ANNUAL SURVEY OF FOOTBALL INJURY RESEARCH

1931 - 2019

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To learn more about NCCSIR please visit: http://nccsir.unc.edu/about/

To learn more about the Consortium please visit: http://nccsir.unc.edu/consortia-and-partners/

To access online reports please visit: http://nccsir.unc.edu/reports/

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INTRODUCTION

In 1931 the American Football Coaches Association initiated the First Annual Survey of Football Fatalities. The original survey committee was chaired by Marvin A. Stevens, M.D., of Yale University, who served from 1931-1942. Floyd R. Eastwood, Ph.D., from Purdue University succeeded Dr. Stevens in 1942 and served through 1964. Carl S. Blyth, Ph.D., of the University of North Carolina at Chapel Hill was appointed in 1965 and served through the 1979 football season. In 1977, the National Collegiate Athletic Association (NCAA) initiated a *National Survey of Catastrophic Football Injuries*, which is also conducted at the University of North Carolina. In January 1980, Frederick O. Mueller, Ph.D., from the University of North Carolina at Chapel Hill was appointed by the American Football Coaches Association and the National Collegiate Athletic Association to continue this research under the new title, *Annual Survey of Football Injury Research*.

The primary purpose of the *Annual Survey of Football Injury Research* is to make the game of football a safer and, therefore, a more enjoyable sports activity. Because of these surveys, the game of football has realized many benefits in regard to rule changes, improvement of equipment, improved medical care, and improved coaching techniques. The 1976 rule change that made it illegal to make initial contact with the head and face while blocking and tackling was the direct result of this research (Mueller & Cantu 2011).

The 1990 report was historic in that it was the first year since the beginning of the research in 1931 that there was not a direct fatality in football at any level of play (Mueller & Schindler 1991). This illustrates that data collection and analysis is important and plays a major role in injury prevention. Due to the success of these two football projects the research was

expanded to all sports for both men and women, and a National Center for Catastrophic Sports Injury Research (NCCSIR) was established in 1982. The NCCSIR was directed for 30 years by Dr. Frederick Mueller. Dr. Mueller retired Spring of 2013 and the NCCSIR continues under direction of 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 traumatic, cardiac, and exertional-related sport injuries (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), and 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

Outcome Definitions

Football fatalities are classified for this report as direct and indirect. The criteria used to classify football fatalities are as follows:

Direct (traumatic injury) – Those fatalities which resulted directly from participation in the fundamental skills of football (e.g. spine fracture).

Indirect (exertional/systemic) – Those fatalities that are caused by systemic failure as a result of exertion while participating in a football-related activity (e.g. heat stroke, sudden cardiac arrest) or by a complication which was secondary to a non-fatal injury (e.g. infection).

Non-exertion related – Beginning in 2014, NCCSIR is collecting information on suspected cardiac-related deaths that did not occur during exertion (e.g. died in sleep). These events are reported as "non-exertion related fatalities."

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. NCCSIR and the Consortium for Catastrophic Injury Monitoring in Sport have developed an online portal where anyone can report a catastrophic event (https://www.sportinjuryreport.org/). Throughout the year (January 1 to December 31), upon notification of a suspected football fatality, 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 https://www.sportinjuryreport.org/. Autopsy reports are used when available. All activities are approved by the Institutional Review Board (IRB) of the University of North Carolina at Chapel Hill (IRB# 05-0018).

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 participants in 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. Sandlot is defined as non-school, youth football, but organized and using full protective equipment (e.g., Pop Warner, American Youth Football League). These figures give an estimate of 4,200,000 total football participants in the United States each year (Mueller & Colgate 2012).

NCCSIR staff in collaboration with NFHS staff and Dr. David Klossner, PhD, ATC compiled and prepared this survey 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 fatalities 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 reported to the NCCSIR by the NCAA, the NFHS, online reports, colleagues, coaches, and athletic trainers. There may be additional catastrophic football fatalities that are not reported to the NCCSIR. The authors acknowledge that not every catastrophic fatality is included in this report.

RESULTS

Overall, NCCSIR captured 20 fatalities among football players of all play levels (2 college, 11 high school, 3 middle school, and 1 youth league). Of these 20 deaths, 17 were either directly (n=3) or indirectly (n=14) related to football participation for an overall rate of 0.40 per 100,000 players (95% confidence interval: 0.21-0.60). Of the 17 deaths, 14 autopsies were conducted: 10 autopsies were available (9 received and reviewed at the time of this report, 1 is pending receipt) and 5 autopsies were not available (e.g., require family release).

Direct Fatalities

There were three fatalities directly related to football during the 2019 football season: two fatalities were in high school football and one was in middle school (Table I). There were no direct fatalities reported in college/university, organized youth or professional/semi-professional football.

For the approximately 4,200,000 participants in 2019, the rate of direct fatalities was 0.07 per 100,000 participants (95% confidence interval: 0.001 to 0.152). The rate of direct fatalities in

2019 for high school (grades 9-12) was 0.18 per 100,000 participants (95% CI: 0.00 to 0.43) (Table III).

All direct fatalities in 2019 occurred during competition in regularly scheduled games. The football activities attributed to the direct fatalities were tackling and unknown (Table V). Of the direct fatalities, all were brain injuries (subdural/epidural hematoma, hemorrhage/bleed, and AVM) (Table V).

Indirect Fatalities

In 2019, there were 14 indirect fatalities that occurred among football players during football-related activities or physical exertion (Table II). Nine fatalities (64.3%) were associated with high school football (7 cardiac-related, 1 brain aneurysm, 1 drowning, and 1 heat stroke), three (21.4%) at the college/university level (2 cardiac-related, and 1 heat hyponatremia), and two (14.3%) at the middle school level (cardiac-related) (Table VI).

For the approximately 4,200,000 participants in 2019, the rate of indirect fatalities was 0.33 per 100,000 participants (95% confidence interval: 0.16 to 0.51). The rate of indirect fatalities in 2019 for high school (grades 9-12) was 0.82 per 100,000 participants (95% CI: 0.28 to 1.35) and for collegiate was 2.67 per 100,000 participants (95% CI: 0.001 to 6.36) (Table III).

