

ANNUAL SURVEY OF CATASTROPHIC FOOTBALL INJURIES

1977 - 2018

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Prepared for:

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National Collegiate Athletic Association, Indianapolis, Indiana
National Federation of State High School Associations,
Indianapolis, Indiana
National Athletic Trainers' Association, Dallas, Texas
National Operating Committee on Standards for Athletic Equipment

August 8, 2019
FINAL

Report #: 2019-02



We acknowledge the significant contributions of recently retired Frederick O. Mueller, Ph.D. who directed The National Center for Catastrophic Sport Injury Research (NCCSIR) from 1982 to 2013. Dr. Mueller’s work over the past 30 years has improved the safety of football for the participants and these impacts are demonstrated in the pages of this football report.

We also acknowledge NCCSIR staff members Lily Wang, Leah Cox Thomas, Hannah Price, Dr. Rebecca Yau Lee and members of the Consortium for Catastrophic Sport Injury Monitoring: Drs. Douglas Casa, Jonathan Drezner, Kevin Guskiewicz, Johna Register-Mihalik, Steve Marshall, Dawn Comstock, David Klossner, Tom Dompier, Zack Kerr, and Christine Collins.

We also thank all the athletes, families, coaches, athletic trainers, medical providers, school staff, state associations, researchers, journalists, and others who have participated in this research and have shared information with the NCCSIR.

Funding & Disclosures:

The National Center for Catastrophic Sport Injury Research is funded by the American Football Coaches Association, the National Collegiate Athletic Association, National Federation of State High School Associations, National Athletic Trainers’ Association, the American Medical Society for Sports Medicine, the National Operating Committee on Standards for Athletic Equipment, and The University of North Carolina at Chapel Hill.

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INTRODUCTION

In 1977, the National Collegiate Athletic Association initiated funding for the First Annual Survey of Catastrophic Football Injuries. Frederick O. Mueller, Ph.D., and Carl S. Blyth, Ph.D., both professors in the Department of Exercise and Sport Science at the University of North Carolina at Chapel Hill were selected to conduct the research. The Annual Survey of Catastrophic Football Injuries was part of a concerted effort put forth by many individuals and research organizations to reduce the steady increase of football head and neck injuries taking place during the 1960's and 1970's. The primary purpose of the research was and is to make the game of football a safer sport.

An early investigation into serious head and neck football injuries conducted by Schneider et al. reported 30 permanent cervical spinal cord injuries in high school and college football during the period from 1959 to 1963 (Schneider 1973). A later study by Torg et al. reported a total of 99 permanent cervical spinal cord injuries occurring in high school and college football from 1971 to 1975 (Torg, Truex et al. 1979). A study published in 1976 reported the incidence of neck injuries based on roentgenographic evidence was as high as 32% in a sample of 104 high school students and 75 college freshmen in Iowa (Albright, Moses et al. 1976). In order to help alleviate this problem the National Collegiate Athletic Association (NCAA) and the National Federation of State High School Associations (AFCA) implemented rule changes in 1976 to prohibit using the head as the initial contact point when blocking and tackling. Furthermore, the American Football Coaches Association (AFCA) Ethics Committee went on record opposing this type of blocking and tackling. A reduction of these events occurred following these rule changes. Torg has since discontinued his research, however his

work demonstrated a decline in permanent cervical cord injuries in high school and college from 34 cases in 1976 to 5 cases in 1984 (Torg, Vegso et al. 1985).

Recent Rule Changes and Safety Recommendations

Both the NCAA and the NFHS have further defined illegal helmet contact and have established return to play rules if a concussion is suspected. The NFHS 2013 Football Rules Book (page 31 Rule 2-20-1) defined illegal helmet contact as “an act of initiating contact with the helmet against an opponent” (Gardner and Colgate 2013). The rule book further defines the three types of illegal helmet contact:

- a) Butt blocking is an act by an offensive or defensive player who initiates contact against an opponent who is not a runner with the front of his helmet.
- b) Face tackling is an act by a defensive player who initiates contact with a runner with the front of his helmet.
- c) Spearing is an act by an offensive or defensive player who initiates contact against any opponent with the top of his helmet. (NFHS 2013 Football Rules Book, page 31, Rule 2-20-1)

All three of these illegal techniques can cause catastrophic head and neck injuries to the athlete. In 2014, NFHS rules committee added a definition of targeting (page 31, rule 2-20-2) as “an act of taking aim and initiating contact to an opponent above the shoulders with the helmet, forearm, hand, fist, elbow, or shoulder” and made it a separate personal foul (page 71, rule 9-4-3m) (Gardner and Colgate 2014). They also added a definition of a defenseless player to reduce the risk of injury: “A defenseless player is a player who, because of his physical position and focus of concentration, is especially vulnerable to injury.” In 2015, NFHS rules committee

changed the spearing rule: “Spearing is an act by any player who initiates contact against an opponent at the shoulders or below with the crown (top portion) of his/her helmet” (Gardner and Colgate 2015). In 2017 a definition of the blindside block was created: “Unless initiated with open hands, it is a foul for excessive and unnecessary contact when the block is forceful and outside of the free-blocking zone” (Gardner and Colgate 2017).

The concussion rule (3-5-10b) was revised in 2013 as follows: “any player who exhibits signs, symptoms, or behavior consistent with a concussion (such as loss of consciousness, headache, dizziness, confusion or balance problems) shall be immediately removed from the game and shall not return to play until cleared by an appropriate health-care professional.” This time-out, if not charged, is an official’s time-out. Appendix B, page 95, guidelines are provided for management of concussion injuries.

The Second Safety in College Football Summit held by the NCAA in 2016 resulted in an interassociation consensus document that addressed athlete safety and head impact exposure in football. This summit focused on both concussion prevention and catastrophic injury prevention. Consensus outcomes included, but not limited to:

- Head accelerometers are currently unable to function as concussion detectors.
- Tackling and blocking should be performed with technique emphasizing hands and shoulder contact and elimination of head contact.
- Preseason, Inseason, and Postseason practice guidelines.
- Definitions for football contact and equipment.
- A set of six best practice recommendations were published in 2019 (NCAA 2019) that cover:

1. Sportsmanship

2. Protective Equipment
3. Acclimatization and Conditioning
4. Emergency Action Plan
5. Responsibilities of Athletics Personnel
6. Education and Training

This 2016 interassociation consensus document (NCAA 2016) outlined the following definitions, with the intent of providing a framework on varying intensity levels from non-contact/minimal contact practices to live contact/tackling to the ground practices. This framework is consistent with USA Football as follows (italicized content is from USA Football):

Non-contact/minimal contact practices do not involve tackling, thud, “wrapping up” or full-speed blocking. Non-contact/minimal contact practices are those practices in which drills are not run at a competitive speed, as follows:

- **Air.** *Players run a drill unopposed without contact.*
- **Bags.** *Drill is run against a bag or other soft-contact surface.*
- **Control.** *Drill is run at an assigned speed until the moment of contact.*

One player is designated by the coach ahead of time as the pre-determined winner. Contact remains above the waist and players stay on their feet.

Live contact/thud is any practice in which players are not taken to the ground, including “thud” sessions or drills that involve “wrapping up,” irrespective of uniform worn. *Drill is run at competitive speed through the moment of contact with no predetermined winner. Contact remains above the waist, players stay on their feet and a quick whistle ends the drill.*

Live contact/tackling is any practice that involves tackling to the ground. *Drill is run in game like conditions and is the only time that players are taken to the ground.*

This research has been conducted as part of the National Center for Catastrophic sports Injury Research (NCCSIR), University of North Carolina at Chapel Hill. The NCCSIR was directed by Dr. Frederick Mueller from 1980 to 2013. Dr. Mueller retired Spring of 2013 and the NCCSIR is now directed by Dr. Kristen Kucera. The NCCSIR has expanded to become a consortium (University of North Carolina, Boston University, University of Washington, University of Connecticut, University of Colorado, the University of Maryland, and the Datalys Center) with expertise in head/neck, cardiac, and heat-related sports medicine (these three areas account for the overwhelming majority of catastrophic events). The NCCSIR is supported by the American Football Coaches Association (AFCA), the National Collegiate Athletic Association (NCAA), the National Federation of State High School Associations (NFHS), the National Athletic Trainers' Association (NATA), the American Medical Society for Sports Medicine (AMSSM), the National Operating Committee on Standards for Athletic Equipment (NOCSAE), and The University of North Carolina at Chapel Hill (UNC-CH).

METHODS

Data Collection

Data were compiled with the assistance of coaches, athletic trainers, athletic directors, executive officers of state and national athletic organizations, online news reports, online reports, and professional associates of the researchers. In January of 2015, NCCSIR and the Consortium

for Catastrophic Injury Monitoring in Sport developed an online portal where anyone can report a catastrophic event ([www.https://sportinjuryreport.org](https://sportinjuryreport.org)). Throughout the year (January 1 to December 31), upon notification of a suspected catastrophic football injury, contact by telephone, email, or personal letter questionnaire was made with the appropriate individuals including state high school association official, school or team administrator, coach, athletic trainer, team physician, and/or the family. Individuals are asked to complete a brief survey about the event at online portal ([www.https://sportinjuryreport.org](https://sportinjuryreport.org)). All activities were and currently are approved by the Institutional Review Board (IRB) of the University of North Carolina at Chapel Hill (IRB# 05-0018).

Outcome Definitions

Catastrophic injuries were originally defined as football injuries which resulted in brain or spinal cord injury or skull or spine fracture (Mueller and Arnold 1978). Injuries, which result in death, are not included in this report. It should be noted that brain and spine injuries involved some disability at the time of the injury. Neurological recovery was defined as either complete or incomplete (e.g. quadriplegia or paraplegia). Yearly follow-up was not done, thus neurological status (complete or incomplete recovery) refers to when the athlete was entered into the database. Cases with unknown or uncertain disability status at the time of the capture were updated with information available regarding recovery for this report. Other non-fatal catastrophic injuries such as internal organ injuries, commotio cordis, etc. are also noted in this report (Table VII).

Participation in Football

Reports prior to 2012 showed 1,800,000 participants in all levels of football (Mueller & Colgate 2011). Participation numbers gathered by the National Operating Committee for Standards in Athletic Equipment (NOCSAE), NFHS, and USA Football show the following: NFHS has estimated that there are approximately 1,100,000 high school player's grades 9-12. Research also indicates there are 100,000 post high school players including the National Football League (NFL), NCAA, National Association of Intercollegiate Athletics (NAIA), National Junior College Athletic Association (NJCAA), Arena Football, and Semi-professional football. USA Football estimates there are 3,000,000 youth football players in the United States. Organized Youth is defined as non-school, youth football, but organized and using full protective equipment (e.g., Pop Warner, American Football League). These figures give an estimate of 4,200,000 total football participants in the United States each year (Mueller & Colgate 2012). Note these denominators are consistent with those used by NCCSIR's Annual Football Fatality Reports (<https://nccsir.unc.edu/reports/>).

NCCSIR staff and Consortium compiled the data and the report authors prepared this report. Medical data for the report were reviewed by Dr. Robert C. Cantu, MD – medical director of NCCSIR.

