; 95% CI = 1.13, 1.51; Table 1). In men’s ice hockey, total injury rates did not differ by division (I versus II: IRR = 0.92, 95% CI = 0.81, 1.04; I versus III: IRR = 0.95, 95% CI = 0.88, 1.03; II versus III: IRR = 1.04, 95% CI = 0.91, 1.18). In women’s ice hockey, Division II had a higher total injury rate than Division I (IRR = 1.95; 95% CI = 1.55, 2.45) and Division III (IRR = 1.23; 95% CI = 1.00, 1.52); also, Division III had a higher total injury rate than Division I (IRR = 1.58; 95% CI = 1.34, 1.87).

### School Size and Division

In boys’ ice hockey, the total injury rate was higher in high schools with ≤1000 students than in high schools with >1000 students (IRR = 1.31; 95% CI = 1.13, 1.51; Table 1). In men’s ice hockey, total injury rates did not differ by division (I versus II: IRR = 0.92, 95% CI = 0.81, 1.04; I versus III: IRR = 0.95, 95% CI = 0.88, 1.03; II versus III: IRR = 1.04, 95% CI = 0.91, 1.18). In women’s ice hockey, Division II had a higher total injury rate than Division I (IRR = 1.95; 95% CI = 1.55, 2.45) and Division III (IRR = 1.23; 95% CI = 1.00, 1.52); also, Division III had a higher total injury rate than Division I (IRR = 1.58; 95% CI = 1.34, 1.87).

### Event Type

The majority of injuries occurred during competitions in boys’ ice hockey (80.0%), men’s ice hockey (66.9%), and
women’s ice hockey (55.3%; Table 1). The competition injury rate was higher than the practice injury rate in boys’ ice hockey (IRR = 8.14; 95% CI = 6.87, 9.65), men’s ice hockey (IRR = 6.58; 95% CI = 6.06, 7.13), and women’s ice hockey (IRR = 3.63; 95% CI = 3.14, 4.19).

No linear trends were found in the annual injury rates for high school practices (annual average change of −0.04/1000 AEs; 95% CI = −0.14, 0.06) or competitions (annual average change of −0.11/1000 AEs; 95% CI = −0.32, 0.10; Figure). In collegiate men’s ice hockey, a decrease was present in the 2004–2005 through 2008–2009 academic years for competitions (annual average change of −0.79/1000 AEs; 95% CI = −1.20, −0.39) but not practices (annual average change of −0.09/1000 AEs; 95% CI = −0.19, 0.02). No linear trends were noted in the 2009–2010 through 2013–2014 academic years for practices (annual average change of 0.04/1000 AEs; 95% CI = −0.17, 0.25) or competitions (annual average change of −0.13/1000 AEs; 95% CI = −0.93, 0.66). In collegiate women’s ice hockey, a decrease occurred in the 2004–2005 through 2008–2009 academic years for practices (annual average change of −0.31/1000 AEs; 95% CI = −0.50, −0.12) but not for competitions (annual average change of −0.25/1000 AEs; 95% CI = −0.84, 0.35). No linear trends were observed in the 2009–2010 through 2013–2014 academic years for practices (annual average change of 0.03/1000 AEs; 95% CI = −0.37, 0.43) or competitions (annual average change of 0.74/1000 AEs; 95% CI = −0.49, 1.97).

Time in Season

The majority of injuries occurred during the regular season in boys’ (90.2%), men’s (85.8%), and women’s (84.7%; Table 2) ice hockey. In men’s ice hockey, the injury rate was higher in the regular season than in the preseason (IRR = 1.17; 95% CI = 1.03, 1.33) and postseason (IRR = 2.11; 95% CI = 1.73, 2.59); also, the injury rate was higher in the preseason than in the postseason (IRR = 1.80; 95% CI = 1.43, 2.27). In women’s ice hockey, the injury rate was higher in the regular season than in the preseason (IRR = 1.32; 95% CI = 1.05, 1.66) and postseason (IRR = 1.58; 95% CI = 1.10, 2.27); however, injury rates in the preseason did not differ from those in the postseason (IRR = 1.20; 95% CI = 0.79, 1.81). Injury rates by time in season could not be calculated for high school athletes as the AEs were not stratified by time in season.

Time Loss From Participation

In boys’, men’s, and women’s ice hockey, the largest proportion of injuries resulted in time loss of less than 1 week (Table 3); the 1 exception was competitions in boys’ ice hockey, in which the largest proportion of injuries resulted in time loss of 1 to 3 weeks.

