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, 19341 from soccer, and 114706 from American football. These could be broken down as follows: 4964 contusions, sprains, or strains from ice hockey, 17927 from soccer, and 104483 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, 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. 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. 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. 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.

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.

**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:**
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. 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 were 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).
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. 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.
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, 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/strains) remained relatively stable within each sport over the different years studied. This is different from the results of a previous head injury study. 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 may 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.

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. 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 player. 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 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) |
| Year | Hockey | Rate | 95% CI upper limit | 95% CI lower limit | Soccer | Rate | 95% CI upper limit | 95% CI lower limit | Football | 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 |

| 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) |
| Year | Hockey | Rate | 95% CI upper limit | 95% CI lower limit | Soccer | Rate | 95% CI upper limit | 95% CI lower limit | Football | 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 | 1.68 | 1.74 | 1.62 | 1.14 | 1.19 | 1.08 | 4.25 | 4.34 | 4.16 |
| 1997 | 0 | 0 | 0 | 0.037 | 0.046 | 0.029 | 0.099 | 0.114 | 0.084 |
| 1998 | 0 | 0 | 0 | 0.068 | 0.08 | 0.057 | a | a | a |
| 1999 | 0 | 0 | 0 | 0 | 0 | 0 | a | a | a |

* a, Estimates not available for this year.
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.

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.

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