Two occurred during competition (14.3%), six occurred during practice (42.9%), one each occurred during conditioning sessions and strength and weight session (7.1% each), one was during another team activity (7.1%), and three were during other non-team recreational activities (21.4%) (Table VI). Six occurred during September-October and 2 each occurred

during May-June and July-August, 3 occurred in March-April, and 1 occurred during January-February.

Non-exertion Related Fatalities

There were three non-exertion fatalities captured by NCCSIR: one collegiate (seizure during sleep), one high school (cardiac-related during sleep), and one organized youth level (asthma attack hours after game).

DISCUSSION

Fatalities in the sport of football are rare but tragic events. A total of 17 direct and indirect fatalities were recorded for the 2019 football season out of 20 fatalities collected by NCCSIR. Even though the rate of *direct* fatal injuries was very low on a 100,000 participant basis, the majority occurred during competition situations. It should be noted that practices outnumber the number of game exposures because there are typically five practice sessions for every one game and all players participate during practices. This 2019 report continues the 10-year trend of direct fatal events at an overall rate of 0.07 per 100,000 football participants (FIGURE II). Roughly 80% of brain football-related fatalities from 1990 to 2010 occurred during competition (Boden et al. 2013) and the current year's results continue this trend. In 2019, two high school football athletes and 1 middle school athlete died from direct traumatic brain injuries. There has been no change in the number of direct traumatic injury-related deaths in high school and middle school football the past 10 years from 2010-2019 compared to the previous 10 years from 2000-2009 (35 deaths each period). However, the past 10 years from

2010-2019, there were 7 direct traumatic injury-related deaths in college football compared to 1 death the previous 10 years from 2000-2009 – a seven-fold difference between the 2 periods.

There were no fatal traumatic internal organ injuries captured in 2019. Fatal traumatic internal organ injuries are rare (less than one per year captured by NCCSIR); from 1990-2010 NCCSIR recorded three fatal traumatic internal organ injuries in high school football (Boden et al. 2013).

The data illustrates the importance of injury event collection and the analysis of this data in making changes in the game of football that help reduce the incidence of serious injuries. This effort must be continued in order to keep these numbers low and to strive for the minimization of football fatalities.

Indirect fatalities have been in double figures on an annual basis for 14 of past 20 years including this year (range 7-18 per year). Since 1990, indirect fatalities have outnumbered direct fatalities on average 3 to 1 (FIGURE II). Cardiac events (n=10) were the primary cause of indirect deaths due to exertion in 2019 which is consistent with published research (Harmon et al. 2011). There was also one reported death due to heat stroke—down from 3 in 2017 and 2 in 2018. Continued safety efforts surrounding practicing in hot weather are still needed to continue this trend. There were no deaths captured due to exertional sickling in 2019. The college football level has recorded two fatalities (2014 and 2016) due to complications of sickle cell trait since 2010 when regulations were adopted requiring the athlete know their sickle cell trait status and the publication of multiple best practice documents.

Beginning in 2014, NCCSIR has been collecting information on non-exertion related fatalities that are suspected to be cardiac-related in order to improve our understanding of the

etiology of cardiac-related events and how to prevent sudden cardiac arrest in competitive athletes. NCCSIR captured three non-exertion related fatalities in 2019, six fatalities in 2018 and 2017. It is important to capture these events because in 2017 and 2018 it more than doubled the number of athletes that died due to cardiac-related causes within a calendar year (i.e. 6 during exertion plus 6 non-exertional for total of 12 cardiac events).

Head and Neck Injuries

In 2019, all direct fatalities in football were the result of traumatic brain injuries (n=3). The 10-year period of 2005-2014 recorded 31 head and neck fatalities compared to when data collection began in 1931 (Table VIII and Figure I). There have been fewer than 10 head and neck fatalities per year for the past twenty-five years (Cantu & Mueller 2002; Boden et al. 2013). Rule changes beginning in the 1976 football season that eliminated the head and face as a primary and initial contact area for blocking and tackling were of utmost importance. The original 1976 rule defined spearing as "the intentional use of the helmet (including the face mask) in an attempt to punish an opponent." In 2005 "intentional" was dropped from the rule: "spearing is the use of the helmet (including the face mask) in an attempt to punish an opponent". A 2006 point of emphasis covered illegal helmet contact and defined spearing, face tackling, and butt blocking. Butt blocking, face tackling, and spearing were defined as "Helmet Contact – Illegal" to place more emphasis on risk-minimization concerns (NFHS Football Rules Book 2014). Examples of illegal helmet contact that could result in disqualification include illegal helmet contact against an opponent lying on the ground, illegal helmet contact against an opponent held up by other players, and illegal helmet-to-helmet contact against a defenseless

opponent. In 2014 the NFHS further defined illegal contact to include "targeting" or "an act of taking aim and initiating contact to an opponent above the shoulders with the helmet, forearm, hand, fist, elbow or shoulders" (NFHS Football Rules Book 2014, rule 2-20-2, pg. 31). In 2015, spearing was further defined as "an act by any player who initiates contact against an opponent at the shoulders or below with the crown (top portion) of his helmet" (NFHS Football Rules Book 2015, rule 2-20-1c, pg. 31).

Head first/head down contact was identified as contributing to eight of the 28 deaths 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). **Coaches who do not correct improper tackling and blocking techniques are placing their players at risk for permanent paralysis or death. Football officials who do not penalize players for this type of tackling and blocking are placing players at risk. This type of tackling and blocking technique was the direct cause of 36 football fatalities and 30 permanent paralysis injuries in 1968.** Since 1960 most of the direct fatalities were the result of brain and neck injuries. Since 1990, 100 of the 110 brain and cervical spine deaths have been brain injuries. Continuing to reduce head and neck injuries in the sport is paramount.

Another important effort has been and continues to be the improvement of football protective equipment. The helmet technical standard established by the National Operating Committee on Standards for Athletic Equipment (NOCSAE) was adopted by the NCAA in 1978 and by the NFHS in 1980 and likely contributed to the decrease in football-related direct fatalities. Beginning in June 2018, all manufacturers of football helmets have to meet a new NOCSAE standard that includes rotational forces (maximum of 6,000 radians per second squared) if they are to be certified. This change was to address concussion risks. It is imperative that helmets be purchased, fitted, and properly reconditioned by manufacturer standards. Coaches should follow the manufacturer's recommendations for fitting, replacement, and reconditioning. In addition, helmets 10 years or older will not be reconditioned or returned to the team per the guidelines established by the NAERA (National Athletic Equipment Reconditioners Association). Manufacturers, coaches, athletic trainers, athletes, and physicians should continue their joint and individual efforts in preventing head and neck trauma.

