
Sports Related Head and Brain Trauma

Frederick O. Mueller, PhD

In 1931 the American Football Coaches Association conducted the first annual survey of football fatalities; since 1965, the data from the annual survey have been collected by the Department of Exercise and Sport Science at the University of North Carolina at Chapel Hill (UNC).¹ In 1977, also through UNC, the National Collegiate Athletic Association began a national survey of catastrophic football injuries. Data from both these research projects have led to important modifications of the sport of football, most notably the rule changes in 1976, the establishment of football helmet standards, improved medical care for players, and better coaching techniques.

With the success of the two football projects, data collection was expanded to include all sports for both men and women, and in 1982 UNC decided to establish a National Center for Catastrophic Sports Injury Research (NCCSIR). The NCCSIR was deemed necessary for several reasons: (1) research based on reliable data is essential to progress in sports safety; (2) there is a paucity of information on injuries in sports of all kinds; (3) there has been a rapid expansion of (and little information about injury in) women's sports. The Center defines as "catastrophic" any severe injury incurred during participation in a school/college sponsored sport. Catastrophic injuries are further classified as follows: Fatal; Non-Fatal but with Permanent Severe Functional Disability; and Serious Injury without Permanent Disability (for example, fractured cervical vertebra with no paralysis).

Sports injuries are also classified as direct or indirect. Direct injuries are those that result directly from participation in the skills of the sport; indirect injuries are those caused by systemic failure as a result of exertion while participating in a sport activity or by a complication secondary to a non-fatal injury. In this paper I will discuss only direct injuries.

Dr. Mueller chairs the Department of Exercise and Sport Science at UNC Chapel Hill. Address correspondence to him there at CB #8700, 204 Fetzer Gymnasium, Chapel Hill, NC 27599-8700. Telephone: 919/962-5171. Email: mueller@email.unc.edu

Brain Injury in Sports

Most football fatalities are caused by brain trauma, and fatal brain injury can also occur in other sports, like soccer, wrestling, track, and baseball.³⁻⁵ Traumatic brain injury is common in contact sports (an estimated 250,000 concussions occur every year in football alone⁶). Repeated concussions within a short period can be fatal.^{7,8} Second impact syndrome, in which there is rapid brain swelling and herniation when a second head injury follows a first, occurs when an athlete who has sustained a head injury returns to play or practice before symptoms of the first injury have cleared.

Cantu⁹ states that this is more common than previously thought, and between 1980 and 1991, the NCCSIR identified 29 probable cases in football players alone. For a catastrophic condition with a mortality rate approaching 50% and a near-100% morbidity rate, prevention of second-impact syndrome takes on the utmost importance.⁹

In a recent study, Guskiewicz, et al¹⁰ found that football players who sustained a concussion were three times more likely to sustain a second concussion in the same season than were uninjured players. Recent statistics estimate 300,000 sports-related traumatic brain injuries or head injuries in the United States every year. The Centers for Disease Control and Prevention reports a high incidence of repeated head injuries in several sports, and warns of the likelihood of serious sequelae increases with repeated head injury.¹¹

Football Fatalities

Data on football fatalities have been collected since 1931, but because of uncertainties surrounding early data collection, I report here only the data on football fatalities from 1945 through 2000. Except in 1990, every year from 1945 through 2000 has produced at least one fatal brain injury to participants in high school, college, professional or recreational football. There were a total of 714 football deaths between 1945 and 2000; of these, 492 (69%) were due to brain injuries; 116 (16%) due to cervical spine injuries; and 107 (15%) due to other injuries.

Table 1. Head/brain fatalities in football at all levels of play, 1945–2000

Level of play	Number	Rate*
High school	369 (75%)	0.60
College	34 (6.9%)	0.81
Sandlot	76 (15.5%)	0.68
Professional	13 (2.6%)	5.80
Total	492 (100%)	

*Events/100,000 participants, based on 61,600,000 high school players, 4,200,000 college players, 11,200,000 sandlot players and 224,000 professional players

Table 2. Types of fatal head/brain injuries in football, 1945–2000

Type of injury	Number (% of total)
Subdural hematoma	366 (74.4%)
Brain injury	33 (6.7%)
Fracture	18 (3.7%)
Aneurysm	7 (1.4%)
Unknown	68 (13.8%)
Total	492 (100.0%)

During the period 1945–2000, there were more fatal brain injuries in high school than college football (Table 1), but there were many more high school and middle school football players (about 1,100,000 annually) than college players (about 75,000 annually) so the rate of injury per 100,000 participants is actually lowest for high school football (and vastly higher for professional football).