Body Parts Injured and Diagnoses

Boys. The most commonly injured body part in practices and competitions was the head/face (practices = 24.1%, competitions = 36.1%; Table 4). Other frequently injured
body parts were the hip/thigh/upper leg (14.5%) and knee (13.2%) during practices and the shoulder (22.1%) during competitions. The most often reported injury diagnosis in practices and competitions was concussion (practices = 21.8%, competitions = 31.4%; Table 5). Other common diagnoses were contusions (21.2%) and muscle/tendon strains (20.0%) in practices and contusions (16.0%), fractures/avulsions (14.3%), and ligament sprains (13.6%) in competitions.

**Men.** The most frequently injured body parts were the hip/thigh/upper leg (21.5%) during practices and the shoulder/clavicle (22.1%) and head/face (19.5%) during competitions (Table 4). The most frequent injury diagnoses in practices and competitions were muscle/tendon strains (practices = 23.5%, competitions = 18.8%), and contusions (17.3%) in practices and ligament sprains (14.2%), contusions (15.2%), and concussions (15.2%, competitions = 26.9%), and contusions (practices = 14.0%, competitions = 14.9%; Table 5).

### Mechanisms of Injury and Activities

**Boys.** The most often reported mechanisms of injury in practices and competitions were contact with another person (practices = 36.5%, competitions = 50.0%) and contact with the playing surface (practices = 22.6%, competitions = 21.6%; Table 6). The most common activities during injury in practices and competitions were general play (practices = 54.6%, competitions = 37.8%) and checking (practices = 27.7%, competitions = 52.4%; Table 7).

### Abbreviations:
- HS RIO, High School Reporting Information Online
- NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program

### Table 2. Injury Rates by Time in Season and Type of Athlete-Exposure in High School Boys’, Collegiate Men’s, and Collegiate Women’s Ice Hockey

| Sport/Surveillance System and Time in Season | Exposure Type | Injuries in Sample, No. (%) | Athlete-Exposures | Injury Rate/1000 Athlete-Exposures (95% Confidence Interval) |
|-------------------------------------------|--------------|-----------------------------|-------------------|----------------------------------------------------------|
| Boys’ ice hockey—HS RIO (2008–2009 through 2013–2014) | Preseason | Practice 40 (64.5) | 61,882 | 3.62 (3.15, 4.09) |
| | | Competition 22 (35.5) | 1854 | 25.89 (18.57, 33.21) |
| | | Total 62 (100.0) | 63,736 | 4.27 (3.76, 4.77) |
| | Regular season | Practice 126 (16.8) | 329,147 | 1.84 (1.69, 1.98) |
| | | Competition 623 (83.2) | 118,426 | 13.82 (13.15, 14.49) |
| | | Total 749 (100.0) | 447,573 | 5.01 (4.80, 5.21) |
| | Postseason | Practice 0 (0.0) | 31,817 | 1.16 (0.79, 1.54) |
| | | Competition 19 (100.0) | 9517 | 6.41 (4.80, 8.02) |
| | Total 19 (100.0) | 41,334 | 2.37 (1.90, 2.84) |
| Men’s ice hockey—NCAA-ISP (2004–2005 through 2013–2014) | Preseason | Practice 224 (82.4) | 61,882 | 3.62 (3.15, 4.09) |
| | | Competition 48 (17.6) | 1854 | 25.89 (18.57, 33.21) |
| | | Total 272 (100.0) | 63,736 | 4.27 (3.76, 4.77) |
| | Regular season | Practice 604 (27.0) | 329,147 | 1.84 (1.69, 1.98) |
| | | Competition 1637 (73.0) | 118,426 | 13.82 (13.15, 14.49) |
| | | Total 2241 (100.0) | 447,573 | 5.01 (4.80, 5.21) |
| | Postseason | Practice 37 (37.8) | 31,817 | 1.16 (0.79, 1.54) |
| | | Competition 61 (62.2) | 9517 | 6.41 (4.80, 8.02) |
| | Total 98 (100.0) | 41,334 | 2.37 (1.90, 2.84) |
| Women’s ice hockey—NCAA-ISP (2004–2005 through 2013–2014) | Preseason | Practice 84 (100.0) | 31,989 | 2.63 (2.06, 3.19) |
| | | Competition 0 | 296 | 0.00 |
| | | Total 84 (100.0) | 32,285 | 2.60 (2.05, 3.16) |
| | Regular season | Practice 235 (36.9) | 130,031 | 1.81 (1.58, 2.04) |
| | | Competition 402 (63.1) | 55,457 | 7.25 (6.54, 7.96) |
| | | Total 637 (100.0) | 185,488 | 3.43 (3.17, 3.70) |
| | Postseason | Practice 17 (54.8) | 10,972 | 1.55 (0.81, 2.29) |
| | | Competition 14 (45.2) | 3305 | 4.24 (2.02, 6.45) |
| | Total 31 (100.0) | 14,277 | 2.17 (1.41, 2.94) |

