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Descriptive Epidemiology of Collegiate Women's Ice Hockey Injuries: National Collegiate Athletic Association Injury Surveillance System, 2000–2001 Through 2003–2004

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Objective: To review 4 years of National Collegiate Athletic Association (NCAA) injury surveillance data for women's ice hockey and to identify potential areas for injury prevention initiatives.

Background: The NCAA ISS prospectively collects data on injuries sustained during collegiate participation. Women's NCAA ice hockey began participation in the ISS during the 2000–2001 season. On average, over the 4 years, 15.6% of the eligible schools elected to send their injury data.

Main Results: Over the 4 years of study, the rate of injury in games was more than 5 times higher than the injury rate in practices (12.6 versus 2.5 injuries per 1000 athlete-exposures, rate ratio = 5.0, 95% confidence interval = 4.2, 6.1, $P < .01$). Preseason practice injury rates were almost twice as high as in-season practice rates (4.2 versus 2.3 injuries per 1000 athlete-exposures, rate ratio = 1.8, 95% confidence interval = 1.7, 2.0, $P < .01$). Concussions were the most common injury in both games (21.6%) and practices (13.2%). The rate of concussions in games appeared to be trending upward over the study period. The greatest number of game injuries (approximately 50%) resulted from player contact, whereas practice injuries were from either contact with another object or noncontact mechanisms.

Recommendations: Women's ice hockey is an evolving NCAA sport. Only 4 years of ISS data are available and, therefore, data should be interpreted with caution. Women's ice hockey does not allow for formal body checking; however, approximately 50% of all game injuries were reported to result from contact with another player. Future researchers need to evaluate the effectiveness of the no-checking rule. Additional years of data collection will be required to allow the data to become more stable, and to increase attention to mechanism-of-injury issues. We anticipate that the hypothesized inconsistencies in skill level across and within the various women's teams also will be reduced as more consistently skilled players develop, allowing for more stability in the injury scenario.

Key Words: athletic injuries, injury prevention, concussions

The National Collegiate Athletic Association (NCAA) conducted its first women's ice hockey championship in 2001 for Divisions I and III. Division II currently does not host a championship. In the 2000–2001 academic year, 63 schools began sponsoring varsity women's ice hockey teams, with approximately 1380 participants. By 2003–2004, the number of varsity teams had increased 10% to 69, involving 1600 participants.[1] This sport is evolving, and data must be interpreted with caution because only 4 years of data were available.

SAMPLING AND METHODS

Over the 4-year period from 2000–2001 through 2003–2004, an average of 15.6% of schools sponsoring varsity women's ice hockey programs participated in annual NCAA Injury Surveillance Systems (ISS) data collection (Table 1). On average, 11 schools contributed data each year; only 1 Division II school reported data and only in 1 year. The sampling process, data collection methods, injury and exposure definitions, inclusion criteria, and data analysis methods are described in detail in the ''Introduction and Methods'' article in this special issue.[2]

RESULTS

Game and Practice Athlete-Exposures

The average annual numbers of games, practices, and athletes participating for each NCAA division, condensed over the study period, are shown in Table 2. The data for Division II come from only 1 school in only 1 year and are included largely in the interests of consistency with the other papers in this special issue. Divisions I and III averaged a similar number of game and practice participants annually; Division I teams, however, averaged 20 more practices and 10 more games per year than Division III.

Injury Rate by Activity, Division, and Season

Game and practice injury rates over time combined across divisions, along with 95% confidence intervals (CIs), are displayed in Figure 1. The test for linear trend was nonsignificant for game ($P = .71$) and practice ($P = .78$) injury rates. Over the 4 years of the study, the rate of injury in games was 5 times higher than the rate in practices (12.6 versus 2.5 injuries per 1000 athlete-exposures [A-Es], rate ratio = 5.0, 95% CI = 4.2, 6.1, $P < .01$).

Table 1. School Participation Frequency (in Total Numbers) by Year and National Collegiate Athletic Association (NCAA) Division, Women's Ice Hockey, 2000–2001 Through 2003–2004*

Academic Year	Division I Schools		Division II Schools		Division III Schools		All Divisions		
	Participating	Sponsoring	Participating	Sponsoring	Participating	Sponsoring	Participating	Sponsoring	Percentage
2000–2001	7	27	0	2	5	34	12	63	19.0
2001–2002	5	29	0	1	6	39	11	69	15.9
2002–2003	3	30	0	1	10	39	13	70	18.6
2003–2004	2	30	1	2	4	40	7	73	9.6
Average	4	29	0.25	2	6	38	11	69	15.6

*"Participating" refers to schools that provided appropriate data to the NCAA Injury Surveillance System; "Sponsoring" refers to the total number of schools offering the sport within the NCAA divisions.

