

# Spinal Injuries in Canadian Ice Hockey: Documentation of Injuries Sustained from 1943-1999

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**ABSTRACT: Objectives:** Study objectives were: (a) to examine the causes and incidence of major spinal cord injuries sustained by ice hockey players; and (b) to add recently reported Canadian cases to the Canadian Ice Hockey Spinal Injury Registry to determine the effectiveness of prevention efforts. **Methods:** The study was a review of questionnaires returned retrospectively by physicians and other sources reporting ice hockey related spinal injuries in Canada. Physicians reported on the mechanism of injury, vertebral level of injury, presence of neurologic deficit, type of event, and type of fracture. **Results:** Between 1943 and 1999, 271 major spinal injuries were reported in Canadian ice hockey players, of which 49.0% occurred to players 16-20 years of age. Ontario has had a disproportionately large number of injuries compared to some provinces, especially Quebec. Of the spinal cord injuries, 65.8% resulted from colliding with the boards, and 36.6% were due to players being pushed or checked from behind. The recent survey shows that there has been a decline in the number of major spinal cord injuries in Canadian ice hockey, especially those causing paralysis due to checking or pushing from behind. **Conclusions:** Impact of the head with the boards after being checked or pushed from behind was the most common mechanism of spinal cord injury. Injury prevention programs are becoming effective in reducing the overall number of injuries, especially those due to checking from behind. Greater awareness of the occurrence and mechanisms of injury through educational programs and rules changes by organized hockey have reduced the annual incidence of catastrophic spinal injuries in Canadian ice hockey.

**RÉSUMÉ: Blessures à la moelle épinière au hockey sur glace au Canada: blessures subies de 1943 à 1999. Objectifs :** Les objectifs de l'étude étaient les suivants: (a) d'examiner les causes et l'incidence des blessures majeures à la moelle épinière chez les joueurs de hockey sur glace; (b) d'analyser les cas canadiens récents répertoriés dans le registre canadien des blessures médullaires au hockey sur glace pour déterminer l'efficacité des efforts de prévention. **Méthodes :** Il s'agit d'une revue des questionnaires remplis par les médecins et les autres informateurs rapportant des blessures médullaires subies dans la pratique du hockey sur glace au Canada. Les médecins rapportaient le mécanisme de la blessure, le niveau de la lésion spinale, la présence de déficits neurologiques, le type d'événement et le type de fracture. **Résultats :** Entre 1943 et 1999, 271 blessures spinales majeures ont été rapportées chez des joueurs de hockey sur glace au Canada, dont 49,0% chez des joueurs de 16 à 20 ans. Un nombre disproportionné de cas provenait de l'Ontario si on compare ce chiffre à celui d'autres provinces, en particulier du Québec. Parmi les cas de blessures à la moelle épinière, 65,8% résultaient d'une collision avec la bande et 36,6% d'une mise en échec ou d'un coup provenant de l'arrière. **Conclusions :** L'impact de la tête contre la bande après une mise en échec ou un coup provenant de l'arrière était le mécanisme le plus fréquent de blessures à la moelle épinière. Les programmes de prévention des blessures sont de plus en plus efficaces pour réduire le nombre de blessures, surtout celles dues à la mise en échec de l'arrière. Une prise de conscience de la fréquence de ce type de blessure et une meilleure connaissance des mécanismes en cause par des programmes éducatifs et des changements des règlements du hockey organisé ont diminué l'incidence annuelle des blessures spinales catastrophiques au hockey sur glace au Canada.