Analysis

Yearly frequencies and incidence rates of catastrophic injuries per 100,000 participants were calculated based on participation estimates as described in the **Participation in Football** section above and stratified by level (organized youth, pro/semi-pro, middle school & high school, and college). **Note: Rates with number of incidents less than 5 should be interpreted with caution.**

It is important to note that information is continually being updated due to the fact that catastrophic injury information may not always reach the NCCSIR in time to be included in the current report. The report includes data that is captured by publicly available media sources and directly reported to the NCCSIR by the NCAA, the NFHS, online reports, colleagues, coaches, and athletic trainers. There may be additional catastrophic football injuries that are not reported to the NCCSIR. The authors acknowledge that not every catastrophic injury is included in this report.

RESULTS

Catastrophic Cervical (Neck) Injuries with Incomplete Recovery

During the six year period from 2013-2018 there were a total of 49 cervical spine injuries with incomplete neurological recovery (10, 3, 10, 4, 11, and 11, respectively, Table I). 37 of the injuries occurred at the middle and high school level, 7 at the college level, 3 at the organized youth level, and 2 at the professional or semi-professional level. The five year average number of cervical spine injuries with incomplete neurological recovery has decreased since the late 1970's from 10.6 to 9.4 in 2007-2011 (Table I and Figure I).

For the approximately 4,200,000 participants per year, the rate of cervical spine injuries with incomplete neurological recovery during the 6-year period 2013-2018 was 0.19 per 100,000 participants (95% CI: 0.14 to 0.25). Annual rates for high school ranged from 0.18 per 100,000 in 2014 to 0.73 per 100,000 in 2013, 2017 and 2018 (Table II). The rate at the college level ranged from 0 per 100,000 in 2013 and 2016 to 4.00 per 100,000 in 2015.

Since 1977, 49.2% of players with cervical spine/cord injuries with incomplete recovery were on the defensive side of the ball and 18.3% were on the offensive side, 10.8% were playing special teams, and 21.8% the position was unknown (Table III). The pattern over this time period has not substantially changed (Figure 2a). However, there were fewer special teams injuries and more offensive side injuries in the most recent 5-year period 2014-2018 compared to the previous 5-year period. Defensive backs continue to be the most frequent position associated with cervical cord injuries with incomplete recovery (31.2%) followed by linebackers (12.1%), kickoff/punt coverage (7.5%), and running backs (7.0%) (Table III). The overwhelming majority occur during competition (75.3%) followed by practice (17.7%), scrimmage (2.7%), or

unknown (4.3%). Tackling (64.2%) or being tackled (11.8%) remain the most frequent activity at the time of the injury. Most were cervical spine fractures (84.4%).

A majority of catastrophic spinal cord injuries during the 6-year period occurred during competition (81.6%) (Table IIIa). Tackling (51.0%), being tackled (14.3%), and blocking (8.2%) were associated with the majority of catastrophic cervical spine/cord injuries during this period. For 22.5% the activity was unknown (general play or unknown). Most of the events were cervical spine fractures (57.1%) followed by cervical cord/nerve injuries (12.2%), cervical cord contusions (12.2%), or not specified (16.3%).

Catastrophic Brain Injuries with Incomplete Recovery

During the six year period from 2013-2018 there were 45 brain injuries which resulted in incomplete recovery (9, 5, 8, 9, 8, and 6 respectively, Table IV). 41 of the injuries occurred at the middle and high school level, 1 at the college level, 2 at the organized youth level, and 1 at the professional or semi-professional level. The five year average number of brain injuries with incomplete neurological recovery has doubled since data collection began in 1984 from 4.2 to 8.8 in 2009-2013 (Table IV and Figure I).

For the approximately 4,200,000 participants per year, the rate of brain injuries with incomplete neurological recovery during the 6 year period was 0.18 per 100,000 participants (95% CI: 0.13 to 0.23). Annual rates for high school ranged from 0.36 per 100,000 in 2014 to 0.82 per 100,000 in 2016 (Table V). There was only 1 collegiate event during the 6-year period for a rate of 1.33 per 100,000 in 2018.

Since 1984, most players with catastrophic brain injuries with incomplete recovery were on the defensive side of the ball (35.2%), and 23.9% were on the offensive side, 8.0% were

playing special teams, and 32.4% were unknown (Table VI). The pattern over this time period indicates fewer offensive side injuries during the most recent 5-year period 2014-2018 compared to the previous 5-year period (Figure 2b). Linebacker continue to be the most frequent position associated with brain injuries with incomplete recovery (16.9%) followed by defensive backs (12.1%), and running backs (12.1%) (Table VI). The overwhelming majority occur during competition (77.0%) followed by practice (21.1%), scrimmage (0.9%), or other/unknown (1.0%). Tackling (24.9%) or being tackled (13.6%) remain the most frequent activity at the time of the injury. Unlike cervical spine/cord injuries where the activity is often known, activities associated with catastrophic brain/head injuries are difficult to classify [general play (28.2%) or unknown (19.7%)] as they often collapse on the sideline or away from the ball in play. Most were subdural/epidural hematomas (64.8%).

A majority of catastrophic brain injuries with incomplete recovery during the 6-year period occurred during competition (91.1%) (Table VI-a). Tackling (24.4%), being tackled (11.1%), and being blocked (6.7%) were associated with a majority of catastrophic brain injuries during this period. However, for almost half (48.9%) the activity was not known: general play 35.6% or unknown 13.3%. Most of the events were subdural and/or epidural hematomas (28.8%) followed by brain hemorrhage (8.9%), second impact syndrome (2.2%), aneurism (2.2%) or not specified (57.8%).

Characteristics of All Catastrophic Traumatic Injuries 2013-2018

During the period 2013-2018, there were a total of 168 nonfatal catastrophic football-related injuries captured by NCCSIR – an average of 28 injuries per year over the 6 year period. Yearly totals were as follows: 24 in 2013, 17 in 2014, 44 in 2015, 24 in 2016, 33 in 2017, and

26 in 2018. Most injuries (59.5%, n=100) had incomplete recovery while 36.9% (n=62) had complete or 3.6% (n=6) unknown recovery (Table VII). The majority of injuries were cervical spine/cord (51.8%, n=87) followed by head/brain (34.5%, n=58) and other (13.7%, n=23). Other injuries included: internal organ (n=8), thoracic/lumbar spine/cord (n=8), lung (n=3), lower leg amputation (n=3), and eye injury with vision loss (n=1).

The majority over the 6 year period were among middle school and high school athletes (78%); this pattern held across each of the 2-year periods (Table VII). However, a greater number of collegiate events occurred during 2015-2016 (19.1%) compared to 2013-2014 (9.8%) and 2017-2018 (10.2%). Events occurred during competitions and tackling and being tackled remained the most frequent activity associated with catastrophic injury during this period.

DISCUSSION

For the past 42 years there have been a total of 372 football players with incomplete neurological recovery from cervical spine/cord injuries. The majority of these injuries have been to high school (80.1%) and collegiate (12.4%) players. These data indicate a reduction in the number of cervical cord injuries with incomplete neurological recovery when compared to data published in the early 1970's: 5-year average of 19.8 from 1971-1975 (Torg, Truex et al. 1979) versus 7.8 from 2014-2018. However, the most recent years 2017-2018 indicate 11 injuries per year with incomplete neurological recovery and continued surveillance of these injuries is critical for monitoring and prevention.

Since 1984, there have been 213 brain injuries with incomplete recovery. If the cervical cord injuries and the brain injuries with incomplete recovery are combined, the number of incomplete recovery cervical and brain injuries from 1984 to 2018 was 510—an average of 14.6 injuries per year with incomplete recovery over the past 35 years. Coaches, players, athletic trainers, physicians and administrators must continue efforts to prevent spinal cord and brain disability injuries among football players at all levels of play.

From 2013-2018, there 41 brain injuries with incomplete neurological recovery at the middle and high school level—an average of 8.2 per year. While the number of football-related catastrophic brain deaths decreased from 1969 to 2008, non-fatal catastrophic brain injuries with incomplete recovery has increased (Figure IIIb – note non-fatal brain injury data collection not started until 1984). This decrease in the number of fatalities along with increase in non-fatalities may be reflective of improvements in equipment, medical care, rule changes and coaching techniques which may result in a less severe outcome. The increase in non-fatal may also be reflective of increased attention and reporting in the football and sports medicine communities.

However, the most recent decade from 2009-2018 indicated no change in the number of fatal brain injuries and nonfatal brain injuries with incomplete recovery. We observed similar decreases in cervical spine fatalities, however non-fatal catastrophic cervical spine injuries with incomplete recovery have remained unchanged (Figure IIIa).

As indicated in past reports, a majority of the cervical spine/cord injuries with incomplete recovery are taking place in games. Table III indicates that when comparing cervical cord injuries between offensive and defensive players, it is safer playing offensive football. Defensive backs continue to be injured at a higher rate than other positions and a majority of the defensive players were tackling when injured. During this time period over half of the cervical spine/cord injuries with incomplete recovery were related to tackling. Despite efforts to teach players to tackle with the head up and new rules and penalties for targeting, this report indicates that players still lower their heads before making contact—a frequent mechanism of catastrophic brain and cervical spine/cord injuries. This report indicates that in 2017 three players and in 2018 one player suffered cervical cord/spine injuries with incomplete recovery due to head-first/down contact. Head-first/head down contact was identified as contributing to eight of the 28 deaths (29%) captured in high school and college football from 2005-2014 (Kucera et al. 2017). This emphasizes the importance of instruction in proper tackling techniques (both delivery and receipt of tackles) for all players, but particularly for running backs, linebackers, and defensive backs. Football is a collision sport played at high velocity, and players must act and react quickly. In such situations, new techniques might be difficult to deploy, resulting in players possibly reverting to past behaviors and reactions unless coaches routinely intervene to correct their technique (Kucera et al. 2017). These findings illustrate the importance of keeping the head up when tackling as well as when blocking and ball carrying.

Educational programs that focus on safer tackling techniques are available (e.g., USA Football's Heads Up Football (<http://usafootball.com/headsup>); University of New Hampshire's Helmetless Tackling Training, or HUTT™ Technique (<http://www.unh.edu/unhtoday/2014/11/keeping-their-heads-out-game>)). Recently national and state high school associations have recommended limiting both the frequency and duration of full contact in football practices (NFHS 2014). As of 2016 a total of 44 state high school associations had enacted policies to limit some full-contact football practices (Concussion Legacy Foundation, 2016). Earlier this year in February 2019, New Jersey set more conservative limits decreasing full contact during practices from 90 minutes to 15 minutes per week and a total of 6 hours of full contact practice during the 3 week preseason (Bogage 2019).

In 2016, the kickoff line was moved from the 35-yd to the 40-yd line and the touchback line was moved from the 25-yd to the 20-yd line. The intention was to have more kickoffs land in the end zone and thereby reduce the likelihood the receiving player will advance the ball, thus increasing touchbacks. The kickoff rule change in Ivy League football was associated with a reduction in concussions: 7.51 fewer concussions occurred for every 1000 kickoff plays after versus before the rule change (Wiebe et al. 2018).