The authors of this research report acknowledge that the current rules which limit the use of the head in blocking and tackling, coaches teaching the proper fundamentals of blocking and tackling, the helmet technical standard established by NOCSAE, excellent player physical conditioning, proper medical intervention and care, and an independent data collection system have played a significant role in reducing fatalities and serious brain and neck injuries in football. However, the football community should continue to strive even more to reduce the number of head and neck injuries.

Several suggestions for reducing, identifying, and managing head and neck injuries are as follows:

1. **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.
2. **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 tacking 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 that lead to fatal and catastrophic events.
3. **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 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.

4. **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.
5. **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 deaths. 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, and stoppage of play for injured players to ensure medical care can be accessed for injuries. 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, (1982-2019). Available at: https://www.nfhs.org/media/1020416/1982-2019-nfhs-risk-minimization-rules-8-28-19.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

Heat Stroke

A continuous effort should be made to eliminate heat stroke deaths associated with football. Between 1931 and 1959 there were five cases of heat stroke death reported. However, these events were not routinely monitored during this period. From 1960 through 2019 there have been 149 heat stroke cases that resulted in death (Table IV). Authors believe that heat stroke deaths are preventable with the proper precautions, early recognition and emergency management. Since 1995, 67 football players have died from heat stroke (48 high school, 14 college, 2 professional, 2 organized youth, and 1 middle school). During the most recent five-year period from 2015-2019, there was an average of 2 heat stoke deaths per year compared to 2.8 per year during the previous five-year period 2010-2014. This overall decline is encouraging and supports continued efforts to educate coaches, school administrators, medical providers, players, and parents concerning the proper procedures and precautions when practicing or playing in the heat. **However, during the most recent five-year period, 7 of the 10 deaths were during conditioning sessions compared to 2 of 14 during the previous five-year period. This highlights the need for appropriate oversight and monitoring of conditioning sessions.** In a recent position statement the NCAA outlined recommendations for conditioning sessions that include: transition periods, acclimatization, conditioning session activities are evidence-based, monitored and approved by credentialed strength and conditioning professionals or the head coach, performed in locations defined in the emergency action plan, and modifiable in hazardous environmental conditions (Parsons JT, et al. 2020) (direct link to report:

https://ncaaorg.s3.amazonaws.com/ssi/injury_prev/SSI_PreventingCatastrophicInjuryBooklet.pdf). It is important to note that in addition to the five heat stroke deaths the last three years, there were two deaths in 2015 and one in 2019 that were a result of athletes *over-hydrating* in order to prevent heat-related issues. Prevention messages must go beyond hydrating but emphasize how to properly hydrate, how to acclimate to the environment, how to acclimate to the addition of equipment, and achieve the appropriate fitness baseline for the intended rigors of practice.

Heat stroke and heat exhaustion are prevented by careful control of various factors in the conditioning program of the athlete. The NATA has a heat illness position statement on their web site with recommendations for prevention (http://natajournals.org/doi/pdf/10.4085/1062-6050-50.9.07; Casa et al., 2015). When football activity is carried on in hot weather, the following suggestions and precautions should be taken:

1. **Pre-Participation Physicals:** Each athlete should have a complete physical examination with a medical history and an annual health history update. History of previous heat illness, general illness, sickle cell trait, supplements, medications, and type of training activities before organized practice begins should be included.
2. **Acclimatization:** Acclimatize athletes to increasing exercise intensity, equipment, and hot/humid environments gradually by providing progressive practice sessions for the first fourteen days of football preseason and any other subsequent practice in hot or humid days. States and governing bodies have rules pertaining to when full football uniforms may be worn. See recent NCAA statement on preventing sudden death in sport for acclimatization recommendations:

https://ncaaorg.s3.amazonaws.com/ssi/injury_prev/SSI_PreventingCatastrophicInjuryBooklet.pdf

3. **Monitoring Environmental Conditions:** Know both the temperature and the humidity since it is more difficult for the body to cool itself in high humidity. Anytime the wet-bulb temperature is over 82 degrees Fahrenheit (28 degrees Celsius) suggests that careful control of all activity should be undertaken. Additional precautions should be taken when wearing protective equipment. The ACSM, NATA, NFHS, and NCAA have all published guidelines for conducting athletic activities in hot and humid environments.
4. **Adjust Activity Levels:** The intensity of exercise is the leading factor that can increase core body temperature higher and faster than any other. Adjusting activity level and providing frequent rest periods can minimize the risk of heat illness in football. Minimize multiple practice sessions during the same day and allow at least three hours of recovery between sessions. Rest during workouts in cool, shaded areas with some air movement and remove helmets and loosen or remove jerseys.
5. **Hydration:** Fluids should be readily available and consumed to aid in the body's ability to regulate itself and reduce the impact of heat stress in practice and games. Players should have water available and be encouraged to drink to minimize dehydration throughout a practice session. Athletes should drink water before, during, and after practice. Athletes are also encouraged to weigh in before and after exercise to establish individualized hydration plan to prevent excess dehydration and over-

drinking. Sports drinks that contain sodium (salt) and potassium can be consumed to replace electrolytes lost during activity.