Table 2. Average Annual Games, Practices, and Athletes Participating by National Collegiate Athletic Association Division per School, Women's Ice Hockey, 2000–2001 Through 2003–2004

Division	Games	Athletes per Game	Practices	Athletes per Practice
I	33	18	84	21
II	29	19	77	21
III	23	17	64	20

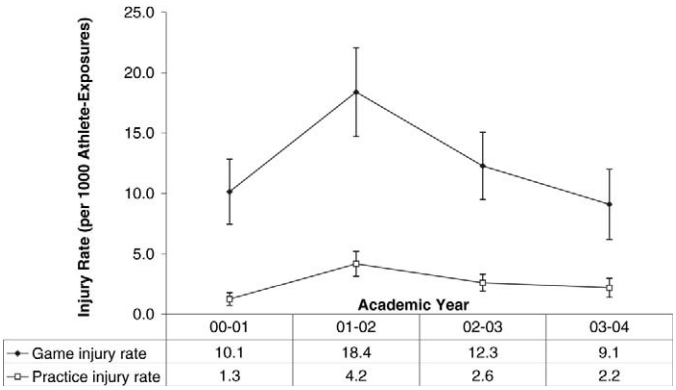

Figure 1. Injury rates and 95% confidence intervals per 1000 athlete-exposures by games, practices, and academic year, women's ice hockey, 2000–2001 through 2003–2004 (n = 264 game and 167 practice injuries). Game time trend, *P* = .71. Practice time trend, *P* = .78.

The total number of games and practices and associated injury rates collapsed over years by division and season (preseason, in season, and postseason) are presented in Table 3. As with Table 1, the data for Division II are based on only 1 school and should be interpreted with caution. Over the 4-year period, 264 injuries from more than 1100 games and 167 injuries from more than 3200 practices were reported. Injury rates were similar across divisions. Preseason practice injury rates were almost twice as high as regular-season practice rates (4.2 versus 2.3 injuries per 1000 A-Es, rate ratio = 1.8, 95% CI = 1.7, 2.0, $P < .01$).

Body Parts Injured Most Often and Specific Injuries

The frequency of injury to 5 general body parts (head/neck, upper extremity, trunk/back, lower extremity, and other/system) for games and practices with years and divisions combined is shown in Table 4. Nearly one third of all game injuries (31.8%) and practice injuries (31.1%) were to the lower extremity, with the upper extremity (30.3%) and head and neck (25.4%) accounting for the majority of other game injuries.

The most common body part and injury type combinations for games and practices with years and divisions combined are displayed in Table 5. All injuries that accounted for at least 2% of reported injuries over the 4-year sampling period are shown. Rates could not be computed for injuries below the 2% threshold due to small numbers of reported injuries.[3] In games, concussions (21.6%) were the primary injury, followed by knee internal derangement (12.9%) and acromioclavicular joint injury (6.8%). In practices, concussions (13.2%), pelvis or hip muscle-tendon strains (12.0%), and foot contusions (7.2%) were the most predominant injuries. A participant was almost 11 times as likely to sustain an internal derangement of the knee in a game than in a practice (1.63 versus 0.15 per 1000 A-Es, rate ratio = 10.9, 95% CI = 5.4, 22.0) and more than 8 times as likely to receive a concussion in a game than in a practice (2.72 versus 0.33 per 1000 A-Es, rate ratio = 8.2, 95% CI = 5.0, 13.5).

Mechanism of Injury

The 3 primary injury mechanisms—player contact, other contact (eg, pucks, boards, ice), and no contact (ie, no direct contact to the injured body part)—in games and practices with division and years combined are presented in Figure 2. The majority of game injuries (48.1%) resulted from player contact. Another 40.9% of game injuries resulted from other contact. Practice injuries were primarily associated with no direct contact or other contact.