STRENGTHS AND LIMITATIONS

The following strengths and limitations should be noted. Annual totals are continually updated as cases are found and/or reported, therefore the numbers in this report may not match those in past reports. All events have been reviewed for inclusion in this report. Research based on reliable data is essential if progress is to be made. Surveillance of non-fatal catastrophic injuries on a national scale is challenging. Given the heavy reliance on media reports to identify

cases, we recognize that these numbers represent an underestimate of the true number of these events, particularly for the events with incomplete or full recovery. These numbers likely represent the “tip of the iceberg” and the true number of non-fatal catastrophic injuries, both incomplete and full recovery injuries, is not known. In January of 2015 **NCCSIR and the Consortium developed a national centralized reporting site where anyone can report a catastrophic injury or illness event: <https://www.sportinjuryreport.org/>**. This site is the result of a collaborative effort between NCCSIR and the Consortium and is a major step towards improving the capture of the catastrophic sport injury and illness events and increasing our understanding about how they can be prevented.

Given these limitations, the NCCSIR has been collecting catastrophic football injury data at the University of North Carolina at Chapel Hill for fatalities since 1966 and for nonfatal disabling and serious injuries since 1977. Data collection efforts revealed a reduction of football fatalities from 35 in 1968 to zero in 1990 and a reduction of cervical cord injuries from 30 per year in the late 1960s to less than 15 per year since 1991. Football catastrophic injuries may never be totally eliminated, but ongoing surveillance and research efforts has resulted in rule changes, equipment standards, improved medical care both on and off the playing field, and changes in teaching the fundamental techniques of the game. These changes were the result of a united effort by coaches, administrators, researchers, equipment manufacturers, physicians, athletic trainers and players. NCCSIR will continue to collect this data and to make safety recommendations to the NFHS, the NCAA, and youth football programs.

RECOMMENDATIONS

Specific recommendations resulting from the current report are as follows:

1. **Preseason physical exams:** Mandatory medical examinations and medical history should be passed before allowing an athlete to participate in football. The NCAA requires a thorough medical examination when the athlete first enters the college athletic program and an annual health history update with use of referral exams when warranted. If the physician or coach has any questions about the athlete's readiness to participate, the athlete should not be allowed to play. High school coaches should follow the recommendations set by their State High School Association. Most state associations require the use of their own medical examination form.
2. **Conditioning:** All personnel involved with training football athletes should emphasize proper, gradual, and sport-specific physical conditioning. Athletes must be given proper conditioning exercises that will strengthen bodies to withstand the workloads and energy expenditure throughout the game given their positions and time played. Strengthening their necks in order to hold their heads in proper position when tackling and to absorb impact energy to control head movement is important. Players should also have appropriate flexibility and range of motion of the shoulder and neck complex. These preparatory activities can provide the athlete with the ability sustain good tackling and athletic skills throughout the game situations.
3. **Skills:** Coaches should teach and drill the athletes in the proper execution of the fundamental skills, particularly blocking and tackling. Players should keep their head up while tackling and running with the ball. Contact should never be initiated with the top or crown of the head/helmet. Initial contact should never be made with the head/helmet or

face mask. Research is needed to analyze the mechanisms of impacts during competitions and practices that lead to fatal and catastrophic events.

4. **Rules:** Rules are in place to protect defenseless players, the tackler initiating contact, and the ball carrier. Coaches and game officials should discourage the players from using their helmets in initiating contact when blocking and tackling. The rules prohibiting spearing and targeting should be enforced in practice and in games. The players should be taught and held accountable through the rules of play, film sessions, and on the practice field to respect the helmet as a protective device and that the helmet should not be used to initiate contact or as a weapon.
5. **Equipment:** All coaches, equipment managers, athletic trainers, and physicians should take special care to see that players equipment is properly fitted, particularly the helmet. Players should be educated about the use and care of the helmet and other protective equipment and adhere to proper fit guidelines and proper use as outlined by the manufacturer.
6. **Medical care and emergency preparedness:** Emergency measures must be in place for all games and practice sessions. Whenever possible certified athletic trainers should be present for all football practices and games. Physicians should be onsite or accessible for all practices and onsite for all games. Have a written emergency action plan and ensure all personnel have copies and have reviewed the plan. The CDC has guidelines and templates for these plans (<http://www.cdc.gov/niosh/docs/2004-101/emrgact/emrgact1.html>). NCAA and the NFHS have guidelines for these plans at the following websites: www.nfhs.org and www.ncaa.org.

7. **Brain Injury and Concussion:** A brain injury, including concussions, can be caused either by a direct blow to the head, face, neck or elsewhere on the body with an impulsive force transmitted to the head. This sudden impact or movement of the brain can cause stretching and tearing of brain cells, damaging the cells and create chemical changes in the brain.
- a. Signs & Symptoms: When a player has experienced or shown signs and symptoms of head trauma (such as a change in the athlete's behavior, thinking, or physical functioning), they should receive immediate medical attention from an appropriate medical provider and should not be allowed to return to practice or game without an evaluation by an appropriate medical provider and permission from a physician if diagnosed with a brain injury.
 - b. Reporting & Care: Some cases associated with brain trauma reported that players complained of symptoms or had a previous concussion prior to their catastrophic injury. The team physician, athletic trainer, or coach should ensure players understand signs and symptoms of concussion and brain trauma. Players should also be encouraged to inform the team physician, athletic trainer, or coach if they are experiencing any of the signs or symptoms of brain trauma outlined by the CDC. Heads Up on Concussion in Sports: *Information for Parents, Coaches, and School & Sports Professionals*. Available at:
<http://www.cdc.gov/headsup/index.html>
 - c. Management & Return to Play: Medical staff must have the unchallengeable authority to assess and make medical decisions for head injuries. Coaches should never make the decision whether a player has a concussion or return the player

back to a game or active participation in a practice if that player is experiencing signs or symptoms of brain trauma. In rare cases, an athlete who has not recovered from a concussion and returned to play and receives another severe hit can experience second impact syndrome.

- d. Policies: All athletes and athletic personnel should follow the state, NFHS, NCAA, or NFL policies related to concussion prevention, identification, management, and return to play depending on their level of play. See the following CDC resource for a list of states with concussion policies: Get a Heads Up on Concussion in Sports Policies: *Information for Parents, Coaches, and School & Sports Professionals*. Available at:
<http://www.cdc.gov/headsup/policy/index.html>

For the most up to date information on concussion management please refer to the updated Consensus Statement on Concussion in Sport: the 5th International Conference on Concussion in Sport held in Berlin, October of 2016 (McCrory et al. 2017 available at: <http://bjsm.bmj.com/content/51/11>).

Over the last decade, sport governing bodies have adopted new or modified playing rules for football to protect defenseless players, remove targeting from the game, eliminate dangerous play, stoppage of play for injured players to ensure medical care can be accessed for injuries, and limits on full contact during preseason and inseason practices. In addition, these same governing bodies have published best practices for prevention, recognition, management and return to

play for athletes with suspected concussion, spine and brain injuries. Member institutions of these organizations should implement these best practices.

NFHS rules changes affecting risk, (1982-2018). Available at:

http://www.nfhs.org/media/1019586/1982-2018_nfhs_risk_minimization_rules.pdf

NCAA rules for football and all sports are available at:

<http://www.ncaa.org/championships/playing-rules>

NCAA Football Practice Guidelines: Year-Round Football Practice Contact Guidelines (<http://www.ncaa.org/health-and-safety/football-practice-guidelines>).

The Safety in College Football Summit. Inter-association consensus guidelines for three paramount safety issues in collegiate athletics:

1. Independent medical care in the collegiate setting
2. Concussion diagnosis and management
3. Football practice contact.

NFL timeline of rule changes related to health and safety. Available at:

<http://static.nfl.com/static/content/public/photo/2015/11/12/0ap3000000578872.pdf>

8. **Cervical Cord and Spine Injuries:** Early recognition, prompt medical evaluation and management of cervical cord and spine injuries is critical for preventing permanent

disability and death. Certified athletic trainers are trained to recognize and manage these injuries and whenever possible should be present for all football practices and games.

For the most up to date information on management and prevention of these injuries see the following websites:

National Athletic Trainers Association: (<https://www.nata.org/practice-patient-care/health-issues/spine-injury>)

Kory Stringer Institute: <https://ksi.uconn.edu/emergency-conditions/cervical-spine-injury/>

9. **Internal Organ Injuries:** Like cervical cord and spinal injuries, early recognition and prompt medical evaluation and treatment of internal organ injuries is critical for ensuring the best possible outcome. Emergency action plans, access to certified athletic trainers, and on-site medical services for competitions constitute best practices for these injuries. A better understanding of the activities and mechanisms associated with these injuries and use of protective gear worn is needed for prevention. Wearing protective gear (e.g., padded belt or shirt) that extends beyond the bottom of the shoulder pads to cover the torso may protect internal organs from direct contact.

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CASE SUMMARIES 2018

Summaries compiled for 26 cases from publicly available media sources. Note: summaries for cases 2013-2017 are available on request. Email the director (kkucera@email.unc.edu).

CERVICAL SPINE

ORGANIZED YOUTH

None in 2018

MIDDLE SCHOOL

Incomplete Recovery

A male 13 year old middle school football defensive back was injured during a football game. He was involved in a helmet-to-helmet collision, resulting in him not being able to move from the chest down. He was transported to a hospital and underwent surgery for a shattered C5 vertebra. A long term prognosis is unknown but he has regained movement in his arms and legs.

Complete Recovery

A male 13 year old middle school football player was injured during a football game. He landed on his neck after being tackled. He was attended to by paramedics and then airlifted to a nearby hospital. He was diagnosed with a bruised spinal cord and released from the hospital two days later. A full recovery is expected.

HIGH SCHOOL

Incomplete Recovery

A male high school senior football defensive back suffered a spinal cord injury while making a tackle during a scrimmage. The athlete was immediately attended to by the opposing team's athletic trainer, who provided care until EMS arrived. He was transported to a hospital where he was diagnosed with fractured C1 and C2 vertebrae. He underwent spinal stabilization surgery. The athlete is currently paralyzed from the neck down.

A male high school football linebacker was injured during a football game. He fractured a vertebra in his neck and has an incomplete spinal cord injury. He is currently paralyzed.

A male 16 year old high school sophomore football player sustained an injury during a football game. He was immediately taken to a hospital and underwent surgery to stabilize the fractured C3, C4, and C5 vertebrae. He is currently paralyzed from the neck down but has been regaining feeling in his extremities. Long term prognosis is unknown.

A male high school senior football quarterback was injured during a football game. He was blindsided by a tackle and was unable to get up. He was taken to a hospital and was diagnosed with spinal shock. With physical therapy, he has regained movement. A long term prognosis is unknown.

A male high school football player was injured during a football game, causing him to lose movement and sensation in his body. He was airlifted to a hospital and diagnosed with a spinal cord contusion. He regained feeling but a long term prognosis is unknown.

A male high school junior football player sustained an injury during a football game. He was injured while making a tackle during a kickoff-return. The athlete was transported to a hospital and diagnosed with a fractured C1 and C6 vertebrae. His injuries did not require surgery and the athlete is recovering at home. A long term prognosis is unknown.