**Abbreviations:** HS RIO, High School Reporting Information Online; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.
Another often reported mechanism of injury was contact with another person (37.8%), contact with the boards (17.4%), and contact with the puck (16.1%) during practices and contact with another person (20.9%) during competitions. The most common activities during injury in practices and competitions were general play (practices = 69.9%, competitions = 62.9%) and checking (practices = 11.6%, competitions = 25.7%); Table 7).

**Women.** The most frequent mechanisms of injury were no contact (26.6%) and contact with another person (20.9%) during practices and contact with another person (37.8%), contact with the boards (17.4%), and contact with the playing surface (16.9%) during competitions (Table 6). Another often reported mechanism of injury was contact with the puck (12.7%) during practices. The most common activity during injury in practices and competitions was general play (practices = 73.3%, competitions = 83.6%; Table 7).

**Position-Specific Injuries During Competitions**

During competitions in boys’, men’s, and women’s ice hockey, concussion was the most frequent injury among almost all positions, with most concussions being due to contact with another person (Table 8). The 1 exception was men’s goalkeepers, who more often had hip/thigh/upper leg strains. Other common injuries in competitions across boys’, men’s, and women’s ice hockey were hip/thigh/upper leg strains and knee sprains, as well as injuries to the shoulder that resulted in sprains, dislocations, fractures/avulsions.

**DISCUSSION**

This study is the first to directly compare injury rates and patterns across high school and collegiate female ice hockey players over multiple seasons in the United States. Although several injury patterns were similar between the 2 age cohorts, such as higher injury rates in competition than in practice, we found interesting trends when comparing men’s ice hockey data with those of women’s and boys’ ice hockey and also when comparing these data with previously published ice hockey injury data. Also, collegiate men’s ice hockey had the overall highest injury rate compared with boys’ high school and women’s collegiate ice hockey. These findings may allow for the development of effective injury-prevention strategies targeted to the level of play.

**Comparison of Injury Rates With Previous Research**

Men’s collegiate ice hockey practice injury rates in the current investigation were nearly identical to previously published rates, but the competition injury rate we reported (13.45/1000 AEs) appears to be lower than a previous estimate (16.27/1000 AEs). Similarly, the women’s ice hockey competition injury rate was lower in the current investigation (7.04/1000 AEs) than in previously published data (12.60/1000 AEs). It is difficult to say whether our results can identify a true decrease in injury incidence. It is also possible that methodologic changes, including but not limited to improved epidemiologic capture methods between the study periods, contributed to the differences reported here. Further, although there is some evidence of decreases in collegiate...
practices in the 2004–2005 through 2008–2009 academic years, no additional linear trends were detected. Our findings warrant the continued use of consistent methods to better detect and verify the possibility of longitudinal decreases in injury incidence in ice hockey.

Previous men’s and women’s collegiate ice hockey epidemiology reports are the most feasible for comparison given the similar methods, but investigations of elite ice hockey players have been conducted. Our overall women’s competition injury rate (7.04/1000 AEs) was comparable with but slightly higher than the rates reported during the International Ice Hockey Federation World Women’s Championship, World Women’s under-18 Championship, and Olympic Winter Games tournaments for women (5.7/1000 AEs) and youth girls (6.4/1000 AEs). Our reported men’s collegiate ice hockey competition injury rate (13.45/1000 AEs) is similar to that documented for men’s international ice hockey competitions over a 7-year period (14.2/1000 AEs). These findings are interesting given the sample differences. Further, rule and rink differences in international ice hockey compared with American collegiate hockey do

