ORIGINAL ARTICLE

Neck injuries presenting to emergency departments in the United States from 1990 to 1999 for ice hockey, soccer, and American football

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Objective: To examine the number and rate of neck injuries in the community as a whole for ice hockey, soccer, and American football by analysing data from patients presenting to emergency departments in the United States from 1990 to 1999.

Methods: Data compiled for the US Consumer Product Safety Commission were used to generate estimates for the total number of neck injuries and the more specific diagnoses of neck fractures, dislocations, contusions, sprains, strains, and lacerations occurring nationally from 1990 to 1999. These data were combined with yearly participation figures to generate rates of injury presenting to emergency departments for each sport.

Results: There were an estimated 5038 neck injuries from ice hockey, 19 341 from soccer, and 114 706 from American football. These could be broken down as follows: 4964 contusions, sprains, or strains from ice hockey, 17 927 from soccer, and 104 483 from football; 105 neck fractures or dislocations from ice hockey, 214 from soccer, and 1588 from football; 199 neck lacerations for ice hockey, 0 for soccer, and 621 for football. The rates for total neck injuries and combined neck contusions, sprains, or strains were higher for football than for ice hockey or soccer in all years for which data were available.

Conclusion: The rate of neck injury in the United States was higher in football than in ice hockey or soccer in the time period studied.

American football, ice hockey, and soccer are popular contact sports in North America. Although they are recognised as high risk sports for head injuries in both elite and recreational athletes,[1–24] there has been less research into neck injuries. The literature on neck injuries in these sports has usually focused on catastrophic ones resulting in paralysis or death.[24–31] Both football and ice hockey have had to address such injuries in the past. After it was found that most catastrophic neck injuries in football occurred in tackling players who were hitting opponents with the top of their helmets, several rule changes, including prohibition of spearing (deliberate use of the helmet to punish an opponent), were introduced as well as teaching techniques to prevent players from hitting opponents with the top of their helmets.[32] The officialdom of ice hockey introduced a ban on hitting from behind because such actions can result in head first collision with the boards and thereby neck injury.[28] Although not uniform across the United States, many hockey associations have also introduced the mandatory use of neck guards to prevent the occurrence of neck lacerations.[33]

Whereas neck injuries resulting in paralysis or death are highly publicised, there has been scant research into the incidence of total neck injuries, including fractures, dislocations, sprains, strains, contusions, and lacerations at the community level for these sports. To obtain a better understanding of the total number of sports related neck injuries occurring in the community as a whole, the number of patients presenting to emergency departments (EDs) in the United States with injuries from three different sports (ice hockey, soccer, and American football) for the years 1990–1999 was examined. Data were obtained from the records of the Consumer Product Safety Commission (CPSC) of visits to EDs in the United States for neck injuries related to participation in ice hockey, soccer, or football.

The rate of injury per 10 000 participants per year in the United States was calculated for each sport. This information was used to assess whether rates of neck injury were comparable for ice hockey, soccer, and football.

This article is one of a series examining sport related injuries occurring in the community.[1]

MATERIALS AND METHODS

The CPSC collects data from selected hospital EDs across the United States to estimate the total number of injuries occurring during specific activities and/or with specific products. It uses the National Electronic Injury Surveillance System (NEISS) as a monitoring device.

NEISS figures are based on a sample of participating EDs rather than a census of all of them. The sample hospitals are chosen to make the group representative of all institutions with EDs located in the United States. After obtaining the annual data from participating hospitals, NEISS then estimates the total visits to EDs in the whole country for each year for a particular injury. At selected hospitals, all patients who are injured while participating in a specific activity, or injured while using a particular product, are selected for data entry. All injuries are then classified by location diagnosis. Once an area of injury has been selected, only one diagnosis that best describes the type of injury is chosen. The diagnosis may be amputation, concussion, contusion/abrasion, dislocation, fracture, laceration, internal injury, strain/sprain, avulsion, not stated/unknown, or other. Information about individual cases is descriptive, and injury estimates are not meant to imply that injuries were caused by a specific activity or product.

