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Descriptive Epidemiology of Collegiate Men's Ice Hockey Injuries: National Collegiate Athletic Association Injury Surveillance System, 1988–1989 Through 2003–2004

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Objective: To review 16 years of National Collegiate Athletic Association (NCAA) injury surveillance data for men's ice hockey and to identify potential areas for injury prevention initiatives.

Background: The NCAA began injury surveillance of men's ice hockey during the 1988–1989 academic year. These data represent all 3 NCAA divisions; the last Division II championship, however, was held during the 1998–1999 academic year.

Main Results: The rate of injury was more than 8 times higher in games than in practices (16.27 versus 1.96 injuries per 1000 athlete-exposures [A-Es], rate ratio = 8.3, 95% confidence interval [CI] = 7.9, 8.8). A significant average annual increase of 1.3% in game injury rates occurred over the sample period ($P = .05$), but practice rates stayed static ($P = .77$). Preseason practice injury rates were more than twice as high as regular-season practice rates (5.05 versus 1.94 injuries per 1000 A-Es, rate ratio = 2.6, 95% CI = 2.4, 2.9, $P < .01$). The majority of game and practice injuries occurred to the lower extremity. Knee internal derangement (13.5%) was the most common lower extremity injury reported for games, whereas pelvis and hip muscle strains (13.1%) were the most common injury reported during practices. Player-to-player contact was the most frequent game mechanism of injury (50.0%). The majority of injuries occurred between the blue line and face-off circles (28.0%), in the corner (23.5%), and in the neutral zone (21.4%).

Recommendations: Preventive efforts should focus on strategies that limit player-to-player contact in the neutral zone and at the top of the offensive and defensive zones. In addition, clinicians and researchers should identify risk factors and interventions for muscle strains at the pelvis and hip region.

Key Words: athletic injuries, injury prevention, knee injuries, pelvis injuries, hip injuries

The National Collegiate Athletic Association (NCAA) conducted its first men's ice hockey championship in 1974. In the 1988–1989 academic year, 126 schools were sponsoring varsity men's ice hockey teams, with 3842 participants. By 2003–2004, although the number of participants dropped slightly to 3782, the number of varsity teams had increased 6% to 134.[1] Slight participation growth during this time was apparent in Divisions I and III, whereas Division II held its last championship in the sport in the 1998–1999 academic year.

SAMPLING AND METHODS

Over the 16-year period from 1988–1989 through 2003–2004, an average of 24.7% of schools sponsoring varsity men's ice hockey programs participated in annual NCAA Injury Surveillance System (ISS) data collection (Table 1). The number of sponsoring schools in Division II declined over the sampling period, with the result that in some years, no Division II schools contributed data to the ISS. 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 3 divisions averaged a similar number of game and practice participants annually. However, Division I averaged 11 more practices and 5 more games than Division II and 28 more practices and 11 more games 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. A significant average annual increase in game injury rates (1.3%, $P = .05$) occurred over the sample period. Over the 16 years of the study, the rate of injury was more than 8 times higher in games than in practices (16.27 versus 1.96 injuries per 1000 athlete-exposures [A-Es], rate ratio = 8.3, 95% CI = 7.9, 8.8). Practice injury rates remained static ($P = .77$).

The total number of games and practices and associated injury rates, collapsed over years, by division and season (pre-

Table 1. School Participation Frequency (in Total Numbers) by Year and National Collegiate Athletic Association (NCAA) Division, Men's Ice Hockey, 1988–1989 Through 2003–2004*