As might be expected, most of the fatal head/brain injuries in football occurred while the participant was tackling or being tackled in a game. Table 2 shows that approximately 75% of these fatal injuries were subdural hematomas, and an additional 33 were listed as other brain injury. If, as seems likely, the latter were actually subdural hematomas, then this lesion would account for over 80% of all fatal head/brain injuries. A large number of fatal injuries are listed as “unknown type”; if even at least some of them and of those listed as “fracture” were subdural hematomas, it would make this injury the cause of nearly all fatalities.

Figure 1 shows the average yearly number of fatal football head/brain injuries by decade. The rate increased to an all-time high during 1965–1974, then steadily declined through 1985–1994. The decade 1995–2004 is not yet complete, and so it is not certain that the declining trend has been halted; the rate for the first six years (1995–2000) is higher than the rate for the preceding decade. The number of fatalities began rising in the early 1960s and continued into the early 1970s. This can be directly related to the techniques for tackling and blocking that were being taught during those years (characterized by terms like “spearing,” “butt blocking and tackling,” “face to the numbers,” “face in the chest,” etc). Players were told to make initial contact by driving the head and face into the opponent’s chest. Not only did

fatal head/brain injuries increase, but so did fatal cervical spine injuries. The rules changes of 1976 prohibited initial contact with the head or face, leading to a dramatic decrease in both fatal head/brain and cervical spine injuries. Figure 2 shows the rapid

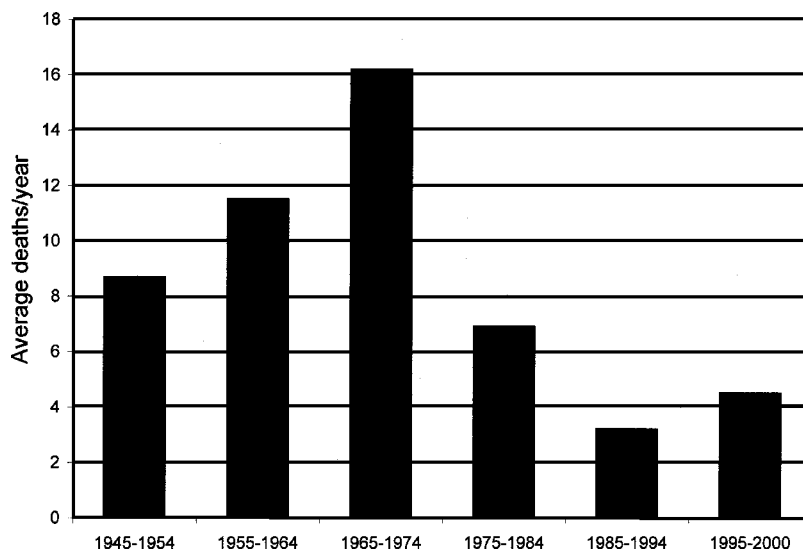


Figure 1. Average yearly number of fatal football head/brain injuries by decade.

rise and fall in fatality rate, peaking in the late 1960s and falling to low levels in recent years.

Catastrophic Football Injuries

In 1977 the National Collegiate Athletic Association initiated an Annual Survey of Catastrophic Football Injuries² (conducted by the University of North Carolina at Chapel Hill as part of the NCCSIR). Catastrophic, non-fatal football injuries are those that result in brain or spinal cord injuries, or head or

spine fractures, and all involve some disability at the time of the injury, but only some produce permanent residual disabilities. At first only data about spinal cord injuries were collected, but beginning in 1984 data from head/brain injuries were included. As shown in Table 3, from 1984 through 2000, 70 high school and seven college-level players suffered catastrophic head/brain injuries. During this same time span, 111 high school and 17 college players sustained spine injuries.