Abbreviations: CPSC, Consumer Product Safety Commission; ED, emergency department; NEISS, National Electronic Injury Surveillance System; SBRnet, Sports Business Research Network

Table 1 Cumulative neck injuries presenting to emergency departments in the United States from 1990 to 1999 for ice hockey, soccer, and American football

Cumulative injuries	Ice hockey	Soccer	Football
Total neck injuries	5038	19341	114706
Total neck fractures and dislocations	105	214	1588
Total neck contusions/ sprains/strains	4964	17927	104483
Total neck lacerations	199	0	621

Source: US Consumer Product Safety Commission and the National Electronic Injury Surveillance System.

Data were obtained from NEISS through the CPSC for all neck injuries presenting to hospital EDs in the United States from 1990 to 1999 for ice hockey, soccer, and American football. In 1990, NEISS was updated to take into account changes between the 1975 and 1985 sampling frame. Therefore data from previous years cannot be directly compared with estimates after the 1990 update.

Information on the number of participants in each of these sports was obtained from the Sports Business Research Network (SBRnet). This is a fee based website (www.sbrnet.com) which gathers information about sports equipment sales, participation, broadcasting, sponsorship, and marketing.[34] Estimates for the number of participants are available for a variety of different activities, including sports such as ice hockey, soccer, and football. These estimates are based on data compiled primarily from different sports associations and leagues, as well as data from different publications, government agencies, marketing research information, and the National Sporting Goods Association.

The CPSC produces generalised sampling error estimates for NEISS data by applying a non-linear regression curve fitting procedure to the data collected each year. The generalised sampling errors are approximate values derived from fitting a curve through points determined by estimates and calculated sampling errors for a defined set of product groups. The estimated relative sampling errors for NEISS injury data are a measure of the estimated sampling error of the injury data expressed as a proportion of the injury estimates.

Incidence rates were obtained by dividing the number of athletes with the injury by the total number of athletes. All rates are expressed as injuries per 10 000 athletes. Confidence intervals for all incidence rates were obtained using the method for binomial proportions. These incidence rates and their confidence intervals for each sport were plotted over time for total neck injuries, combined neck fractures and dislocations, combined neck contusions, sprains or strains, and finally neck lacerations.

RESULTS

Table 1 presents the cumulative number of total neck injuries, and the specific diagnoses of neck lacerations, combined neck fractures or dislocations, and combined neck contusions, sprains, or strains for ice hockey, soccer, and American football. Table 2 presents participation rates in the United States from 1993 to 1999 for the three different sports. Reliable participation data were available for ice hockey and soccer from 1993 onward, whereas accurate data for all types of football are available only from 1995 onwards.

Table 3 lists rates of total neck injuries from 1993 to 1999. Calculations were made using all participants in a sport and not just frequent participants (table 2). All rates for football injuries were calculated using players who had played either tackle or touch football—that is, the ''football (total)'' data from table 2—because information about whether injuries occurred in a game of tackle or touch football was not always available.

Table 4 presents rates for neck fractures or dislocations from 1993 to 1999 for ice hockey, soccer, and football. Table 5 shows rates for less serious neck injuries (contusions, sprains, and strains), and table 6 shows rates for neck laceration injuries.

DISCUSSION

As reported previously,[1] football had the highest number of participants for each year from 1995 to 1999, soccer had the second largest number of participants during the same period, and ice hockey had the least number of participants for each year for which data were available. Probably, at least in part, because of its large number of participants, football accounted for the largest number of total neck injuries, neck lacerations, combined neck fractures or dislocations, and combined neck contusions, sprains or strains, presenting to EDs from 1990 to 1999 (table 1). In keeping with the number of participants, soccer was associated with the second largest number of total neck injuries, combined neck fractures and dislocations, and combined neck contusions, sprains, or strains. Ice hockey, with the fewest participants, had the lowest number of all injury groups, except neck lacerations (the second highest number over the same time period).

Table 2 Participation rates for ice hockey, soccer, and American football in the United States from 1993 to 1999

	1993	1994	1995	1996	1997	1998	1999
Ice hockey							
All participants	1.70	1.90	2.50	2.10	1.90	2.10	1.90
Frequent participants	0.40	0.50	0.80	0.70	0.50	0.90	0.70
Soccer							
All participants	10.30	12.50	12.00	13.90	13.70	13.20	13.20
Frequent participants	3.00	3.70	3.70	4.20	4.70	4.90	5.00
Football (tackle)							
All participants	a	a	8.30	9.00	8.20	7.40	8.70
Frequent participants	a	a	2.60	3.20	2.90	2.80	3.40
Football (touch)							
All participants	a	a	12.10	11.60	11.90	9.60	11.10
Frequent participants	a	a	1.70	1.70	1.90	1.30	2.00
Football (total)							
All participants	a	a	20.40	20.60	20.10	17.00	19.80
Frequent participants	a	a	4.30	4.90	4.80	4.10	5.40

Data presented in millions of participants. Frequent participation was 40+ days a year except for ice hockey, which was 30+ days a year. a, Estimates not available for this year. Source: Sports Business Research Network SBRnet (www.SBRnet.com).