7. **Monitor Athletes:** Athletes should weigh each day before and after practice and weight charts checked in order to treat the athlete who loses excessive weight each day. Generally, athlete should return to their previous day's weight before practicing.
8. **Clothing & Equipment:** Clothing is important and a player should wear moisture wicking apparel to dissipate heat. Never use rubberized clothing or sweat suits.
9. **Identify At-Risk:** Some athletes are more susceptible to heat injury. These individuals are not accustomed to physical activity in the heat, may be overweight, ill with a fever or other medical condition, and may be the eager athlete who constantly competes at his maximum capacity without heeding warning signs. Athletes with previous heat problems should be monitored.
10. **Emergency Action Plan:** Sports teams should have written emergency procedures in place, all personnel should have copies, and procedures should be reviewed annually. 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: https://www.nfhs.org/media/1014745/nfhs-heat-acclimatization-final-april-2018.pdf and www.ncaa.org.
11. **Heat Illness:**

a. Signs & Symptoms: It is important to observe for signs of heat illness. Some trouble signs are nausea, incoherence, fatigue, weakness, vomiting, cramps, weak rapid pulse,

flushed appearance, visual disturbances, and unsteadiness. Exertional heat stroke victims, contrary to popular belief, may sweat profusely as athletes are exercising. If heat illness is suspected, seek immediate medical service.

b. Recognition & Care: Coaches, athletic trainers, and players should refer to the multiple published best practices by the NATA, American College of Sports Medicine (ACSM), NFHS, and NCAA on preventing and managing heat illness. Emergency action plans should be activated. First aid should include removal from activity, taking off all equipment and placing the student-athlete in a cool, shaded environment. Fluids should be given orally. Core temperature and vital signs should be serially assessed. The student-athlete should be cooled by ice immersion and ice towels. Use of IV fluid replacement should be determined by a physician. Some schools have plastic outdoor tubs or swim pools filled with ice water available at practice facilities in hot and humid environments. Best practices emphasize core temperature measured rectally as most reliable measure of core body temperature. Reducing core temperature and minimizing the duration of hyperthermia is essential in reducing the risk of potential organ damage or death (i.e., "Cool First, Transport Second") (Casa et al. 2015).

RECOMMENDATIONS

Specific recommendations resulting from the 2018 survey data are as follows:

1. 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. All personnel involved with training football athletes should emphasize proper, gradual, and sport-specific physical conditioning.
3. 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.
4. All personnel associated with football participation should be cognizant of the safety measures related to physical activity in hot weather.
5. Each institution should strive to have access to a certified athletic trainer.
6. All individuals, groups and organizations interested in sport safety should continue their efforts and collaborations to ensure the safety of football for all participants.

7. There should be strict enforcement of game rules, and administrative regulations should be enforced to protect the health of the athlete. Coaches and school officials must support the game officials in their conduct of the athletic contests.
8. There should be a renewed emphasis on employing well-trained athletic personnel, providing excellent facilities, and securing the safest and best equipment possible.
9. There should be continued research concerning the safety of football players in practice and games (rules, facilities, equipment, etc.).
10. Coaches should continue to teach and emphasize the proper fundamentals of blocking and tackling to help reduce brain and neck fatalities. KEEP THE HEAD OUT OF FOOTBALL.
11. Strict enforcement of the rules of the game by both coaches and game officials will help reduce serious injuries. Be aware of the 2005 rule change to the 1976 definition of spearing and to the 2007 high school rules concerning illegal helmet contact (see pages 9-10 of report).
12. When a player has shown signs or symptoms of head trauma, the player should receive immediate medical attention from an appropriate medical provider and should not be allowed to return to practice or game without permission from a physician if diagnosed with a brain injury. 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.
13. The number of cardiac related deaths has increased over the years and it is recommended that schools have an emergency action plan that is reviewed and

rehearsed annually. Automated external defibrillators (AED) should be available for emergency situations (within three minutes).

14. A more recent concern for indirect deaths in football players is sickle cell trait. From 1980-2010, 15 college football players have died after an on field collapse due to complication of sickle cell trait (Harris et al. 2012). Many athletes do not know their sickle cell status even though screening is done at birth. The NCAA mandates that all student-athletes know their sickle cell trait status or seek testing to confirm their status with a physician. The NATA supports this concept with their statement– *Consensus Statement: Sickle Cell Trait and the Athlete* available at: (http://www.nata.org/sites/default/files/SickleCellTraitAndTheAthlete.pdf). (Inter-Association Task Force on Sickle Cell Trait and the Athlete, 2007) The statement includes precautions for athletes with sickle cell trait.

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CASE SUMMARIES CALENDAR YEAR 2019

All summaries compiled from publicly available media sources.

DIRECT FATALITIES (n=3)

ORGANIZED YOUTH (SANDLOT)
NONE IN 2019

PROFESSIONAL/SEMI-PROFESSIONAL
NONE IN 2019

HIGH SCHOOL
A male 16 year old high school football player suffered an injury to his head during a game. The athlete's head made contact with the ground after making a tackle. He was unconscious following the hit and transported to a hospital by EMS. He had too much swelling around his brain to operate. He died three days later. Cause of death is pending autopsy but is expected to be due to brain swelling.

A male 17 year-old high school football player was unable to stand following a tackle. He was attended to by EMS and transported to a hospital. He suffered a severe brain bleed due to a preexisting condition. Cause of death was brain arteriovenous malformation rupture.

MIDDLE SCHOOL
A male 13 year-old middle school football player was hurt during a game. Paramedics arrived 15 minutes after the hit and attempted CPR on the field. The athlete suffered traumatic brain injury and did not survive. Cause of death was traumatic subdural hematoma.

COLLEGE
NONE IN 2019

INDIRECT FATALITIES (n=14)

ORGANIZED YOUTH (SANDLOT)
NONE IN 2019

PROFESSIONAL/SEMI-PROFESSIONAL
NONE IN 2019

HIGH SCHOOL

A male 17 year old high school junior football player was lifting weights at school when an aneurysm in his brain burst. He died as a result of the event.

A male 16 year old high school football player collapsed while conditioning in the weight room at the high school. He was transported to a hospital by EMS where he died about an hour later. Cause of death was determined to be probable cardiac dysrhythmia in an individual with ventricular hypertrophy.

A male 14 year old freshman suddenly collapsed 20 minutes into conditioning drills. He was attended to by EMS and transported to a nearby hospital where he later died. His body temperature when he arrived at the hospital was 102 degrees. Cause of death was due to exertional hyperthermia (heat stroke). Contributing factors included cardiac hypertrophy and hypernatremia.

A male 15 year old football player collapsed in the locker room following a late night practice. EMS crews administered CPR and were able to get a pulse, before transporting him to a hospital. He was pronounced dead shortly after arrival at a hospital. Cause of death is pending autopsy but is suspected to be cardiac related.

