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Epidemiology of acute head injuries in Canadian children and youth soccer players

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ABSTRACT

Background: Limited studies have been done to assess head injury characteristics for children and youth soccer players in Canada.
Objectives: To describe acute head injury characteristics in children and youth soccer players and identify the characteristics of patients who required hospital admission.
Methods: Analysis was based on the Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP). Soccer-related head injuries amongst 5–19 year old children presenting at 16 hospital emergency departments during 1994–2004 were selected in the study. All head injury-related variables (nature of injury, mechanism of injury, location of play, soccer type and season of play) were stratified by age and sex. A logistic regression model, consisting of the injury-related variables, sex and age as the independent variables, was performed to examine the characteristics of those head-injured patients who required hospital admission.
Results: Overall, there were 4720 head injury cases identified (15% of all soccer-related emergency department visits). The highest proportion of head injuries was amongst males (70%) and children aged 10–14 years (50%). Of head injury cases, 35% were superficial and/or open wounds, 28% minor head injuries, 11% concussions, 9% eye injuries and 5% fractures. The total number of cases that required hospital admission was 164 (3.5%). Based on logistic regression analysis, head-injured youth aged 15–19 years were almost two times more likely to be admitted to hospital than their younger counterparts (OR = 2.2, 95% CI: 1.3–3.6). Compared to ball contact injuries, contact with structures/surfaces, other players/persons and other unspecified objects increased the odds of hospital admission at least by two-folds. Moreover, those who played unorganised soccer were significantly more likely to be admitted to the hospital as compared to those who played organised soccer (OR = 1.7, 95% CI: 1.2–2.6). Finally, playing in the non-winter seasons had increased likelihood of hospital admissions.
Conclusions: Head injuries constituted a significant proportion of soccer-related injuries presenting to emergency departments. Future studies need to evaluate the nature and safety of the playing surfaces/turf and other structures on or around the field of play.

Introduction

Soccer is the most played game in the world with over 265 million active players.[13] In recent years, soccer has become the most prevalent sport played by Canadians, with the highest proportion of players being youth.[8] Nevertheless, with an increase in exposure to playing soccer, comes an increase in the risk of injury. Although soccer appears to be a relatively safe sport for children to play, it is now considered a contact/collision sport by the American Academy of Pediatrics.[19]

The literature reports that head injuries in children and youth soccer account for approximately 15% of all reported injuries.[1,25,28,32] Soccer is unique in that there is intentional use of the head to control the ball. Whilst the majority of published research focuses on the chronic effects of long term exposure to heading of the soccer ball,[2,12,20] evidence has shown that the most severe head injuries are likely to occur due to acute contact mechanisms.[3,15,21,25] These mechanisms can include: acute contact with other players such as head to head contact, head to upper extremity namely the elbow, head to lower extremity namely the knee and foot, head to turf and other playing surfaces, head to goal posts/nets, head to other equipment and structures on or around the field of play, and non-direct head-contact injuries that lead to flexion-hyper extension action (whiplash injury).[3,15,25,26]

The resultant nature of soccer head injury due to acute contact mechanisms includes minor contusions, lacerations and dental injuries.[12,19,32] It also involves moderate injuries like mild head injury,[20,32] concussions[32] and mild traumatic brain injury.[33]

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Reported injuries can be more severe in nature, such as eye injuries,[19,32] that can result in permanent visual impairment[9,18,23] or even fatal injuries, such as skull fractures, resulting usually from impact with goal posts.[6,14,19] Other resultant head fractures such as maxillofacial,[11,30,32] and craniomaxillofacial fractures[10] are common and typically require surgical intervention and hospital admission.

Few studies have examined the epidemiology of head injuries amongst children and youth playing at both organised and unorganised levels of participation. Only one published Canadian study conducted by Pickett et al. aimed to describe acute soccer-related injuries with a focus on head trauma.[32] The latter study, however, was limited to data from Kingston's emergency departments, included only children older than 10 years of age and focused on injuries due to intentional heading of the soccer ball. Therefore, data on soccer-related head injuries amongst Canadian children and youth remain scarce. The objectives of the current study were to (i) investigate acute head injury characteristics in children and youth soccer players (aged 5–19 years) by age and sex who presented to hospital emergency departments in Canada; and (ii) examine the characteristics of those patients who required hospital admission.