Can. J. Neurol. Sci. 2004; 31: 461-466

Sports and recreational injuries represent a significant public concern in terms of impairment of health and financial burden.<sup>1</sup> Participation in such activities has led to a broad range of injuries, including major spinal cord injuries. In many countries, sports and recreation are frequent causes of spinal cord injuries, although the activities leading to spinal injuries differ between countries.<sup>2</sup> For decades, diving has been a leading cause of spinal cord injuries in Canada,<sup>3</sup> and hockey was a rare cause until the late 1970s. During the 1980s and early 1990s, cervical spine injuries suffered in ice hockey increased, and several specific measures were introduced to combat these injuries.<sup>4</sup>

For the past 20 years, research has indicated that the cause of spinal cord injuries in hockey is multifactorial. Increases in aggressiveness, player size and speed have been considered important determining factors resulting in such catastrophic

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RECEIVED MARCH 3, 2004. ACCEPTED IN FINAL FORM JUNE 22, 2004.  
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injuries. Furthermore, despite the increased use of hockey helmets in Canada since the late 1960s, the rates of both spinal and brain injuries have increased.<sup>4,6</sup> It is believed that “the same general mechanisms that cause spinal injuries in ice hockey are also responsible for what appears to be a significantly increased incidence of head injuries and career threatening concussions among North American professional ice hockey players,”<sup>6</sup> although our recent report suggests that increased awareness and reporting are also important factors.<sup>7</sup> In 1981, our group, now named the ThinkFirst-SportSmart Sports and Recreational Injuries Research and Prevention Centre, was the first to identify checking or pushing from behind as a major cause of spinal cord injury in Canadian ice hockey.<sup>8,9</sup> An axial loading force, applied to the helmeted head due to striking another object, especially the boards, was found to be the most common mechanism of spine or spinal cord injury. Collision of the helmeted head with the boards, specifically after the player was checked or pushed from behind into the boards was the most common mechanism of spinal cord injury.

Through continuing and consistent documentation of the burden of spinal injuries in hockey, the current incidence and causes of such injuries can be identified and assessment made of the effectiveness of prevention programs. Furthermore, additional needs can be identified to develop targeted prevention programs to reduce the risk of these catastrophic injuries. This report discusses the findings of the Canadian Ice Hockey Spinal Injury Registry. This Registry was established in 1981 by the Committee on Prevention of Spinal Cord Injuries Due to Hockey and continued by its successor, the ThinkFirst-SportSmart Sports and Recreational Injuries Research and Prevention Centre. The database now contains a total of 271 injuries sustained in Canada from 1943 to 1999. This report describes the 271 cases, the methods of data collection, and the demographic and medical details of the injuries. The present report includes injuries sustained in Canadian ice hockey from 1943 to December 31, 1999, and is an update from the last report that documented injuries to December 31, 1996.<sup>6</sup>

## METHODS

### Identification of Cases

Every two to three years since 1981, we have conducted surveys on a national level to record the incidence and epidemiological features of spinal injury in ice hockey in Canada. Also recorded were the level of injury, extent of any neurological deficit, type of bony injury and type of play. The initial survey, in English and French, was distributed in 1981 to all neurosurgeons, orthopedic surgeons and physical medicine and rehabilitation specialists in Canada, the specialists most likely to treat a patient with a spinal injury in the acute and rehabilitation phases of care. Questions were also asked about the exact mechanisms of injury in order to develop prevention strategies. Cases were also identified in media reports, and these were always corroborated by physician-derived information. Hockey Canada (formerly The Canadian Hockey Association) also collaborated in the data collection by providing information from its records of major injuries recorded for insurance purposes. To qualify for inclusion in the Registry, a spinal or

spinal cord injury had to be a “major injury” defined as a fracture or dislocation of the spine with or without injury to the spinal cord or nerve roots, with or without a permanent neurologic deficit. Minor spinal injuries such as strains, sprains or whiplash were excluded.

### Participation Rates

Information about participation rates were obtained from two sources. These sources include Hockey Canada and the Canadian Adult Recreational Hockey Association (CARHA).

## RESULTS

### Annual Incidence

**Table 1: Annual Number of Spinal Injuries<sup>a</sup>**

Year	Total <sup>b</sup> Injuries	From <sup>c</sup> behind	Cervical/ <sup>d</sup> behind	Cervical <sup>e</sup> cord/behind
1943	1	0	0	0
1959	1	0	0	0
1966	1	0	0	0
1974	1	0	0	0
1975	1	1	1	1
1976	2	0	0	0
1977	2	1	1	1
1978	4	0	0	0
1979	2	0	2	2
1980	8	3	3	2
1981	12	2	1	1
1982	14	5	5	3
1983	13	6	4	2
1984	14	0	0	0
1985	11	5	3	1
1986	16	6	5	2
1987	9	2	2	1
1988	17	8	5	3
1989	16	7	4	4
1990	18	6	3	2
1991	17	4	4	3
1992	18	7	6	4
1993	14	3	3	1
1994	7	2	1	0
1995	17	3	2	1
1996	11	3	0	0
1997	7	3	1	0
1998	4	1	1	1
1999	12	1	0	0
TOTAL	271	79	55	33

<sup>a</sup> Total number of injuries annually and annual number of injuries with checking from behind as a mechanism.