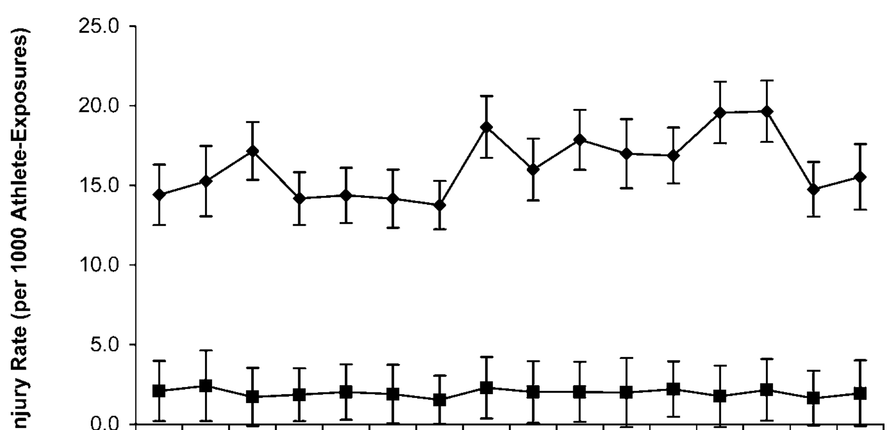
Academic Year	Division I Schools		Division II Schools		Division III Schools		All Divisions		
	Participating	Sponsoring	Participating	Sponsoring	Participating	Sponsoring	Participating	Sponsoring	Percentage
1988–1989	10	48	4	16	9	62	23	126	18.3
1989–1990	9	48	1	15	11	60	21	123	17.1
1990–1991	14	48	4	15	17	60	35	123	28.5
1991–1992	17	50	3	14	14	59	34	123	27.6
1992–1993	15	51	1	12	17	58	33	121	27.3
1993–1994	15	51	2	13	12	59	29	123	23.6
1994–1995	18	50	4	13	21	59	43	122	35.2
1995–1996	17	50	3	13	12	60	32	123	26.0
1996–1997	13	51	5	13	14	63	32	127	25.2
1997–1998	15	52	3	13	15	64	33	129	25.6
1998–1999	9	53	2	12	13	66	24	131	18.3
1999–2000	17	53	1	7	18	66	36	126	28.6
2000–2001	15	58	1	7	19	67	35	132	26.5
2001–2002	16	59	0	7	19	68	35	134	26.1
2002–2003	14	60	0	7	19	68	33	135	24.4
2003–2004	5	58	5	7	13	68	23	134	17.2
Average	14	53	2	12	15	63	31	127	24.7

*"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, Men's Ice Hockey, 1988–1989 Through 2003–2004

Division	Games	Athletes per Game	Practices	Athletes per Practice
I	36	19	95	26
II	31	19	84	26
III	25	19	67	26

season, in season, and postseason) are presented in Table 3. Over the 16-year period, 4673 injuries from more than 14 000 games and 1966 injuries from more than 38 000 practices were reported. Game injury rates did differ among divisions ($P <$ .01; Division III had lower rates than Division I) but practice injury rates did not ($P =$ .09). Preseason practice injury rates were more than twice as high as in-season practice rates (5.05 versus 1.94 injuries per 1000 A-Es, rate ratio = 2.6, 95% CI = 2.4, 2.9, $P <$ .01). In-season game injury rates were higher than those in the postseason (16.27 versus 11.91 injuries per 1000 A-Es, rate ratio = 1.4, 95% CI = 1.2, 1.6, $P <$ .01).



	88-89	89-90	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04
Game injury rate	14.4	15.3	17.2	14.2	14.4	14.2	13.8	18.7	16.0	17.9	17.0	16.9	19.6	19.7	14.8	15.5
Practice injury rate	2.1	2.4	1.7	1.9	2.0	1.9	1.5	2.3	2.0	2.0	2.0	2.2	1.8	2.2	1.6	1.9

Academic Year

Figure 1. Injury rates and 95% confidence intervals per 1000 athlete-exposures by games, practices, and academic year, men's ice hockey, 1988–1989 through 2003–2004 (n = 4673 game and 1966 practice injuries). Game time trend, P = .05. Average annual change in game injury rate = 1.3% (95% confidence interval = 0.0, 2.5). Practice time trend, P = .77. Average annual change in practice injury rate = −0.2 (95% confidence interval = −1.6, 1.2).

Table 3. Game and Practices With Associated Injury Rates by National Collegiate Athletic Association Division and Season, Men's Ice Hockey, 1988–1989 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	186	15.94	11.84, 20.05	2587	5.18	4.65, 5.71
In season	7027	18.24	17.52, 18.96	16 283	1.52	1.40, 1.62
Postseason	544	12.46	10.32, 14.61	1213	0.73	0.43, 1.04
Total Division I	7757	17.77	17.10, 18.45	20 083	1.98	1.86, 2.10
Division II						
Preseason	25	4.21	0.00, 10.05	565	4.58	3.53, 5.63
In season	988	17.74	15.85, 19.64	2247	1.46	1.15, 1.78
Postseason	57	18.12	10.18, 26.06	133	0	N/A
Total Division II	1070	17.55	15.73, 19.36	2945	2.05	1.73, 2.38
Division III						
Preseason	149	7.30	4.18, 10.42	3039	4.29	3.84, 4.73
In season	5532	14.60	13.87, 15.32	11 712	1.34	1.21, 1.47
Postseason	422	10.36	8.15, 12.58	1026	0.70	0.37, 1.02
Total Division III	6103	14.12	13.44, 14.80	15 777	1.91	1.78, 2.04
All Divisions						
Preseason	360	11.59	9.07, 14.11	6191	5.05	4.58, 5.52
In season	13 547	16.72	16.22, 17.22	30 242	1.94	1.82, 2.05
Postseason	1023	11.91	10.39, 13.44	2372	1.27	1.15, 1.39
Total	14 943	16.27	15.80, 16.73	38 820	1.96	1.87, 2.04

*Wald χ^2 statistics from negative binomial model: game injury rates differed among divisions ($P < .01$) and within season ($P < .01$). Practice injury rates did not differ among divisions ($P = .09$) but did differ within season ($P < .01$). 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. N/A indicates not applicable.

