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A 15-year regional emergency department study of youth sport and recreational injuries

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Original article

Abstract

Purpose: The aim of this study was to determine frequency and distribution of sports- and recreation-related injuries (SRIs) affecting children and adolescents who visited a northern tier regional medical center emergency department during a 15-year period.

Material and methods: A descriptive epidemiologic design was employed to retrospectively examine age, gender, month and year of injury, location of injury, sport/recreational activity, mechanism of injury, type and severity of injury, hospital admission and length of stay. Frequency of reported injuries were compared in categories of single factors using Chi-square tests of homogeneity. The impact of risk factors – gender, age class, and sport/activity – on incidence ratios were analyzed via Poisson regression. All statistical analyses were run in R.

Results: Findings heretofore unreported or inconsistent with previous emergency department (ED) studies include a peak injury occurrence of SRIs during September; a preponderance of head/neck injuries and fractures and a higher percent of admitted patients; frequent occurrence of ice hockey injuries; increased severity of injury during ages 10-14; and a trend during 2000-2014 showing increased injury rate of various types of recreational injuries. Findings consistent with previous ED studies included variable distribution of injuries by age, gender and sport/activity; increased frequency of SRIs during ages 12-15 years and during the warmer months of the year; and trends of increased frequency of SRIs affecting females, increased injury rate of closed head injuries, and decreased occurrence of bicycle injuries during the study period. Further to these findings, several suggestions are made to inform and guide local injury prevention efforts and further research.

Conclusions: Our study results provide information on a region-specific occurrence and distribution of SRIs in a northern tier hospital catchment area that can be valuable to guide regional injury prevention efforts and further research to evaluate specific patterns identified and success of prevention efforts.

Keywords

- sports
- sport and recreation injury
- children
- youth
- hospital
- emergency department

Contribution

A – the preparation of the research project
B – the assembly of data for the research undertaken
C – the conducting of statistical analysis
D – interpretation of results
E – manuscript preparation
F – literature review
G – revising the manuscript

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Introduction

Sports- and recreation-related (SR) activities are the most frequently reported cause of unintentional injury-related hospital emergency department (ED) visits, representing approximately 1 in 5 injury-related visits among patients aged 19 and under.[1,2] More than 2.6 million children and adolescents (youth ≤19 years) are treated in EDs in the United States (US) each year for sports- and recreation-related injuries (SRIs).[3] SRIs not only reduce future participation but also lead to overweight/obesity, post-traumatic osteoarthritis, or post-concussion syndrome.[4] Of particular concern, are traumatic brain injuries (TBIs), including concussions, because of the potential long-term effects on a child's developing brain.[5]

In the US, the National Electronic Injury Surveillance System (NEISS) was established by the US Consumer Product Safety Commission and represents a national probability sample of hospitals in the US and its territories.[6] Studies using NEISS have highlighted the disproportionately high frequency of hospital emergency room visits made by child and adolescent patients for SRIs.[1,2,7-12] In one report, 63.8% of all SRIs seen over a period of one year involved patients ≤19 years.[12] However, these studies are designed to provide national estimates and therefore may not necessarily be generalizable to all geographical regions.[13]

Of the 50 states, North Dakota (ND) is the nineteenth largest in area, the fourth least populous, and the fourth most sparsely populated with half of all residents living in rural areas.[14] In addition to the usual school-based sports like football and soccer, North Dakota's youth also enjoy participating in ice hockey and a variety of outdoor SR activities such as bicycling, skiing, motocross, rodeo and skate-boarding. Given the proclivity of these activities for serious head and other injuries, it is of course important to monitor sport- and region-specific injuries and trends over time so that specific primary prevention efforts can be initiated in a timely manner to reduce risk of injury.

We thus embarked on a descriptive epidemiological study of child and adolescent (i.e., youth) SRIs impacting a regional hospital in ND. In cooperation with *Safe Kids Grand Forks*, the present study was designed: (1) to determine the frequency and distribution of SRIs affecting youth who presented to a northern tier regional medical center ED during the period 2000–2014, (2) to identify any injury trends apparent during this study period, and (3) to propose suggestions for region-specific targeted injury prevention measures arising from these data.

Materials and methods

Study participants

The participants in this study were youth who visited a northern tier regional medical center ED with an SRI during 2000–2014. Institutional Review Board approval was obtained from both the University of North Dakota (UND) and the regional medical center (RMC). Access to the medical records was obtained from the RMC where we accessed the medical records in this study.

Study procedures

This population-based descriptive epidemiologic study examined retrospectively the frequency, incidence, circumstances and characteristics of SRIs in a northern tier regional medical center ED. This study was a search of years 2000–2014 of the RMC records for injuries sustained by youth during SR activities, excluding motorized sports vehicles. This study followed the International Classification of Diseases (9th ed.)[15] using the ICD-9-CM external cause of injury codes, or E-codes, to identify injuries specific to the study.

The ED database was searched for SRIs and results were coded for age, gender, month and year of injury, location of injury, sport/recreational activity, mechanism of injury, type and severity of injury, hospital admission and length of stay. The ED records were queried for E codes that designate specific sports and recreational injuries. Before 2009 the E codes used were E826.0-E917.5 which grouped sports together with other types of non-athletic related injuries. Codes E001.0 to 010.9 and E826.1 to 917.5 were used following 2009 and seemed to catch all the injury types of interest. The details of each incident were recorded on a Microsoft Excel spread sheet. The medical record number, date of injury, and patient's name were not included on the spread sheet.