<sup>b</sup> Number of spinal ice hockey injuries.

<sup>c</sup> Number of spinal injuries due to a check from behind.

<sup>d</sup> Cervical spine injuries due to a check from behind.

<sup>e</sup> Cervical cord injuries due to a check from behind (Data for b - e include only those injuries for whom adequate documentation was available).

**Table 2: Provincial Location of Spinal Injuries in Canadian Hockey (1943-1999) and Injury Rates in Each Province Based on Hockey Canada Data**

Location	Total Injuries in each Province (43-99)		Severe Injuries* in each Province (43-99)		Mean Annual Total No. Injuries (43-99)	Mean Annual Total No. Participants (93/94-99/00)	Annual No. Spinal Injuries Per 100,000 Participants
	#	%	#	%			
Ontario	134	49.4	25	18.7	2.35	198,000	1.19
British Columbia	28	10.3	5	17.9	0.49	46,000	1.07
Quebec	28	10.3	12	42.9	0.49	97,000	0.51
Alberta	23	8.5	6	26.1	0.40	58,000	0.69
Saskatchewan	20	7.4	8	40.0	0.35	33,000	1.06
Manitoba	10	3.7	3	30.0	0.18	26,000	0.69
Nova Scotia	9	3.3	4	44.4	0.16	16,000	1.00
New Brunswick	8	3.0	1	12.5	0.14	16,000	0.89
Prince Edward Island	6	2.2	2	33.3	0.11	6,000	1.83
Newfoundland	3	1.1	2	66.7	0.05	10,000	0.50
Yukon	1	0.4	-	-	-	-	-
Visiting Player	1	0.4	-	-	-	-	-
TOTAL	271	100.0	68	100.0			

\*Severe Injuries: CM+CS, CM+IS, CM, as defined in Table 6

**Table 3: Age of Injured Hockey Players**

Age	Frequency	%
11-15	54	21.2
16-20	125	49.0
21-25	20	7.8
26-30	22	8.6
31-35	19	7.5
36-40	9	3.5
41-45	3	1.2
46-50	3	1.2
TOTAL	255	100.0

**Table 4: Type of Collision**

	Frequency	%
Boards	148	65.8
Other Players	33	14.7
Ice	13	5.8
Goal Post	2	0.9
Boards + Players	19	8.4
Players + Ice	5	2.2
Boards + Ice	3	1.3
Boards + Goal Post	1	0.4
Players + Goal Post	1	0.4
TOTAL	225	100.0

**Table 5: Mode of Injury**

Mechanism	Frequency	%
<b>Single Mechanism</b>		
Pushed/checked from behind	74	36.6
Pushed/checked	48	23.7
Tripped on ice	42	19.8
Slide	18	8.9
Tripped by player	7	3.5
<b>Multiple Mechanisms</b>		
Slide + push/check from behind	5	2.5
Tipped on ice + slide	4	2.0
Slide + push/check	3	1.5
Tripped on ice + tripped by player	1	0.5
Tripped on ice + push/check	1	0.5
Trip on ice + slide + trip by player	1	0.5
TOTAL	202	100.0

As can be seen in Table 1, the first recorded case was in 1943. Hockey-related spinal injuries were rare in the 1950s, 1960s and 1970s. It was not until the 1980s that there was a significant increase in the annual number of cases. Then, from 1980, the numbers rose dramatically, and between 1982 and 1999, there were approximately 13 major spinal injuries in hockey per year in Canada. A total of 271 cases have been reported to the Registry up to December 31, 1999.