Table 3 Rates of total neck injuries presenting to emergency departments in the United States from 1993 to 1999 for ice hockey, soccer, and American football (expressed as injuries for every 10 000 participants)

	Hockey			Soccer			Football		
Year	Rate	95% CI upper limit	95% CI lower limit	Rate	95% CI upper limit	95% CI lower limit	Rate	95% CI upper limit	95% CI lower limit
1993	2.81	4.24	1.38	1.96	2.61	1.28	a	a	a
1994	4.11	6.21	2.02	1.41	1.86	0.95	a	a	a
1995	4.26	6.43	2.09	1.34	1.76	0.91	5.86	7.04	4.68
1996	2.43	3.67	1.19	1.36	1.81	0.91	5.47	6.56	4.38
1997	1.68	2.54	0.83	1.28	1.70	0.86	4.56	5.85	3.26
1998	3.01	4.54	1.48	2.60	3.56	1.51	7.18	8.63	5.73
1999	2.66	4.02	1.31	1.78	2.36	1.12	6.19	7.44	4.94

a, Estimates not available for this year.

A very rough estimate of injury rates for each sport per year can be calculated by dividing the total number of neck injuries per year by the annual number of participants in each sport. These rates give a better idea of the chances of sustaining a neck injury that requires medical attention in an ED than just examining the total number of neck injuries per year. The data in table 3 show that the rates for total neck injury are significantly higher for football than for soccer or hockey. The rates for soccer and hockey are comparable, as the 95% confidence intervals overlap for most years from 1993 to 1999.

Although it might seem intuitive to suggest that, owing to its physical nature and the propensity for players to tackle or hit other players with their helmets, tackle football is responsible for most neck injuries, our data do not allow such a conclusion. It is believed that since the advent of the protective football helmet, most serious neck injuries resulting in death or paralysis have been due to tackling or hitting head first.[29] However, our data cannot differentiate between injuries from tackle football and non-tackle football, as the information is not recorded at the time of entry into the NEISS database. All that can be safely concluded is that, for the years studied, those people playing football in the community had a higher risk of suffering a neck injury that required a visit to the ED than those playing soccer or ice hockey.

It is difficult to draw any firm conclusions from the rates of neck fractures and dislocations in table 4, as the numbers are very low. Football is the only sport in which fractures occurred in all the years for which data are available for the sport, and the rates of fracture are higher for football than for soccer for all years for which data are available. The ice hockey data reveal that no fractures occurred in some years, whereas for one year (1999), it had the highest rate of neck fractures of the three sports. This wide flux is to be expected when dealing with an uncommon injury, as extrapolation to the entire United States was used. Therefore, when no injuries presented to the NEISS sampling hospitals during the sampling year, the calculations predicted no injuries across the entire country. If in one year a handful of rare injuries such as neck fractures and dislocations occurred and presented to some of the NEISS sampling hospitals, extrapolation to the entire country would indicate a dramatic increase in that year.

Table 5 shows that football also had the highest rate of less severe injuries such as contusions, sprains, and strains. These three diagnoses were combined to give a better idea of the rates of non-life threatening and non-catastrophic injuries. These injuries were most likely to represent injuries to the soft tissue, including muscles, tendons, and ligaments. The rate of injury was significantly higher for football than for ice hockey and soccer for each year for which data were available, and higher for ice hockey than for soccer for all years analysed. This was probably due to differences in the style of each game. There is arguably more importance placed on preventing forward movement in tackle football than in the other two sports, as the number of yards gained by an offensive player may allow another set of downs to be awarded to the offensive team. Although high energy collisions occur in all three sports, a football defender is routinely required to completely impede an offensive player's motion, and in some cases drive the offensive player backwards. These types of collisions probably require more force and occur more often in football than in the other sports.