Severe Injuries: 10+ Days of Activity Time Loss

Due to the limited number of years available for analysis and the resulting small cell size, we were unable to generate a table of injuries that restricted activities for 10 or more days. Approximately 27% of game and 11% of practice injuries restricted participation for at least 10 days. The most common injury mechanism for severe injuries, particularly in games, was player contact.

Game Injuries

The mechanisms of injury specific to women's ice hockey in games over all years are shown in Figure 3. Player contact accounted for 46.8% of all game injuries, whereas contact with the boards or ice surface accounted for another 31.9%. Contact with the stick or puck accounted for 9.5% of game injuries.

A nonsignificant upward trend in game concussion rates was noted over the 4 years ($P = .96$, data not shown). Game con-

Table 3. Games and Practices With Associated Injury Rates by National Collegiate Athletic Association Division and Season, Women's Ice Hockey, 2000–2001 Through 2003–2004*

	Total No. of Games Reported	Game Injury Rate per 1000 Athlete-Exposures	95% Confidence Interval	Total No. of Practices Reported	Practice Injury Rate per 1000 Athlete-Exposures	95% Confidence Interval
Division I						
Preseason	15	10.7	0.0, 22.8	220	4.0	2.2, 5.9
In season	504	13.9	11.4, 16.3	1199	2.1	1.5, 2.6
Postseason	35	14.8	5.1, 24.5	86	1.1	0.0, 2.6
Total Division I	554	14.2	11.9, 16.6	1505	2.5	2.0, 3.1
Division II						
Preseason	1	0.0	N/A	27	8.1	1.0, 15.3
In season	87	7.2	3.1, 11.3	204	1.6	0.4, 2.8
Postseason	N/A	N/A	N/A	N/A	N/A	N/A
Total Division II	88	7.1	3.1, 11.2	231	2.4	1.0, 3.8
Division III						
Preseason	7	8.7	0.0, 25.7	295	4.0	2.4, 5.6
In season	503	12.8	10.4, 15.1	1119	2.6	1.9, 3.3
Postseason	23	4.6	0.0, 11.0	53	—	—
Total Division III	533	12.3	10.0, 14.6	1467	2.8	2.2, 3.4
All Divisions						
Preseason	23	9.6	0.2, 19.1	542	4.2	3.0, 5.4
In season	1094	12.8	11.2, 14.4	2522	2.3	1.9, 2.7
Postseason	58	10.6	4.3, 16.8	139	0.7	0.0, 1.6
Total	1180	12.6	11.1, 14.1	3208	2.5	2.1, 2.9

*Wald χ^2 statistics from negative binomial model: game injury rates did not differ among divisions ($P = .22$) or within season ($P = .62$). Practice injury rates did not differ among divisions ($P = .98$) but did differ within season ($P < .01$). N/A indicates not applicable. Postseason sample sizes are much smaller (and have a higher variability) than preseason and in season sample sizes because only a small percentage of schools participated in the postseason tournaments in any sport, and not all of those were a part of the Injury Surveillance System sample. Numbers do not always sum to totals because of missing division or season information.

Table 4. Percentage of Game and Practice Injuries by Major Body Part, Women's Ice Hockey, 2000–2001 Through 2003–2004

Body Part	Games	Practices
Head/neck	25.4	16.2
Upper extremity	30.3	22.2
Trunk/back	11.4	26.4
Lower extremity	31.8	31.1
Other/system	1.1	4.2

cussion rates increased from 1.8 per 1000 A-Es in the 2000–2001 season to 3.6 per 1000 A-Es in the 2003–2004 season. The specific mechanism of game concussions over all years is displayed in Figure 4. Player contact was the primary mechanism for concussions, followed by contact with the ice and contact with the boards or glass.

The weighted game position played at time of injury is presented in Figure 5. This analysis of injury by position was adjusted (weighted) for the fact that there are usually 3 forwards, 2 defense players, and 1 goalie on the ice at any time. Injuries were distributed equally between defense players and forwards.

The athletes' general location on the ice at the time of the game injury is shown in Figure 6. The areas of injury were distributed fairly equally among the corner, in front of the goal, between the blue line and the face-off circle, and the neutral zone.