A male 15 year old high school football player collapsed during conditioning at an indoor practice while running bleachers. The coaches noticed him struggling to finish the drill and he took multiple doses from his inhaler, but he continued to get worse. The assistant athletic trainer was brought to the scene and called for EMS. The athlete lost consciousness and became unresponsive within about 15 minutes of the start of the asthma attack. EMS began life CPR and advanced life support then transported him to the hospital. He was pronounced dead later that night at the hospital. Cause of death was cardiac arrest and asthma attack according to the Coroner report.

A male high school football player collapsed during a game. He was attended to immediately by EMTs who were stationed at the game, then taken to the hospital. The athlete later died. Cause of death is pending autopsy.

A 15 year old male high school football player collapsed during a football game. He collapsed on the field, got up and began to jog to the sideline and collapsed again. The athlete was attended to by EMS and transported to a hospital where he later died. The cause of death was due to congenital heart disease. The athlete had heart surgery several years ago to correct a congenital heart defect.

A 14 year old high school football player was found unresponsive at the bottom of the high school's pool. The football team had been giving access to the pool after football practice. Coaches and lifeguards were both present. Athletic trainers performed CPR on the athlete and administered an AED before he was taken to the hospital. Cause of death was due to drowning and other contributing factors are pending autopsy.

A male 16 year old high school defensive-tackle suffered sudden cardiac arrest while running with his family playing tag in a parking lot. He collapsed to his knees and his brother caught him. His brother immediately called EMS. He was pronounced dead in an ambulance. Cause of death was cardiomegaly.

MIDDLE SCHOOL

A male 13 year old football player collapsed during practice and began seizing. EMS provided CPR on the field then he was taken to a hospital by EMS where he later died. Athlete had a history of asthma but no other medical problems. Cause of death is pending autopsy but suspected to be sudden cardiac arrest.

A male 12 year old middle school football athlete collapsed with seizure-like activity during a non-tackle drill at practice. CPR was initiated by bystanders and two shocks were provided by an AED. EMS arrived on the scene and transported the athlete to the hospital after return of spontaneous circulation. He died later that night in the hospital despite additional resuscitative attempts. Cause of death was determined to be right ventricular cardiomyopathy.

COLLEGE

A male 23 year old collegiate football player died following a hospitalization for hyponatremia. The athlete injured his upper leg at football practice, was treated with ice and stayed on the sidelines the remainder of practice, and later went to the hospital with muscle pain and spasms. His sodium levels had dropped dangerously low, and he was diagnosed with hyponatremia. His condition worsened, causing seizures and brain swelling and athlete died after three days in the hospital.

A male 23 year old male collegiate football player collapsed during non-contact drills at practice. He was attended to by athletic training staff and EMS immediately. CPR was initiated then the athlete was transported to a hospital where he later died. The cause of death was acute aortic dissection.

A male 21 year old collegiate football player collapsed and hit his head while practicing step dancing with friends. He began convulsing and foaming at the mouth. He was then transported by friends to a hospital, but was not able to be revived. The cause of death was cardiac arrhythmia due to cardiomegaly.

NON EXERTION-RELATED FATALITIES (n=3)

ORGANIZED YOUTH (SANDLOT)

A 10 year old male youth-league football player died from an asthma attack hours after a football game.

PROFESSIONAL/SEMI-PROFESSIONAL

NONE IN 2019

HIGH SCHOOL

A 15-year old male high school football athlete was found dead in his home. His mother went to wake him up in the morning and he had apparently died in his sleep. Cause of death was hypertrophic cardiomyopathy.

COLLEGE

A male 19 year old collegiate freshman football kicker was found dead in the prone position on his bed. Cause of death was seizure sequelae. Athlete had a history of nocturnal seizures. There were no cardiac abnormalities found during the autopsy.

Table I. FATALITIES DIRECTLY DUE TO FOOTBALL - 1931-2019[1]

Year	Organized youth Direct	Pro & Semi-pro Direct	Middle & High School Direct	College Direct	Total Direct
1931-1965[2]	133	73	347	56	609
1966	4	0	20	1	25
1967	5	0	16	3	24
1968	4	1	26	4	35
1969	2	0	18	1	21
1970	3	0	23	3	29
1971	2	0	15	3	20
1972	3	1	16	2	22
1973	2	0	7	0	9
1974	0	0	10	1	11
1975	1	0	13	1	15
1976	3	0	12	0	15
1977	1	0	7	1	9
1978	0	0	9	0	9
1979	0	0	3	1	4
1980	0	0	9	0	9
1981	2	0	5	2	9
1982	2	0	7	1	10
1983	0	0	4	0	4
1984	1	0	4	1	6
1985	2	0	4	1	7
1986	1	0	11	1	13
1987	0	0	4	0	4
1988	0	0	7	0	7
1989	0	0	4	0	4
1991	0	0	3	0	3
1992	0	0	2	0	2
1993	0	0	3	1	4
1994	0	0	0	1	1
1995	0	0	4	0	4
1996	0	0	5	0	5
1997	0	0	6	1	7

Year	Organized youth Direct	Pro & Semi-pro Direct	Middle & High School Direct	College Direct	Total Direct
1998	0	0	6	1	7
1999	1	0	4	1	6
2000	0	0	3	0	3
2001	1	0	8	0	9
2002	1	1	3	1	6
2003	1	0	2	0	3
2004	1	0	4	0	5
2005	0	1	2	0	3
2006	0	0	1	0	1
2007	0	1	3	0	4
2008	0	0	7	0	7
2009	1	0	2	0	3
2010	1	0	2	2	5
2011	1	0	3	2	6
2012	0	2	1	0	3
2013	0	0	8	0	8
2014	0	0	5	1	6
2015	0	0	7	0	7
2016	0	1	2	0	3
2017	0	0	2	2	4
2018	0	0	2	0	2
2019	0	0	3	0	3
Total:	**179**	**81**	**704**	**96**	**1,060**
Percent:	**16.9%**	**7.6%**	**66.4%**	**9.1%**	**100.0%**

[1]No study was made in 1942.

[2]Yearly totals available from past reports.