A male 16 year old high school senior football safety (varsity) sustained an injury during a football game. He was injured attempting to tackle the opposing team's running back when his face mask collided with the player's hip. After being evaluated by an athletic trainer and team doctor, he was transported to a hospital by his mother. There he underwent surgery to remove a fractured C5 vertebra. He can no longer play contact sports and long term prognosis is unknown.

Complete Recovery

A male high school football cornerback was injured making a tackle during a football game. He was attended to by an on-field athletic trainer and then transported to a hospital. He was diagnosed with two fractured vertebrae in his neck and underwent emergency surgery to have five screws inserted to stabilize his neck. A full recovery is expected.

A male 16 year old high school football player was injured in a football jamboree. He felt tingling in his extremities after making a tackle. The pain worsened over the following days and he went to a hospital. He was diagnosed with a fractured C6 vertebra and underwent emergency surgery. A full recovery is expected.

A male high school football player fractured a vertebra in his neck being tackled during a football game. He did not require surgery but was placed in a neck brace. A full recovery is expected.

A male 15 year old junior varsity football running back was injured during a football game. He was struck in the thoracic spine with an opponent's knee and fell to the ground. He complained of weakness, pain, and paralysis in the extremities but symptoms resolved on field. When the athlete had imaging done, cervical spinal stenosis was discovered. The athlete is no longer allowed to compete in contact sports.

COLLEGE

Incomplete Recovery

A male 19 year old collegiate sophomore football offensive lineman was injured during a football game. He was injured during a tackle and was immediately unable to move his legs. He is currently paralyzed from the waist down and is recovering in a long term facility. A long term prognosis is unknown.

A male collegiate football player was injured attempting to make a tackle during a football game. The athlete was attended to on-field and airlifted to a hospital. He underwent emergency surgery

for a fractured C5 vertebra. He will graduate from college though he can no longer play football. Long term prognosis is unknown.

PROFESSIONAL

Incomplete Recovery

A male 32 year old professional football player was injured during a football game. After the game he went to a hospital and was diagnosed with two spinal fractures. He was out for the rest of the season and has retired from football.

HEAD/BRAIN

ORGANIZED YOUTH

None in 2018

MIDDLE SCHOOL

None in 2018

HIGH SCHOOL

Incomplete Recovery

A male high school senior football cornerback was injured making a tackle in a football game. He was transported to a hospital and underwent emergency surgery for a brain bleed. A long term prognosis is unknown.

A male high school football player was injured during a football game. He was knocked out during a kickoff return and began convulsing. He was transported to a hospital by EMS personnel. A long term prognosis is unknown.

A male 16 year old high school sophomore football player was injured during a football game. He was attempting to make a tackle when his head made contact with an opposing player's hip. He was taken to a hospital where he underwent emergency surgery for a subdural hematoma with a midline shift. Long term prognosis is unknown but he is recovering well.

A male 17 year old high school football player suffered a head injury during a football practice. He was injured during a helmet-to-helmet hit. He was attended to by athletic personnel and then life-flighted to a nearby hospital. The athlete remained in a coma for weeks and is still recovering. A long term prognosis is unknown.

A male high school football linebacker collapsed during a football game. The athlete had just come to the sideline when he collapsed. He was attended to by medical personnel and transported to a nearby hospital and diagnosed with a subdural hematoma. No surgery was required but a long term prognosis is unknown.

Complete Recovery

Athlete collapsed on the sideline during a football game. He was immediately attended to by athletic trainers and EMS personnel before being transported to a hospital. He immediately

underwent emergency brain surgery to relieve pressure and stop a hemorrhage. Athlete has fully recovered but cannot play football.

COLLEGE

Incomplete Recovery

A male 20 year old collegiate football linebacker was injured during a football game. He came off the field complaining of a headache and was placed into concussion protocol. While heading toward the locker room for treatment, he collapsed. On site EMS personnel transported him to a hospital. He underwent emergency brain surgery. A long term prognosis is unknown.

PROFESSIONAL

None in 2018

OTHER INJURY

ORGANIZED YOUTH

None in 2018

MIDDLE SCHOOL

None in 2018

HIGH SCHOOL

Incomplete Recovery

A male high school football player was injured during a football game. He was tackled catching a pass and injured his knee. The following day he was diagnosed with a knee dislocation, tibial plateau fracture, and popliteal artery obstruction. The injuries required amputation of the lower portion of the lower leg. The athlete is recovering and adjusting to prosthetics.

A male high school football junior varsity running back was injured during a football game. He suffered a thoracic vertebra fracture and spinal bruise. The athlete underwent surgery to correct the damage. He is currently paralyzed below the waist but is starting to regain feeling. A long term prognosis is unknown.

Complete Recovery

A male 16 year old high school football player was injured during a football game. During a kick-off return he was blindsided by a tackle. The athlete was taken to the hospital and was diagnosed with a lacerated spleen. A full recovery is expected.

COLLEGE

None in 2018

PROFESSIONAL

None in 2018

Table I. Catastrophic Football Cervical Cord Injuries with Incomplete Recovery, 1977-2018*

Year	Organized youth	Pro & Semi-pro	Middle & High School	College	Total	5-year average
1977	0	0	10	2	12	
1978	0	0	12	0	12	12.0
1979	0	0	6	3	9	
1980	0	0	10	2	12	
1981	1	0	5	2	8	
1982	0	1	7	2	10	
1983	0	0	11	1	12	10.2
1984	1	0	6	0	7	
1985	0	0	8	3	11	
1986	0	1	4	0	5	
1987	0	0	11	0	11	
1988	0	0	10	1	11	9.0
1989	0	0	13	2	15	
1990	0	0	11	2	13	
1991	0	1	1	0	2	
1992	0	1	7	0	8	
1993	1	1	5	0	7	9.0
1994	0	0	1	1	2	
1995	0	0	8	1	9	
1996	0	0	6	3	9	
1997	1	0	9	1	11	
1998	0	0	4	0	4	7.0
1999	1	0	8	1	10	
2000	0	0	6	2	8	
2001	0	0	8	0	8	
2002	0	0	6	1	7	
2003	0	1	9	1	11	8.8
2004	1	1	10	0	12	
2005	0	0	4	0	4	
2006	0	0	9	2	11	
2007	1	2	5	0	8	
2008	0	3	11	0	14	9.8
2009	0	1	8	1	10	
2010	0	0	5	3	8	
2011	1	1	5	0	7	
2012	0	1	2	2	5	
2013	2	0	8	0	10	8.0

Year	Organized youth	Pro & Semi-pro	Middle & High School	College	Total	5-year average
2014	0	0	2	1	3	
2015	0	0	7	3	10	
2016	0	0	4	0	4	
2017	1	1	8	1	11	
2018	0	1	8	2	11	7.8
Total	11	17	298	46	372	
Percent	3.0%	4.6%	80.1%	12.4%	100.0%	

*Figures are updated annually due to new cases investigated after publication.

Table II. Incidence of Catastrophic Football Cervical Cord Injuries with Incomplete Recovery per 100,000 Participants, 1977-2018

Year	Middle & high school¹	College²
1977	1.00	2.67
1978	1.20	0.00
1979	0.60	4.00
1980	1.00	2.67
1981	0.50	2.67
1982	0.70	2.67
1983	1.10	1.33
1984	0.60	0.00
1985	0.62	4.00
1986	0.31	0.00
1987	0.85	0.00
1988	0.77	1.33
1989	1.00	2.67
1990	0.85	2.67
1991	0.08	0.00
1992	0.54	0.00
1993	0.38	0.00
1994	0.08	1.33
1995	0.62	1.33
1996	0.46	4.00
1997	0.69	1.33
1998	0.31	0.00
1999	0.62	1.33
2000	0.46	2.67
2001	0.62	0.00
2002	0.46	1.33
2003	0.69	1.33
2004	0.77	0.00
2005	0.31	0.00
2006	0.69	2.67
2007	0.38	0.00
2008	0.85	0.00
2009	0.62	1.33
2010	0.38	4.00
2011	0.33	0.00
2012	0.18	2.67
2013	0.73	0.00
2014	0.18	1.33
2015	0.64	4.00
2016	0.36	0.00

Year	Middle & high school¹	College²
2017	0.73	1.33
2018	0.73	2.67

¹Rates based on 1, 1.3, 1.5 and 1.1 million in 1968-1984, 1985-2010, 2011 and 2012-2018, respectively, for players grades 9-12.

²Rates based on 75,000 in all years for college players.

Note: Rates with number of incidents less than 5 should be interpreted with caution.

Table III. Characteristics of Catastrophic Football Cervical Cord Injuries with Incomplete Recovery, 1977-2018

Characteristics	Organized youth		Pro & Semi-Pro		Middle & High school		College		All	
	N	%	N	%	N	%	N	%	N	%
Type of Activity										
Being blocked	0	0.0%	0	0.0%	3	1.0%	1	2.2%	4	1.1%
Being tackled	1	9.1%	3	17.6%	36	12.1%	4	8.7%	44	11.8%
Blocking	1	9.1%	1	5.9%	16	5.4%	4	8.7%	22	5.9%
General play	3	27.3%	0	0.0%	15	5.0%	3	6.5%	21	5.6%
Loose ball	0	0.0%	0	0.0%	1	0.3%	1	2.2%	2	0.5%
Receiving pass	0	0.0%	0	0.0%	2	0.7%	1	2.2%	3	0.8%
Tackling	4	36.4%	11	64.7%	193	64.8%	31	67.4%	239	64.2%
Unknown	2	18.2%	2	11.8%	32	10.7%	1	2.2%	37	9.9%
Type of Session										
Competition/Game	8	72.7%	15	88.2%	223	74.8%	34	73.9%	280	75.3%
Practice	3	27.3%	2	11.8%	50	16.8%	11	23.9%	66	17.7%
Scrimmage	0	0.0%	0	0.0%	10	3.4%	0	0.0%	10	2.7%
Unknown	0	0.0%	0	0.0%	15	5.0%	1	2.2%	16	4.3%
Suspected Cause										
Contusion (Hematoma)	1	9.1%	2	11.8%	11	3.7%	2	4.3%	16	4.3%
Fracture	8	72.7%	14	82.4%	254	85.2%	38	82.6%	314	84.4%
Other	1	9.1%	1	5.9%	26	8.7%	4	8.7%	32	8.6%
Nervous System	1	9.1%	0	0.0%	6	2.0%	2	4.3%	9	2.4%
Strain/Tear	0	0.0%	0	0.0%	1	0.3%	0	0.0%	1	0.3%
Position										
Defensive Lineman	1	9.1%	3	17.6%	16	5.4%	0	0.0%	20	5.4%
Defensive back	1	9.1%	2	11.8%	91	30.5%	22	47.8%	116	31.2%
Kicker/punter	0	0.0%	0	0.0%	1	0.3%	0	0.0%	1	0.3%
Kickoff/punt coverage	0	0.0%	4	23.5%	19	6.4%	5	10.9%	28	7.5%
Kickoff/punt return	0	0.0%	0	0.0%	10	3.4%	1	2.2%	11	3.0%
Linebacker	0	0.0%	2	11.8%	36	12.1%	7	15.2%	45	12.1%
Offensive Lineman	0	0.0%	2	11.8%	4	1.3%	2	4.3%	8	2.2%
Quarterback	0	0.0%	1	5.9%	11	3.7%	1	2.2%	13	3.5%
Running back	1	9.1%	2	11.8%	22	7.4%	1	2.2%	26	7.0%
Tight end/Wide receiver	0	0.0%	1	5.9%	15	5.0%	5	10.9%	21	5.6%
Other	1	9.1%	0	0.0%	1	0.3%	0	0.0%	2	0.5%
Unknown	7	63.6%	0	0.0%	72	24.2%	2	4.3%	81	21.8%
Offense or Defense										
Defense	3	27.3%	7	41.2%	144	48.3%	29	63.0%	183	49.2%
Offense	1	9.1%	6	35.3%	52	17.4%	9	19.6%	68	18.3%