### Geographic Location

Almost half the injuries that occurred from 1943 to 1999 were in Ontario (49.4%). For other provinces, 10.3% of the injuries occurred in each of British Columbia and Quebec, followed by Alberta (8.5%) and Saskatchewan (7.4%). The other cases were distributed across the country in proportion to the rest of the population (Table 2). Table 2 also shows the number and percentage of severe injuries that occurred in each province. It can be seen that there was a wide range in the percentage of severe injuries among the provinces.

Data were obtained from Hockey Canada about the annual number of registered hockey players in each province for the seven year period from 1993-94 to 1999-2000. During this time frame, there were an average of 410,000 players registered annually with Hockey Canada. The mean number of hockey players in each province was calculated for those years, and used to derive the annual rates of spinal injuries per 100,000 participants in each province. It can be seen that the rate in provinces such as Ontario and British Columbia was twice that in Quebec (Table 2). These numbers, however, omit those players not registered with Hockey Canada. The Canadian Adult Recreational Hockey Association indicated that there were approximately 500,000 to 550,000 adult recreational and old-timer players registered with the CARHA (L. Lopez, personal communication). Thus, the injury rates shown in Table 2 would be reduced by approximately 50% if all the adult recreational players were included.

### Sex and Age

Of the 271 players injured between 1943 and 1999, 264 were male and seven were female. Of the 255 cases with data about age, 49% of the injured players ranged from 16 to 20 years of age ( $n=125$ ) and 21.2% were 11 to 15 years of age ( $n=54$ ). The mean age of the injured players was 20.6 years and the median 18 years. The youngest injured player was 11 years old and the oldest 50 years old (Table 3).

### Mechanism of Injury

Of the 225 cases with adequate documentation, 65.8% of injuries resulted from colliding with the boards. Impact with other players (14.7%), and the ice (5.8%), were other frequent mechanisms of injury. Colliding with the goal post was also recorded (0.9%), but was not a frequent mechanism of injury (Table 4). Of 202 injuries with adequate documentation, the highest percentage, 36.6%, resulted from being pushed or checked from behind. An additional 23.7% of injuries resulted from being pushed or checked, but not from behind. Other modes of injury included players tripping on the ice (19.8%), being tripped by another player (3.5%), and sliding on the ice (8.5%)(Table 5).

### Type of Event

The majority (91%) of the 199 adequately documented cases occurred during supervised, scheduled games within an organized hockey league. A minimal number of injuries occurred during hockey practice (6%) and unstructured or unsupervised events (3%).

### Vertebral Level of Injury

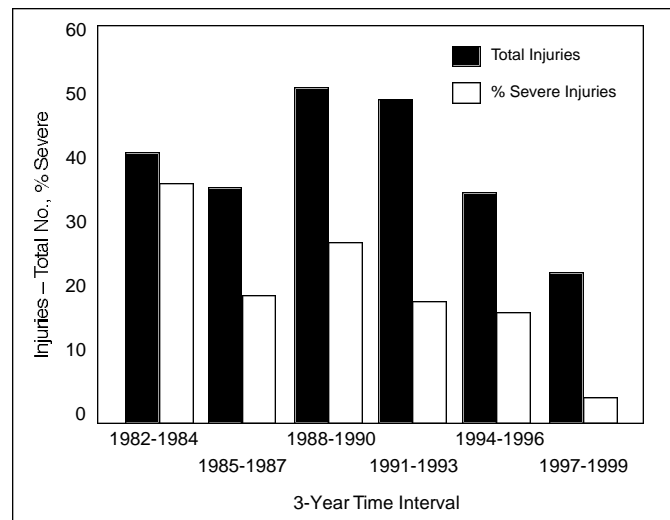
The vertebral level of injury was documented in 236 cases and 83.5% were to the cervical vertebrae (C1-C7/T1), 5.1% were thoracic (T1-T11), 5.9% thoraco-lumbar (T11/12-L1/2) and 5.5% lumbo-sacral (L2-S5).