| Sport/Surveillance System and Body Part Injured | Practice | Injury Rate/1000 Athlete-Exposures (95% Confidence Interval) | Competition | Injury Rate/1000 Athlete-Exposures (95% Confidence Interval) |
|-----------------------------------------------|----------|----------------------------------------------------------|------------|----------------------------------------------------------|
| Boys’ ice hockey—HS RIO (2008–2009 through 2013–2014) | | | | |
| Head/face | 40 (24.1) | 0.17 (0.12, 0.22) | 240 (36.1) | 2.04 (1.78, 2.30) |
| Neck | 2 (1.2) | 0.01 (0.00, 0.02) | 11 (1.7) | 0.09 (0.04, 0.15) |
| Shoulder/clavicle | 18 (10.8) | 0.08 (0.04, 0.11) | 147 (22.1) | 1.25 (1.05, 1.45) |
| Arm/elbow | 6 (3.6) | 0.03 (0.01, 0.05) | 30 (4.5) | 0.25 (0.16, 0.35) |
| Hand/wrist | 18 (10.8) | 0.08 (0.04, 0.11) | 50 (7.5) | 0.42 (0.31, 0.54) |
| Trunk | 14 (8.4) | 0.06 (0.03, 0.09) | 4 (6.5) | 0.37 (0.26, 0.47) |
| Hip/thigh/upper leg | 24 (14.5) | 0.10 (0.06, 0.14) | 47 (7.1) | 0.40 (0.29, 0.51) |
| Knee | 22 (13.3) | 0.09 (0.05, 0.13) | 52 (7.8) | 0.44 (0.32, 0.56) |
| Lower leg | 4 (2.4) | 0.02 (0.00, 0.03) | 15 (2.3) | 0.13 (0.06, 0.19) |
| Ankle | 10 (6.0) | 0.04 (0.02, 0.07) | 22 (3.3) | 0.19 (0.11, 0.26) |
| Foot | 5 (3.0) | 0.02 (0.00, 0.04) | 6 (0.9) | 0.05 (0.01, 0.09) |
| Other | 3 (1.8) | 0.01 (0.00, 0.03) | 2 (0.3) | 0.02 (0.00, 0.04) |
| Men’s ice hockey—NCAA-ISP (2004–2005 through 2013–2014) | | | | |
| Head/face | 110 (12.7) | 0.26 (0.21, 0.31) | 341 (19.5) | 2.63 (2.35, 2.91) |
| Neck | 15 (1.7) | 0.04 (0.02, 0.05) | 33 (1.9) | 0.25 (0.17, 0.34) |
| Shoulder/clavicle | 116 (13.4) | 0.27 (0.22, 0.32) | 385 (22.1) | 2.97 (2.67, 3.26) |
| Arm/elbow | 20 (2.3) | 0.05 (0.03, 0.07) | 48 (2.7) | 0.37 (0.27, 0.47) |
| Hand/wrist | 85 (9.8) | 0.20 (0.16, 0.24) | 144 (8.2) | 1.11 (0.93, 1.29) |
| Trunk | 90 (10.4) | 0.21 (0.17, 0.26) | 122 (7.0) | 0.94 (0.77, 1.11) |
| Hip/thigh/upper leg | 186 (21.5) | 0.44 (0.38, 0.50) | 235 (13.5) | 1.81 (1.58, 2.04) |
| Knee | 85 (9.8) | 0.20 (0.16, 0.24) | 251 (14.4) | 1.93 (1.69, 2.17) |
| Lower leg | 13 (1.5) | 0.03 (0.01, 0.05) | 25 (1.4) | 0.19 (0.12, 0.27) |
| Ankle | 75 (8.7) | 0.18 (0.14, 0.22) | 111 (6.4) | 0.86 (0.70, 1.01) |
| Foot | 43 (5.0) | 0.10 (0.07, 0.13) | 36 (2.1) | 0.28 (0.19, 0.37) |
| Other | 27 (3.1) | 0.06 (0.04, 0.09) | 15 (0.9) | 0.12 (0.06, 0.17) |
| Women’s ice hockey—NCAA-ISP (2004–2005 through 2013–2014) | | | | |
| Head/face | 55 (16.4) | 0.32 (0.23, 0.40) | 116 (27.9) | 1.96 (1.61, 2.32) |
| Neck | 9 (2.7) | 0.05 (0.02, 0.09) | 19 (4.6) | 0.32 (0.18, 0.47) |
| Shoulder/clavicle | 21 (6.3) | 0.12 (0.07, 0.17) | 64 (15.4) | 1.08 (0.82, 1.35) |
| Arm/elbow | 10 (3.0) | 0.06 (0.02, 0.09) | 16 (3.8) | 0.27 (0.14, 0.40) |
| Hand/wrist | 22 (6.5) | 0.13 (0.07, 0.18) | 34 (8.2) | 0.58 (0.38, 0.77) |
| Trunk | 46 (13.7) | 0.27 (0.19, 0.34) | 40 (9.6) | 0.68 (0.47, 0.89) |
| Hip/thigh/upper leg | 58 (17.3) | 0.34 (0.25, 0.42) | 31 (7.5) | 0.52 (0.34, 0.71) |
| Knee | 47 (14.0) | 0.27 (0.19, 0.35) | 48 (11.5) | 0.81 (0.58, 1.04) |
| Lower leg | 7 (2.1) | 0.04 (0.01, 0.07) | 9 (2.2) | 0.15 (0.05, 0.25) |
| Ankle | 18 (5.4) | 0.10 (0.06, 0.15) | 25 (6.0) | 0.42 (0.26, 0.59) |
| Foot | 12 (3.6) | 0.07 (0.03, 0.11) | 9 (2.2) | 0.15 (0.05, 0.25) |
| Other | 31 (9.2) | 0.18 (0.12, 0.24) | 5 (1.2) | 0.08 (0.01, 0.16) |