Table 6 shows that neck lacerations requiring a visit to the ED were rare. There were no such reported injuries in soccer during the years studied. Interestingly, neck lacerations requiring a visit to the ED in 1993–1995 were reported in ice hockey, but none thereafter. This may be due to the relatively rare occurrence of the injury and the possibility that no such injuries were reported to NEISS sampling hospitals in that period. It is also possible that no such injuries occurred at all during those years in the entire United Sates.

Table 4 Rates of bony neck injuries (fractures or dislocations) presenting to emergency departments in the United States from 1993 to 1999 for ice hockey, soccer, and American football (expressed as injuries for every 10 000 participants)

	Hockey			Soccer			Football		
Year	Rate	95% CI upper limit	95% CI lower limit	Rate	95% CI upper limit	95% CI lower limit	Rate	95% CI upper limit	95% CI lower limit
1993	0.0996	0.115	0.085	0	0	0	a	a	a
1994	0	0	0	0	0	0	a	a	a
1995	0	0	0	0.014	0.021	0.007	0.094	0.107	0.08
1996	0.081	0.093	0.068	0.025	0.033	0.016	0.077	0.089	0.065
1997	0	0	0	0	0	0	0.086	0.098	0.073
1998	0	0	0	0.064	0.077	0.05	0.105	0.154	0.056
1999	0.375	0.384	0.33	0	0	0	0.057	0.068	0.046

a, Estimates not available for this year.

Table 5 Rates of contusions, sprains, or strains of the neck presenting to emergency departments in the United States from 1993 to 1999 for ice hockey, soccer, and American football (expressed as injuries for every 10 000 participants)

	Hockey			Soccer			Football		
Year	Rate	95% CI upper limit	95% CI lower limit	Rate	95% CI upper limit	95% CI lower limit	Rate	95% CI upper limit	95% CI lower limit
1993	2.33	2.40	2.25	1.80	1.88	1.71	a	a	a
1994	3.34	3.42	3.26	1.34	1.40	1.28	a	a	a
1995	3.80	3.87	3.72	1.29	1.35	1.22	5.35	5.45	5.25
1996	1.82	1.88	1.76	1.32	1.40	1.26	5.04	5.14	4.94
1997	1.68	1.74	1.62	1.14	1.19	1.08	4.25	4.34	4.16
1998	2.92	2.99	2.85	2.31	2.40	2.23	6.38	6.50	6.26
1999	2.29	2.22	2.35	1.51	1.58	1.45	5.43	5.53	5.32

a, Estimates not available for this year.

If this were true, this may have occurred by chance or there may have been a change in the game or protective equipment that caused this to occur. Neck guards were introduced in the 1980s in an attempt to protect against neck injuries, and lacerations in particular. Although their use is not mandatory across the whole country,[35] it is possible that they played a protective role in decreasing the incidence of neck lacerations in ice hockey through the mid-1990s. Relevant sales data for these products could not be obtained to substantiate this observation.

Except for neck lacerations, the rates of neck injuries (total neck injuries, fractures or dislocations, contusions/sprains/stains) remained relatively stable within each sport over the different years studied. This is different from the results of a previous head injury study.[1] In that study, the rates of head injuries, concussions and combined concussions/skull fractures/internal head injuries tended to increase for all three sports during the late nineties. It was suggested that this might be due to chance, changes in the games, players becoming more aggressive, a higher percentage of injured athletes presenting to EDs instead of other healthcare facilities, and a greater awareness of head injuries and concussions. As the number of neck injuries remained stable over the same period of time, it gives some weight to the argument that the increase in number of head injuries and concussions in the past decade was due, at least in part, to an increasing awareness of head injuries and less to changes in the games or players themselves. If the games had become much more violent overall, one might have expected to see an increase in other injuries such as neck fractures, dislocations, contusions, sprains, strains, and lacerations as well.

It should be noted that, whereas rates of injury for athletes are often expressed as the number of injuries per 1000 athletic exposures, catastrophic neck injuries (injuries resulting in paralysis or death) are sometimes expressed as injuries per 100 000 athletes.[4 36] We have expressed our rates of injury as the number of injuries per 10 000 participants. It is very difficult to make comparisons with other studies as the rates may be expressed differently and we have not identified neck injuries that resulted in paralysis or death.