### Neurologic Deficit

As can be seen in Table 6, of the 245 cases with adequate documentation, 64.9% of the injuries involved the spinal cord, whereas 10.6% of the injuries involved damage to one or more nerve roots without causing cord damage. Thus, about 75% had some form of neurological deficit. Of the players with spinal cord injuries, 47.3% sustained a permanent injury. Approximately one-third of the 271 cases will likely be in wheelchairs for life.

Table 7 shows the annual number of injuries and the annual number of severe injuries for the years 1980-1999, and Table 8 shows the total number of injuries and the number of severe injuries per three-year interval, for the years 1982-1999. Severe injuries included players with complete motor and complete sensory loss, complete motor and incomplete sensory loss or complete motor loss only. The Figure illustrates the total number of injuries and the percent of severe injuries. There was a modest reduction in the annual number of cases and a more marked reduction in the number of severe injuries over time, with the lowest number of severe injuries in the most recent three-year interval, 1997-1999.

A Chi-square analysis showed that there are significant



**Figure:** Total number of injuries and % severe injuries for each three-year interval from 1982 to 1999. The total number and the % of severe injuries are decreasing over time. The definition of severe injuries include those with complete motor and complete sensory loss, complete motor and incomplete sensory loss or complete motor loss only.

**Table 6: Neurological Injuries**

Spinal Cord Injury*	Frequency	%
CM + CS	58	23.7
CM+IS	9	3.7
CM	1	0.4
IM + IS	43	17.6
IM	1	0.4
IS	4	1.6
Transient Sens Loss/Transient Paralysis	43	17.6
SUB-TOTAL	159	64.9
Root Injury Only	26	10.6
No Neurological Deficit	60	24.5
SUB-TOTAL	86	35.1
TOTAL	245	100.0

\* CM=complete motor loss; CS=complete sensory loss; IM=incomplete motor loss; IS=incomplete sensory loss

**Table 7: Numbers of Annual Total and Severe Hockey Spinal Injuries, 1980 - 1999**

Year	Total # of Injuries	Total # of Severe Injuries	% of Severe Injuries
1980	8	4	50.0
1981	12	3	25.0
1982	14	6	42.9
1983	13	4	30.8
1984	14	5	35.7
1985	11	3	27.8
1986	16	1	6.3
1987	9	3	33.3
1988	17	4	23.5
1989	16	6	37.5
1990	18	4	22.2
1991	17	1	5.9
1992	18	5	27.8
1993	14	3	21.4
1994	7	3	42.9
1995	17	3	17.6
1996	11	0	0
1997	7	0	0
1998	4	1	25.0
1999	12	0	0
TOTAL	255	59	23.1

\*Severe Injuries: CM+CS, CM+IS, CM, as defined in Table 6

**Table 8: Numbers of Total and Severe Hockey Injuries per Three-Year Intervals, 1982-1999**

Period	Total Number of Injuries per Period	Number of Severe Injuries per Period	% of Severe Injuries
1982 - 1984	41	15	36.5
1985 - 1987	36	7	19.4
1988 - 1990	51	14	27.5
1991 - 1993	49	9	18.4
1994 - 1996	35	6	17.1
1997 - 1999	23	1	4.3

\*Severe Injuries: CM + CS, CM + IS, CM, as defined in Table 6

differences between the observed and expected frequencies for total, severe and percent of severe injuries over time. There is a significant difference between the observed and expected frequencies for the total number of injuries ( $\chi^2_5=13.50$ ;  $p=0.02$ ), the number of severe injuries ( $\chi^2_5=15.85$ ;  $p=0.01$ ) and the percent of severe injuries ( $\chi^2_5=30.32$ ;  $p=0.00$ ). Indeed, Table 8 shows that there were fewer total and severe injuries from 1988-1990 onward. For the total number of injuries, 1988-1990 and 1991-1993 differ from 1997-1999, illustrating a decline in injuries. In terms of injury severity, there is a contrast between the periods 1982-1984 and 1988-1990, with a reduced number of severe injuries reported in 1997-1999. The percentage of severe injuries in 1982-1984 and 1988-1990 contrast markedly with 1997-1999.