Table II. FATALITIES INDIRECTLY DUE TO FOOTBALL - 1931-2019[1]

Year	Organized youth Indirect	Pro & Semi-pro Indirect	Middle & High School Indirect	College Indirect	Total Indirect
1931-1965[2]	88	14	164	40	306
1966	0	0	5	2	7
1967	0	0	4	1	5
1968	2	0	8	2	12
1969	4	2	8	3	17
1970	0	0	12	2	14
1971	2	2	7	2	13
1972	0	0	10	1	11
1973	0	0	5	3	8
1974	0	0	5	3	8
1975	2	0	3	3	8
1976	1	0	10	2	13
1977	0	0	7	0	7
1978	0	0	8	1	9
1979	1	1	8	1	11
1980	0	0	4	0	4
1981	0	0	6	0	6
1982	1	0	7	3	11
1983	0	0	6	3	9
1984	0	0	3	0	3
1985	0	0	1	1	2
1986	0	0	6	1	7
1987	1	0	4	3	8
1988	0	0	10	0	10
1989	0	0	9	2	11
1990	0	0	3	3	6
1991	0	0	3	1	4
1992	1	0	9	1	11
1993	0	0	8	1	9
1994	1	0	2	2	5
1995	0	0	8	1	9
1996	0	1	10	1	12

Year	Organized youth Indirect	Pro & Semi-pro Indirect	Middle & High School Indirect	College Indirect	Total Indirect
1997	1	0	7	0	8
1998	1	0	6	1	8
1999	1	0	12	0	13
2000	0	0	11	2	13
2001	0	2	10	3	15
2002	1	0	9	3	13
2003	1	1	4	1	7
2004	0	0	7	3	10
2005	1	1	8	2	12
2006	2	0	12	2	16
2007	1	1	6	1	9
2008	3	0	7	3	13
2009	2	0	14	2	18
2010	0	0	9	2	11
2011	0	0	11	2	13
2012	0	0	6	5	11
2013	0	0	9	1	10
2014	1	0	5	3	9
2015	2	1	7	1	11
2016	2	0	5	2	9
2017	0	0	6	2	8
2018	0	0	4	5	9
2019	0	0	11	3	14
Total:	**123**	**26**	**549**	**138**	**836**
Percent:	**14.7%**	**3.1%**	**65.7%**	**16.5%**	**100.0%**

[1]No study was made in 1942.

[2]Yearly totals available from past reports.

TABLE III. DIRECT & INDIRECT FATALITIES INCIDENCE PER 100,000 # PARTICIPANTS – 1968-2019[1, 2]

	Direct		Indirect	
Year	Middle & high school[3]	College[4]	Middle & high school[3]	College[4]
1968	2.60	5.33	0.80	2.67
1969	1.80	1.33	0.80	4.00
1970	2.30	4.00	1.20	2.67
1971	1.50	4.00	0.70	2.67
1972	1.60	2.67	1.00	1.33
1973	0.70	0.00	0.50	4.00
1974	1.00	1.33	0.50	4.00
1975	1.30	1.33	0.30	4.00
1976	1.20	0.00	1.00	2.67
1977	0.70	1.33	0.70	0.00
1978	0.90	0.00	0.80	1.33
1979	0.30	1.33	0.80	1.33
1980	0.90	0.00	0.40	0.00
1981	0.50	2.67	0.60	0.00
1982	0.70	1.33	0.70	4.00
1983	0.40	0.00	0.60	4.00
1984	0.40	1.33	0.30	0.00
1985	0.31	1.33	0.08	1.33
1986	0.85	1.33	0.46	1.33
1987	0.31	0.00	0.31	4.00
1988	0.54	0.00	0.77	0.00
1989	0.31	0.00	0.69	2.67
1990	0.00	0.00	0.23	4.00
1991	0.23	0.00	0.23	1.33
1992	0.15	0.00	0.69	1.33
1993	0.23	1.33	0.62	1.33
1994	0.00	1.33	0.15	2.67
1995	0.31	0.00	0.62	1.33
1996	0.38	0.00	0.77	1.33
1997	0.46	1.33	0.54	0.00

	Direct		Indirect	
Year	Middle & high school[3]	College[4]	Middle & high school[3]	College[4]
1998	0.46	1.33	0.46	1.33
1999	0.31	1.33	0.92	0.00
2000	0.23	0.00	0.85	2.67
2001	0.62	0.00	0.77	4.00
2002	0.23	1.33	0.69	4.00
2003	0.15	0.00	0.31	1.33
2004	0.31	0.00	0.54	4.00
2005	0.15	0.00	0.62	2.67
2006	0.08	0.00	0.92	2.67
2007	0.23	0.00	0.46	1.33
2008	0.54	0.00	0.54	4.00
2009	0.15	0.00	1.08	2.67
2010	0.15	2.67	0.69	2.67
2011	0.20	2.67	0.73	2.67
2012	0.09	0.00	0.55	6.67
2013	0.73	0.00	0.82	1.33
2014	0.45	1.33	0.45	4.00
2015	0.64	0.00	0.64	1.33
2016	0.18	0.00	0.45	2.67
2017	0.18	2.67	0.55	2.67
2018	0.18	0.00	0.36	6.67
2019	0.27	0.00	1.00	4.00

[1]No study was made in 1942.

[2]Yearly totals available from past reports.

[3]Rates based on 1, 1.3, 1.5 and 1.1 million in 1968-1984, 1985-2010, 2011 and 2012-2019, respectively, for players grades 9-12.

[4]Rates 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 IV. HEAT STROKE FATALITIES – 1931-2019[1]

Year	Total
1931-1954[1]	0
1955	1
1956	0
1957-1959	4
1960	3
1961	3
1962	5
1963	0
1964	5
1965	6
1966	1
1967	2
1968	5
1969	5
1970	8
1971	4
1972	7
1973	3
1974	1
1975	0
1976	1
1977	1
1978	4
1979	2
1980	1
1981	2
1982	2
1983	1
1984	3
1985-1986	0
1987	1
1988	2
1989	2
1990	1
1991	0
1992	1

Year	Total
1993-1994	0
1995	5
1996	2
1997	1
1998	4
1999	2
2000	3
2001	3
2002-2003	0
2004	3
2005	3
2006	5
2007	2
2008	6
2009	4
2010[2]	5
2011	6
2012	1
2013	0
2014	2
2015	2
2016	2
2017	3
2018	2
2019	1
Total since 1996	62
Total, 1931-2018	154

[1]No study was made in 1942.

[2]In 2010 two were a combination of heat and sickle cell trait.