Abbreviations: HS RIO, High School Reporting Information Online; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.

a Percentages may not add up to 100.0 due to rounding error. High school data originated from HS RIO surveillance data, 2008–2009 through 2013–2014; collegiate data originated from NCAA-ISP surveillance data, 2004–2005 through 2013–2014. Injuries included in the analysis were those that (1) occurred during a sanctioned practice or competition; (2) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; and (3) restricted the student-athlete from participation for at least 24 hours past the day of injury. All concussions, fractures, and dental injuries were included in the analysis, regardless of time loss. Data may include multiple injuries that occurred at 1 injury event.
Comparisons Among and Within High School Boys', Collegiate Men's, and Collegiate Women's Ice Hockey

Our data highlight differences among the 3 cohorts examined. Men's collegiate ice hockey had the highest overall injury rate. The difference between the sexes at the collegiate level was not unexpected, as women's ice hockey players are not allowed to body check. However, the higher injury rate in collegiate men versus high school boys is interesting given that similar rules apply at both levels of play. Our results may suggest an increased injury risk due to a number of factors. First, the intensity of play may be greater in collegiate versus high school ice hockey, and collegiate players as a population possess greater body mass and speed, which may elevate the injury risk. In other sports, players at the collegiate level also have more exposure to participation, which may further increase their likelihood of sustaining injury. Our results may also be explained by the fact that collegiate athletes are more likely to have more exposure to participation, which may further increase their likelihood of sustaining injury. However, due to a number of factors, including the intensity of play and the capacity to sustain injury, the injury rate in collegiate men versus high school boys is interesting given that similar rules apply at both levels of play. Our results suggest that an increased injury risk is due to a number of factors. First, the intensity of play may be greater in collegiate versus high school ice hockey, and collegiate players are a population that possesses greater body mass and speed, which may elevate the injury risk. In other sports, players at the collegiate level also have more exposure to participation, which may further increase their likelihood of sustaining injury. Our results may also be explained by the fact that collegiate athletes are more likely to have more exposure to participation, which may further increase their likelihood of sustaining injury.

Compared to high school boys, collegiate men's and women's ice hockey players are not allowed to body check. However, the higher injury rate in collegiate men versus high school boys is interesting given that similar rules apply at both levels of play. Our results may suggest an increased injury risk due to a number of factors. First, the intensity of play may be greater in collegiate versus high school ice hockey, and collegiate players as a population possess greater body mass and speed, which may elevate the injury risk. In other sports, players at the collegiate level also have more exposure to participation, which may further increase their likelihood of sustaining injury. Our results may also be explained by the fact that collegiate athletes are more likely to have more exposure to participation, which may further increase their likelihood of sustaining injury.
Table 6. Number of Injuries and Injury Rates by Mechanism of Injury and Type of Athlete-Exposure in High School Boys’, Collegiate Men’s, and Collegiate Women’s Ice Hockey