Data analysis

Frequency of reported injuries were compared in categories of single factors using Chi-square tests of homogeneity. Single variable tests included the following factors: age, gender, anatomical region of injury, anatomical location of injury, sport/activity, month, year, mechanism, type, severity, hospital admission and length of stay. Interdependence of select pairs of risk factors were tested using Chi-square tests of independence. All statistical analyses were run in R.[16]

There is no comprehensive and systematic data collection method that enumerates exposure to sports and recreational injuries.[17] Consequently, to determine exposure for calculating injury rates, we aggregated US Census data annual estimates for each of the counties in the hospital catchment. The Census data were aggregated to match the injury data under investigation (e.g., the number of all children between 0–19 years of age when looking at total injuries or the number of children of a specific gender and in a specific age class if looking at finer subset data).

The impact of risk factors – gender, age class, and sport/activity – on incidence ratios were analyzed via Poisson regression. Using multiple Poisson regression allowed us to incorporate correlations between the risk factors. Furthermore, to adjust for varying exposure between levels of the risk factors and over time, exposure in terms of person-years from the US Census for the counties in the hospital catchment was included in the Poisson model as an offset factor. Poisson regression analyses were performed in R.[16]

Results

Who is affected?

A total of 4017 medical records were reviewed for youth who presented to the ED following an SRI during the study period. A breakdown of injury frequency relative to exposure (total person-years), and injury rate (injuries per 1000 person years) by age classes is provided in Table 1. Overall, there were 4,017 injuries and 535,931 person years for an overall injury incidence of 7.50 injuries per thousand person-years. Injury incidence was greatest in the 10–14 age group (8.7 times higher than the lowest age class, children between 0–4; $\chi^2 = 1259.9$, df = 3, $p < 0.0001$).

Table 1. Injury frequency, exposure (total person years), and injury incidence (injuries per 1000 people years) by gender and age classes

		Age class				Overall
Gender		**0–4**	**5–9**	**10–14**	**15–19**	**0–19**
Male	Frequency	115	503	1,240	1,017	2,877
	Exposure	62,936	60,968	65,175	88,018	277,097
	Rate	1.83	8.25	19.03	11.55	10.38
Female	Frequency	75	325	481	246	1,128
	Exposure	58,499	58,209	61,152	80,974	258,834
	Rate	1.28	5.58	7.87	3.04	4.36
Overall	Frequency	197	831	1,722	1,264	4,017
	Exposure	121,435	119,177	126,327	168,992	535,931
	Rate	1.62	6.97	13.63	7.48	7.50

Note that rows and columns may not add up as age class was missing in 3 cases and gender was missing in 12 cases.

Males incurred 2,877 (71.8%) and females 1,128 (28.2%) of all injuries ($\chi^2 = 763.8$, df = 1, $p < 0.0001$). Injury rates were higher for males than females overall and across age classes, with the difference most pronounced in the 15–19 age group (Table 1). The distribution of injury frequency by age and gender is shown in Figure 1, which shows an obvious peak in injury frequency covering the ages 12 to 15, occurring earlier for females than males.

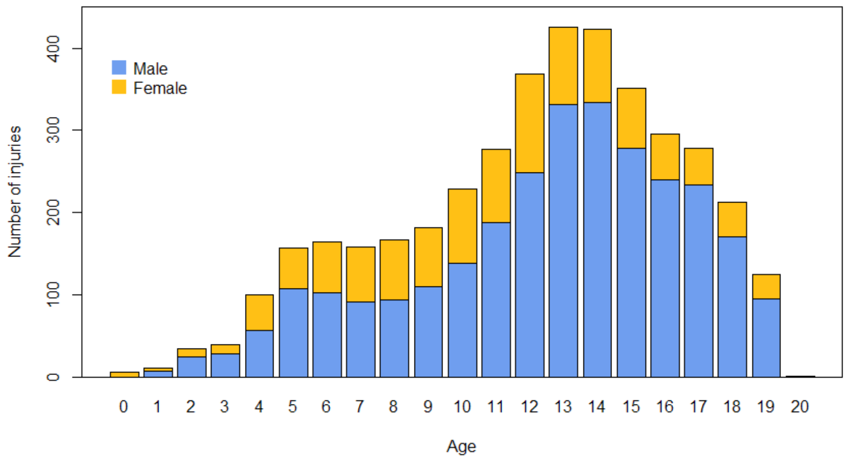

Figure 1. Distribution of injuries across ages, separated by gender

Where did injuries occur?

Anatomical

Head/neck was the most frequent site of injury (19.4%) followed by hand (15.4%) and face (13.1%) (χ^2 = 1083.9, df = 9, p < 0.0001). Differences in injury by body region were also statistically significant (χ^2 = 911.56, df = 3, p < 0.0001). The upper extremity (UE) (arm, forearm, hand) was most frequently injured (38.7%), followed by head/neck/face (32.5%) then lower extremity (LE) (leg, ankle, foot) (21.4%).

The distribution of regions of injury was significantly different between age groups (χ^2 = 165.58, df = 9, p < 0.0001) and between genders (χ^2 = 42.963, df = 9, p < 0.0001). Children 0–4 years were more likely to experience a head/face/neck injury (59.2% of injuries in children between 0 and 4 years vs. 25 to 40% of injuries in the other age classes) and less likely to experience an upper extremity injury (20.9% of injuries in children between 0 and 4 years vs. 33 to 45% of injuries in the other age classes). The most frequently injured locations for males were head/neck (21.0% of male injuries) followed by hand (14.8%) and face (13.2%); whereas for females it was hand (17.3% of female injuries) followed by head/neck (15.2%) and forearm (15.2%).