Methods

Study design and data source

Data on soccer injuries in Canada were collected from the Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP), which is a program of the Health Surveillance and Epidemiology Division of the Public Heath Agency of Canada. CHIRPP data is collected from 16 participating hospitals across Canada (10 pediatric hospitals and 6 general hospitals). During the period of the study, CHIRPP was collecting from 10 of the eleven pediatric emergency departments in Canada. Currently, the CHIRPP captures all of the pediatric emergency department hospitals in Canada.

When an injured or accompanying person (guardian or caregiver of the child) presents to a CHIRPP site, they are asked by hospital staff to complete a CHIRPP data collection form. The form includes questions related to the circumstances that led to the injury, as well as, demographic characteristics. The hospital staff also collect information regarding clinical data such as the diagnosis, body part injured and treatment rendered. All collected data are reviewed by the CHIRPP site data coordinator(s) for any missing data. The completed forms are sent to The Public Health Agency of Canada (Ottawa) for entry into the system by trained coders.[35]

All males and females, aged 5–19 years at the time of injury presenting to a designated CHIRPP site with a soccer-related head injury from 1994 to 2004 were selected in the study. Included patients were primary admissions who had head injuries as their principal diagnosis. Head injuries were identified using unique CHIRPP codes for injured body parts. The study participants encompassed the broad population of children and youth soccer players, including both organised and unorganised participating players.

Study variables

To investigate the characteristics of acute head injuries, in addition to sex and age of the patients, different injury-related variables were examined. These variables included nature of injury (superficial, open wound, fracture, sprain/strain, eye injury, minor head injury, concussion, dental injury, other/unspecified), mechanism of injury (other players or persons, balls, structures, surfaces or objects, other/unspecified), location of play (schools, sports/recreational facilities, residential/other), type of soccer (organised, unorganised) and season of play (summer, spring, fall, winter).[17] To examine the overall severity of head soccer injuries, hospital admission was investigated as a proxy variable. The dispositions rendered in the emergency department defined this variable. Those with the outcome of hospital admission suffered from at least one of the following dispositions: (i) admittance to the hospital; (ii) transference to another hospital; and/or (iii) dead on arrival or died in the emergency department.[17]

Statistical analysis

To meet the first objective of the study, all head injury-related variables were stratified by age and sex. Chi square statistics using significance level of 5% was used to detect the differences in the injury-related variables amongst the different age and sex groups. In order to examine the characteristics of those patients who required hospital admission, a logistic regression model was performed. The independent variables considered in the model were age, sex, mechanism of injury, location of play, type of soccer and season of play. Interaction terms for age and sex with mechanism of injury, type of soccer and location of play was examined but proved to be insignificant. Odds ratios (OR) and 95% confidence intervals (95% CI) were reported for the final models. All analyses were conducted using the Statistical Package for Social Sciences (SPSS, version 15.0).[24]

Results

Approximately 15% ($N = 4720$) of all soccer-related emergency department visits were head injury cases. The proportion of emergency department visits for the age groups 5–9, 10–14 and 15–19 years were 27%, 50% and 23%, respectively. Of all age groups, males constituted the highest proportion of injury (70%). The proportions of dispositions at emergency departments were 39% for observation/advice, 36% for treated follow-up as needed, 22% for treated follow-up required and 3.5% for hospital admission.

Of head injury cases, 35% were superficial and or/open wounds, 28% minor head injuries, 11% concussions, 9% eye injuries and 5% fractures (Table 1). With an increase in age, there was an increase in the proportion of head fractures. For concussion and minor head injury cases, proportions were similar for males and females across all age categories. The leading mechanism of head injury was contact with other players (35%), followed by contact with structures/surfaces (32%) and contact with balls (18%). Moreover, as age increased the proportion of injuries due to contact with other players increased and the proportion of injuries due to contact with structures/surfaces decreased. Across all age categories, injuries due to contact with balls was significantly higher for females, whereas injuries due to contact with other players was significantly higher for males.