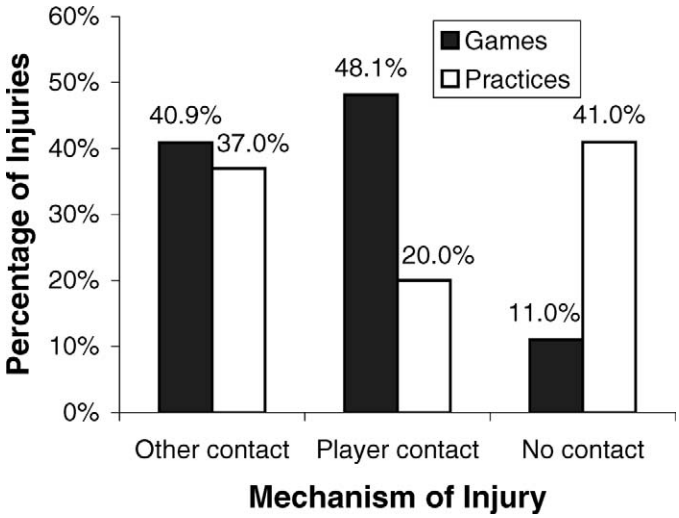

Figure 2. Game and practice injury mechanisms, all injuries, women's ice hockey, 2000–2001 through 2003–2004 (n = 264 game injuries and n = 167 practice injuries). "Other contact" refers to contact with items such as pucks, boards, or the ice. Injury mechanism was unavailable for 2% of practice injuries.

COMMENTARY

We hypothesize that during the 4-year sample period, several factors may have contributed to the variances seen in the data. Because women's ice hockey is an emerging sport, the level of skill of the players in the early years may not be consistent, and the variance in skill level between the top teams and the bottom teams is probably great. The less-skilled players may have found themselves in certain injury scenarios because they were unskilled skaters, not very familiar with the game, or not accustomed to competitive play. The improved

Table 5. Most Common Game and Practice Injuries, Women's Ice Hockey, 2000–2001 Through 2003–2004

Body Part	Injury Type	Frequency	Percentage of Injuries	Injury Rate per 1000 Athlete-Exposures	95% Confidence Interval
Games					
Head	Concussion	57	21.6	2.72	2.02, 3.43
Knee	Internal derangement	34	12.9	1.63	1.08, 2.17
Shoulder	Acromioclavicular joint injury	18	6.8	0.86	0.46, 1.26
Ankle	Ligament sprain	11	4.2	0.53	0.22, 0.84
Pelvis, hip	Muscle-tendon strain	11	4.2	0.53	0.22, 0.84
Shoulder	Subluxation	9	3.4	0.43	0.15, 0.71
Pelvis, hip	Contusion	7	2.7	0.33	0.09, 0.58
Shoulder	Muscle-tendon strain	6	2.3	0.29	0.06, 0.52
Practices					
Head	Concussion	22	13.2	0.33	0.19, 0.47
Pelvis, hip	Muscle-tendon strain	20	12.0	0.30	0.17, 0.44
Foot	Contusion	12	7.2	0.18	0.08, 0.29
Knee	Internal derangement	10	6.0	0.15	0.06, 0.25
Patella	Patella or patella tendon injury	6	3.6	0.09	0.02, 0.16
Shoulder	Subluxation	6	3.6	0.09	0.02, 0.16
Upper leg	Muscle-tendon strain	6	3.6	0.09	0.02, 0.16
Lower back	Muscle-tendon strain	5	3.0	0.08	0.01, 0.14
Unspecified†	Unspecified	5	3.0	0.08	0.01, 0.14
Wrist	Ligament sprain	4	2.4	0.06	0.00, 0.12

*Only injuries that accounted for at least 2% of all injuries are included.
†"Unspecified" indicates injuries that could not be grouped into existing categories but that were believed to constitute legitimate injuries.