Situational (sport/activity)

Bicycle incidents (18.0% of all injuries) occurred most often, followed by football (17%) and hockey (16.2%) (χ^2 = 1148.7, df = 9, p < 0.0001) (Table 2). The frequency of injuries by sport/activity varies significantly by age group (χ^2 = 1188.5, df = 27, p < 0.0001) and gender (χ^2 = 490.52, df = 9, p < 0.0001). The frequency of injuries in bicycle, playground and other recreation injuries decreased as age increased, while the frequency of injuries in organized sports – such as football, hockey, and basketball – increased as age increased. SR activities characterized by the highest injury frequency for males were football (23.6%) followed by ice hockey (19.8%) then bicycling (17.3%). For females, it was bicycling (19.7%) followed by playground (16.8%) and other recreational activities (16.2%).

How did injury occur?

Injury mechanism

There were significant differences between injury mechanisms (χ^2 = 4439.3, df = 4, p < 0.0001) with falls to the ground most common (61.0%), followed by player-to-player collision (13.9%), collision with immobile object (13.6%), and collision with mobile object (11.6%).

The frequency of injury mechanism differed significantly between age classes (χ^2 = 12042, df = 9, $p \leq 0.0001$). Young children were more likely to be injured by fall (77.0% of injuries in 0–4 years and 71.1% in 5–9 years vs. 59.2% in 10–14 years and 54.1% in 15–19 years), and older youth more likely to be injured by a collision (17.3% of injuries in 15-19 years vs. 3.6% in 0–4 years). Compared to other SR activities (χ^2 = 780.78, df = 27, p < 0.0001), cycling and board sports had a much higher proportion of injuries due to falls (92.8% and 93.1%, respectively) while hockey and football had the highest proportions of injuries due to collisions (23.6% and 20.0%, respectively).

Table 2. Frequency and percent values for youth ED visits for injuries due to sports and recreational activities. Data are reported for all injuries, divided by age class, and divided by gender. Percent values are calculated for each column. The shaded cells represent the three most common injury types in each column

Sport/Activity	All injuries	Age class				Gender	
		0–4	5–9	10–14	15–19	Male	Female
Bicycle	723 (18.0%)	53 (26.9%)	250 (30.1%)	322 (18.7%)	98 (7.8%)	499 (17.3%)	222 (19.7%)
Football	698 (17.4%)	4 (2.0%)	38 (4.6%)	331 (19.2%)	325 (25.7%)	678 (23.6%)	19 (1.7%)
Hockey	649 (16.2%)	19 (9.6%)	61 (7.3%)	317 (18.4%)	250 (19.8%)	554 (19.3%)	92 (8.2%)
Basketball	422 (10.5%)	4 (2.0%)	20 (2.4%)	197 (11.4%)	201 (15.9%)	244 (8.5%)	177 (15.7%)
Other recreation	414 (10.3%)	22 (11.2%)	121 (14.6%)	164 (9.5%)	107 (8.5%)	235 (8.2%)	179 (15.9%)
Playground	394 (9.8%)	74 (37.6%)	244 (29.4%)	69 (4.0%)	7 (0.6%)	201 (7.0%)	190 (16.8%)
Other organized sport	255 (6.3%)	3 (1.5%)	30 (3.6%)	118 (6.9%)	103 (8.1%)	147 (5.1%)	107 (9.5%)
Baseball/softball	199 (5.0%)	11 (5.6%)	32 (3.9%)	90 (5.2%)	66 (5.2%)	151 (5.2%)	47 (4.2%)
Soccer	132 (3.3%)	2 (1.0%)	12 (1.4%)	57 (3.3%)	61 (4.8%)	80 (2.8%)	52 (4.6%)
Board sports	131 (3.3%)	5 (2.5%)	23 (2.8%)	57 (3.3%)	46 (3.6%)	88 (3.1%)	43 (3.8%)
Total	**4,017 (100%)**	**197 (100%)**	**831 (100%)**	**1,722 (100%)**	**1,264 (100%)**	**2,877 (100%)**	**1,128 (100%)**

What was the outcome?

Type of injury

There were significant differences between injury types ($\chi^2 = 1375.9$, df = 5, $p < 0.0001$) with fractures most common (30.4%), followed by soft tissue injuries (22.6%), lacerations (21.6%) sprains/strains (15.5%), and closed head injuries (9.7%). Among fractures, 16.6% involved the physis, with most diagnosed as Salter-Harris type II lesions. Football was the SR activity most often associated with physeal fracture, although most SR activities were represented.

Frequency of injury types varied by age class ($\chi^2 = 307.56$, df = 15, $p < 0.0001$) and between SR activities ($\chi^2 = 489.45$, df = 49, $p < 0.0001$). The most common injury types among age groups were: 0–4 (lacerations; 44.2%), 5–9 (fractures; 35.9%), 10–14 (fractures 34.5%), and 15–19 (soft tissue; 24.9%). Most notable were the high frequency of fractures in playground injuries (48.8% vs. 19 to 40% in other sports) and lacerations in bicycling injuries (36.4% vs. 7 to 28% in other sports).

Fractures were more common in football (20.4% of all fractures reported), bicycling (16.6%), playground injuries (15.8%) and hockey (13.6%) compared to all other sports (<9.0% in any one of the remaining SR activities). Closed head injuries were most common in football (22.8%), hockey (19.9%), and bicycling (15.3%) compared to all other SR activities (<8% in any of the remaining activities).

Injury severity

Injury severity was indicated by one of three grades: (1) severe: bone fracture with reduction or surgery; concussion with significant symptoms; (2) moderate: bone fracture; grade 3 ligament sprain; concussion with moderate symptoms; laceration with longer length and significant gapping; and (3) mild: grade 1 or 2 ligament sprain; concussion with mild symptoms; and limited wound gapping.