Table V. CHARACTERISTICS OF DIRECT FATALITIES 2019

	Organized youth		Pro & Semi-Pro		Middle & High school		College		All	
Characteristics	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Month										
Sep-Oct	0	0.0%	0	0.0%	3	100.0%	0	0.0%	3	100.0%
Type of Activity										
General play	0	0.0%	0	0.0%	1	33.3%	0	0.0%	1	33.3%
Tackling	0	0.0%	0	0.0%	2	66.7%	0	0.0%	2	66.7%
Type of Session										
Competition/Game	0	0.0%	0	0.0%	3	100.0%	0	0.0%	3	100.0%
Position										
Cornerback	0	0.0%	0	0.0%	1	33.3%	0	0.0%	1	33.3%
Linebacker	0	0.0%	0	0.0%	1	33.3%	0	0.0%	1	33.3%
Unknown	0	0.0%	0	0.0%	1	33.3%	0	0.0%	1	33.3%
Location of Injury										
Competitive Venue	0	0.0%	0	0.0%	3	100.0%	0	0.0%	3	100.0%
Type of Injury										
Other Traumatic Injury	0	0.0%	0	0.0%	1	33.3%	0	0.0%	1	33.3%
Traumatic Brain Injury	0	0.0%	0	0.0%	2	66.7%	0	0.0%	2	66.7%
Suspected Cause										
Arteriovenous Malformation	0	0.0%	0	0.0%	1	33.3%	0	0.0%	1	33.3%
Brain Hemorrhage/Bleed	0	0.0%	0	0.0%	1	33.3%	0	0.0%	1	33.3%
Subdural/Epidural Hematoma	0	0.0%	0	0.0%	1	33.3%	0	0.0%	1	33.3%
Total	**0**	**0.0%**	**0**	**0.0%**	**3**	**100.0%**	**0**	**0.0%**	**3**	**100.0%**

Table VI. CHARACTERISTICS OF INDIRECT FATALITIES 2019

Characteristics	Organized youth		Pro & Semi-Pro		Middle & High school		College		All	
	N	%	N	%	N	%	N	%	N	%
Month										
Jan-Feb	0	0.0%	0	0.0%	1	9.1%	0	0.0%	1	7.1%
Mar-Apr	0	0.0%	0	0.0%	1	9.1%	2	66.7%	3	21.4%
May-Jun	0	0.0%	0	0.0%	2	18.2%	0	0.0%	2	14.3%
Jul-Aug	0	0.0%	0	0.0%	2	18.2%	0	0.0%	2	14.3%
Sep-Oct	0	0.0%	0	0.0%	5	45.5%	1	33.3%	6	42.9%
Type of Activity										
Conditioning (land)	0	0.0%	0	0.0%	3	27.3%	0	0.0%	3	21.4%
Conditioning (water)	0	0.0%	0	0.0%	1	9.1%	0	0.0%	1	7.1%
Does not apply	0	0.0%	0	0.0%	1	9.1%	1	33.3%	2	14.3%
General play	0	0.0%	0	0.0%	0	0.0%	2	66.7%	2	14.3%
Unknown	0	0.0%	0	0.0%	5	45.5%	0	0.0%	5	35.7%
Weights	0	0.0%	0	0.0%	1	9.1%	0	0.0%	1	7.1%
Type of Session										
Competition/Game	0	0.0%	0	0.0%	2	18.2%	0	0.0%	2	14.3%
Conditioning Session	0	0.0%	0	0.0%	1	9.1%	0	0.0%	1	7.1%
Other Team activity	0	0.0%	0	0.0%	1	9.1%	0	0.0%	1	7.1%
Practice	0	0.0%	0	0.0%	4	36.4%	2	66.7%	6	42.9%
Strength/Weight Session	0	0.0%	0	0.0%	1	9.1%	0	0.0%	1	7.1%
Unaffiliated Recreational Activity	0	0.0%	0	0.0%	2	18.2%	1	33.3%	3	21.4%
Position										
Defensive Tackle	0	0.0%	0	0.0%	1	9.1%	0	0.0%	1	7.1%
Does not apply	0	0.0%	0	0.0%	1	9.1%	1	33.3%	2	14.3%
Linebacker	0	0.0%	0	0.0%	0	0.0%	1	33.3%	1	7.1%
Offensive Lineman	0	0.0%	0	0.0%	1	9.1%	0	0.0%	1	7.1%
Unknown	0	0.0%	0	0.0%	7	63.6%	0	0.0%	7	50.0%
Wide Receiver	0	0.0%	0	0.0%	1	9.1%	1	33.3%	2	14.3%
Location of Injury										
Competitive Venue	0	0.0%	0	0.0%	4	36.4%	1	33.3%	5	35.7%
Other Private Property	0	0.0%	0	0.0%	1	9.1%	0	0.0%	1	7.1%
Public Park	0	0.0%	0	0.0%	0	0.0%	1	33.3%	1	7.1%
School Athletic Facility	0	0.0%	0	0.0%	6	54.5%	1	33.3%	7	50.0%
Type of Injury										
Cardiac/Sudden Cardiac Arrest	0	0.0%	0	0.0%	8	72.7%	2	66.7%	10	71.4%

Characteristics	Organized youth		Pro & Semi-Pro		Middle & High school		College		All	
	N	%	N	%	N	%	N	%	N	%
Heat-Related Injury	0	0.0%	0	0.0%	1	9.1%	0	0.0%	1	7.1%
Hyponatremia	0	0.0%	0	0.0%	0	0.0%	1	33.3%	1	7.1%
Other	0	0.0%	0	0.0%	1	9.1%	0	0.0%	1	7.1%
Other Traumatic Injury	0	0.0%	0	0.0%	1	9.1%	0	0.0%	1	7.1%
Suspected Cause										
Brain Aneurysm	0	0.0%	0	0.0%	1	9.1%	0	0.0%	1	7.1%
Cardiac/Sudden Cardiac Arrest	0	0.0%	0	0.0%	8	72.7%	2	66.7%	10	71.4%
Drowning/Near Drowning	0	0.0%	0	0.0%	1	9.1%	0	0.0%	1	7.1%
Heat Hyponatremia	0	0.0%	0	0.0%	0	0.0%	1	33.3%	1	7.1%
Heat Stroke	0	0.0%	0	0.0%	1	9.1%	0	0.0%	1	7.1%
Total	**0**	**0.0%**	**0**	**0.0%**	**11**	**100.0%**	**3**	**100.0%**	**14**	**100.0%**

