This is Your Brain on Sports

Measuring Concussions in High School Athletes in the Twin Cities Metropolitan Area

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Concussions can have a negative impact on students' ability to perform in the classroom as well as on their health and well-being. Therefore, timely treatment is especially important. To better understand the prevalence of concussion on high school athletics, the Minnesota Department of Health piloted an online sports-related concussion reporting system in 36 public high schools in the Twin Cities metropolitan area. In the 2013-2014 academic year, 730 concussions were reported to our system from certified athletic trainers working with those schools, with one out of every 100 Minnesota high school athletes sustaining concussions. From this, we estimated that 2,974 sports-related concussions occurred among high school athletes statewide. This data is useful for evaluating and guiding prevention efforts, and for informing clinicians on how to treat concussions.

Traumatic brain injuries (TBI), including concussions, can have short- and long-term effects on memory and reasoning, communication, expression and understanding. They also can cause personality changes, social inappropriateness, depression and anxiety.[1] One study done in the United Kingdom found that concussions placed children at risk for developing behavioral problems that may affect their school performance.[2] Several other studies found correlations between pediatric concussions and poor visual memory and reduced reaction time and processing speed.[3-5]

In 2011, Minnesota passed a law requiring the Minnesota State High School League to provide information to coaches, officials, athletes and parents/guardians about the nature and risks of concussions, including the effects of continued play following a suspected concussion. The law also requires coaches and officials to receive online training about concussions,[6] including how to recognize the signs (headache, temporary loss of consciousness, confusion, amnesia surrounding the event, dizziness, ringing in the ears, nausea, vomiting, slurred speech, delayed response to questions and fatigue).[7]

The 2011 Minnesota Special Emphasis Report on TBI estimated that a total of 10,800 concussions occur each year in the state; more than 2,200 (21%) of those occur in youths between 15 and 18 years of age.[8] Of those concussions that are treated in Minnesota hospitals, 43% are caused by participation in sports and recreational activities.[9] Coded hospital discharge data has been the best available source of information on sports-related concussions in Minnesota. However, that information tells only part of the story because of limitations of the ICD-9-CM coding system and because most high school athletes who experience concussions are not treated in a hospital.[10,11]

Reporting Information Online (RIO), an Internet-based surveillance system developed at Nationwide Children's Hospital in Columbus, Ohio, shows a more complete picture. RIO collects from certified athletic trainers national injury and exposure data for all injuries occurring among high school athletes involved in 20 sports including football, boys' ice hockey, lacrosse, soccer, basketball and boys' wrestling.[12,13] In order to better document the scope of sports-related concussions in high school athletes, the Minnesota Department of Health piloted an online reporting system modeled after RIO but focused solely on concussion.

Methods

We initially piloted our online sports-related concussion reporting system in public high schools in the Twin Cities

metropolitan area during the 2012-2013 academic year. We then refined the system (primarily by reducing the number of data elements collected) and conducted a second-stage pilot during the 2013-2014 school year. Between August 1, 2013, and June 13, 2014, certified athletic trainers from 36 schools entered sports-related concussion incident data into the online reporting system; trainers received a $100 incentive for participating. Data collected included the athlete's gender, grade and sport. In cases where there were persistent symptoms (lasting more than two weeks), the athletes' addresses and telephone numbers were collected so they and their families could receive information about post-concussion resources. Although all Minnesota State High School League sports were included in the study, concussion reports were only submitted for ice hockey, football, gymnastics, wrestling, soccer, lacrosse, basketball, baseball, dance team, cross country and volleyball.

The Minnesota Department of Education provided athlete participant data. An average rate for the 36 schools included in the pilot study was calculated using the number of participants in a particular sport as the denominator and the number of concussion incident reports for that sport as the numerator. We estimated the number of concussions at each of the remaining schools in the state by multiplying the concussion rate for each sport by the number of participants in that sport at a particular school. Finally, an estimate of the total number of sports-related concussions in the state was calculated by applying the rates found in our study to participant numbers from schools statewide.