There were significant differences between grade of injury severity ($\chi^2 = 150.44$, df = 2, $p < 0.0001$) with moderate injuries most common (42.3%), followed by minimal (36.0%), then severe (21.7%). Injury severity differs between age classes ($\chi^2 = 38.851$, df = 6, $p < 0.0001$) with injuries in the 10–14 age group more severe (only 29.1% of injuries in the minimal category compared to 39.2–41.6% in the other three categories). Injury severity also differs with injury type ($\chi^2 = 548.17$, df = 10, $p < 0.0001$) with fractures twice as likely to result in severe injuries compared to other types of injuries (39.7% of fractures were severe injuries vs. < 20% of all other injury types being severe injuries).

Significant differences occurred in the frequency of those admitted vs not admitted to the hospital ($\chi^2 = 856.66$, df = 1, $p < 0.0001$) and length of stay ($\chi^2 = 167.65$, df = 5, $p < 0.0001$). The majority of youth (93.0%) were treated and released from the hospital on the same day. If admitted, length of stay ranged from 1 to 6 nights with most patients admitted staying for 1 night (68.8% of all stays). Severe injuries were more likely to result in hospital admission ($\chi^2 = 318.63$, df = 2, $p < 0.0001$) and more likely to result in a longer stay ($\chi^2 = 321.25$, df = 12, $p < 0.0001$).

Temporal variation

There were significant differences in injury frequency between months ($\chi^2 = 449.79$ df = 11, $p < 0.0001$), primarily due to September (15.7%), which ranged from 1.6 to 3.2 times higher injury frequency than the other months (Figure 2, panel A). Figure 2 (panels B–H) indicates a varying monthly distribution of injuries among different SR activities.

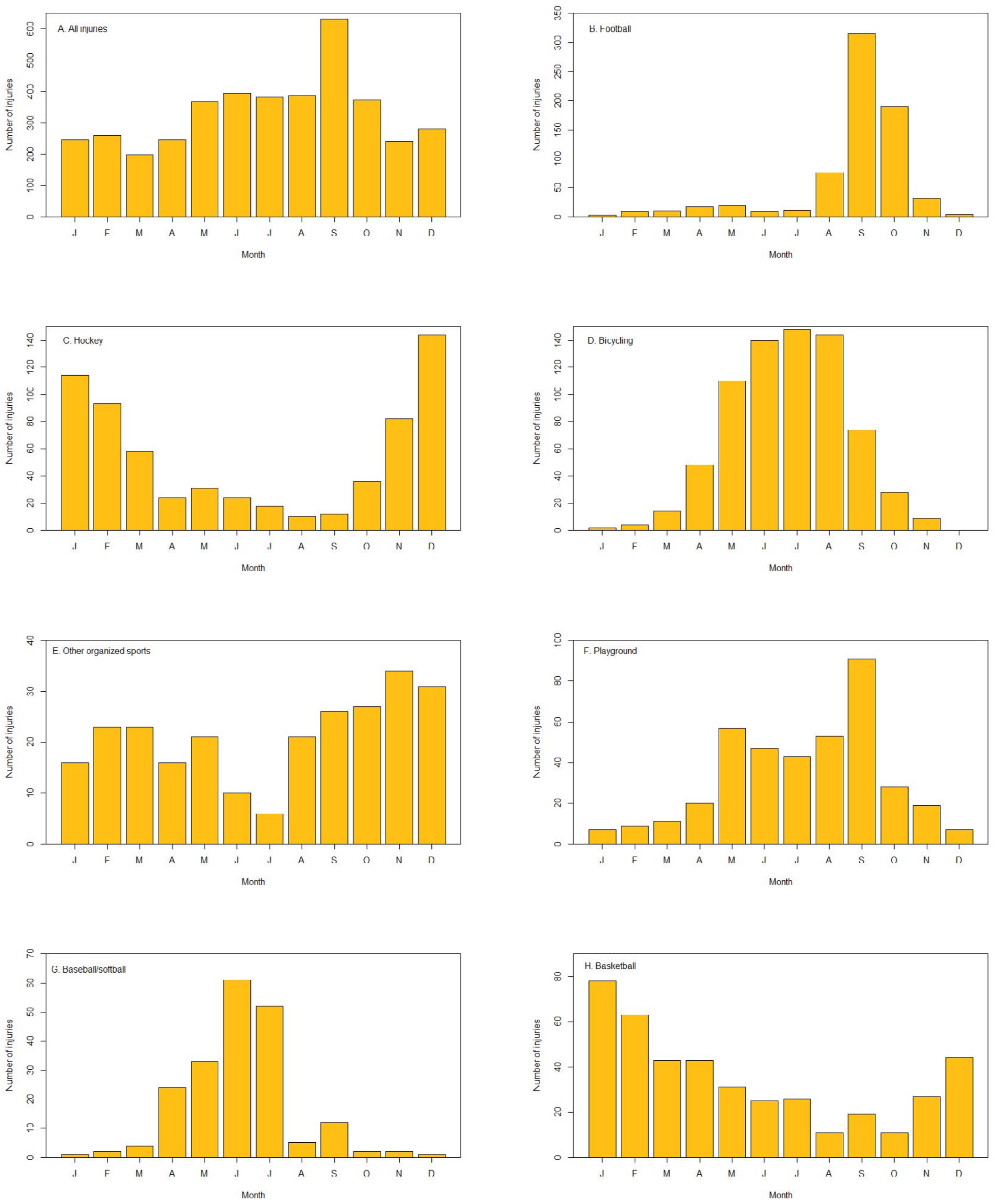

Figure 2. Distribution of injuries during the months of the year for all injuries (panel A) or for injuries due to specific activities (B – football, C – hockey, D – bicycling, E – other organized sports, F – playground, G – baseball/softball, and H – basketball)

In most years, there were 6 to 8 injuries per 1000 person-years (Figure 3, panel A). Years 2005 and 2006 are just below that range, but 2007, 2008 and 2009 are above with 2009 having almost twice as many injuries as a usual year. Interestingly, for closed head injuries (Figure 3, panel B) there is an increase in incidence rate through 2002, gradual decrease through 2005, then a sharp increase in 2007 and again in 2010, then leveling out.