As illustrated in Table 2, injuries due to contact with other players resulted in the highest proportion of fractures (11.1%); whereas, ball contact injuries resulted in the highest proportion of eye injuries (28%). Furthermore, injuries due to contact with structures/surfaces resulted in the highest proportion of concussions (12.9%) and minor head injuries (35.9%).

The total number of cases that required hospital admission was 164 (3.5%). The leading natures of head injuries requiring hospital admission were concussions (36.6%), minor head injuries (26.8%) and fractures (17.1%). Of the cases that required hospital admission, 66 (41%) were due to body contact with other players, 39 (24%) due to contact with playing surfaces such as Astroturf, gym floors, and natural grass, 30 (18%) due to contact with balls and 15 (9%) due to contact with structures on or around the field of play, such as field

Table 1
Distribution of soccer head injuries by nature of injury, mechanism of injury, location of play, type of soccer and season by age and sex of patient, CHIRPP 1994–2004 ($N = 4720$).

	5–9 years		10–14 years		15–19 years		All Ages
	Males	Females	Males	Females	Males	Females	
	$N = 1063$	$N = 198$	$N = 1614$	$N = 762$	$N = 650$	$N = 433$	$N = 4720$
	N^a (%^{b})	N^a (%^{b})	N^a (%^{b})	N^a (%^{b})	N^a (%^{b})	N^a (%^{b})	N^a (%^{b})
Nature of head injury							
Superficial	189 (17.8)	33 (16.7)	328 (20.3)	149 (19.6)	96 (14.8)	79 (18.2)	874 (18.5)
Open wound	273 (25.7)	40 (20.2)	227 (14.1)	47 (6.2)	133 (20.5)	39 (9.0	759 (16.1)
Fracture	17 (1.6)	7 (3.5)	72 (4.5)	37 (4.9)	73 (11.2)	46 (10.6)	252 (5.3)
Sprain/strain	38 (3.6)	11 (5.6)	104 (6.4)	68 (8.9)	20 (3.1)	31 (7.2)	272 (5.8)
Eye injury	91 (8.6)	22 (11.1)	154 (9.5)	76 (10.0)	56 (8.6)	43 (9.9)	442 (9.4)
Minor closed head injury	321(30.2)	55 (27.8)	449 (27.8)	233 (30.6)	144 (22.2)	104 (24.0)	1306 (27.7)
Concussion	84 (7.9)	23 (11.6)	186 (11.5)	86 (11.3)	92 (14.2)	62 (14.3)	533 (11.3)
Dental injury	14 (1.3)	2 (1.0)	18 (1.1)	5 (0.7)	12 (1.8)	5 (1.2)	56 (1.2)
Other/unspecified	36 (3.4)	5 (2.5)	76 (4.7)	61 (8.0)	24 (3.7)	24 (5.5)	226 (4.8)
Mechanism of injury							
Contact with other players or persons	238 (22.4)	27 (13.6)	603 (37.4)	235 (30.8)	371 (57.1)	192 (44.3)	1666(35.3)
Contact with structures, surfaces or objects	545 (51.3)	83 (41.9)	502 (31.1)	201 (26.4)	109 (16.8)	76 (17.6)	1516 (32.1)
Other/unspecified mechanism	157 (14.8)	39 (19.7)	231 (14.3)	110 (14.4)	82 (12.6)	76 (17.6)	695 (14.7)
Contact with ball	123 (11.6)	49 (24.7)	278 (17.2)	216 (28.3)	88 (13.5)	89 (20.6)	843 (17.9)
Location of play							
Schools	605 (57.3)	92 (47.2)	813 (51.0)	255 (34.0)	193 (30.3)	121 (28.3)	2079 (44.6)
Sports/recreational facility	233 (22.1)	55 (28.2)	615 (38.6)	418 (55.7)	367 (57.6)	267 (62.5)	1955 (42.0)
Residential/other	218 (20.6)	48 (24.6)	165 (10.4)	77 (10.3)	77 (12.1)	39 (9.1)	624 (13.4)
Type of soccer							
Organised	176 (17.8)	36 (21.4)	523 (34.5)	363 (50.8)	301 (48.6)	253 (61.7)	1652 (37.4)
Unorganised	810 (82.2)	132 (78.6)	994 (65.5)	352 (49.2)	318 (51.4)	157 (38.3)	2763 (62.6)
Season of play							
Summer	277 (26.1)	62 (31.3)	456 (28.3)	230 (30.2)	225 (34.6)	157 (36.3)	1407 (29.8)
Spring	329 (31.0)	58 (29.3)	451 (27.9)	204 (26.8)	164 (25.2)	132 (30.5)	1338 (28.3)
Fall	275 (25.9)	46 (23.2)	448 (27.8)	225 (29.5)	181 (27.8)	101 (23.3)	1276 (27.0)
Winter	182 (17.1)	32 (16.2)	259 (16.0)	103 (13.5)	80 (12.3)	43 (9.9)	699 (14.8)