Over the 17 years of data collection, there was an average

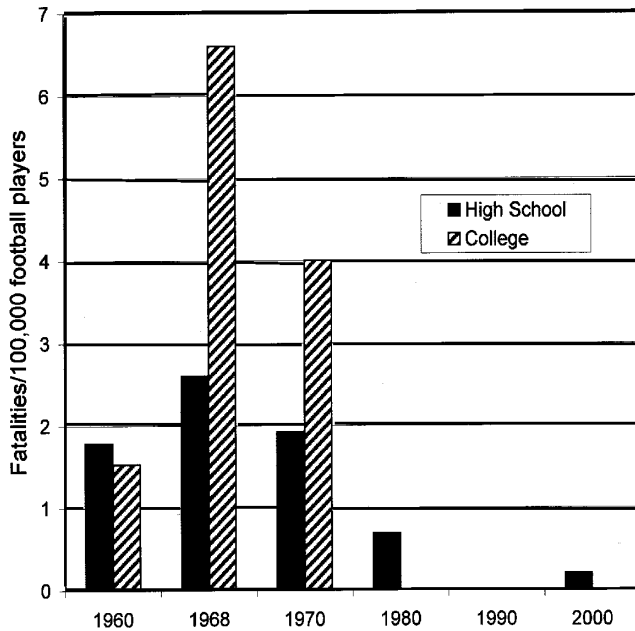


Figure 2. Rate of fatalities from football head/brain injuries.

Table 3. Catastrophic head/brain injuries in football, 1984–2000

Level of play	Number	Rate*
High school	70	0.27
College	7	0.55
Total	77	

*Events per 100,000 participants based on 1,500,000 junior and senior high school players and 75,000 college players annually

of 4.5 catastrophic head/brain injuries/year; in the peak year, 1997, eight players (seven high school and one college player) were injured. The catastrophic head injury rate from 1984 through 2000 is 0.27 injuries per 100,000 high school football players and 0.55 injuries per 100,000 college players. In addition to catastrophic injuries with incomplete recovery, there are a number of serious head injuries each year that end in complete recovery.

Catastrophic Head Injuries in Other Sports

Football has received the most attention with regard to catastrophic athletic injury. In fact, until the formation of the NCCSIR in 1982, football was the only sport with a catastrophic injury data collection system. Table 4 shows ten high school sports that led to catastrophic or severe injuries. Five (track and field, baseball, gymnastics, ice hockey, and cheerleading) had high rates of catastrophic head/brain injuries, but two—gymnastics and ice hockey—attracted relatively small

Table 4. Catastrophic head/brain injuries in high school sports other than football, 1982–2000

Sport	Fatal injury	Rate*	Permanent disability	Rate*	Temporary disability	Rate*	Total	Rate*
Basketball	1	0.01	0	0.0	3	0.02	4	0.02
Track & field	13	0.08	7	0.05	14	0.09	34	0.22
Soccer	2	0.02	1	0.02	4	0.04	7	0.07
Baseball	3	0.04	7	0.09	10	0.12	20	0.25
Softball	1	0.02	0	0.0	1	0.02	2	0.03
Wrestling	1	0.02	0	0.0	0	0.0	1	0.02
Swimming	0	0.0	1	0.03	0	0.0	1	0.03
Cheerleading	1	0.07	1	0.07	11	0.82	13	0.96
Ice hockey	0	0.0	1	0.19	1	0.19	2	0.37
Gymnastics	1	0.22	0	0.0	0	0.0	1	0.22
Total	23		18		44		85	

*Events per 100,000 participants, based on following annual participation numbers for high school men and women: Basketball (1,000,000); Track and Field (850,000); Soccer (550,000); Baseball (450,000); Softball (330,000); Wrestling (230,000); Swimming (200,000); Cheerleading (75,000); Ice Hockey (30,000); Gymnastics (25,000).

numbers of participants, which may have inflated the apparent injury rates.

Pole-vault events produced most of the catastrophic track and field injuries, including three pole-vaulting deaths in 1983, and a number of cervical spine injuries. Pole-vaulting accidents happen in one of three ways: (1) the vaulter bounces out of the landing pit onto the hard surrounding surface; (2) the vaulter misses the landing pit and lands on the hard surrounding surface; (3) the vaulter assumes an upside down position holding onto the pole, is unable to get over the bar, and falls head first into the metal pole planting box. In addition to pole vaulting, track and field produced a number of catastrophic head/brain injuries when participants were struck by a thrown discus, shot put, or javelin. All of these injuries are preventable and should never happen. Most baseball injuries occur during head-first sliding, collisions with other players, or when players are struck by a pitched or thrown ball. Cheerleading, which has changed dramatically over the past 18 years, now has two distinctive purposes. One is to lead cheers on the sideline, and the other is to compete as highly skilled athletes. Cheerleading accounts for approximately one-half of the catastrophic injuries to high school and college women athletes.