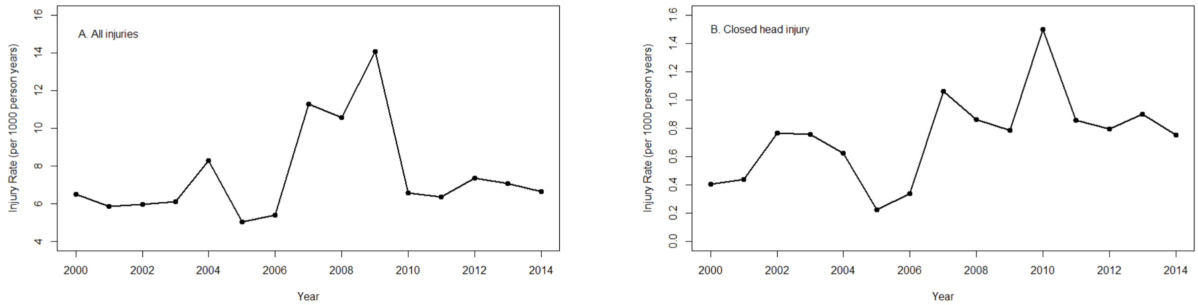

Figure 3. Injury rate for all injuries (Panel A) and concussion / closed head injury (Panel B) over time

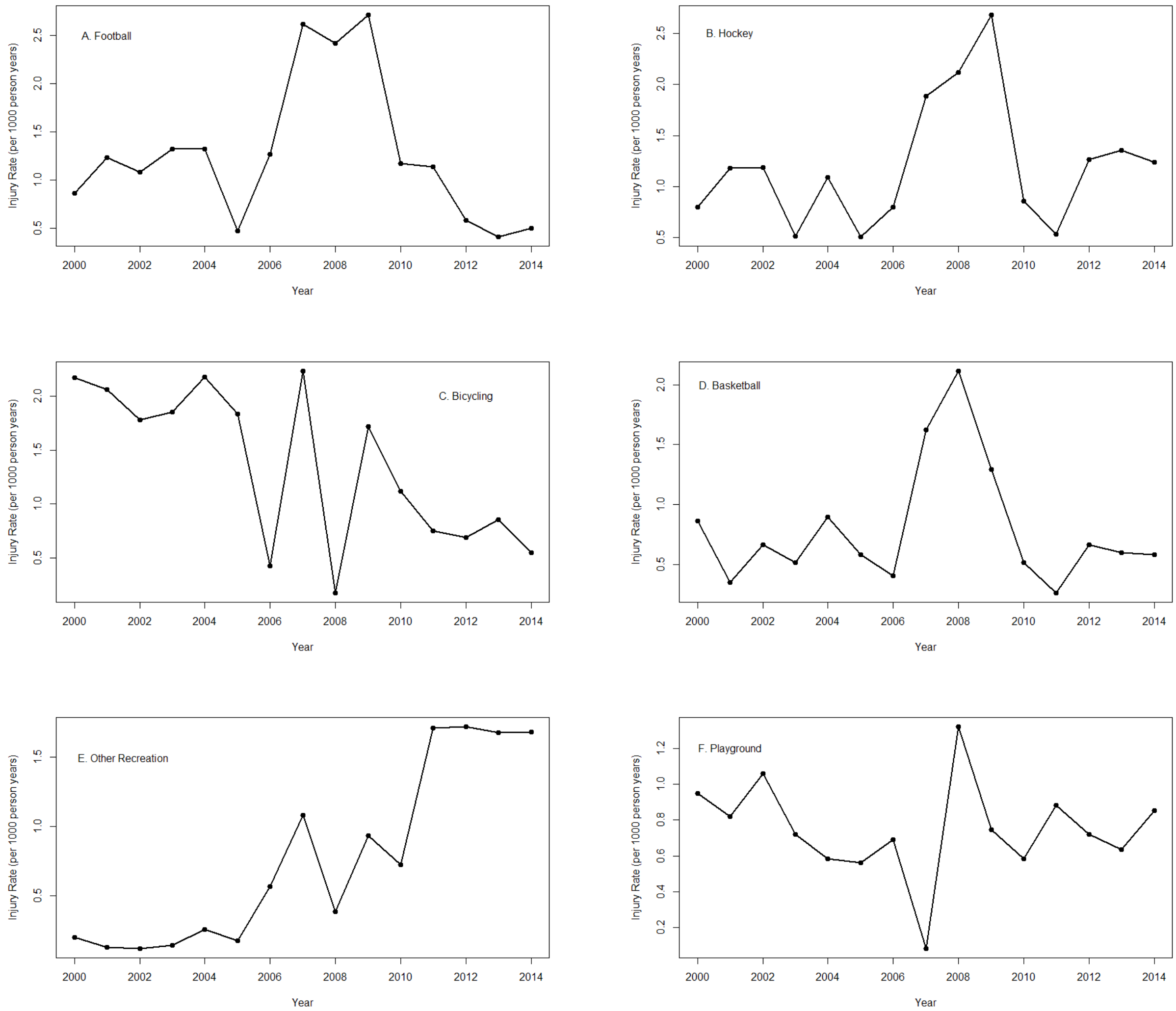

Figure 4. Injury rate (per 1000 person years) for the six sports/activities with the most injuries

Injury frequency was consistently greater in males than females; however, injuries became more common in females over time ($\chi^2 = 70.507$, df = 14, $p < 0.0001$), The temporal pattern on injury frequency also varied in different sports ($\chi^2 = 1004.2$, df = 126, $p < 0.0001$) (Figure 4). While football, hockey, and basketball all show peaks in injury rate between 2006–2010, bicycling saw injury rates declining over time, whereas 'other recreational activities' (e.g., trampoline, horseback riding, sledding, gymnastics, roller blading, figure skating) experienced an increasing injury rate over time.