| Sport/Surveillance System and Mechanism of Injury | Practice | Injury Rate/1000 Athlete-Exposures (95% Confidence Interval) | Competition | Injury Rate/1000 Athlete-Exposures (95% Confidence Interval) |
|-------------------------------------------------|----------|---------------------------------------------------------------|-------------|---------------------------------------------------------------|
| Boys’ ice hockey—HS RIO (2008–2009 through 2013–2014) | 58 (36.5) | 0.24 (0.18, 0.30) | 370 (58.0) | 3.14 (2.82, 3.46) |
| Contact with another person | 36 (22.6) | 0.15 (0.10, 0.20) | 138 (21.6) | 1.17 (0.98, 1.37) |
| Contact with stick | 1 (0.6) | <0.01 (0.00, 0.01) | 16 (2.5) | 0.14 (0.07, 0.20) |
| Contact with puck | 16 (10.1) | 0.07 (0.03, 0.10) | 23 (3.6) | 0.20 (0.12, 0.28) |
| Contact with skate | 2 (1.3) | 0.01 (0.00, 0.02) | 1 (0.2) | 0.01 (0.00, 0.03) |
| Contact with board | 13 (8.2) | 0.05 (0.02, 0.08) | 59 (9.3) | 0.50 (0.37, 0.63) |
| Contact with goal | 0 | 0 | 0 | 0.00 |
| Contact with other playing equipment | 0 | 0 | 0 | 0.00 |
| Contact with out-of-bounds object | 0 | 0 | 0 | 0.00 |
| No contact | 24 (15.1) | 0.10 (0.06, 0.14) | 25 (3.9) | 0.21 (0.13, 0.30) |
| Overuse/chronic | 7 (4.4) | 0.03 (0.01, 0.05) | 4 (0.6) | 0.03 (0.00, 0.07) |
| Illness/infection | 2 (1.3) | 0.01 (0.00, 0.02) | 2 (0.3) | 0.02 (0.00, 0.04) |
| Men’s ice hockey—NCAA-ISP (2004–2005 through 2013–2014) | 244 (29.5) | 0.58 (0.50, 0.65) | 955 (55.4) | 7.36 (6.89, 7.82) |
| Contact with another person | 51 (6.2) | 0.12 (0.09, 0.15) | 91 (5.3) | 0.70 (0.56, 0.85) |
| Contact with stick | 14 (1.7) | 0.03 (0.02, 0.05) | 58 (3.4) | 0.45 (0.33, 0.56) |
| Contact with puck | 133 (16.1) | 0.31 (0.26, 0.37) | 144 (8.3) | 1.11 (0.93, 1.29) |
| Contact with skate | 8 (1.0) | 0.02 (0.01, 0.03) | 14 (0.8) | 0.11 (0.05, 0.16) |
| Contact with board | 88 (10.6) | 0.21 (0.16, 0.25) | 265 (15.4) | 2.04 (1.80, 2.29) |
| Contact with goal | 6 (0.7) | 0.01 (0.00, 0.03) | 9 (0.5) | 0.07 (0.02, 0.11) |
| Contact with other playing equipment | 1 (0.1) | 0.00 | 16 (2.5) | 0.14 (0.07, 0.20) |
| Contact with out-of-bounds object | 0 | 0.00 | 16 (2.5) | 0.14 (0.07, 0.20) |
| No contact | 199 (24.1) | 0.47 (0.41, 0.54) | 149 (8.6) | 1.15 (0.96, 1.33) |
| Overuse/chronic | 54 (6.5) | 0.13 (0.09, 0.16) | 24 (1.4) | 0.18 (0.11, 0.26) |
| Illness/infection | 29 (3.5) | 0.07 (0.04, 0.09) | 6 (0.3) | 0.05 (0.01, 0.08) |
| Women’s ice Hockey—NCAA-ISP (2004–2005 through 2013–2014) | 66 (20.9) | 0.38 (0.29, 0.47) | 154 (37.8) | 2.61 (2.20, 3.02) |
| Contact with another person | 37 (11.7) | 0.21 (0.14, 0.28) | 69 (16.9) | 1.17 (0.89, 1.44) |
| Contact with stick | 9 (2.8) | 0.05 (0.02, 0.09) | 15 (3.7) | 0.25 (0.13, 0.38) |
| Contact with puck | 40 (12.7) | 0.23 (0.16, 0.30) | 28 (6.9) | 0.47 (0.30, 0.65) |
| Contact with skate | 0 | 0.00 | 3 (0.7) | 0.05 (0.00, 0.11) |
| Contact with board | 25 (7.9) | 0.14 (0.09, 0.20) | 71 (17.4) | 1.20 (0.92, 1.48) |
| Contact with goal | 4 (1.3) | 0.02 (0.00, 0.05) | 6 (1.5) | 0.10 (0.02, 0.18) |
| Contact with other playing equipment | 1 (0.3) | 0.01 (0.00, 0.02) | 3 (0.7) | 0.05 (0.00, 0.11) |
| Contact with out-of-bounds object | 3 (0.9) | 0.02 (0.00, 0.04) | 4 (1.0) | 0.07 (0.00, 0.13) |
| No contact | 84 (26.6) | 0.49 (0.38, 0.59) | 43 (10.5) | 0.73 (0.51, 0.95) |
| Overuse/chronic | 24 (7.6) | 0.14 (0.08, 0.19) | 8 (2.0) | 0.14 (0.04, 0.23) |
| Illness/infection | 23 (7.3) | 0.13 (0.08, 0.19) | 4 (1.0) | 0.07 (0.00, 0.13) |

Abbreviations: HS RIO, High School Reporting Information Online; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.