Note: Overall significant difference ($p < 0.05$) of listed variables by sex and age were observed. Within each age group (except for 5–9 years), significant difference ($p < 0.05$) between sex and nature of injury were observed. Within each age group, significant difference between sex and mechanism of injury were observed. Within each age group (except for 15–19 years), significant difference between sex and location of play were observed. Within each age group (except for 5–9 years), significant difference between sex and type of soccer were observed. Within each age group, significant difference was not observed between sex and season.

[a] Values do not add to total due to missing data.

[b] Column percent.

boundary fences/boards, equipment, benches/bleachers and field debris (*data not shown*). Furthermore, 13 cases (8%) of hospitalisations were due to contact with the goal posts/nets and one of these cases was fatal (*data not shown*). Logistic regression analysis was used to determine the characteristics of head injury patients requiring hospital admission (Table 3). Based on the results, head-injured youth aged 15–19 years were almost two times more likely to be admitted to hospital than their younger counterparts (OR = 2.2, 95% CI: 1.3–3.6). Compared to ball contact injuries, contact with structures/surfaces, other players/persons and other unspecified objects increased the odds of hospital admission at least by two-folds. Moreover, those who played unorganised soccer were significantly more likely to be admitted to the hospital as compared to those who played organised soccer (OR = 1.7, 95% CI: 1.2–2.6). In terms of the season, playing in the non-winter seasons had increased likelihood of hospital admissions.

Table 2
Nature of head injury by each type of mechanism of injury, CHIRPP 1994–2004.

Nature of injury	Mechanism of Injury				
	Contact with other players	Contact with structures	Other/unspecified mechanism	Contact with balls	Total
	N^a (%)^b	N^a (%)^b	N^a (%)^b	N^a (%)^b	N^a (%)^b
Superficial	363 (22.0)	190 (13.0)	112 (21.9)	168 (21.3)	833 (18.9)
Open wound	279 (16.9)	332 (22.7)	59 (11.5)	24 (3.0)	694 (15.7)
Fractures	184 (11.1)	21 (1.4)	23 (4.5)	16 (2.0)	244 (5.5)
Sprain/strain	114 (6.9)	91 (6.2)	18 (3.5)	37 (4.7)	260 (5.9)
Eye injury	60 (3.6)	58 (4.0)	77 (15.0)	219 (27.8)	414 (9.4)
Minor head injury	367 (22.2)	525 (35.9)	139 (27.1)	192 (24.4)	1223 (27.7)
Concussion	192 (11.6)	189 (12.9)	57 (11.1)	65 (8.2)	503 (11.4)
Dental injury	21 (1.3)	14 (1.0)	5 (1.0)	7 (0.9)	47 (1.1)
Other/unspecified	73 (4.4)	42 (2.9)	22 (4.3)	60 (7.6)	197 (4.5)
Total	1653 (100.0)	1462 (100.0)	512 (100.0)	788 (100.0)	4415 (100.0)

Note: Except for balls, significant relationships ($p < 0.05$) between nature of injury and type of soccer were observed within each type of mechanism of injury. Significant relationships ($p < 0.05$) between nature of injury and type of soccer were observed.

[a] Values do not add to total due to missing data.

[b] Column percent.

Table 3
Logistic regression model determining the odds of hospital admission amongst head-injured children ($N = 4356$).