Characteristics	Organized youth		Pro & Semi-Pro		Middle & High school		College		All	
	N	%	N	%	N	%	N	%	N	%
Special Teams	0	0.0%	4	23.5%	30	10.1%	6	13.0%	40	10.8%
Unknown	7	63.6%	0	0.0%	72	24.2%	2	4.3%	81	21.8%
Location of Injury										
Competitive Venue	3	27.3%	5	29.4%	81	27.2%	18	39.1%	107	28.8%
School Athletic Facility	0	0.0%	0	0.0%	4	1.3%	1	2.2%	5	1.3%
Unknown	8	72.7%	12	70.6%	213	71.5%	27	58.7%	260	69.9%
Total	11	100.0%	17	100.0%	298	100.0%	46	100.0%	372	100.0%

**Table IIIb. Characteristics of Catastrophic Football Cervical Cord Injuries with
Incomplete Recovery, 2013-2018**

Characteristics	Organized youth		Pro & Semi-Pro		Middle & High school		College		All	
	N	%	N	%	N	%	N	%	N	%
Type of Activity										
Being tackled	1	33.3%	0	0.0%	5	13.5%	1	14.3%	7	14.3%
Blocking	0	0.0%	0	0.0%	3	8.1%	1	14.3%	4	8.2%
General play	1	33.3%	0	0.0%	2	5.4%	1	14.3%	4	8.2%
Receiving pass	0	0.0%	0	0.0%	2	5.4%	0	0.0%	2	4.1%
Tackling	0	0.0%	1	50.0%	20	54.1%	4	57.1%	25	51.0%
Unknown	1	33.3%	1	50.0%	5	13.5%	0	0.0%	7	14.3%
Type of Session										
Competition/Game	3	100.0%	2	100.0%	29	78.4%	6	85.7%	40	81.6%
Practice	0	0.0%	0	0.0%	5	13.5%	1	14.3%	6	12.2%
Scrimmage	0	0.0%	0	0.0%	3	8.1%	0	0.0%	3	6.1%
Suspected Cause										
Contusion (Hematoma)	0	0.0%	1	50.0%	5	13.5%	0	0.0%	6	12.2%
Fracture	1	33.3%	1	50.0%	22	59.5%	4	57.1%	28	57.1%
Miscellaneous	1	33.3%	0	0.0%	6	16.2%	2	28.6%	9	18.4%
Nervous System	1	33.3%	0	0.0%	4	10.8%	1	14.3%	6	12.2%
Diagnosis										
Cervical Spinal Cord Contusion	0	0.0%	1	50.0%	5	13.5%	0	0.0%	6	12.2%
Cervical Spinal Cord/Nerve Injury	1	33.3%	0	0.0%	4	10.8%	1	14.3%	6	12.2%
Cervical Spine Fracture	1	33.3%	1	50.0%	22	59.5%	4	57.1%	28	57.1%
Cervical Spine Injury, n.s.	1	33.3%	0	0.0%	5	13.5%	2	28.6%	8	16.3%
Other Neck Injury	0	0.0%	0	0.0%	1	2.7%	0	0.0%	1	2.0%
Position										
Defensive Lineman	0	0.0%	0	0.0%	1	2.7%	0	0.0%	1	2.0%
Defensive back	0	0.0%	0	0.0%	9	24.3%	2	28.6%	11	22.4%
Kickoff/punt coverage	0	0.0%	0	0.0%	1	2.7%	0	0.0%	1	2.0%
Kickoff/punt return	0	0.0%	0	0.0%	4	10.8%	0	0.0%	4	8.2%
Linebacker	0	0.0%	1	50.0%	5	13.5%	2	28.6%	8	16.3%
Offensive Lineman	0	0.0%	1	50.0%	0	0.0%	2	28.6%	3	6.1%
Quarterback	0	0.0%	0	0.0%	1	2.7%	0	0.0%	1	2.0%
Running back	0	0.0%	0	0.0%	2	5.4%	0	0.0%	2	4.1%
Tight end/Wide receiver	0	0.0%	0	0.0%	4	10.8%	1	14.3%	5	10.2%
Unknown	3	100.0%	0	0.0%	10	27.0%	0	0.0%	13	26.5%
Offense or Defense										
Defense	0	0.0%	1	50.0%	15	40.5%	4	57.1%	20	40.8%
Offense	0	0.0%	1	50.0%	7	18.9%	3	42.9%	11	22.4%

Characteristics	Organized youth		Pro & Semi-Pro		Middle & High school		College		All	
	N	%	N	%	N	%	N	%	N	%
Special Teams	0	0.0%	0	0.0%	5	13.5%	0	0.0%	5	10.2%
Unknown	3	100.0%	0	0.0%	10	27.0%	0	0.0%	13	26.5%
Location										
Competitive Venue	3	100.0%	2	100.0%	33	89.2%	6	85.7%	44	89.8%
School Athletic Facility	0	0.0%	0	0.0%	4	10.8%	1	14.3%	5	10.2%
Total	3	100.0%	2	100.0%	37	100.0%	7	100.0%	49	100.0%

Table IV. Catastrophic Football Brain Injuries with Incomplete Recovery, 1984-2018*

Year	Organized youth	Pro & Semi-pro	Middle & High School	College	Total	5-year average
1984	0	0	5	2	7	
1985	0	0	4	1	5	
1986	0	0	2	0	2	
1987	0	0	5	0	5	
1988	0	0	2	0	2	4.2
1989	0	0	5	0	5	
1990	0	0	1	0	1	
1991	0	0	3	1	4	
1992	0	0	4	0	4	
1993	0	0	5	0	5	3.8
1994	0	0	4	1	5	
1995	0	0	5	0	5	
1996	0	0	5	0	5	
1997	0	0	8	1	9	
1998	0	0	4	0	4	5.6
1999	0	0	5	0	5	
2000	0	0	6	1	7	
2001	0	0	2	0	2	
2002	0	0	2	1	3	
2003	0	0	8	1	9	5.2
2004	0	0	3	1	4	
2005	1	0	7	1	9	
2006	0	0	9	0	9	
2007	0	0	6	0	6	
2008	1	1	9	0	11	7.8
2009	0	0	12	0	12	
2010	0	0	6	0	6	
2011	1	0	14	0	15	
2012	0	0	2	0	2	
2013	0	1	8	0	9	8.8
2014	1	0	4	0	5	
2015	0	0	8	0	8	
2016	0	0	9	0	9	
2017	1	0	7	0	8	
2018	0	0	5	1	6	7.2
Total	5	2	194	12	213	
Percent	2.3%	0.9%	91.1%	5.6%	100.0%	

*Figures are updated annually due to new cases investigated after publication.

Table V. Incidence of Catastrophic Football Brain Injuries with Incomplete recovery per 100,000 Participants, 1984-2018

Year	Middle & high school¹	College²
1984	0.50	2.67
1985	0.31	1.33
1986	0.15	0.00
1987	0.38	0.00
1988	0.15	0.00
1989	0.38	0.00
1990	0.08	0.00
1991	0.23	1.33
1992	0.31	0.00
1993	0.38	0.00
1994	0.31	1.33
1995	0.38	0.00
1996	0.38	0.00
1997	0.62	1.33
1998	0.31	0.00
1999	0.38	0.00
2000	0.46	1.33
2001	0.15	0.00
2002	0.15	1.33
2003	0.62	1.33
2004	0.23	1.33
2005	0.54	1.33
2006	0.69	0.00
2007	0.46	0.00
2008	0.69	0.00
2009	0.92	0.00
2010	0.46	0.00
2011	0.93	0.00
2012	0.18	0.00
2013	0.73	0.00
2014	0.36	0.00
2015	0.73	0.00
2016	0.82	0.00
2017	0.64	0.00
2018	0.45	1.33

¹Rates based on 1, 1.3, 1.5 and 1.1 million in 1984, 1985-2010, 2011 and 2012-2018, respectively, for players grades 9-12.

²Rates based on 75,000 in all years for college players.

Note: Rates with number of incidents less than 5 should be interpreted with caution.

Table VI. Characteristics of Catastrophic Brain Injuries with Incomplete Recovery, 1984-2018

Characteristics	Organized youth		Pro & Semi-Pro		Middle & High school		College		All	
	N	%	N	%	N	%	N	%	N	%
Type of Activity										
Being blocked	0	0.0%	0	0.0%	9	4.6%	3	25.0%	12	5.6%
Being tackled	0	0.0%	0	0.0%	26	13.4%	3	25.0%	29	13.6%
Blocking	0	0.0%	0	0.0%	10	5.2%	2	16.7%	12	5.6%
General play	2	40.0%	1	50.0%	57	29.4%	0	0.0%	60	28.2%
Receiving pass	0	0.0%	0	0.0%	3	1.5%	0	0.0%	3	1.4%
Running	0	0.0%	0	0.0%	1	0.5%	0	0.0%	1	0.5%
Tackling	2	40.0%	0	0.0%	49	25.3%	2	16.7%	53	24.9%
Other	0	0.0%	0	0.0%	1	0.5%	0	0.0%	1	0.5%
Unknown	1	20.0%	1	50.0%	38	19.6%	2	16.7%	42	19.7%
Type of Session										
Competition/Game	4	80.0%	2	100.0%	151	77.8%	7	58.3%	164	77.0%
Practice	1	20.0%	0	0.0%	39	20.1%	5	41.7%	45	21.1%
Scrimmage	0	0.0%	0	0.0%	2	1.0%	0	0.0%	2	0.9%
Other	0	0.0%	0	0.0%	1	0.5%	0	0.0%	1	0.5%
Unknown	0	0.0%	0	0.0%	1	0.5%	0	0.0%	1	0.5%
Suspected Cause										
Cardiovascular	0	0.0%	0	0.0%	4	2.1%	0	0.0%	4	1.9%
Contusion (Hematoma)	4	80.0%	0	0.0%	126	64.9%	8	66.7%	138	64.8%
Fracture	0	0.0%	0	0.0%	1	0.5%	0	0.0%	1	0.5%
Hemorrhage/Bleed	0	0.0%	0	0.0%	5	2.6%	0	0.0%	5	2.3%
Other	0	0.0%	0	0.0%	3	1.5%	0	0.0%	3	1.4%
Traumatic Brain Injury, nec	1	20.0%	2	100.0%	55	28.4%	4	33.3%	62	29.1%
Position										
Defensive Lineman	0	0.0%	0	0.0%	11	5.7%	1	8.3%	12	5.6%
Defensive back	0	0.0%	0	0.0%	25	12.9%	1	8.3%	26	12.2%
Kicker/punter	0	0.0%	0	0.0%	1	0.5%	1	8.3%	2	0.9%
Kickoff/punt coverage	0	0.0%	0	0.0%	10	5.2%	2	16.7%	12	5.6%
Kickoff/punt return	0	0.0%	0	0.0%	3	1.5%	0	0.0%	3	1.4%
Linebacker	0	0.0%	1	50.0%	34	17.5%	1	8.3%	36	16.9%
Offensive Lineman	0	0.0%	0	0.0%	8	4.1%	1	8.3%	9	4.2%
Quarterback	0	0.0%	0	0.0%	6	3.1%	1	8.3%	7	3.3%
Running back	2	40.0%	0	0.0%	22	11.3%	2	16.7%	26	12.2%
Tight end/Wide receiver	0	0.0%	0	0.0%	7	3.6%	2	16.7%	9	4.2%
Other	0	0.0%	0	0.0%	2	1.0%	0	0.0%	2	0.9%
Unknown	3	60.0%	1	50.0%	65	33.5%	0	0.0%	69	32.4%