*a Mechanism of injury excluded 34 injuries reported in HS RIO, 59 injuries reported in the NCAA-ISP men’s ice hockey, and 28 injuries reported in the NCAA-ISP women’s ice hockey due to missing data or athletic trainer reporting Other or Unknown. Percentages may not add up to 100.0 due to rounding error. High school data originated from HS RIO surveillance data, 2008–2009 through 2013–2014; collegiate data originated from NCAA-ISP surveillance data, 2004–2005 through 2013–2014. Injuries included in the analysis were those that (1) occurred during a sanctioned practice or competition; (2) were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; and (3) restricted the student-athlete from participation for at least 24 hours past the day of injury. All concussions, fractures, and dental injuries were included in the analysis, regardless of time loss. Data may include multiple injuries that occurred at 1 injury event.

Differences were observed between large and small schools at the high school level and when comparing collegiate divisions. At the high school level, small schools reported higher overall injury rates than did big schools. Similarly, Division II and III women’s collegiate ice hockey players had higher overall injury rates than those in Division I, whereas no division differences were seen in the men’s collegiate game. Understanding injury rates across different school sizes and divisions may be important to identify the development of appropriate rules to mitigate injury risk. Currently, research on this topic is minimal. Investigators should pursue more detailed studies in order to develop a better understanding of our reported differences.

In collegiate women’s ice hockey competitions, 38% of all injuries resulted from contact with another person. This value appears to be lower than findings reported for high school boys (58%) and collegiate men (55%). However,
findings agree. Consequently, it is also possible that rules allowed, although it should be noted that not all of injury in youth hockey leagues where checking was not made safer. Previous researchers have shown a reduced risk of injury involving the NCAA-ISP data, concussion rates in our study varied; the rate among collegiate men was higher (2.29 versus 1.47/1000 AEs), whereas the rate among collegiate women was lower (1.90 versus 2.72/1000 AEs). It can be argued that both findings are promising, given the push by the NCAA to better detect, diagnose, and manage given that body checking is not allowed in women’s ice hockey, the finding is alarming, particularly because a small percentage of injuries were attributed to checking (5%). Although it is possible that a proportion of these injuries were due to incidental player contact, current surveillance methods do not allow ATs to report injury mechanisms to this extent. More knowledge of how incidental and intentional contact may differ in their mechanisms to this extent. More knowledge of how they enter injury activity in their respective surveillance programs; this is evidenced by the far larger percentages of injuries denoted as occurring during general play in the NCAA-ISP (men = 63%; women = 84%) than in HS RIO (38%). Furthermore, even though eliminating or reducing checking at the boys’ high school level may be appropriate, it is also important to understand the potential implications as high school players move on to the collegiate level.

Concussions

Comparison of the results of previous investigations involving the NCAA-ISP data, concussion rates in our study varied; the rate among collegiate men was higher (2.29 versus 1.47/1000 AEs), whereas the rate among collegiate women was lower (1.90 versus 2.72/1000 AEs). It can be argued that both findings are promising, given the push by the NCAA to better detect, diagnose, and manage
The higher rate in men may be due to increased reporting after implementation of the new policy, the decreased rate in women may be due to better education and prevention efforts. However, it is important to note that researchers found minimal change in concussion rate. Additional investigation is needed to verify the utility of such guidelines at the collegiate level.

Compared with collegiate men, the concussion rate in high school boys was lower. It is not uncommon for collegiate men’s ice hockey athletes to matriculate after high school boys was lower. It is not uncommon for collegiate ice hockey players’ knowledge of concussion. Additional investigation is needed to verify the utility of such guidelines at the collegiate level.

Table 8. Most Common Injuries Associated With Position in Competitions in High School Boys’, Collegiate Men’s, and Collegiate Women’s Ice Hockey

| Position | Most Common Injuries | HS RIO (2008–2009 Through 2013–2014) | NCAA-ISP (2004–2005 Through 2013–2014) |
|----------|----------------------|--------------------------------------|----------------------------------------|
| Boys/men’s ice hockey | | | |
| Defense | Concussion | 31.2 | Concussion | 16.1 |
| | Shoulder dislocation | 5.8 | Shoulder sprain | 13.8 |
| | Knee sprain | 5.8 | Knee sprain | 9.5 |
| | Concussion | 30.8 | Concussion | 18.0 |
| | Shoulder fracture/avulsion | 6.9 | Shoulder sprain | 15.7 |
| | | | Knee sprain | 9.2 |
| Forward | Concussion | 23.5 | Hip/thigh/upper leg sprain | 26.1 |
| | Trunk contusion | 23.5 | Knee sprain | 19.6 |
| | Hip/thigh/upper leg sprain | 11.8 | Contact with another person | No contact |
| | | | | |
| Goalkeeper | Concussion | 28.6 | Concussion | 25.0 |
| | Hip/thigh/upper leg sprain | 26.1 | Knee sprain | 25.0 |
| | Shoulder sprain | 17.9 | Contact with another person | No contact |