TABLE

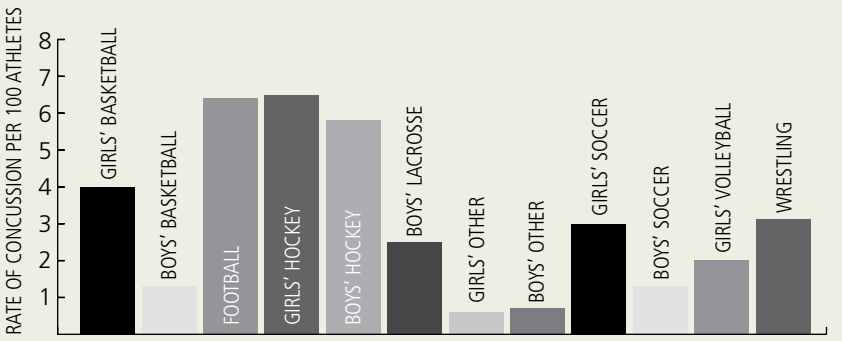
Percent of Total Concussion Reports in Athletes from 36 Twin Cities-area Public High Schools by Sport

AUGUST 2013-MAY 2014 (N=730)

Girls' basketball	6%
Boys' basketball	3%
Cheerleading	3%
Football	42%
Girls' hockey	7%
Boys' hockey	8%
Girls' other	5%
Boys' other	4%
Girls' soccer	9%
Boys' soccer	4%
Volleyball	5%
Wrestling	5%

FIGURE 1

Concussion Rates from 36 Twin Cities-area Public High Schools by Sport AUGUST 2013 TO MAY 2014 (N=730)



Results

A total of 730 sports-related concussion reports were collected from 67,212 participants in the 36 metro-area schools between August 1, 2013, and May 27, 2014, resulting in a rate of one concussion per 100 athletes in the sports studied. An additional 34 concussions were ; however, they were not included in the analysis because they occurred outside of the Minnesota High School Sports League season. Overall, 304 (42%) of the reports involved football players, making it the sport with the most concussions. The sports with the next-highest number of reported concussion were girls' soccer (67 or 9% of total reports), boys' hockey (56 or 8%), girls' hockey (50 or 7%), and girls' basketball (47 or 6%) (Table).

Football and boys' and girls' ice hockey had the highest rates of concussion (six per 100 athletes) (Figure 1). The next-highest rates occurred in girls' basketball (four per 100 athletes), girls' soccer (three per 100), boys' wrestling (three per 100), and girls' volleyball (two per 100).

Among all sports studied, 174 reports were made for athletes in grade 9; 219 for those in grade 10; 181 for those in grade 11; and 139 for those in grade 12 (Figure 2). Of the cases involving athletes who played football, 90 reports involved students in grade 9; 88 involved those in grade 10; 76 involved athletes in grade 11; and 50 involved students in grade 12. The Minnesota Department of Education does not gather information about the grade level of high school athletes, so rates could not be calculated by grade level.

Overall, 5% (42) of all reported cases were noted by the athletic trainers as having persistent symptoms.

A synthetic estimate, or an approximation of the total number of sports-related concussions in the state of Minnesota, was calculated by applying the metro-area rates statewide. Based on our pilot data, we estimated that 2,974 sports-related concussions occurred among Minnesota high school athletes during the 2013-2014 academic year (Figure 3).

Discussion

A 2012 national study using data from the RIO system estimated national rates of concussion by sport using "athlete-exposures" (AEs), or the number of times

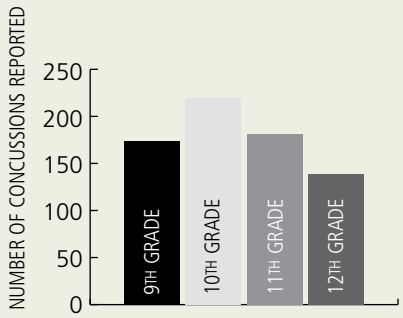
an athlete participated in a game or practice, as the denominator in its calculations.[13] Although we tried to collect AEs in the initial pilot (the 2012-2013 academic year), we found it significantly complicated the athletic trainers' reporting. For the second stage of the pilot (the 2013-2014 academic year), we excluded the question about AEs in order to simplify reporting and increase the number of completed reports; the rates in our study were calculated using the number of participants instead of the number of AEs, making it inappropriate to compare our rates with the national rates. The number of concussions reported may be an undercount because athletic trainers 1) provide variable levels of support to the different sports, 2) are not at all sporting events, and 3) may not have been informed of all concussions to high school athletes. Yet, we included the participants from all sanctioned sports in our rate calculations; hence, the overall rate of one concussion per 100 athletes is very likely conservative.