Risk model

Risk of injury was compared to a referent category for each age class, gender, and sport/activity (Table 3). Each of the age classes had significantly higher rate ratios than the youngest age class, with the 10–14 age class having the highest rate ratio which is almost 9 times more likely to be injured than 0–4. Females had a significantly lower rate ratio than males, which indicates that females were about 0.4 times as likely to be injured.

Table 3. Poisson regression estimates of rate ratios for injuries per 1000 people years in the catchment for the hospital. All variables are categorical and rate ratios are compared to the indicated referent for each factor. *P* values were determined from Z tests of the coefficient. Significant *p* values (<0.05) are indicated in **bold**

Risk Factor	Rate Ratio	95% CI	*p* value
Gender			
Male	Referent		
Female	0.419	0.391, 0.449	**<0.0001**
Age class			
0–4	Referent		
5–9	4.465	3.823, 5.241	**<0.0001**
10–14	8.724	7.532, 10.165	**<0.0001**
15–19	4.767	4.104, 5.569	**<0.0001**
Sport/Activity			
Football	Referent		
Hockey	0.924	0.830, 1.028	0.8342
Bicycle	1.034	0.932, 1.148	0.9264
Baseball/ Softball	0.284	0.242, 0.332	**0.0001**
Board sports	0.188	0.155, 0.226	**<0.0001**
Other organized sports	0.363	0.314, 0.418	**0.0046**
Other recreation	0.594	0.526, 0.670	0.1487
Playground	0.561	0.495, 0.634	0.2955
Basketball	0.604	0.535, 0.681	0.2055
Soccer	0.189	0.157, 0.227	**<0.0001**

Four sports had significantly lower rate ratios than football: baseball/softball with 0.3 times risk, board sports (e.g., skateboarding) with 0.2 times risk, other organized sports with 0.4 times risk, and soccer with 0.2 times risk. Hockey, bicycle, other recreation, playground, and basketball were not significantly different from football in terms of the rate ratio.

Discussion

Engaging in SR activities during youth has important physical health benefits, but also involves risk of injury. For children and adolescents who are injured during SR activities, the ED is often the first point of contact with the medical system.[13] ED registries are a pro-active mechanism to document numbers and characteristics of moderate to severe injuries requiring emergency treatment.[13] They are also useful in assessing the 'burden' of injury and in bringing public health and political attention to injury prevention priorities.[18]

Most ED studies of SRIs in the United States stem from the NEISS which represents a national probability sample of hospitals in the United States.[2,3,6-12] However, national studies may not be applicable to local areas due to geographical differences in SRIs.[13] Our study is the first study to describe the characteristics and distribution of SRIs affecting youth who visited a northern tier regional medical center. Data were analyzed over a period of 15 years to enable assessment of injury trends.

Who is affected?

Our data show an obvious peak in frequency of SRIs at 12–15 years. Incidence data show a similar pattern with incidence of injuries significantly higher in the 10–14 age group. These results are consistent with previous ED studies which show an increased rate of SRIs occurring through the 0–4 to 10–14 age groups, and a decreased rate in the 15–19 age group.[9,19,20] It is of course possible that faster-growing children are exposed to greater risk for injury because they played more. However, it is also likely that growth-related factors associated with the growth spurt – such as joint stiffness, tendon maturity, impaired movement efficiency, and decreased physeal strength and bone density – may predispose young adolescents to increased risk of injury, especially during the adolescent growth spurt.[21] The results of several recent studies linking higher growth rates (e.g., changes in height, leg length or body mass index) and peak height velocity have been associated with increased injury risk in high-level youth football players.[22-24]

Injury frequency and incidence of injury were more than two times greater for males than females, as has been reported elsewhere in the ED literature.[2,11,12,20] In addition to differences in social-related participation patterns, possible explanations include hormonal differences, increased joint laxity in female athletes, anatomical differences, and differences in motor control.[26] However, girls tend to have higher exposure-based injury rates than boys in gender-comparable high school sports.[27] Also, girls may actually be at increased risk for anterior cruciate ligament injuries in the knee[28] and sport-related concussions.[29]

In our study, the higher rates of injury in males were most pronounced in the 15–19 age group. An increasing gender gap for injury occurrence with age has been reported elsewhere[12,30] and may reflect the more pronounced decline in baseline physical activity during adolescence among girls compared to boys.[31]

Where did injuries occur?

Identification of commonly injured anatomical locations alerts healthcare professionals to sites in need of special attention during pre-participation examination (PPE). Previous research indicates that the upper extremity and LE are commonly injured body regions,[1,7,17,19,20] often followed by head/neck/face injuries.[1,7,17] UE injuries were most frequent in our study, but followed by head/neck/face, then the lower extremity. Almost one-fifth (19.3%) of all injuries in our study involved the head/neck. Notably, sports and activities associated with the greatest frequency and rate of injuries in our study – bicycle, football and hockey – were also associated with the greatest proportions of head region injuries (19.3%, 17.7% and 22.9%, respectively).