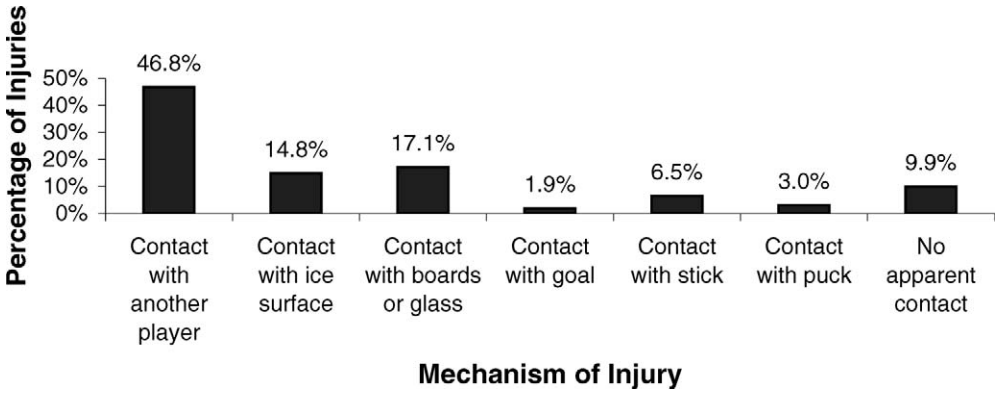

Figure 3. Sport-specific game injury mechanisms, women's ice hockey, 2000–2001 through 2003–2004 (n = 264).

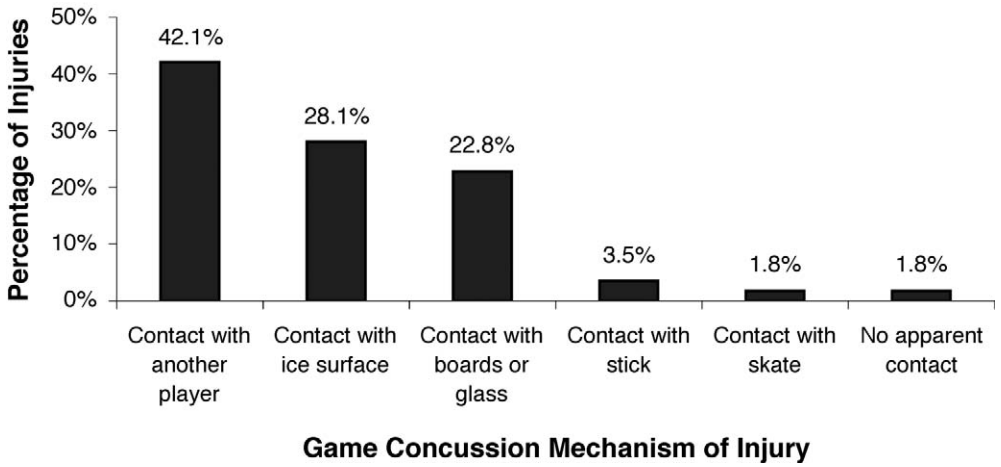

Figure 4. Game concussion injury mechansisms, women's ice hockey, 2000–2001 through 2003–2004 (n = 57).

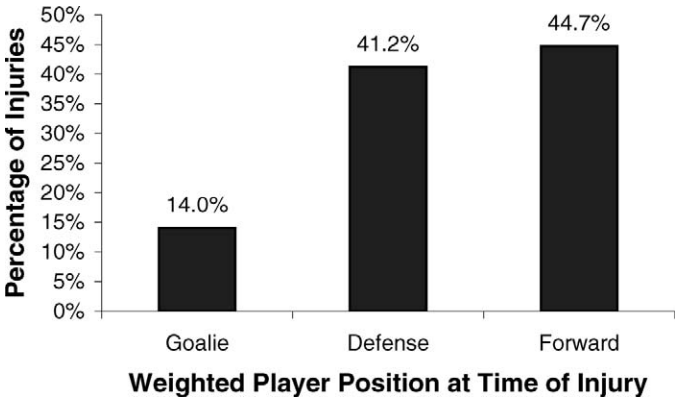

Figure 5. Game injuries by player position, weighted percentages, women's ice hockey, 2000–2001 through 2003–2004 (n = 114).

level of skill and, thus, increased velocity of the game may have created yet another scenario for injuries in later years. Because the skill of players is not a variable that is measured in the ISS, the influence of skill cannot be quantified within these data. In the future, the variance in injury rates should stabilize, allowing for a more reliable injury scenario.

Women's ice hockey is a high-velocity sport that involves player-to-player contact without deliberate body checking. As with most collision sports, the rate of injury is higher in games than in practices. Although body checking is illegal in the women's game, collisions can and do occur, especially near the boards and the goal.

To illustrate the nature of the sport, approximately 50% of all game injuries were reported to result from contact with another player, despite the rule against body checking. Nearly all of the remaining game injuries resulted from contact with the boards or contact with the ice. We are unable to determine from the data if these injuries followed contact with another player before contact with the boards or the ice. Practice injuries rarely resulted from player contact. Equipment and basic game play are similar in women's and men's ice hockey.