Table 4. Percentage of Game and Practice Injuries by Major Body Part, Men's Ice Hockey, 1988–1989 Through 2003–2004

Body Part	Games	Practices
Head/neck	15.4	10.3
Upper extremity	34.4	24.9
Trunk/back	14.3	26.4
Lower extremity	34.3	35.9
Other/system	1.6	2.5

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. More than one third of all game (34.3%) and practice (35.9%) injuries were to the lower extremity. Upper extremity (34.4%) and head/neck injuries (15.4%) accounted for the majority of other game injuries, whereas the upper extremity (24.9%) and trunk/back (26.4%) were commonly injured during practice.

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 1% of reported injuries over the 16-year sampling period are shown. In games, knee internal derangements (13.5%), concussions (9.0%), acromioclavicular joint injuries (8.9%), upper leg contusions (6.2%), and pelvis and hip muscle strains (4.5%) accounted for the majority of injuries. In practices, pelvis and hip muscle strains accounted for 13.1% of reported injuries, followed by knee internal derangements (10.1%), ankle ligament sprains (5.5%), and concussions (5.3%). A participant was much more likely to receive any of these injuries in games (eg, more than 14 times more likely to receive a concussion in a game than in a practice [1.47 versus 0.10 injuries per 1000 A-Es, rate ratio = 14.7, 95% CI = 11.9, 18.2], 11 times more likely to sustain a knee internal derangement in a game [2.20 versus 0.20 injuries per 1000 A-Es, rate ratio = 11.0, 95% CI = 9.4, 12.9], and almost 3 times as likely to sustain a pelvis or hip muscle strain in a game [0.73 versus 0.26 injuries per 1000 A-Es, rate ratio = 2.8, 95% CI = 2.3, 3.4]).

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 greatest number of game injuries (50.0%) resulted from player contact. Another 40.0% of game injuries resulted from other contact, primarily contact with the boards, stick, or puck. Practice injuries were distributed equally among the 3 categories.

Severe Injuries: 10+ Days of Activity Time Loss

The top injuries that resulted in at least 10 consecutive days of restricted or total loss of participation and their primary injury mechanisms combined across divisions and years are shown in Table 6. For this analysis, time loss of 10+ days was considered a measure of severe injury. Approximately 26% of game and practice injuries restricted participation for at least 10 days. In both games and practices, knee internal derangement by far accounted for the highest percentage of these more severe injuries (26.2% of game and 18.6% of prac-

Table 5. Most Common Game and Practice Injuries, Men's Ice Hockey, 1988–1989 Through 2003–2004*