In our study, distribution of injury by anatomical location varied by age group, gender, and sport/activity. For example, children 0–4 years were most likely to experience a head/face/neck injury. Rui et al.[1] report head and neck injuries were more frequent among young patients, ages 5–9 (33.8%), compared with older patients (17.8% for age group 10–14). These findings are perhaps not surprising given the increased risk of falling among younger children due to a disproportionately larger head and trunk.

Rui et al.[1] reported that for males, the UE followed by LE were most frequently injured; whereas for females, it was LE followed by the UE. In our study, head/neck/face injuries were most prevalent for males, whereas for females it was the UE. These gender differences may reflect the greater participation of males in contact sports such as gridiron football.

Bicycling, football and hockey accounted for half (50.8%) of all injuries in our study (Table 2). While football and bicycling were most often associated with injury in other studies,[1,2,8,21] the inclusion of hockey in the top three likely represents the regional popularity of this sport. Our findings that frequency of injuries in bicycling, playground, and other recreation decreased with age, whereas injury frequency increased with age in sports like football, hockey and baseball are consistent with previous reports[1,12,17,32] and largely reflect changing exposure patterns with age as children continue to grow and develop.

How did injury occur?

An understanding of injury mechanism associated with the definitive onset of injury is of obvious importance to injury prevention. Most SRIs treated in EDs result from falls, being struck by an object, collisions, and overexertion during unorganized or informal sports activities.[30,33] In our study, falling on the ground was also a common SRI mechanism, especially among children ages 0–9 years during bicycling and board sports; thereafter, an increasing proportion of injuries was due to collision, especially in hockey and football; again, likely reflecting the changing injury mechanism and exposure patterns with age.

What was the outcome?

The three most common injury types reported in many ED studies are contusions, sprains/strains and fractures.[1,7,20,25] In our study and two others[2,20] fractures were the most common type of injury across sports/activities. Notably, fractures were more than twice as likely as other injuries to result in severe injuries.

Acute growth plate injuries such as those incurred by falling off bicycles, skateboards, playground equipment, out of trees, and so forth, are common to childhood misadventures and are associated with potential for growth disturbance.[34] Consistent with our results, physeal fractures account for about 15% of all fractures in children in the ED setting.[35]

ED studies report from 3–6.5% of all injuries[2,17,30] are closed head injuries. In our study, almost 1 of 10 (9.8%) injuries were closed head injuries, which may reflect the high frequency of these injuries in football, hockey and bicycling and the relatively high proportion of head/neck (19.8%) injuries overall.

We found that the age group with the greatest severity of injuries was the 10–14-year-old group. This finding has not been reported previously and raises the importance of establishing measures to control both incidence and severity of injury during this age range.

Previous ED studies[2,30,36] report from 1.3–4.6% of ED visits for SRIs resulted in admission to the hospital. Our slightly higher (7.0%) admittance rate may reflect the preponderance of fractures (30.4%) and relatively higher frequency of head region and closed head injuries in our study.[1,7,19,26]

Temporal variations and injury trends

If injury rates and/or severity of injury increase over time, it follows that efforts to better understand the reasons for the elevated risk are in order and appropriate preventive measures should be applied to reduce risk during this time. Consistent with previous research,[10,13] our study shows temporal variations in injury patterns relative to timing of sport seasons. Our analysis revealed an increased frequency of injuries occurring during May-October, the warmer months when participation in organized sports and outdoor recreational activities is greatest. Notably, frequency of injury was highest in September, the beginning of school fall sports.

Our study showed only slight variation in injury rate during the study period except for an elevation during 2007–2009. This finding is contrasted by the results of Lykissas et al.[20] who reported that injury incidence decreased between 2000 to 2010 from 16.4 to 14.4/1000 person-years among children 5–14 years of age. Harmon et al.[17] reported a 38.1% decrease in total SRIs between 2000–2010 among youth 5–14 year of age. Similarly, Kamboh et al.[30] reported a significant 14% reduction in rate of injury per 1000 children ages <18 years from 1990–2005. However, this was followed by a non-significant increase during 2005 to 2012.

A noteworthy finding in our study was the annual trend of increased injury frequency in females. Published reports suggest that the number of girls playing high school–sponsored sports has steadily increased since the 1970s, perhaps in part because of the passage of Title IX.[37] Lykassis et al.[20] noted that during 2000 girls (ages 5–14 years) sustained 31.3% of all injuries, whereas in 2010 the girls sustained 37.9% of all injuries.

Consistent with previous research[20,38] we report a decrease in bicycling injuries during 2000–2014. This change may be attributable to fewer bicycle trips, bicycle safety campaigns, and increased use of bicycle helmets. However, the need for continued preventive efforts remains given the extent to which bicycle injuries continue to impact the burden of hospital ER visitations. In this regard, legislation to require bicycle helmets for youth riders in North Dakota is worthy of consideration.[39,40]

Although fractures did not show any clear trends over time, closed head injuries show a gradual increase, more marked during 2007–2010, and maintaining thereafter. These results are consistent with those of Coronado et al.[41] who report rates of ED-treated SR-related TBIs began to increase in 2004 for females and 2006 for males. Reasons for the reported increases in ED visits are unknown but may be associated with increased awareness and care-seeking for concussions, particularly following the passage of “return to play” laws in states throughout the United Sates, beginning in 2009.[30]

Study limitations

This study has several limitations. First, injury rates are underestimated because this study only included children treated in EDs.[5] ED injury surveillance programs capture mainly acute injuries, severe enough to require emergency treatment, and therefore miss many, less severe injuries including those which result in time loss from participation.[13] Because activity-specific exposure data were unavailable, US Census population estimate data were used to calculate injury rates. It is possible that an exposure-based denominator (e.g., total number of hours exposed to risk of injury) would produce different results.[13] Also, the narrative descriptions of injury do not include information about whether the injury occurred in practice or competition, whether protective equipment was used, and whether the injury was a new injury or a reoccurrence of a previous injury.[17]

Practical applications

Despite these limitations, results of this study provide information on the frequency and distribution of injury in a northern tier hospital catchment area that can be valuable to inform local prevention efforts and further research.