**DISCUSSION**

Ice hockey provides individuals with the opportunity to become physically fit, develop skills, and enhance self-confidence and self-esteem. Hockey is a fast paced and competitive sport, and players put themselves at risk. There is a high potential for injury<sup>10-12</sup> because of collisions, fast moving players and pucks, the blades on the skates, the appropriate and inappropriate use of the hockey stick, and hard surfaces such as the ice, goal posts, and the boards.<sup>13</sup> One survey that examined hockey injuries in an emergency department showed that ice hockey injuries accounted for 1.77% of all visits to a Canadian hospital from October 1985 to March 1986.<sup>14</sup>

Since we first reported an increase in the number of catastrophic spinal injuries in hockey in the 1980s, there has been a heightened awareness of this problem and of the personal and financial costs that can result from a catastrophic spinal injury in ice hockey. It has been shown that there are several etiological factors that contribute to spinal injuries in ice hockey. For example, social and psychological factors play a role. The use of an array of protective equipment such as helmets and visors, and major improvements in the effectiveness of such equipment give athletes a sense of invincibility. In the sport of



football, for example, the introduction of hard-shelled helmets and facemasks in the 1950s increased the risk of player injury.<sup>15</sup> Football players perceived themselves as invulnerable because of their protective equipment and were engaging in dangerous activities such as “spearing,” using their helmeted head to make contact with their opponents. By the 1960s, helmet use in football was resulting in an increased incidence of catastrophic injury among the players at risk.<sup>15</sup> We hypothesize that hockey players also perceive themselves to be invincible and mistakenly believe that wearing protective equipment makes them less vulnerable to injury. For these reasons, they may be more likely to play the game with aggression. With respect to helmet use, there is no evidence to suggest that wearing a helmet is related to spinal injuries in ice hockey. It is possible, however, that there is a relationship between certain design features of helmets and the incidence of spinal injury. For example, there is the possibility that the flat crown of some helmets might predispose to a spinal injury by preventing the head from glancing off the boards, as would likely happen with a helmet that had a rounded crown. There are no scientific data on this point.

Social and psychological factors among young players may also enhance aggression and a sense of invincibility. Success in ice hockey is not only based on skill but also involves physical domination; violent play is often used as a strategy to intimidate opponents. Awareness of aggression is heightening, and efforts are being made to make the game more enjoyable and safer.

Several measures, such as rule changes, educational initiatives and targeted prevention programs, have been implemented in an effort to reduce the number of spinal injuries in ice hockey. ThinkFirst-SportSmart in association with the Canadian Hockey Association (now Hockey Canada) and other agencies have played a major role in the education of players and hockey associations about the prevention of spinal injuries. Prior to 1985, there was no specific rule against pushing or checking from behind. As early as 1981, we identified certain behaviours especially checking or pushing from behind into the boards as major causes of spinal cord injuries in hockey, and as a result the Canadian Hockey Association introduced specific rules in 1985–86 against these injurious behaviors. However, even with appropriate rules in place, there must also be rigorous and consistent enforcement of the rules for effective injury prevention. In many of the cases in the Registry, spinal injury victims were injured during illegal forms of play, such as pushing or checking from behind.<sup>4</sup> Failure of leagues and referees to consistently penalize these illegal plays, especially checking or pushing from behind, has an important impact on player safety. Leagues and referees need to continually reinforce rules and regulations, and penalize players for illegal play. In doing so, players may be more likely to respect the rules of the game, thereby facilitating safer play, and resulting in fewer injuries.

The data presented here indicate that there has been a recent decline in the number of severe spinal cord injuries in Canadian hockey which is highly encouraging. In contrast, the total number of injuries occurring annually showed only a modest decline; this may be due, in part, to increased reporting of the less severe injuries. It is likely that increased awareness of the Registry has led to increased reporting. The awareness factor may be the reason that there are greater numbers from some

provinces such as Ontario as compared with Quebec, and it may also account for the increase in the percent of severe injuries from Quebec as compared to Ontario. Thus, it is possible that increased awareness of the registry by Ontario doctors has led to increased reporting of the less severe injuries, with Quebec doctors tending to report only the more severe injuries (Table 2).