Whereas not all neck injuries present to EDs, the injuries that do might be expected to be more severe than those that do not. As the numbers discussed in this paper are merely surrogate markers for the true level and rates of injury occurring annually for each sport, their accuracy and statistical significance should not be overemphasised. The results should be interpreted with the understanding that the actual figures are not meant to illustrate a small significant difference from year to year, or from sport to sport, but merely to analyse general trends. To get a better idea of the risk of one sport compared with another over a longer period of time, a regression model incorporating as much data from as many years as possible would give a better representation than the results presented here. The data available from the CPSC and SBRnet are crude unadjusted figures for numbers of injured athletes presenting to EDs per year (numerators), and the number of athletes participating in a particular sport frequently or infrequently per year (denominators). The generalised sampling errors calculated by the CPSC for the NEISS data were therefore used, although this limits the strength of the statistical conclusions.

The design of the NEISS data collection system may underestimate the total number of individual diagnoses, including total neck injuries, neck fractures, dislocations, contusions, sprains, strains, and lacerations, as only the one most accurate diagnosis may be selected for each injured body part. For example, if an injured patient presented with a neck fracture and a neck laceration, it is possible that the fracture would be considered the most appropriate diagnosis, and therefore the fracture would be recorded in the NEISS database and not the laceration.

In conclusion, football accounted for more total neck injuries and specific diagnoses of neck lacerations, combined neck fractures or dislocations, and combined neck

Table 6 Rates of neck lacerations presenting to emergency departments in the United States from 1993 to 1999 for ice hockey, soccer, and American football (expressed as injuries for every 10 000 participants)

	Hockey			Soccer			Football		
Year	Rate	95% CI upper limit	95% CI lower limit	Rate	95% CI upper limit	95% CI lower limit	Rate	95% CI upper limit	95% CI lower limit
1993	0.40	0.50	0.31	0	0	0	a	a	a
1994	0.18	0.24	0.12	0	0	0	a	a	a
1995	0.32	0.39	0.25	0	0	0	0	0	0
1996	0	0	0	0	0	0	0.017	0.022	0.011
1997	0	0	0	0	0	0	0.037	0.046	0.029
1998	0	0	0	0	0	0	0.099	0.114	0.084
1999	0	0	0	0	0	0	0.068	0.08	0.057

a, Estimates not available for this year.

What is already know on this topic

Most research on neck injuries in football, ice hockey, and soccer has focused on the relatively uncommon occurrence of catastrophic neck injuries, and less so on the occurrence of other neck injuries. Whereas it is known that concussion rates for elite and recreational athletes are similar for all three sports, no such research has been conducted on different types of neck injuries.

What this study adds

This study examines neck injuries in football, ice hockey, and soccer in the United States during 1990–1999 using emergency department data. Football accounted for the greatest number of neck injuries and also the highest estimated rates of total neck injuries and combined neck contusions, sprains, or strains requiring an emergency department visit.

contusions, sprains, or strains presenting to EDs in the United States from 1990 to 1999 than ice hockey or soccer. Football also had the highest estimated rates of total neck injuries and combined neck contusions, sprains, or strains requiring a visit to EDs in the United States for the years for which data were available.