	Hospital admission		
	Yes	No	Adjusted odds ratio
	N (%)	*N* (%)	OR[a] (95% CI[b])
Age			
5–9	37 (2.9)	1224 (97.1)	1
10–14	77 (3.2)	2298 (96.8)	1.3 (0.9–2.1)
15–19	50 (4.6)	1032 (95.4)	2.2 (1.3–3.6)
Sex			
Female	40 (2.9)	1352 (97.1)	1
Male	124 (3.7)	3202 (96.3)	1.5 (1.0–2.2)
Mechanism of injury			
Contact with other players or persons	63 (3.8)	1603 (96.2)	1.9 (1.1–3.6)
Contact with structures, surfaces or objects	55 (3.6)	1460 (96.4)	2.3 (1.2–4.2)
Other/unspecified mechanism	28 (4.0)	666 (96.0)	2.6 (1.3–5.3)
Contact with ball	18 (2.1)	825 (97.9)	1
Location of play			
Schools	59 (2.8)	2019 (97.2)	1
Sports/recreational facility	74 (3.8)	1880 (96.2)	1.3 (0.9–2.0)
Residential/other	27 (4.3)	597 (95.7)	1.3 (0.8–2.1)
Type of soccer			
Organised	107 (3.9)	2655 (96.1)	1
Unorganised	27 (2.8)	1604 (97.2)	1.7 (1.2–2.6)
Season of play			
Summer	62 (4.4)	1343 (95.6)	2.8 (1.4–5.7)
Spring	45 (3.4)	1293 (96.6)	2.2 (1.1–4.5)
Fall	47 (3.7)	1229 (96.3)	2.6 (1.3–5.2)
Winter	10 (1.4)	689 (98.6)	1

[a] OR: odds ratio.
[b] CI: confidence interval.

Discussion

This study is the first to examine the association between head injury characteristics and hospital admission as an outcome of injury severity in the broad population of children and youth soccer players presenting to emergency department in Canada. Overall, 15% of all soccer-related emergency department visits were head injury, out of which 3.5% required hospital admission. The highest proportion of head injuries was amongst males and children aged 10–14 years. The majority of the head injuries were superficial and/or open wounds followed by minor head injuries. Based on the logistic regression analysis, hospital admission was associated with older age, unorganised soccer and playing in non-winter seasons. Mechanism of injury was also found to be significantly correlated with hospital admission.

Similar to other studies,[1,28,32] head injuries constituted a significant proportion of soccer-related injuries presenting to emergency department. Pickett et al., however, reported lower (1.3%) hospital admission rates amongst head-injured youth.[32] The differences in the rates can be attributed to the fact that the present study selected younger children (aged 5–19 years) than Pickett et al. study. Younger children may be hospitalised for prolonged observation due to the complexity of diagnosing head injuries in these populations.

In contrast to previous findings, the majority of head-injured children in this study were aged 10–14 years (50%) and the lowest proportion was for 15–19 year olds (23%). The current study also revealed a higher proportion of head injuries amongst males, which concur with the study of Pickett et al.[32] studies of elite populations[15] and studies that examined overall injury characteristics amongst youth soccer players that presented to emergency department.[1,28] In terms of the mechanism of head injury, the results are in agreement with Pickett et al.[32] as well as studies of elite populations[3,5,7,25] where the highest proportion of head injuries were due to contact with other players. Also, consistent with Pickett et al.[32] with increased age, there was an increase in the proportion of injuries due to contact with other players and a decrease in injuries due to contact with structures/surfaces. This finding may suggest that the nature of the game changes as children physically mature, acquire more skill and increase intensity of play, which may lead to more body contact injuries.

Moreover, the findings demonstrated injuries due to ball contact were significantly higher for females, whilst injuries due to contact with other players were significantly higher for males. These results may indicate that males are more aggressive during play, which might lead to more body contact injuries. Females, on the other hand, have a higher proportion of ball contact injuries because sex differences exist in the head–neck segment stabilisation whilst voluntarily heading of the soccer ball.[38] This is due to less isometric strength, neck girth and head mass in females resulting in lower levels of segment stiffness compared to males.[38] Likewise, these differences may be further increased during acute contact mechanisms where ball contact with the head would be involuntary/accidental.