Abbreviations: HS RIO, High School Reporting Information Online; NCAA-ISP, National Collegiate Athletic Association Injury Surveillance Program.

a Excluded 39 competition injuries reported in HS RIO, 33 competition injuries reported in the NCAA-ISP men’s ice hockey, and 20 competition injuries reported in the NCAA-ISP women’s ice hockey due to position not being indicated. The table reads as follows: For the defense position in high school boys, concussions comprised 31.2% of all competition injuries to that position. The most common mechanism of injury for this specific injury for this specific position was contact with another person. High school data originated from HS RIO surveillance data, 2008–2009 through 2013–2014; collegiate data originated from NCAA-ISP surveillance data, 2004–2005 through 2013–2014. Injuries included in the analysis were those that occurred during a sanctioned practice or competition; were evaluated or treated (or both) by an athletic trainer, physician, or other health care professional; and restricted the student-athlete from participation for at least 24 hours past the day of injury. All concussions, fractures, and dental injuries were included in the analysis, regardless of time loss. Data may include multiple injuries that occurred at 1 injury event.

b Included separations.
school and college in regard to the length of the season in total, as well as the preseason, regular season, and postseason; the potentially longer collegiate season may increase the injury risk. Our calculation of injury rates using AEs may not be as precise an at-risk exposure measure as minutes, hours, or total number of game plays across a season. However, collecting such exposure data is more laborious than for AE data and may be too burdensome for ATs participating in HS RIO and the NCAA-ISP. We also caution regarding comparisons of injury distributions between the high school and collegiate levels as high school data were not available for the 2004–2005 through 2007–2008 academic years.

Although our study is one of few to examine injury incidence across multiple levels of play (eg, high school versus college and competition versus practice), we were unable to assess differences between starters and nonstarters during competitions; analyses that group both types of players may confound and thus weaken the possible exposure-outcome association for some known injury risk factors. Differences may also exist among the freshman, junior varsity, and varsity teams due to differences in maturation. Playing positions may vary in physical demands and resulting injury risk. Athlete-exposures were not collected by position, preventing the calculation of position-specific injury rates.

CONCLUSIONS

Ice hockey is a popular sport that is continuing to grow in popularity, especially for women. We report interesting between-cohorts differences that may have injury-prevention implications specific to each level of ice hockey. At the high school level, very little has been published detailing the overall injury burden or mechanisms leading to injury. The data provided herein give high school hockey ATs important information about injury and also allow for a baseline to be established, such that injury-prevention programs can now be created and implemented, and the results of these programs can be compared with these data. Along these lines, checking led to a higher rate of injury in boys’ ice hockey than in men’s ice hockey. This finding may have injury-prevention implications, which should be further explored. In general, future researchers should continue to explore ice hockey injury epidemiology but include studies that seek to intervene with rule and technique changes at the various levels to improve overall sport safety. As previous investigators have posited, ice hockey has one of the higher injury rates, and AT coverage to properly identify and manage athletes with such injuries is warranted. Our findings also suggested higher injury rates in smaller high schools and lower NCAA divisions. This may highlight a need for AT coverage not only in high schools and colleges sponsoring ice hockey but particularly in smaller high schools and lower-division NCAA programs.

ACKNOWLEDGMENTS

The NCAA ISP data were provided by the Datalys Center for Sports Injury Research and Prevention. The ISP was funded by the NCAA. Funding for HS RIO was provided in part by the Centers for Disease Control and Prevention grants R49/CE00674-01 and R49/CE001172-01 and the National Center for Research Resources award KL2 RR025754. We also acknowledge the research funding contributions of the National Federation of State High School Associations (Indianapolis, IN), National Operating Committee on Standards for Athletic Equipment (Overland Park, KS), DonJoy Orthotics (Vista, CA), and EyeBlack (Potomac, MD). The content of this report is solely the responsibility of the authors and does not necessarily represent the official views of the funding organizations. We thank the many ATs who have volunteered their time and efforts to submit data to HS RIO and the NCAA-ISP. Their efforts are greatly appreciated and have had a tremendously positive effect on the safety of high school and collegiate student-athletes.

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