Characteristics	Organized youth		Pro & Semi-Pro		Middle & High school		College		All	
	N	%	N	%	N	%	N	%	N	%
Offense or Defense										
Defense	0	0.0%	1	50.0%	71	36.6%	3	25.0%	75	35.2%
Offense	2	40.0%	0	0.0%	43	22.2%	6	50.0%	51	23.9%
Special Teams	0	0.0%	0	0.0%	14	7.2%	3	25.0%	17	8.0%
Other	0	0.0%	0	0.0%	1	0.5%	0	0.0%	1	0.5%
Unknown	3	60.0%	1	50.0%	65	33.5%	0	0.0%	69	32.4%
Location of Injury										
Competitive Venue	2	40.0%	1	50.0%	52	26.8%	4	33.3%	59	27.7%
School Athletic Facility	0	0.0%	0	0.0%	1	0.5%	0	0.0%	1	0.5%
Unknown	3	60.0%	1	50.0%	141	72.7%	8	66.7%	153	71.8%
Total	5	100.0%	2	100.0%	194	100.0%	12	100.0%	213	100.0%

Table VIIb. Characteristics of Catastrophic Brain Injuries with Incomplete Recovery, 2013-2018

Characteristics	Organized youth		Pro & Semi-Pro		Middle & High school		College		All	
	N	%	N	%	N	%	N	%	N	%
Type of Activity										
Being blocked	0	0.0%	0	0.0%	2	4.9%	1	100.0%	3	6.7%
Being tackled	0	0.0%	0	0.0%	5	12.2%	0	0.0%	5	11.1%
Blocking	0	0.0%	0	0.0%	1	2.4%	0	0.0%	1	2.2%
General play	1	50.0%	1	100.0%	14	34.1%	0	0.0%	16	35.6%
Receiving pass	0	0.0%	0	0.0%	2	4.9%	0	0.0%	2	4.4%
Running	0	0.0%	0	0.0%	1	2.4%	0	0.0%	1	2.2%
Tackling	1	50.0%	0	0.0%	10	24.4%	0	0.0%	11	24.4%
Unknown	0	0.0%	0	0.0%	6	14.6%	0	0.0%	6	13.3%
Type of Session										
Competition/Game	2	100.0%	1	100.0%	37	90.2%	1	100.0%	41	91.1%
Practice	0	0.0%	0	0.0%	4	9.8%	0	0.0%	4	8.9%
Suspected Cause										
Contusion (Hematoma)	1	50.0%	0	0.0%	12	29.3%	0	0.0%	13	28.9%
Hemorrhage/Bleed	0	0.0%	0	0.0%	4	9.8%	0	0.0%	4	8.9%
Miscellaneous	0	0.0%	0	0.0%	1	2.4%	0	0.0%	1	2.2%
Traumatic Brain Injury, nec	1	50.0%	1	100.0%	24	58.5%	1	100.0%	27	60.0%
Diagnosis										
Brain Aneurysm	0	0.0%	0	0.0%	1	2.4%	0	0.0%	1	2.2%
Brain Hemorrhage/Bleed	0	0.0%	0	0.0%	4	9.8%	0	0.0%	4	8.9%
Epidural Hematoma	0	0.0%	0	0.0%	1	2.4%	0	0.0%	1	2.2%
Second Impact Syndrome	0	0.0%	0	0.0%	1	2.4%	0	0.0%	1	2.2%
Subdural Hematoma	1	50.0%	0	0.0%	9	22.0%	0	0.0%	10	22.2%
Subdural/Epidural Hematoma	0	0.0%	0	0.0%	2	4.9%	0	0.0%	2	4.4%
Traumatic Brain Injury, nec or n.s.	1	50.0%	1	100.0%	23	56.1%	1	100.0%	26	57.8%
Position										
Defensive Lineman	0	0.0%	0	0.0%	3	7.3%	0	0.0%	3	6.7%
Defensive back	0	0.0%	0	0.0%	5	12.2%	0	0.0%	5	11.1%
Kicker/punter	0	0.0%	0	0.0%	0	0.0%	1	100.0%	1	2.2%
Kickoff/punt return	0	0.0%	0	0.0%	1	2.4%	0	0.0%	1	2.2%
Linebacker	0	0.0%	1	100.0%	7	17.1%	0	0.0%	8	17.8%
Offensive Lineman	0	0.0%	0	0.0%	2	4.9%	0	0.0%	2	4.4%
Quarterback	0	0.0%	0	0.0%	2	4.9%	0	0.0%	2	4.4%
Running back	1	50.0%	0	0.0%	3	7.3%	0	0.0%	4	8.9%
Unknown	1	50.0%	0	0.0%	18	43.9%	0	0.0%	19	42.2%

Characteristics	Organized youth		Pro & Semi-Pro		Middle & High school		College		All	
	N	%	N	%	N	%	N	%	N	%
Offense or Defense										
Defense	0	0.0%	1	100.0%	15	36.6%	0	0.0%	16	35.6%
Offense	1	50.0%	0	0.0%	7	17.1%	0	0.0%	8	17.8%
Special Teams	0	0.0%	0	0.0%	1	2.4%	1	100.0%	2	4.4%
Unknown	1	50.0%	0	0.0%	18	43.9%	0	0.0%	19	42.2%
Location										
Competitive Venue	2	100.0%	1	100.0%	40	97.6%	1	100.0%	44	97.8%
School Athletic Facility	0	0.0%	0	0.0%	1	2.4%	0	0.0%	1	2.2%
Total	2	100.0%	1	100.0%	41	100.0%	1	100.0%	45	100.0%

Table VII. Characteristics of All Catastrophic Football Traumatic Injuries, 2013-2018

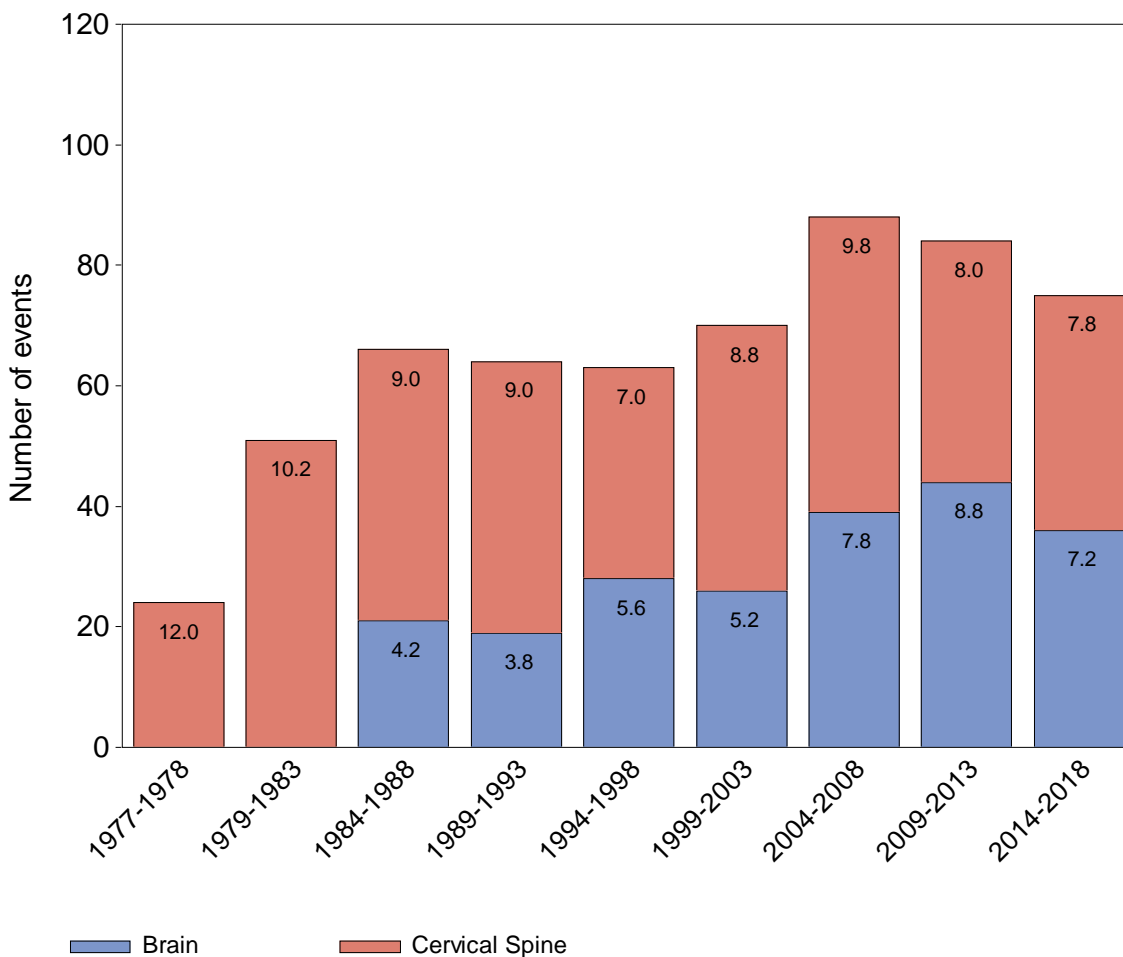
Characteristics	2013-2014		2015-2016		2017-2018		All	
	N	%	N	%	N	%	N	%
Player Level								
College	4	9.8%	13	19.1%	6	10.2%	23	13.7%
Middle & high school	32	78.0%	53	77.9%	46	78.0%	131	78.0%
Organized youth	3	7.3%	0	0.0%	2	3.4%	5	3.0%
Pro & Semi-pro	2	4.9%	2	2.9%	5	8.5%	9	5.4%
Type of Activity								
Being blocked	0	0.0%	1	1.5%	2	3.4%	3	1.8%
Being tackled	7	17.1%	17	25.0%	14	23.7%	38	22.6%
Blocking	3	7.3%	4	5.9%	2	3.4%	9	5.4%
Conditioning (land)	0	0.0%	1	1.5%	0	0.0%	1	0.6%
General play	14	34.1%	10	14.7%	5	8.5%	29	17.3%
Receiving pass	1	2.4%	4	5.9%	1	1.7%	6	3.6%
Running	0	0.0%	2	2.9%	1	1.7%	3	1.8%
Tackling	13	31.7%	26	38.2%	19	32.2%	58	34.5%
Unknown	3	7.3%	3	4.4%	15	25.4%	21	12.5%
Type of Session								
Competition/Game	35	85.4%	60	88.2%	49	83.1%	144	85.7%
Conditioning Session	0	0.0%	1	1.5%	0	0.0%	1	0.6%
Practice	6	14.6%	5	7.4%	6	10.2%	17	10.1%
Scrimmage	0	0.0%	2	2.9%	4	6.8%	6	3.6%
Suspected Cause								
Contusion (Hematoma)	9	22.0%	7	10.3%	12	20.3%	28	16.7%
Dislocation	0	0.0%	0	0.0%	2	3.4%	2	1.2%
Fracture	12	29.3%	23	33.8%	21	35.6%	56	33.3%
Hemorrhage/Bleed	1	2.4%	1	1.5%	3	5.1%	5	3.0%
Internal Organ	2	4.9%	1	1.5%	3	5.1%	6	3.6%
Other	4	9.8%	13	19.1%	5	8.5%	22	13.1%
Nervous System	5	12.2%	5	7.4%	6	10.2%	16	9.5%
Strain/Tear	0	0.0%	1	1.5%	0	0.0%	1	0.6%
Traumatic Brain Injury, nec	8	19.5%	17	25.0%	7	11.9%	32	19.0%
Body Region								
Abdomen	2	4.9%	2	2.9%	4	6.8%	8	4.8%
Cervical Spine/Neck	23	56.1%	37	54.4%	31	52.5%	91	54.2%
Chest/Ribs	0	0.0%	1	1.5%	1	1.7%	2	1.2%
Eye	0	0.0%	1	1.5%	0	0.0%	1	0.6%
Head/Face	14	34.1%	23	33.8%	16	27.1%	53	31.5%
Knee*	0	0.0%	0	0.0%	2	3.4%	2	1.2%
Lower Leg/Achilles*	1	2.4%	0	0.0%	0	0.0%	1	0.6%
Lumbar Spine/Lower Back	0	0.0%	0	0.0%	1	1.7%	1	0.6%
Nervous System	0	0.0%	2	2.9%	1	1.7%	3	1.8%
Respiratory	0	0.0%	1	1.5%	0	0.0%	1	0.6%
Thoracic Spine/Upper Back	1	2.4%	1	1.5%	3	5.1%	5	3.0%
Detailed Suspected Cause								