The results are consistent with previous work that showed the highest proportion of head fractures was due to contact with other players.[10,30,32] The results, as well, match Pickett et al.[32] and other studies[9,23] that found the highest proportion of eye injures were due to contact with the ball. Soccer balls have higher compressibility than other sports balls, therefore allowing the ball to penetrate the orbit more deeply.[39] Moreover, the findings lend support to Pickett et al.[32] whereby the highest proportion of minor head injuries was due to contact with structures/surfaces. In agreement with other studies, the leading mechanism of concussions were due to: contact with the ground,[5,7,26] surrounding concrete surfaces,[7] goal posts,[5,7] indoor walls,[5] and other/unspecified objects.[32]

Based on the regression analysis, older age increased the odds of hospitalisation. These results are analogous to Pickett et al.[32] who also found that the oldest players had the highest proportion of

hospitalisations. This is indicative that the nature of head injury in older players is more severe and may be due to increased intensity/competitiveness of play.[34] Similarly, Leininger et al.[28] who investigated overall injury characteristics of pediatric soccer players (aged 2–18 years) presenting to 100 emergency departments in the United States from 1990 to 2003, revealed that males were more likely to be hospitalised than females. These results suggest that male soccer players might engage in higher risk-taking behaviours.[27] Moreover, injuries due to contact with structures on or around the field of play as well as the playing surfaces/turf were found to be an important factor contributing to hospital admission. In contrast to Pickett et al.,[32] those who played unorganised soccer in the present study had the highest odds of hospital admission. A possible explanation for this association can be attributed to the fact that those who play unorganised soccer are at a lower skill level than those who play organised soccer and thus at greater risk of injury.[22,31] Finally, playing during the summer resulted in the highest odds of hospital admission. The results are consistent with Hawkins et al. whereby the incidence of overall injury was found to be the highest in July and August.[16] In addition to the hazards of playing outdoors during the summer, uncontrollable environmental conditions such as rain and extreme heat may contribute to dangerous playing conditions in the summer.

The main strength of the study is the regulated CHIRPP data collection procedures, whereby clinical data are collected directly from hospital staff whilst details of injury circumstances are collected directly from patients.[29] This study, however, had several limitations. CHIRPP data is limited to patients who presented to participating emergency department and is therefore not generalisable to all children who are injured playing soccer. Moreover, the data has limited details on soccer injuries because the CHIRPP database is not specific to soccer, such as the length of time playing soccer, frequency of playing soccer, etc. Although CHIRPP collects data for product information and safety/protective equipment use, these details are rarely completed for all soccer injury cases. Ideally, it would have been more informative to know more about the product information of the playing surfaces/structures/balls, the type and practice of safety/protective equipments and the characteristics of the children's physical maturity. Further more, no data was collected on the socio-economic status, ethnicity and previous history of head injury of the patients.

Conclusion

Modification of the playing surfaces/turf and structures on or around the field of play may have the greatest potential for safety intervention. Specifically, the goal posts/nets should be anchored to the playing turf[6,19] and their posts padded to reduce the severity of direct impacts. Moreover, age appropriate balls should be used,[26,36] in both organised and unorganised settings. Balls should also be re-constructed with reduction in their mass and pressure/inflation to help reduce head impact.[4,37] Due to the high proportion of eye injuries resulting from ball contact in this study, eye protection is recommended. The use of headgear has also been recommended by Delaney et al. (2008). The latter study, revealed that not wearing headgear was one of the main factors contributing to a concussion amongst 12–17 years Canadian youth.[40] Furthermore, in order to reduce severity of body contact injuries, potential disparity in physical mass and size amongst players should be considered rather than sole reliance on age for team and league formulations.

In conclusion, head injuries constituted a significant proportion of soccer-related injuries presenting to hospital emergency department. Severe injuries were associated with contact during playing with surfaces/turf and structures on or around the field of play. Therefore, the mechanism of injury might be a potential preventive measure for head injury. Finally, further studies should investigate the effectiveness of protective eye and head gear in this population.

Conflict of interest

None.

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