Body Part	Injury Type	Frequency	Percentage of Injuries	Injury Rate per 1000 Athlete-Exposures	95% Confidence Interval
Games					
Knee	Internal derangement	632	13.5	2.20	2.03, 2.37
Head	Concussion	422	9.0	1.47	1.33, 1.61
Shoulder	Acromioclavicular joint injury	418	8.9	1.45	1.32, 1.59
Upper leg	Contusion	292	6.2	1.02	0.90, 1.13
Pelvis, hip	Muscle-tendon strain	209	4.5	0.73	0.63, 0.83
Ankle	Ligament sprain	187	4.0	0.65	0.56, 0.74
Shoulder	Ligament sprain	170	3.6	0.59	0.50, 0.68
Pelvis, hip	Contusion	111	2.4	0.39	0.31, 0.46
Shoulder	Subluxation	96	2.1	0.33	0.27, 0.40
Clavicle	Ligament sprain	80	1.7	0.28	0.22, 0.34
Chin	Laceration	74	1.6	0.26	0.20, 0.32
Shoulder	Contusion	73	1.6	0.25	0.20, 0.31
Foot	Contusion	72	1.5	0.25	0.19, 0.31
Shoulder	Muscle-tendon strain	65	1.4	0.23	0.17, 0.28
Ribs	Contusion	64	1.4	0.22	0.17, 0.28
Knee	Contusion	59	1.3	0.21	0.15, 0.26
Lower back	Muscle-tendon strain	56	1.2	0.19	0.14, 0.25
Unspecified†	Unspecified	56	1.2	0.19	0.14, 0.25
Upper leg	Muscle-tendon strain	56	1.2	0.19	0.14, 0.25
Shoulder	Dislocation	55	1.2	0.19	0.14, 0.24
Hand	Fracture	53	1.1	0.18	0.13, 0.23
Wrist	Ligament sprain	53	1.1	0.18	0.13, 0.23
Patella	Patella or patella tendon injury	48	1.0	0.17	0.12, 0.21
Practices					
Pelvis, hip	Muscle-tendon strain	257	13.1	0.26	0.22, 0.29
Knee	Internal derangement	198	10.1	0.20	0.17, 0.22
Ankle	Ligament sprain	109	5.5	0.11	0.09, 0.13
Head	Concussion	105	5.3	0.10	0.08, 0.12
Shoulder	Acromioclavicular joint injury	86	4.4	0.09	0.07, 0.10
Lower back	Muscle-tendon strain	83	4.2	0.08	0.06, 0.10
Upper leg	Contusion	74	3.8	0.07	0.06, 0.09
Upper leg	Muscle-tendon strain	71	3.6	0.07	0.05, 0.09
Shoulder	Ligament sprain	48	2.4	0.05	0.03, 0.06
Unspecified†	Unspecified	41	2.1	0.04	0.03, 0.05
Shoulder	Subluxation	38	1.9	0.04	0.03, 0.05
Pelvis, hip	Contusion	33	1.7	0.03	0.02, 0.04
Foot	Contusion	31	1.6	0.03	0.02, 0.04
Shoulder	Contusion	27	1.4	0.03	0.02, 0.04
Patella	Patella or patella tendon injury	26	1.3	0.03	0.02, 0.04
Shoulder	Dislocation	25	1.3	0.02	0.02, 0.03
Knee	Contusion	23	1.2	0.02	0.01, 0.03
Finger(s)	Fracture	20	1.0	0.02	0.01, 0.03
Hand	Fracture	20	1.0	0.02	0.01, 0.03
Wrist	Fracture	20	1.0	0.02	0.01, 0.03
Wrist	Ligament sprain	20	1.0	0.02	0.01, 0.03
Ankle	Contusion	19	1.0	0.02	0.01, 0.03
Shoulder	Muscle-tendon strain	19	1.0	0.02	0.01, 0.03

*Only injuries that accounted for at least 1% of all injuries are included.
†"Unspecified" indicates injuries that could not be grouped into existing categories but that were believed to constitute reportable injuries.

tice severe injuries). Acromioclavicular joint injuries accounted for 12.7% of game and 7.6% of practice severe injuries. Concussions accounted for 6.6% of severe game injuries, primarily from player contact.

Game Injuries

The more specific mechanisms of game injury over all years are displayed in Figure 3. Player contact was associated with 47.7% of all reported game injuries. Contact with the boards or glass was involved in another 21.6%. Contact with the stick (6.4%) or puck (7.0%) were other injury mechanisms. Injuries due to contact with the goal were minimal.

The specific mechanisms of game concussions over all years are presented in Figure 4. Most concussions resulted from player contact (60.2%) or contact with the boards or glass (26.3%).

The weighted game position played at time of injury is shown in Figure 5. For weighting purposes, it was assumed that 3 forwards, 2 defense players, and 1 goalie were on the

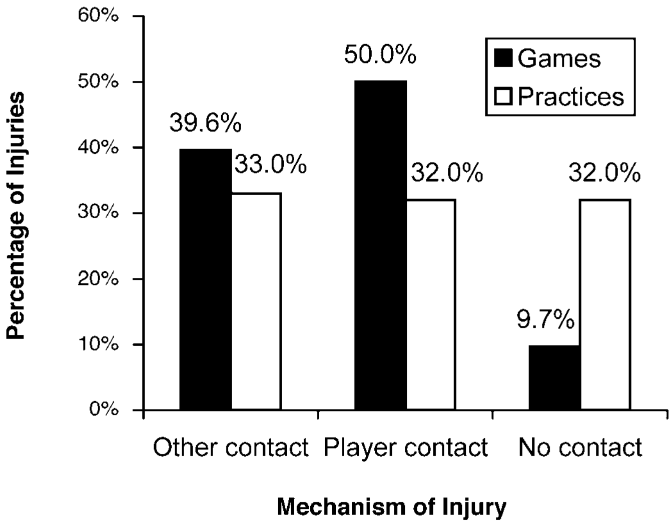


Figure 2. Game and practice injury mechanisms, all injuries, men's ice hockey, 1988–1989 through 2003–2004 (n = 4673 game and 1966 practice injuries). "Other contact" refers to contact with items such as pucks, boards, or the ice. Injury mechanism was unavailable for 1% of game injuries and 2% of practice injuries.

ice at any one time. The majority (48.3%) of the game injuries affected forwards.