Characteristics	2013-2014		2015-2016		2017-2018		All	
	N	%	N	%	N	%	N	%
Brain Aneurysm	0	0.0%	1	1.5%	0	0.0%	1	0.6%
Brain Hemorrhage/Bleed	1	2.4%	1	1.5%	3	5.1%	5	3.0%
Cervical Spinal Cord Contusion	3	7.3%	2	2.9%	5	8.5%	10	6.0%
Cervical Spinal Cord/Nerve Injury	4	9.8%	2	2.9%	4	6.8%	10	6.0%
Cervical Spinal Stenosis	0	0.0%	0	0.0%	1	1.7%	1	0.6%
Cervical Spine Disc Injury	1	2.4%	0	0.0%	0	0.0%	1	0.6%
Cervical Spine Fracture	12	29.3%	22	32.4%	18	30.5%	52	31.0%
Cervical Spine Injury, n.s.	3	7.3%	9	13.2%	3	5.1%	15	8.9%
Cervical Strain/Whiplash	0	0.0%	1	1.5%	0	0.0%	1	0.6%
Epidural Hematoma	0	0.0%	0	0.0%	1	1.7%	1	0.6%
Intestinal Injury	1	2.4%	0	0.0%	0	0.0%	1	0.6%
Knee Dislocation*	0	0.0%	0	0.0%	1	1.7%	1	0.6%
Liver Injury	0	0.0%	0	0.0%	1	1.7%	1	0.6%
Lumbosacral Spine Contusion	0	0.0%	0	0.0%	1	1.7%	1	0.6%
Lung Contusion	0	0.0%	1	1.5%	0	0.0%	1	0.6%
Lung Injury	0	0.0%	1	1.5%	1	1.7%	2	1.2%
Other Abdominal Injury	0	0.0%	1	1.5%	1	1.7%	2	1.2%
Other Eye Injury	0	0.0%	1	1.5%	0	0.0%	1	0.6%
Other Lower Leg Injury*	1	2.4%	0	0.0%	0	0.0%	1	0.6%
Other Neck Injury	0	0.0%	1	1.5%	0	0.0%	1	0.6%
Proximal Tibio-Fibular Dislocation*	0	0.0%	0	0.0%	1	1.7%	1	0.6%
Second Impact Syndrome	0	0.0%	1	1.5%	0	0.0%	1	0.6%
Spleen Injury	1	2.4%	1	1.5%	2	3.4%	4	2.4%
Subdural Hematoma	3	7.3%	4	5.9%	5	8.5%	12	7.1%
Subdural/Epidural Hematoma	2	4.9%	0	0.0%	0	0.0%	2	1.2%
Thoracic Spinal Cord/Nerve Injury	0	0.0%	1	1.5%	0	0.0%	1	0.6%
Thoracic Spine Contusion	1	2.4%	0	0.0%	0	0.0%	1	0.6%
Thoracic Spine Fracture	0	0.0%	0	0.0%	2	3.4%	2	1.2%
Thoracic Spine Injury, n.s.	0	0.0%	0	0.0%	1	1.7%	1	0.6%
Transient Para/Quadriplegia	0	0.0%	2	2.9%	1	1.7%	3	1.8%
Traumatic Brain Injury, nec or n.s.	8	19.5%	16	23.5%	7	11.9%	31	18.5%
Recovery Status								
Incomplete	28	68.3%	32	47.1%	40	67.8%	100	59.5%
Complete	13	31.7%	30	44.1%	19	32.2%	62	36.9%
Unknown	0	0%	6	8.8%	0	0%	6	3.6%
Position								
Defensive Lineman	3	7.3%	4	5.9%	2	3.4%	9	5.4%
Defensive back	6	14.6%	12	17.6%	10	16.9%	28	16.7%
Kicker/punter	0	0.0%	0	0.0%	1	1.7%	1	0.6%
Kickoff/punt coverage	1	2.4%	4	5.9%	1	1.7%	6	3.6%
Kickoff/punt return	2	4.9%	3	4.4%	3	5.1%	8	4.8%
Linebacker	6	14.6%	10	14.7%	6	10.2%	22	13.1%

Characteristics	2013-2014		2015-2016		2017-2018		All	
	N	%	N	%	N	%	N	%
Offensive Lineman	1	2.4%	3	4.4%	4	6.8%	8	4.8%
Quarterback	5	12.2%	5	7.4%	4	6.8%	14	8.3%
Running back	4	9.8%	3	4.4%	7	11.9%	14	8.3%
Tight end/Wide receiver	1	2.4%	6	8.8%	3	5.1%	10	6.0%
Unknown	12	29.3%	18	26.5%	18	30.5%	48	28.6%
Offense or Defense								
Defense	15	36.6%	26	38.2%	18	30.5%	59	35.1%
Offense	11	26.8%	17	25.0%	18	30.5%	46	27.4%
Special Teams	3	7.3%	7	10.3%	5	8.5%	15	8.9%
Unknown	12	29.3%	18	26.5%	18	30.5%	48	28.6%
Location of Injury								
Competitive Venue	36	87.8%	62	91.2%	55	93.2%	153	91.1%
School Athletic Facility	5	12.2%	6	8.8%	3	5.1%	14	8.3%
School Campus	0	0.0%	0	0.0%	1	1.7%	1	0.6%
Total	41	100.0%	68	100.0%	59	100.0%	168	100.0%

*Note: lower extremity injuries resulted in amputation of the lower leg (n=3)

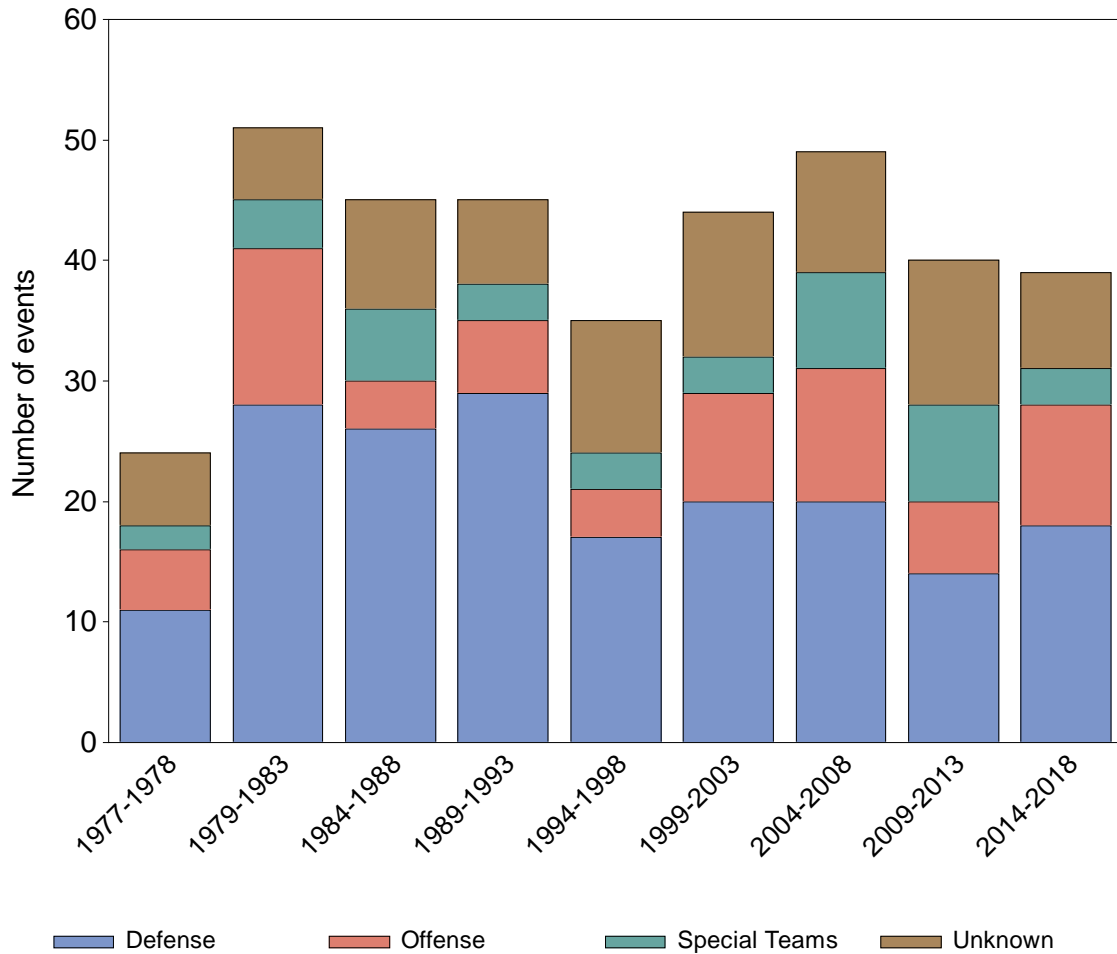
Figure 1. Catastrophic Neck/Cervical Spine (n=372) and Head/Brain (n=213) Injuries with Incomplete Recovery by 5-year periods, 1977-2018



Note 1. Numbers in bars are yearly averages.