Table VII. CHARACTERISTCS OF NON-EXERTION RELATED FATALITIES 2019

Characteristics	Organized youth		Pro & Semi-Pro		Middle & High school		College		All	
	N	%	N	%	N	%	N	%	N	%
Type of Activity										
Non athletic activity	0	0.0%	0	0.0%	1	100.0%	1	100.0%	2	66.7%
Unknown	1	100.0%	0	0.0%	0	0.0%	0	0.0%	1	33.3%
Type of Session										
Other	1	100.0%	0	0.0%	1	100.0%	1	100.0%	3	100.0%
Position										
Does not apply	0	0.0%	0	0.0%	1	100.0%	1	100.0%	2	66.7%
Unknown	1	100.0%	0	0.0%	0	0.0%	0	0.0%	1	33.3%
Location of Injury										
Athlete's Home	0	0.0%	0	0.0%	1	100.0%	1	100.0%	2	66.7%
Other	1	100.0%	0	0.0%	0	0.0%	0	0.0%	1	33.3%
Suspected Cause										
Asthma	1	100.0%	0	0.0%	0	0.0%	0	0.0%	1	33.3%
Cardiac/Sudden Cardiac Arrest	0	0.0%	0	0.0%	1	100.0%	0	0.0%	1	33.3%
Seizure	0	0.0%	0	0.0%	0	0.0%	1	100.0%	1	33.3%
Total	**1**	**100.0%**	**0**	**0.0%**	**1**	**100.0%**	**1**	**100.0%**	**3**	**100.0%**

TABLE VIII: HEAD AND CERVICAL SPINE FATALITIES BY DECADE, 1945-2019

	Cervical Spine		Head/brain	
Year	**N**	**%**	**N**	**%**
1945-1954	32	25.4%	88	15.6%
1955-1964	25	19.8%	117	20.7%
1965-1974	41	32.5%	160	28.4%
1975-1984	15	11.9%	72	12.8%
1985-1994	4	3.2%	36	6.4%
1995-2004	2	1.6%	45	8.0%
2005-2014	5	4.0%	32	5.7%
2015-2018	2	1.6%	14	2.5%
Totals	126	100.0%	564	100.0%

TABLE IX: DIRECT AND INDIRECT FATALITIES BY 5-YEAR PERIOD, 1970-2019

	Direct		Indirect	
Year	**N**	**%**	**N**	**%**
1970-1974	92	26.3%	54	11.0%
1975-1979	52	14.9%	48	9.8%
1980-1984	41	11.7%	34	6.9%
1985-1989	35	10.0%	39	7.9%
1990-1994	10	2.9%	35	7.1%
1995-1999	29	8.3%	50	10.2%
2000-2004	26	7.4%	58	11.8%
2005-2009	18	5.1%	68	13.8%
2010-2014	28	8.0%	54	11.0%
2015-2019	19	5.4%	52	10.6%
Totals	350	100.0%	492	100.0%

FIGURE I: HEAD AND CERVICAL SPINE FATALITIES BY DECADE, 1945-2019

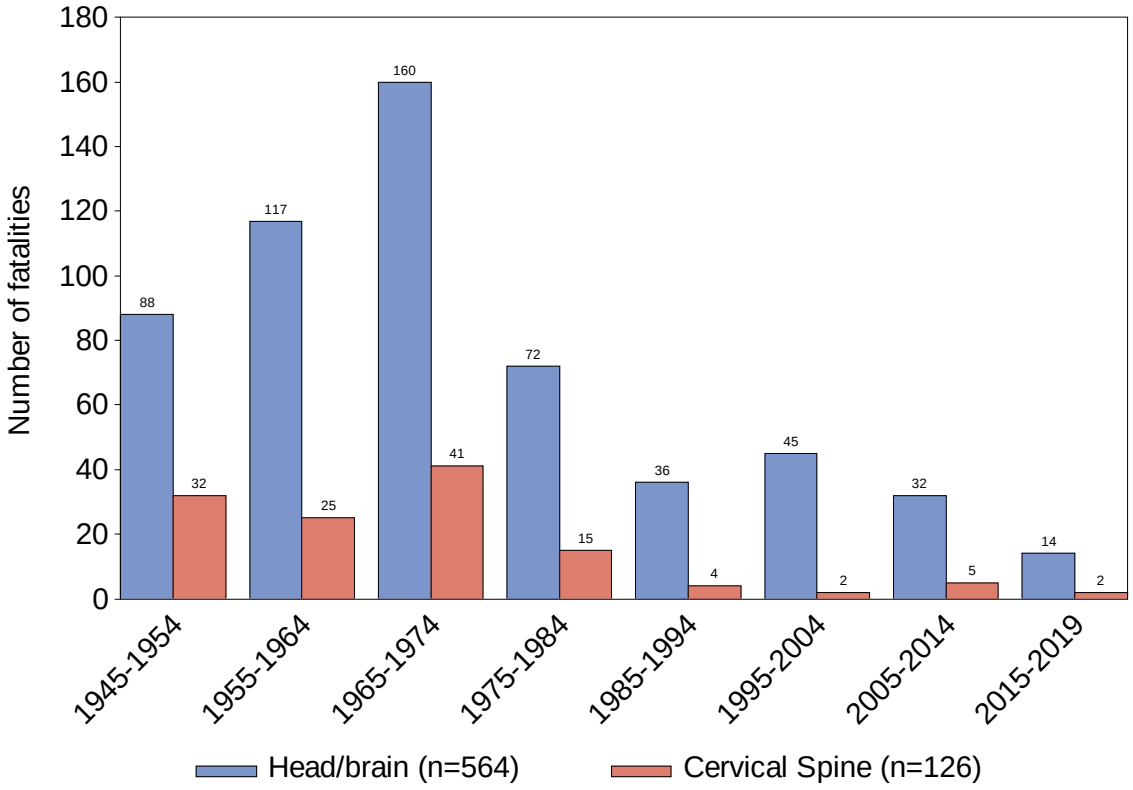

FIGURE II. DIRECT AND INDIRECT FATALITIES BY 5-YEAR PERIOD, 1970 to 2019