Concussions were the most common injury sustained in practices as well as in games. The upward trend in the rate of game concussions in women's ice hockey is of great concern. However, it is possible that the increase in concussions may be due, at least in part, to improvements in self-reporting and detection of mild concussions among women players. Another explanation for the increased rate may be a greater variation in the players' abilities to withstand player-to-player contact. Many of today's collegiate women ice hockey players began their play with boys' teams as youth players. If they played on a boys' team beyond 12 years of age, these women gained experience with body checking. Coaches taught body checking, including proper technique for checking as well as for ''taking'' a body check. Thus, participation on these boys' teams may also have fostered aggressiveness toward body contact. Other women collegiate players may have spent their entire formative years on girls' teams, where body checking is not taught. As a result, players who have great variations in their experiences with body contact were on the ice at the same time. The comparison of injury risks in these groups may warrant future investigations.

The relatively high rate of concussions in games and the high number of player-contact injuries relative to other mechanisms raise the question regarding the effectiveness of the current rules against body checking. The introduction of body checking into youth hockey has been debated in the literature.[4–6] The evidence indicates that both overall injury and concussion rates increase when body checking is introduced, and overall rates continue to increase as the competition level progresses.[5,6] (We caution readers, however, that the concussion rates reported here may be unstable due to small numbers.) The difference in game concussion rates between men's (9%) and women's (21%) ice hockey may reflect the occurrence of unanticipated checking in the women's game. In addition, the severity of, and possible morbidity associated with, concussion also warrant research into the mechanisms leading to this difference.

It is also possible that inconsistent enforcement of the rules resulted in this higher incidence of concussions. Of the 57 concussions, 18 resulted from plays in which a penalty was called. Unfortunately, we have no information regarding rule violations on the other plays in which concussions were sustained. If the rule prohibiting body checking is enforced inconsistently, players will have different expectations regarding body contact. Some players may be not prepared for body contact if they feel the rules will protect them from getting hit by another player.

Future researchers in this emerging collegiate sport need to focus on enhanced data collection. Determining the mecha-

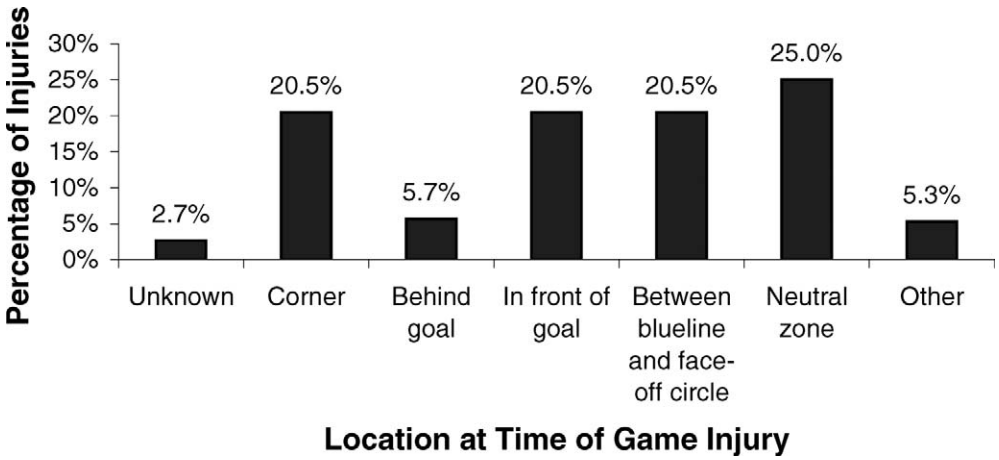

Figure 6. Location at time of game injury, women's ice hockey, 2000–2001 through 2003–2004 (n = 264).

nism of injury that causes concussions as well as other injuries, particularly if these injuries result from illegal body checking, is important. Reviewing game films and encouraging detailed reporting by certified athletic trainers should provide very useful data. Assessing players' experiences with body checking as youth players also would be helpful. This information would allow a more complete evaluation regarding the effectiveness of the current regulations prohibiting body checking in women's ice hockey.

DISCLAIMER

The conclusions in the Commentary section of this article are those of the Commentary authors and do not necessarily represent the views of the National Collegiate Athletic Association.

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