Note 2. Data collection for non-fatal head/brain injuries began in 1984, and 1977 for neck/cervical spine injuries; 1977-1978 represents a 2-year period.

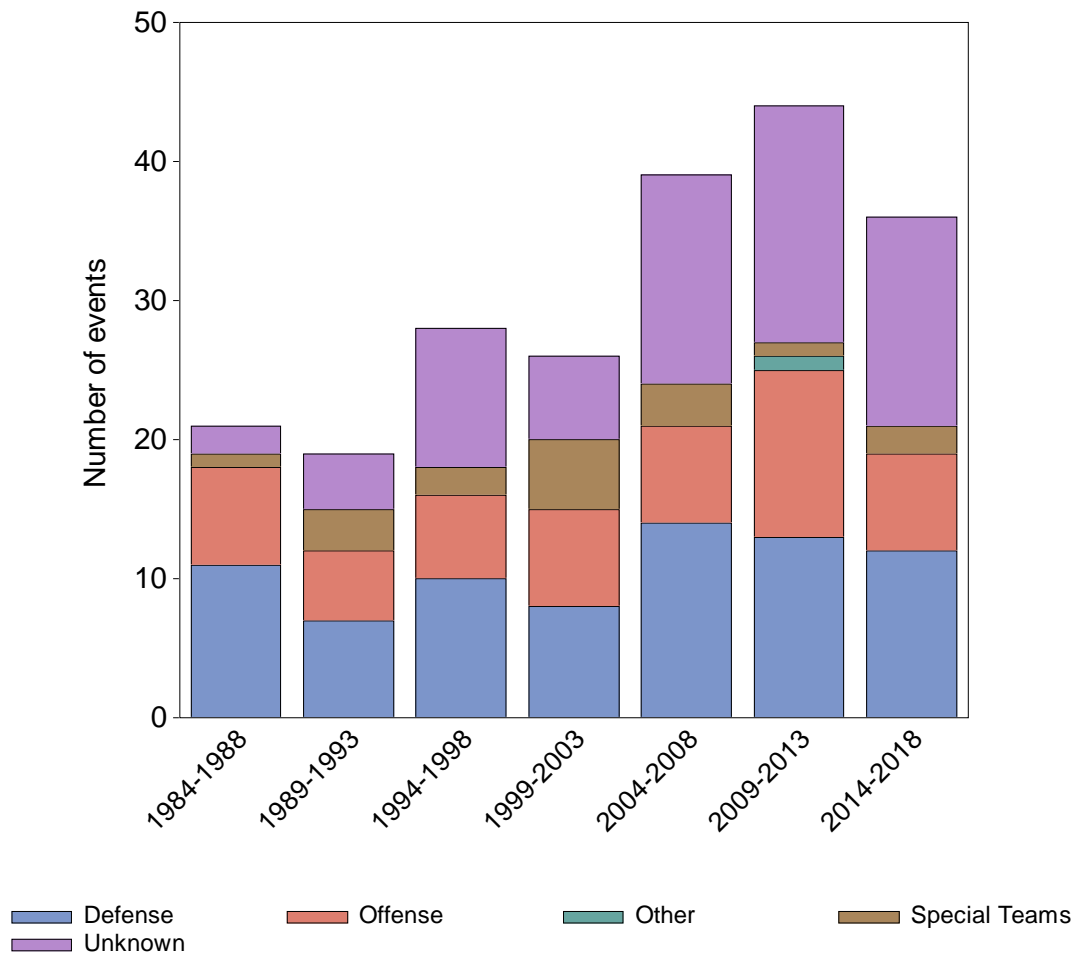
Figure 2a. Catastrophic Neck/Cervical Spine Injuries with Incomplete Recovery by Offensive or Defensive Category by 5-year periods, 1977-2018



*Note: 1977-1978 represents a 2-year period.

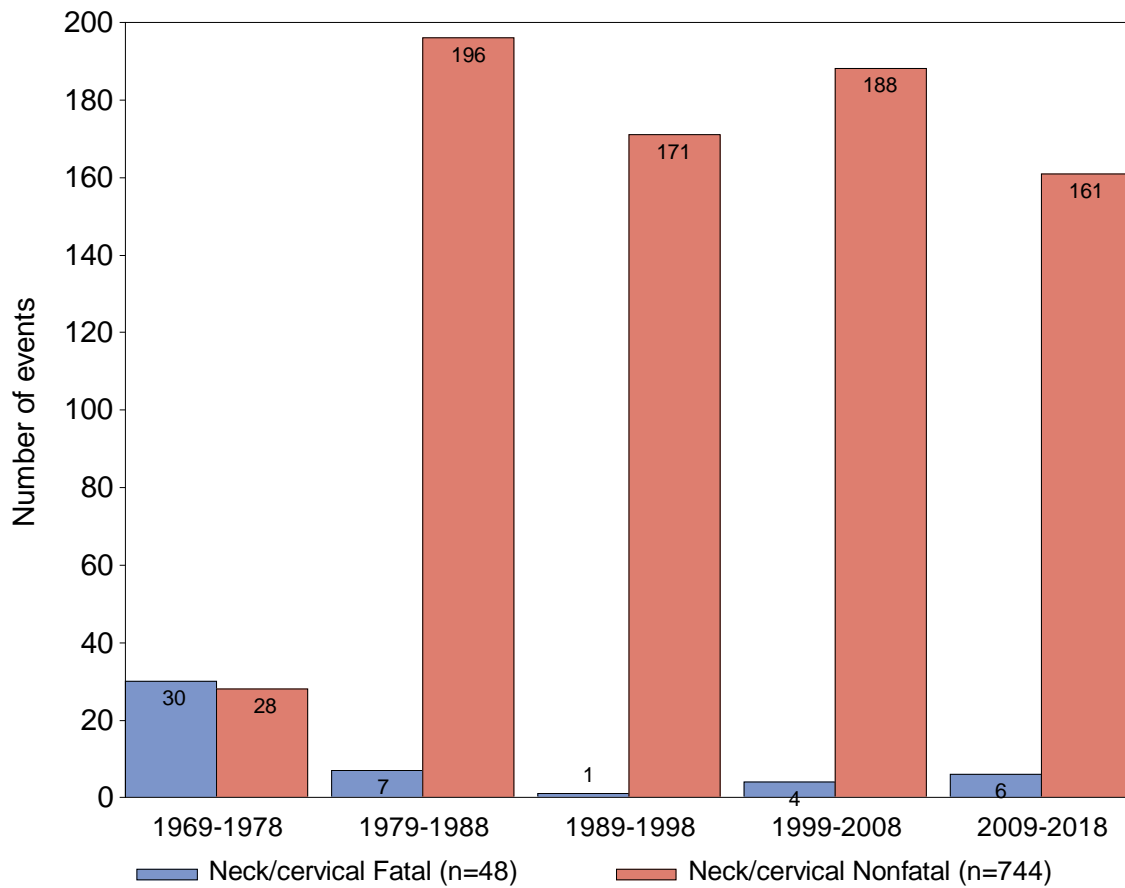
*Defense (n=), Offense (n=), Special Teams (n=), and Unknown (n=)

Figure 2b. Catastrophic Brain Injuries with Incomplete Recovery by Offensive or Defensive Category by 5-year periods, 1984-2018



*Defense (n=), Offense (n=), Other (n=), Special Teams (n=), and Unknown (n=)

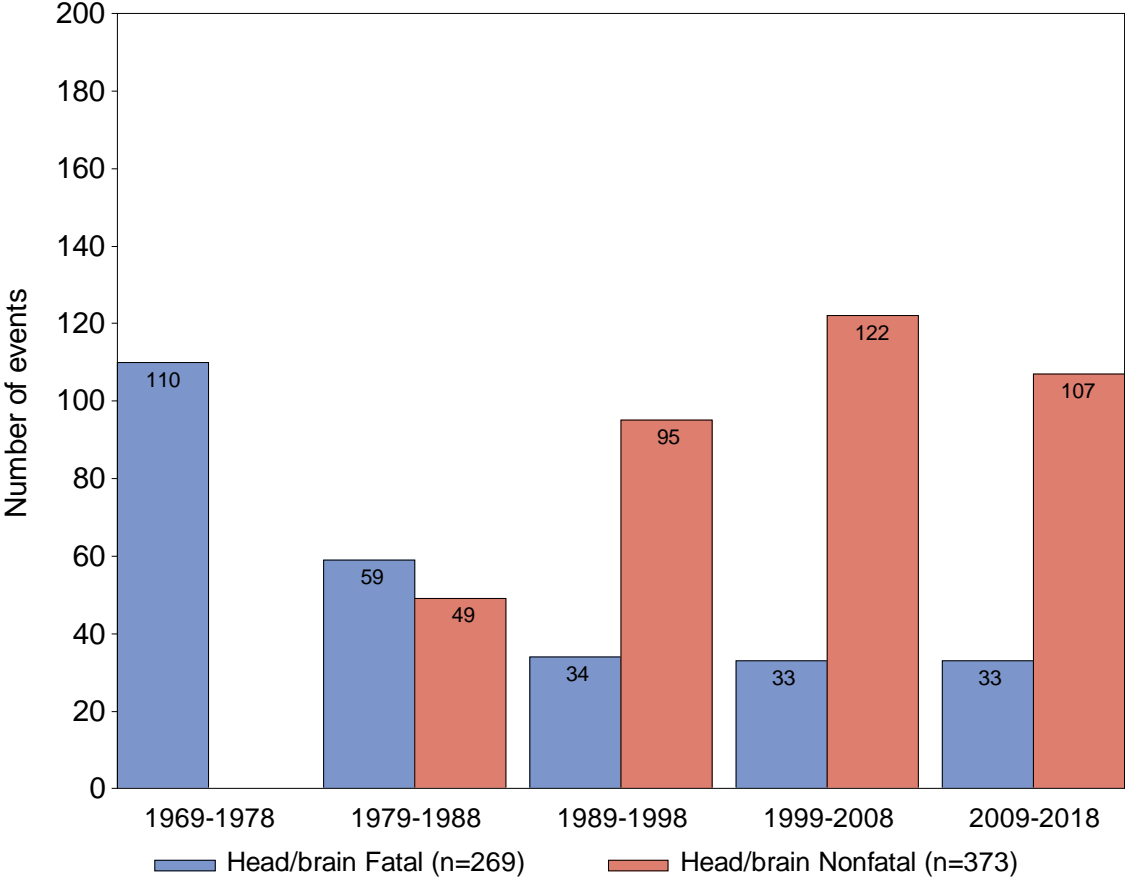
Figure 3a. Catastrophic Cervical Spine Fatalities and Injuries by Severity and Decade, 1969-2018



*Note: data collection for non-fatal neck injuries began in 1977

Figure 3b. Catastrophic Head/Brain Fatalities and Injuries by Severity and Decade, 1969-

2018



*Note: data collection for non-fatal brain injuries began in 1984