There appears to be real differences in the number of cases per 100,000 participants among the provinces, with Ontario, British Columbia, Saskatchewan and New Brunswick generating twice the injury rate as Quebec (Table 2). The exact reason for the much lower injury rate in Quebec is not known but may be related to improved coaching and less violent hockey in Quebec. Furthermore, data collected by our International Registry indicate that the number of injury cases recorded between the 1943–1999 time period, is much higher in Canada (271 cases) than in the USA (40 cases), most likely due to the increased popularity and increased participation rate of hockey in Canada, but possibly also due to decreased reporting in the USA.

In terms of physical conditioning, inadequate attention to strength training, particularly of muscles that are integral to the sport of hockey, such as neck, trunk and abdominal muscles, has led to injury. As can be seen in this study, hockey players most likely to sustain a spinal injury are those between 16 to 20 years, followed by players between 11 to 15 years of age. It is not clear why these age groups may be more susceptible to injury, but the possibilities include an increase in risk taking behaviours and lack of development of axial musculature. Research has shown that young athletes are being exposed to higher forms of intensity training at an earlier age and, as a result of this, are experiencing overuse injuries, which are more commonly associated with athletes of a higher maturity level.<sup>16</sup> The occurrence of such injuries may be a result of the inability of the immature musculoskeletal system to cope with repetitive biomechanical stress.<sup>16</sup> Lack of education of the players by coaches would result in players not having sufficient knowledge of the risk of incurring injury, specifically spinal injury, in ice hockey, and the appropriate measures that can be taken to protect them. For example, players must be coached about the increased risk of injury in the zone about one meter from the boards.

With respect to players' education, an injury prevention program that included a videotape and Leader's guide entitled, *Smart Hockey with Mike Bossy*, was produced by the ThinkFirst-SportSmart group in 1988. The focus of this video was to educate players about spinal injury and to stress the risk of certain aspects of play such as approaching the boards face first. In 2002, ThinkFirst-SportSmart introduced another injury prevention program entitled “*Smart Hockey: More Safety, More Fun!*” This Smart Hockey update educates players not only about spinal injury but about concussion as well. It includes medical information, training lessons, tips on how to avoid getting injured and causing injury to opponents. The prevention messages are reinforced by personal statements from professional hockey players, team physicians, referees, coaches, physicians and trainers. Approximately 35,000 copies of the English and French versions of *Smart Hockey: More Safety, More Fun!* have been distributed with the endorsement and help of Hockey Canada to leagues, schools and to hockey coaching and safety clinics across Canada. Research has shown that the Smart Hockey program produces an increase in knowledge about

mechanisms of injury and a decrease in injurious behavior.<sup>17</sup> The recent reduction in severe injuries documented in the present report suggests that the combination of these and other injury prevention measures are becoming effective. The STOP program that encourages players to wear a STOP badge on the back of their sweaters may also have played a positive role. The finding that there were only two severe cervical cord injuries from being pushed or checked from behind from 1995 to 1999 is especially noteworthy, whereas there were 11 of these injuries in 1985-89 (Table 1).

The decline in injuries may be a result of the effectiveness of injury prevention initiatives. Future research, however, needs to be conducted to observe a causal relationship between injury prevention programs and a decline in injuries. It also appears that the total annual number of injuries has not declined as much as the severe injuries because less severe injuries are being reported more readily by practitioners due to the greater awareness of the existence of the Registry.

Accurate, ongoing and consistent data collection is an important aspect of injury prevention. In Canada, there are some outstanding examples of the usefulness of specific registries of sports and recreational injuries, such as the Eye Injuries Registry maintained by Dr. Tom Pashby in cooperation with the Canadian Ophthalmological Society.<sup>18</sup> This group has recommended improved eye protection in hockey and other sports, and has reported a marked reduction in the incidence of blind eyes in several sports including hockey following the introduction of protective gear. The Canadian Ice Hockey Spinal Injury Registry has played a similar role and, for the first time in the present report, has reported a reduction in the incidence of major spinal cord injuries in hockey. The concept of an ice hockey spinal injury registry based on the Canadian registry was endorsed by the International Ice Hockey Federation in 1999, with ThinkFirst-SportSmart maintaining the International Ice Hockey Spinal Injury Registry based on data received from all the member countries of the International Ice Hockey Federation.