We were able to compare the number of concussions per school in Minnesota with the number reported in the national study: RIO found approximately 19 concussions per school nationally, and we found approximately 22 concussions per school in Minnesota. The percentage of concussions reported among football players in our pilot study (42%) was similar to that found in a 2007 national study (41%).[13] These findings tend to validate the level of reporting in our pilot study.

FIGURE 2

Concussion Rates from 36 Twin Cities-area Public High Schools by Grade Level

AUGUST 2013-MAY 2014 (N=730)



It appears that the greatest opportunity for reducing the overall number of sports-related concussion is in football, since football-related concussions account for almost half of all sports-related concussions reported.

In sports played by both boys and girls in Minnesota, the rate of concussion among girls is higher than that among boys (Figure 1), which mirrors national data showing that girls typically experience higher rates of concussion than boys.[13] There is also evidence that suggests girls experience worse outcomes from concussions than boys.[14]

We noted that, in general, as athletes aged, the number of concussion reports went down. We do not know the reason for this, but we speculate it may be because older athletes tend to be larger and more skilled than younger athletes or because older athletes may have learned not to report concussions because they know they will be taken out of play if they do. Also, there may be fewer athletes in the higher grades than in the lower ones. Being able to obtain participant numbers by grade level would allow us to calculate grade-specific rates and test those hypotheses.

Timely and appropriate access to both medical care and nonmedical services are critical to facilitating recovery from a concussion, improving outcomes and promoting the overall health of youths.[15] One of our concerns is the extent to which physicians and other health care providers know how to screen for and treat concussions. A 2012 study of pediatric primary care and emergency medicine providers who regularly care for concussed patients found those providers may not have adequate training or the necessary support to systematically diagnose and manage these patients.[16]

The CDC's Heads Up toolkit offers education for physicians and other health care providers about concussions and includes recommendations for when to make a referral to a mild traumatic brain injury specialist (if symptoms do not improve within three to five days post injury and if the severity of symptoms is of concern).[17] A 2011 study found mailing the Heads Up toolkit to physicians appeared to positively influence their recommendations regarding returning athletes to play after a concussion.[18]

FIGURE 3

Synthetic Estimate for Total Annual Concussion Reports in Minnesota High School Athletes AUGUST 2013 TO MAY 2014

SPORT	MALES	FEMALES	TOTAL
Basketball	150	350	500
Football	1,355	0	1,355
Hockey	212	168	379
Lacrosse	41	0	41
Soccer	87	194	281
Volleyball	0	245	245
Wrestling	174	0	174
Total	**2,018**	**957**	**2,974**

We provided information about TBI resources to the athletes in our study who experienced persistent symptoms. One of those is a program called Resource Facilitation, which is offered through the Minnesota Brian Injury Alliance. Although the program is geared toward hospitalized traumatic brain injury patients, youths with persistent symptoms of concussion and their families could benefit from it as well.

Conclusion

Sports-related concussions are a threat to the health and well-being of Minnesota's youths. Being able to measure the number and rate of concussions in high school athletes is an important step in assessing the potential overall impact of concussion and evaluating our progress toward preventing them. The Minnesota Department of Health's sports-related concussion reporting system is a valuable tool for collecting data that could be used to shape concussion-prevention efforts such as educational programming, use of improved protective equipment, increased conditioning for athletes, enhanced en-

forcement of sporting rules, and policy changes at the high school level. That data also can be useful to primary care physicians and other clinicians who need to know how to treat patients with suspected concussion. MM

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