The time of game when injuries occurred is displayed in Figure 6. Approximately 36% of game injuries occurred in each of the second and third periods.

The general location on the ice at the time of the game injury is presented in Figure 7. Injuries occurring between the blue line and face-off circle accounted for 28.0% of all injuries, followed by those occurring in the corner (23.5%) and in the neutral zone (21.4%). It should be noted that these data were not collected until the 1991–1992 season.

COMMENTARY

These data demonstrate a unique injury pattern in men's collegiate ice hockey. Game injury rates significantly increased over time, whereas practice injury rates remained stable. The 3 most common injuries reported for practice sessions were pelvis or hip muscle strains, followed by knee internal derangements and ankle sprains. In games, knee internal derangements, concussions, and acromioclavicular sprains were the 3 most frequent injuries. Player contact was the most typical mechanism of injury in general and for concussions in particular. Most injuries occurred between the face-off circles.

Our results are similar to those involving men's collegiate ice hockey injuries as reported by previous authors[3,4] when similar injury and exposure definitions were used. Our overall game injury rate of 16.3 per 1000 A-Es in this analysis was slightly lower than the injury rate (20.0 per 1000 A-Es) reported by Pelletier et al[4] and slightly higher than that reported by Flik et al[3] (13.8 per 1000 A-Es). Hayes[5] published one of the first reports on college ice hockey injuries and found an injury rate of 30.8 per 1000 game A-Es, but he used a more inclusive definition of injury. Injury rates also vary when game-hours of exposure are used instead of A-Es as defined in this study and others.[6,7] Smith et al[6] reported injury rates of 30.3 and 49.7 per 1000 hours of game-exposures for junior varsity and varsity high school hockey players, respectively. Molsa et al[7] noted considerably higher rates of injury (54.0 to 83.0) per 1000 game-hours of exposure in elite Finnish hockey players but included any injury, including those classified as non–time loss. A recent report demonstrated[8] that non–time-loss injury rates may be between 4 and 5 times higher than time-loss injury rates for other collision sports, such as collegiate football and soccer,[7] and a similar disparity may exist in ice hockey.

To our knowledge, these data represent the first comparison of changes over time in annual game and practice injury rates in collegiate ice hockey. A significant increase was seen in game injury rates but not in practice rates. We can only speculate about the reason for this difference, but it may be related to the increased emphasis on strength training and player size. Bigger and stronger players increase the forces involved in collisions, which may account for the game injury rates. The intensity of practices may be lower and may involve more flow drills rather than game situations, which may account for the nonsignificant change in practice rates. Players may be less inclined to apply open-ice body checks to teammates during scrimmages and practices than to opponents during games.

Within-season injury rates were significantly different for both games and practices among the preseason, in season, and postseason. Most notable was the difference between presea-

Table 6. Most Common Game and Practice Injuries Resulting in 10+ Days of Activity Time Loss, Men's Ice Hockey, 1988–1989 Through 2003–2004

Body Part	Injury Type	Frequency	Percentage of Severe Injuries	Most Common Injury Mechanism(s)
Games (26.5% of all injuries required 10+ days of time loss)				
Knee	Internal derangement	325	26.2	Player contact
Shoulder	Acromioclavicular joint injury	158	12.7	Other contact,* player contact
Head	Concussion	82	6.6	Player contact
Other		675	54.4	
Total		1240		
Practices (25.4% of all injuries required 10+ days of time loss)				
Knee	Internal derangement	93	18.6	Player contact
Shoulder	Acromioclavicular joint injury	38	7.6	Player contact
Ankle	Ligament sprain (incomplete tear)	35	7.0	Player contact
Pelvis, hip	Muscle-tendon strain	31	6.2	No contact
Other		303	60.6	
Total		500		

*Indicates contact with boards or glass.