Catastrophic injuries, specifically spinal injury, have been a major problem in Canadian ice hockey since the 1980s. Research has indicated that the causes of spinal cord injury in hockey are multifactorial. Data indicate that the incidence of severe injuries is declining. This may be due to greater awareness of the mechanisms and demographics of injury, and targeted prevention programs developed by organized hockey. Through continuing education provided by leagues and injury prevention programs, and also through rules changes and rules enforcement, knowledge of safety practices while playing ice hockey will be enhanced, and the incidence of incurring catastrophic spinal injury during ice hockey will be further reduced.

#### ACKNOWLEDGEMENTS

ThinkFirst-SportSmart acknowledges the financial assistance of Hockey Canada, Dr. Tom Pashby Sports Safety Fund, and the Foster Hewitt Foundation, and technical assistance from the Medical Committee of the International Ice Hockey Federation.

#### REFERENCES

- Janda DH. Prevention has everything to do with sports medicine. *Clin J Sport Med* 1992; 2: 159-160.
- Kurtzke JF. Epidemiology of spinal cord injury. *Exp Neurol* 1975; 48: 163-236.
- Tator CH, Edmonds VE, New ML. Diving: a frequent and potentially preventable cause of spinal cord injury. *Can Med Assoc J* 1981; 124: 1323-1324.
- Tator CH, Carson JD, Edmonds VE. New spinal injuries in hockey. *Clin J Sport Med* 1997; 7: 17-21.
- Biasca N, Simmen HP, Bartolozzi AR, et al. Review of typical ice hockey injuries. Survey of the North American NHL and Hockey Canada versus European leagues. *Unfallchirurg* 1995; 98: 283-288.
- Tator CH, Carson JD, Cushman R. Spinal injuries in Canadian ice hockey players, 1966-1996. In: Cantu RC, (Ed). *Neurologic athletic head and spine injuries*. Toronto: W.B. Saunders Company, 2000: 289-296.
- Wennberg RA, Tator CH. National Hockey League reported concussions, 1986-87 to 2001-02. *Can J Neurol Sci* 2003; 30: 206-209.
- Tator CH, Edmonds VE. National survey of spinal injuries in hockey players. *Can Med Assoc J* 1984; 130: 875-880.
- Tator CH, Ekong CEU, Rowed D, et al. Spinal injuries due to hockey. *Can J Neurol Sci* 1984; 11: 34-41.
- Cantu RC, Mueller F. Catastrophic spine injury in football 1977-1989. *J Spinal Disord* 1990; 3: 227-231.
- Gerberich SG, Brust JD, Burns SR, et al. Ice hockey. In: Jordan BD, Tsairis P, Warren RF (Eds). *Sports Neurology*, 2nd ed. Philadelphia: Lippincott-Raven, 1998: 407-421.
- Montelpare WJ, Pelletier RL, Stark RM. Ice hockey. In: Caine DJ, Caine CG, Linder KJ (Eds). *Epidemiology of Sports Injuries*. Champaign, Ill: Human Kinetics, 1996: 41-62.
- Tator CH, Edmonds VE. Acute spinal cord injury: analysis of epidemiological factors. *Can J Surg* 1979; 22: 575-578.
- Carson JD, Reesor D. A survey of hockey injuries in an emergency department. *Mod Med Can* 1988; 43: 145-150.
- Cantu RC. *Neurologic athletic head and spine injuries*. Toronto: W.B. Saunders Company, 2000.
- Gerrard DF. Overuse injury and growing bones: the young athlete at risk. *Br J Sports Med* 1993; 27(1):14-18.
- Cook DJ, Cusimano MD, Tator CH, Chipman ML. Evaluation of the ThinkFirst Canada, Smart Hockey, brain and spinal cord injury prevention video. *Inj Prev* 2003; 9:361-366.
- Pashby TJ. Eye injuries in Canadian sports and recreational activities. *Can J Ophthalmol* 1992; 27:226-229.