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REFERENCES

1 **Delaney JS**. Head injuries presenting to emergency departments in the United States from 1990 to 1999 for ice hockey, soccer, and football. *Clin J Sport Med* 2004;**14**:80–7.
2 **Guskiewicz KM**, Weaver NL, Padua DA, *et al*. Epidemiology of concussion in collegiate and high school football players. *Am J Sports Med* 2000;**28**:643–50.
3 **Powell JW**, Barber-Foss KD. Traumatic brain injury in high school athletes. *JAMA* 1999;**282**:958–63.
4 **Buckley WE**. Concussions in college football. A multivariate analysis. *Am J Sports Med* 1988;**16**:51–6.
5 **Benson BW**, Mohtadi NG, Rose MS, *et al*. Head and neck injuries among ice hockey players wearing full face shields vs half face shields. *JAMA* 1999;**282**:2328–32.
6 **Benson BW**, Rose MS Meeuwisse WH. The impact of face shield use on concussions in ice hockey: a multivariate analysis. *Br J Sports Med* 2002;**36**:27–32.
7 **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**:283–8.
8 **Gerberich SG**, Finke R, Madden M, *et al*. An epidemiological study of high school ice hockey injuries. *Childs Nerv Syst* 1987;**3**:59–64.
9 **Gillogly SD**, Whaley W. Medical aspects of professional hockey in Atlanta. *J Med Assoc Ga* 2000;**89**:39–44.
10 **Goodman D**, Gaetz M Meichenbaum D. Concussions in hockey: there is cause for concern. *Med Sci Sports Exerc* 2001;**33**:2004–9.
11 **Honey CR**. Brain injury in ice hockey. *Clin J Sport Med* 1998;**8**:43–6.
12 **Jorgensen U**, Schmidt-Olsen S. The epidemiology of ice hockey injuries. *Br J Sports Med* 1986;**20**:7–9.
13 **Molsa J**, Airaksinen O, Nasman O, *et al*. Ice hockey injuries in Finland. A prospective epidemiologic study. *Am J Sports Med* 1997;**25**:495–9.
14 **Naunheim RS**, Standeven J, Richter C, *et al*. Comparison of impact data in hockey, football, and soccer. *J Trauma* 2000;**48**:938–41.
15 **Roberts WO**, Brust JD, Leonard B, *et al*. Fair-play rules and injury reduction in ice hockey. *Arch Pediatr Adolesc Med* 1996;**150**:140–5.
16 **Roberts WO**, Brust JD Leonard B. Youth ice hockey tournament injuries: rates and patterns compared to season play. *Med Sci Sports Exerc* 1999;**31**:46–51.
17 **Tegner Y**, Lorentzon R. Concussion among Swedish elite ice hockey players. *Br J Sports Med* 1996;**30**:251–5.
18 **Barnes BC**, Cooper L, Kirkendall DT, *et al*. Concussion history in elite male and female soccer players. *Am J Sports Med* 1998;**26**:433–8.
19 **Boden BP**, Kirkendall DT, Garrett WE Jr. Concussion incidence in elite college soccer players. *Am J Sports Med* 1998;**26**:238–41.
20 **Delaney JS**, Drummond R. Has the time come for protective headgear for soccer? *Clin J Sport Med* 1999;**9**:121–3.
21 **Delaney JS**, Lacroix VJ, Gagne C, *et al*. Concussions among university football and soccer players: a pilot study. *Clin J Sport Med* 2001;**11**:234–40.
22 **Matser EJ**, Kessels AG, Lezak MD, *et al*. Neuropsychological impairment in amateur soccer players. *JAMA* 1999;**282**:971–3.
23 **Tysvaer AT**, Lochen EA. Soccer injuries to the brain. A neuropsychologic study of former soccer players. *Am J Sports Med* 1991;**19**:56–60.
24 **Tysvaer AT**. Head and neck injuries in soccer. Impact of minor trauma. *Sports Med* 1992;**14**:200–13.
25 **Mueller FO**. Fatalities from head and cervical spine injuries occurring in tackle football: 50 years' experience. *Clin Sports Med* 1998;**17**:169–82.
26 **Tator CH**. Neck injuries in ice hockey: a recent, unsolved problem with many contributing factors. *Clin Sports Med* 1987;**6**:101–14.
27 **Tator CH**, Carson JD Cushman R. Hockey injuries of the spine in Canada, 1966–1996. *CMAJ* 2000;**162**:787–8.
28 **Tator CH**, Carson JD Edmonds VE. Spinal injuries in ice hockey. *Clin Sports Med* 1998;**17**:183–94.
29 **Cantu RC**, Mueller FO. Catastrophic spine injuries in American football, 1977–2001. *Neurosurgery* 2003;**53**:358–62; discussion 362–3.
30 **Marzo JM**, Simmons EH Whieldon TJ. Neck injuries to high school football players in western New York State. *N Y State J Med* 1991;**91**:46–9.
31 **Torg JS**, Sennett B, Vegso JJ, *et al*. Axial loading injuries to the middle cervical spine segment. An analysis and classification of twenty-five cases. *Am J Sports Med* 1991;**19**:6–20.
32 **Clarke KS**. Epidemiology of athletic head injury. *Clin Sports Med* 1998;**17**:1–12.
33 http://safeusa.org/sports/hockey.htm.
34 http://www.sbrnet.com/about_us.htm.
35 http://www.nfha.com/rulebook/the_equipment.htm.
36 **Clarke KS**. Epidemiology of athletic neck injury. *Clin Sports Med* 1998;**17**:83–97.