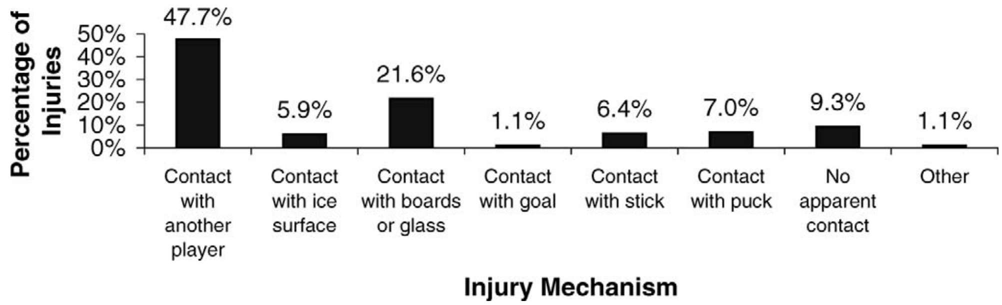


Figure 3. Sport-specific game injury mechanisms, men's ice hockey, 1988–1989 through 2003–2004 (n = 4673). Injury mechanism was not available for all injuries.

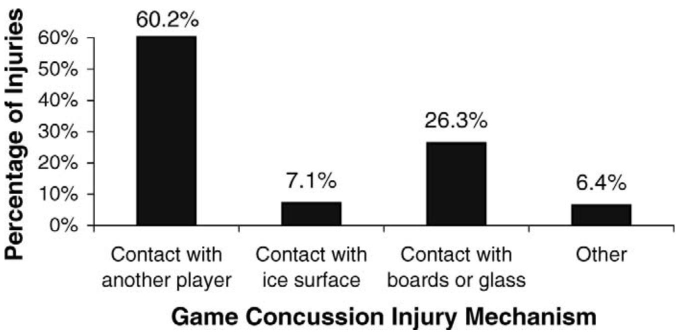


Figure 4. Game concussion injury mechanisms, men's ice hockey, 1988–1989 through 2003–2004 (n = 422).

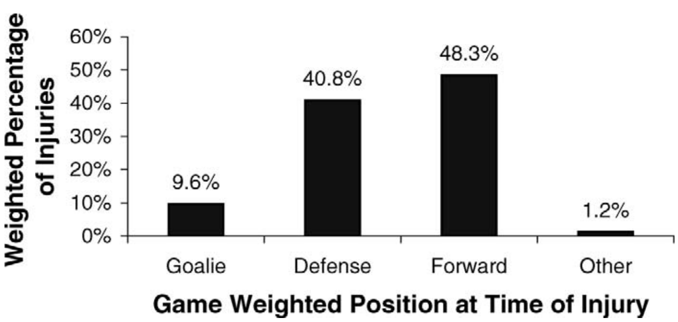


Figure 5. Game injuries by player position, weighted percentages, men's ice hockey, 1988–1989 through 2003–2004 (weighted n = 1967). Percentages of injuries are weighted according to the following distribution of players on the ice during typical play: 3 forwards, 2 defense players, and 1 goalie.

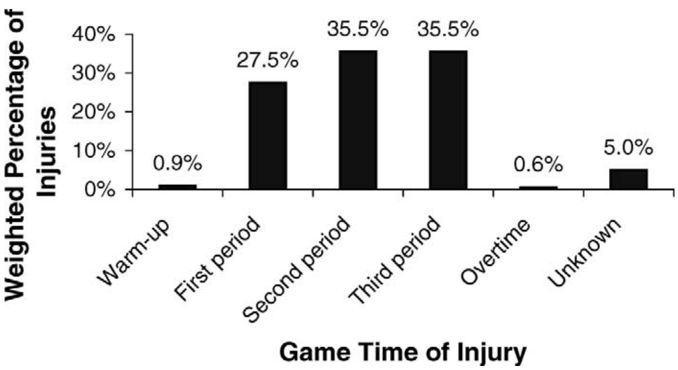


Figure 6. Game time of injury, men's ice hockey, 1988–1989 through 2003–2004 (n = 4673).

son and in-season practice injury rates (5.05 versus 1.94 injuries per 1000 A-Es, rate ratio = 2.6, 95% CI = 2.4, 2.9). This difference may be the result of competition between teammates for starting positions, more intrasquad scrimmages, or other factors. Future researchers should attempt to identify the reasons for this difference. More detailed data collection and more specific analyses would shed light on the potential for preventing these injuries.

These data are consistent with other reports that identified the most commonly injured body parts and injury types, but comparisons are difficult due to differences in the descriptions of body locations and injury types.[3–7,9,10] For example, one group[7] combined ligament sprains and muscle strains into one category, whereas others[4,6] split them into separate categories. These data demonstrate that the most common location and injury during games was knee internal derangement, representing 13.5% of all game injuries. If all knee injuries were classified together, this proportion would be much higher. However, these data are consistent with other reports identifying the knee as the most common site of injury, with percentages ranging from 14.8% to 22%.[3,4,6] Similar reports also suggest that sprains[4] or contusions[6,7] are the most common types of injuries. These data identify contusions as the third most common injury (when all contusions were collated), but even so, contusions likely are underrepresented because many do not require time loss.