Given that more than half of all injuries in our study were sustained in three sports/activities – bicycling, football, and hockey – it follows that these activities should be prioritized for local injury prevention initiatives. This prevention focus is underscored by the finding that these same three activities were also associated with the highest proportions of head/face and closed head injuries.

The use of helmets has been shown to significantly decrease the risk of nonfatal and fatal head injuries in many sports and recreational activities. In addition to helmets, proper safety equipment such as knee pads, elbow pads, wrist guards and mouth guards have been shown efficacious in preventing incidence and severity of SRIs, yet despite this, there is less than optimal uptake of effective equipment strategies.[40,42]

Helmets are not required in ND for wheeled sports activities. A multipronged strategy employing legislation, enforcement of laws and community programs is important for increasing helmet use to decrease deaths and injuries from recreational sports and activities.[40] Educational programs to reinforce the need for bicycle helmets should be introduced immediately before the spring flurry of activity in bicycling and continued through the summer and early fall.[10]

A unique finding of our study was the peak injury occurrence of SRIs in September, at the outset of the new school year. This finding underscores the importance of PPEs to identify, treat and rehabilitate injured and high-risk sport participants.[43] PPEs should be conducted at least 6 weeks before the first preseason practice to allow time to evaluate the athlete and treat any medical conditions.[43] Requiring a PPE for youth participating in non-school sport settings is also recommended.[43]

The finding of increased risk and severity of SRI's during the timing of the adolescent growth spurt warrants maturity-specific prevention programs where coaches are encouraged to identify periods of rapid growth where resources allow and monitor training load of individual athletes to reduce injury risk.[22-24,44] Observing, talking to, and educating players and parents may be equally effective.[22] The employment of bio-banding, a method by which players are grouped together based on their maturity and biological age rather than their birth year, also could potentially help reduce the risk of injury among youth athletes.[45,46]

Finally, the trend of increased frequency of injury among females during the study period is a concern, especially in view of research showing increased risk of for anterior cruciate ligament injuries in the knee[28] and sport-related concussions.[29] Injury prevention strategies specifically targeting these injury types are needed to reduce the increasing number of injuries in girls' SR activities.[42,47] Irrespective of the trend of sports injuries, however, an effort should be made to decrease injuries in all SR activities to promote safe play in children.[20]

Conclusion

The unique feature of this regional study is its geography and climate, both influencing factors in prevailing injuries and the activities that produce them. Being a northern tier regional medical center in the Upper Great Plains, the ED's inventory of SRIs would include activities that thrive in cold and snow and would limit activities that enjoy extended playing seasons in a more southern location and climate. Although several categories of results in this study aligned well with results of other studies not constrained to region and climate, there were findings that deviated from other published results. For example, ice hockey – the sport associated with the greatest percentage of head region injuries – was included among the three most common activities associated with injury.

It is well-known that involvement in SR activity has important and wide-ranging health benefits. However, as evidenced in this report, engaging in SR activities at a young age also involves risk of injury serious enough to require medical attention. In addition to the immediate healthcare costs, these injuries may preclude continued participation in SR activities. In severe cases, they may result in reduced levels of physical activity and, therefore, reduction in wellness. Although it is impossible to eliminate all injuries, attempts to reduce them are obviously warranted.

Despite study limitations, the results of this study provide data on the frequency and distribution of injury in a northern tier hospital catchment area that can be valuable to guide local prevention efforts and further research. The following prevention targets are suggested: (1) a focus on SR activities associated with the highest frequency and rate of injury, including head/face and closed head injuries: bicycling, football, and ice hockey; (2) legislation requiring use of helmets for children ≤18 years during wheeled sports activities; (3) PPE's conducted at least 6 weeks before the first preseason practice of SR activities to allow time to evaluate the athlete and treat any medical conditions, (4) maturity-specific injury prevention programs to reduce risk and severity of injury during the adolescent growth spurt, and (5) prevention programs specifically designed to reduce risk of injury in girls' SR activities.

In North Dakota, there has been legislation to better guide sport concussion management. Additionally, the healthcare systems in ND although not required involve athletic trainers for acute injury management and injury prevention for the larger schools in the state, as well as a satellite type arrangement for smaller area schools. And organizations such as Safe Kids in North Dakota provide educational programs to improve sport safety, including wheeled sport safety, for youth participants. However, ND is presently one of several states which has no state-wide laws or local ordinances requiring the use of helmets among children and youth riding bicycles. We urge legislation in ND for the use of helmets among children ≤18 years for wheeled sports and recreational activities, skiing, snowboarding, skating, and horseback riding. Legislative involvement has been and will continue to be a positive force in enhancing prevention of sports and recreational injuries.

The results of our study indicate that a regional ED registry is useful in assessing the local burden of SRIs and in bringing public health attention to youth injury prevention priorities. However, well-designed epidemiological studies are needed to better define the incidence, distribution and determinants of SRIs in the region, as well as the effectiveness of any specifically targeted preventive programs. In this this regard, the importance of exposure-based information on SR participation is necessary to better characterize the nature and extent of the public health burden imposed by youth SRIs.

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