Catastrophic Head/Brain Injuries to Women

There has been an increase in catastrophic injuries to women participants in sports. For example, in 1982-1983 there was one catastrophic injury to a woman, but over the past 17 years there has been an average of 5-6 injuries/year. Half of the injuries occurred during cheerleading; gymnastics ranked second, followed by swimming, basketball, track, softball, field hockey, and volleyball. Table 5 shows the distribution of catastrophic head/brain injuries to women in high school sports from 1982 to 2000. In this group, cheerleading accounted for approximately 70% of

Table 5. Catastrophic head/brain injuries to high school women, 1982-2000

Sport	Fatal injury	Permanent disability	Temporary disability	Total	Rate*
Track & Field	1	0	3	4	0.06
Softball	1	0	1	2	0.02
Cheerleading	1	1	11	13	1.03
Swimming	0	1	0	1	0.06
Basketball	0	0	1	1	0.01
Total	3	2	16	21	

*Rate of total events, based on annual participation in Track (395,000); Softball (350,000); Cheerleading (70,000); Swimming (98,083); Basketball (411,172).

Table 6. Catastrophic head/brain injuries in college sports other than football, 1982-2000

Sport	Fatal injury	Permanent disability	Temporary disability	Total	Rate*
Track & field	2	4	0	6	0.61
Baseball	1	1	0	2	0.56
Basketball	0	0	1	1	0.22
Ice hockey	0	1	1	2	2.78
Cheerleading	1	2	5	8	NA
Total	4	8	7	19	

*Total events per 100,000 participants, based on the following annual participation numbers for college men and women: Track (55,000); Baseball (20,000); Basketball (25,000); Ice hockey (4,000); Cheerleading (unknown).

the head/brain injuries; most athletes recovered from their injuries, but all were serious.

Table 6 shows the distribution of catastrophic head/brain injuries among college athletes participating in sports other than football. The only injuries to women were incurred in cheerleading; one college woman cheerleader died, two were permanently disabled, and four were temporarily disabled but recovered fully. In terms of rate of injury, ice hockey seems to be the most dangerous sport, but the injury rate is based on a single injury among a small number of participants and therefore may be misleading.

Discussion

Recommendations for Preventing Injury. Catastrophic head/brain injuries may never be totally eliminated from sports, but collection and analysis of reliable data about injuries can dramatically lessen injuries. I list here several recommendations for injury prevention:

- ◆ All athletes should undergo a medical examination,

including a thorough medical history, before participating in sports.

- ◆ All schools and colleges that participate in athletics should have on their faculty an athletic trainer who is certified by the National Athletic Trainers' Association.

- ◆ Games rules should be strictly enforced by officials, coaches, and school officials.

- ◆ Coaches should know and be able to teach the proper fundamental skills of the sport.

- ◆ Athletes who have experienced head trauma (loss of consciousness, visual disturbance, headache, inability to walk correctly, obvious disorientation, memory loss) should receive immediate medical attention and should not return to practice or play without appropriate medical clearance. A qualified doctor should observe head-injured athletes for several days after the injury. Coaches should point out why it is important and encourage athletes to inform them of any symptoms (especially those that can't be seen by others, such as headaches).

- ◆ Coaches should never decide whether a player can return to a game or to active practice if that player has experienced brain trauma. The team's certified athletic trainer or a qualified health professional should make that decision.

- ◆ Before participation, both athletes and parents should be warned of the risks of injuries.

- ◆ We must keep the head out of football. Players must be taught to not make initial contact with their head or face while blocking or tackling.

- ◆ The team's certified athletic trainer must be prepared for catastrophic head injuries. Everyone involved must know what to do in advance of any injury. Advance preparation and

knowing what to do may be the difference that prevents permanent disability. Written emergency plans should be available and copies given to all relevant personnel; these plans should cover the following topics: (1) evacuation plans, (2) availability of transportation, (3) portable and open communication, and (4) provision of game/practice schedules to local hospital emergency departments. These recommendations will not prevent injuries from happening, but they may prevent serious injuries from leading to permanent disability.

Conclusions

Data from the NCCSIR have played a major role in reducing the incidence of sports-related catastrophic injuries. National governing bodies have used the data to identify problem areas in specific sports and to implement changes. The ongoing collection of data on catastrophic injuries has allowed these changes to be evaluated. Continuing surveillance is important because sports are evolving and changing, and inexperienced coaches continue to enter the profession. Catastrophic injuries are rare, but, in the unfortunate event of such an injury, health professionals need to be trained and prepared to deal with the situation. And every school should strive for routine and regular access to the services of a NATA-certified athletic trainer.

Acknowledgment: This research was supported by the National Collegiate Athletic Association, the National Federation of State High School Associations, and the American Football Coaches Association.

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