The level of detail describing injuries and locations in this study is unique, and as a result, care should be taken when comparing Table 5 with previous reports in the literature. Although concussions are listed in this study as the fourth most common injury for practices and second most common for games, most authors do not report such detailed injury information (ie, typically the frequencies of sprains, strains, and contusions are not reported for each body location).[3,4,6,7,9] If all sprains, contusions, and strains for all body locations from this data were collated, each would represent a far greater proportion of the overall injury frequency. If this is taken into account, then the concussion frequency in Table 5 is consistent with other reports, which have ranged from 3.7% to 14.1%, depending on the level of competition and method of data collection.[4,6,9] The rate of concussion (rate = 0.41 per 1000 A-Es for games and practices combined) is lower than that reported by Benson et al[9] (1.55 per 1000 A-Es). Stuart et al[11] reported even higher concussion injury rates, ranging from 2.9 to 12.2 per 1000 hours of exposure, but the CIs were large, ranging from 0.4 to 10.5 and 3.3 to 31.3, respectively. It is problematic to compare injury rates among studies when the

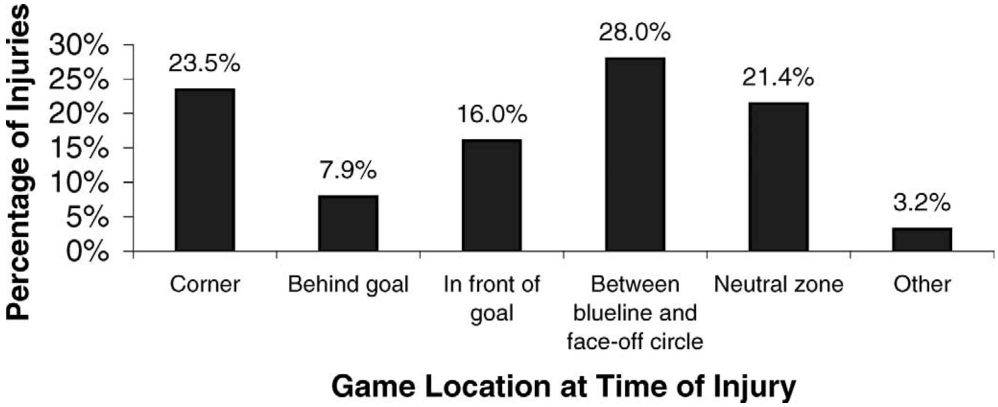


Figure 7. Location at time of game injury, men's ice hockey, 1991–1992 through 2003–2004 (n = 3929). Data on location were not available until the 1991–1992 season.

rates are expressed using A-Es in some studies and game-hours in other studies.

Severity of injury provides useful insights into the morbidity and burden of injury. The most frequent injury resulting in 10 or more days of lost time was knee internal derangement (Table 6). Of all game concussions, 19.4% required 10 or more days of time loss. Acromioclavicular joint injuries, although not as costly in terms of surgical reconstruction when compared with knee internal derangements, represent a significant disruption to the activities of ice hockey players. Manipulating the stick and absorbing checks along the boards are particularly difficult for players with acromioclavicular joint injuries and, therefore, can lead to extended periods of restriction from participation.

These results are also consistent with those of previous researchers who reported that player contact was the most common mechanism of injury during games.[3–5,7,10] It is not surprising that player contact, particularly during games, was the most common mechanism of injury. During practices, players may be less likely to attempt an open-ice check on a teammate, and coaches may specifically discourage that level of intensity. These data also show that forwards are most at risk, accounting for 48.3% of all injuries, even when weighted by position. (Weighted percentages were based on the distribution of player positions during typical play: goalie = 1, forwards = 3, and defense = 2.) These proportions are lower than those reported by Flik et al[3] (61.1%) and Pelletier et al[4] (66.0%) for game injuries.

The unique nature and characteristics of ice hockey make injury prevention a challenge. Hockey players are subjected to high-velocity impacts with players, pucks, sticks, and the unforgiving ice surface and boards. Clinicians must be aware of the physical demands of the sport and the areas of injury prevention that may benefit the athlete. These data indicate several plausible areas of injury prevention and considerations for future research.

Player equipment appears to be effective at preventing specific types of injuries. Contact with the puck and stick represented only 7.0% and 6.4%, respectively, of all injury mechanisms, even though contact with each during a session is common. This suggests that hockey equipment is effective in dissipating some of the forces applied with sticks and pucks but is probably less effective when collisions occur with other players, the boards, or the ice surface. This observation also is supported by the fact that most injuries were sprains, nearly double the frequency of contusions. Few injuries (9.3%) resulted from noncontact mechanisms (ie, no direct contact to the injured body part), suggesting that the majority of sprains were the result of collisions with players, the ice surface, or the boards. The only effective way to reduce injuries caused by contact with another player or with the boards would be to reduce the chances of those collisions occurring, either through changing the environment (eg, rink design, type of glass) or the rules. A variety of rink designs and glass types are installed in ice rinks; future authors will need to determine if any one of the designs is associated with a lower risk of injury.

Fewer player-to-player contacts occur on larger ice surfaces. Wennberg[12] demonstrated that collisions were reduced significantly on both the intermediate (94-ft-wide [28.65-m-wide]) and the large international (100-ft-wide [30.48-m-wide]) ice surfaces compared with the small (85-ft-wide [25.91-m-wide]) ice surface typical in North America. Converting North American ice surfaces to larger sizes would require a significant investment and change in infrastructure, however. These data also demonstrate that a majority of injuries occur in the open ice between the face-off circles, where high-velocity player-to-player impacts are likely to occur. A rule change limiting open-ice checking is another plausible mechanism for reducing player-to-player contact but would change the game drastically and likely would reduce the appeal of hockey for many spectators. Future investigators should seek to provide a cost comparison of the reduction in medical costs from playing on a larger surface versus the cost of converting rinks and also should seek to determine the effect of rule changes on the sport.

Concussions and facial injuries remain a significant concern in ice hockey. Full face protection does not decrease the risk of concussion but does significantly reduce the risk of facial and eye injuries.[11,13] Wennberg and Tator[14] reported that the incidence of concussion more than tripled from the previous decade in the National Hockey League. This is likely the result of better detection and reporting, but concern remains that concussions are underreported at all levels. Further analyses of the NCAA ISS data may provide insights into the year-by-year incidence of concussion in men's collegiate ice hockey, despite the potential reporting bias. Prevention of concussion in ice hockey players is particularly challenging. It is unclear if concussions in hockey are caused by linear accelerations due to direct blows to the head or helmet[15] or if they are caused by rotation-type mechanisms.[16] Future authors should aim to determine the typical mechanisms of concussion in ice hockey. If concussions are more frequently caused by direct contact to the head, without a significant rotational component, further evolution of the protective qualities of the hockey helmet may be warranted.

Although many players are reluctant to wear mouth guards, dental injuries were minimal. Underreporting may be a problem because many of these injuries do not restrict game or practice participation and, therefore, would not meet the ISS time-loss definition. However, these data support the mandatory use of the full face shields and mouth guards in preventing dental injuries. Hawn et al[17] reported that only 63% of ice hockey players surveyed reported consistent use of a mouth guard and that certified athletic trainers do not consistently enforce compliance. Therefore, clinicians should continue to enforce compliance of mouth-guard use in collegiate ice hockey players. Another contributing factor to the low proportion of dental injuries may be the stiff penalties and enforcement for roughing infractions instituted by the NCAA, which have all but eradicated fighting in college hockey.

Muscle strains were the third most frequent injury identified in these data and are a significant cause of morbidity. Emery et al[18] determined that groin and abdominal injuries resulted in about 25 missed games per team per season in National Hockey League players. Injuries to the pelvis and hip were the most common type of muscle strain identified in both practices and games. Muscle imbalances and structural asymmetries are common in ice hockey players due to the frequent rotational forces and collisions to which they are subjected. The early identification and management of imbalances and asymmetries by clinicians may help to minimize the frequency and severity of muscle strains. However, we were unable to identify any research examining risk factors or intervention programs for muscle strains in ice hockey players. Future investigators should identify risk factors and intervention strategies for muscle strains (particularly of the pelvis and hip region) in ice hockey players.

These data demonstrate the importance of injury surveillance programs in men's collegiate ice hockey. From these data, several important injury trends were identified. Future authors should seek to determine the mechanisms responsible for these changes. The nature and forces associated with player-to-player contacts in ice hockey make prevention strategies for injuries such as sprains and concussions elusive, but future researchers should try to determine strategies for reducing player-to-player contacts without drastically changing the nature of the sport. Muscle imbalances and structural asymmetries represent common injuries on which preventive measures may have a direct effect. Future researchers should identify the incidence of these problems and should determine if early identification and interventions reduce the incidence.

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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