

ANNUAL SURVEY OF FOOTBALL INJURY RESEARCH

1931 - 2013

Kristen L. Kucera, MSPH, PhD, ATC
Director, National Center for Catastrophic Sport Injury Research
The University of North Carolina at Chapel Hill

David Klossner, PhD, ATC
Associate Athletics Director/Sports Performance
University of Maryland

Bob Colgate
Director of Sports and Sports Medicine, National Federation of State High School Associations

Robert C. Cantu, MD
Medical Director, National Center for Catastrophic Sport Injury Research

Prepared for:

American Football Coaches Association, Waco, Texas
National Collegiate Athletic Association, Indianapolis, Indiana
National Federation of State High School Associations,
Indianapolis, Indiana
National Athletic Trainers' Association, Dallas, Texas

FINAL
March 2014

Report #: 2014-01

Acknowledgements:

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 National Center for Catastrophic Sport Injury Research research associate Leah M. Cox, MS, CRC, LRT/CTRS for her assistance collecting data and preparing this report.

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, and The University of North Carolina at Chapel Hill.

All rights reserved. This material may not be published, broadcast, rewritten or redistributed in whole or part without express written permission. Contact the National Center for Catastrophic Sport Injury Research for all questions regarding this report at nccsir@unc.edu.

TABLE OF CONTENTS

	<u>Page</u>
Introduction	1
Methods	
Outcome Definitions	2
Data Collection	3
Participation in Football	3
Analysis	4
Results	
Direct Injuries	4
Indirect Injuries	5
Discussion	
Head and Neck Injury	6
Heat Stroke	11
Recommendations	15
References	18
Case Studies 2013 Season	19

LIST OF TABLES

	Page
TABLE I: FATALITIES DIRECTLY DUE TO FOOTBALL – 1931-2013	22
TABLE II: FATALITIES INDIRECTLY DUE TO FOOTBALL – 1931-2013	24
TABLE III: DIRECT FATALITIES INCIDENCE PER 100,000 PARTICIPANTS – 1931-2013	26
TABLE IV: HEAT STROKE FATALITIES 1931-2013	28
TABLE V: DIRECT FATALITIES 2013: TYPE OF ACTIVITY ENGAGED IN	30
TABLE VI: DIRECT FATALITIES 2013: CAUSE OF DEATH	31
TABLE VII: DIRECT FATALITIES 2013: POSITION PLAYED	32
TABLE VIII: INDIRECT FATALITIES 2013: CAUSE OF DEATH	33
TABLE IX: INDIRECT FATALITIES 2013: TYPE OF SESSION OR ACTIVITY	34
TABLE X: HEAD AND CERVICAL SPINE FATALITIES	35

LIST OF FIGURES

	Page
FIGURE I. HEAD AND CERVICAL SPINE FATALITIES BY DECADE, 1945 to 2013	36
FIGURE II. NUMBER OF DIRECT AND INDIRECT FATALITIES BY YEAR, 1966 to 2013	37

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., Purdue University succeeded Dr. Stevens in 1942 and served through 1964. Carl S. Blyth, Ph.D., 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., 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, 1931, that there was not a direct fatality in football at any level of play.(Mueller & Schindler 1991) This clearly 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 has been directed for the past 30 years by Dr. Frederick Mueller. Dr. Mueller retired Spring of 2013 and the NCCSIR continues under new direction (Dr. 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). This research is funded by American Football Coaches Association (AFCA), National Collegiate Athletic Association (NCAA), National Federation of State High School Associations (NFHS), and National Athletic Trainers' Association (NATA).

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

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

In several instances of reported football fatalities, the respondent stated the fatality should not be attributed to football. Reasons for these statements are that the fatality was attributed to physical defects that were unrelated to football injuries.

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, and professional associates of the researchers. Throughout the year (January 1 to December 31), upon notification of a suspected football fatality, contact by telephone, personal letter and questionnaire was made with the appropriate individuals including state high school association official, school or team administrator, coach, athletic trainer, and/or team physician. Autopsy reports are used when available.

Participation in Football

Reports prior to 2012 showed 1,800,000 participants in all levels of football.(Mueller & Colgate 2011) New 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 three million youth football players in the United States. Sandlot is defined as non-school, youth football, but organized and using full protective equipment. 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 incidence rates of football fatality were calculated based on participation estimates as described in the **Participation in Football** section above.

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. There may be additional catastrophic football fatalities that are not reported to the NCCSIR.

RESULTS

Direct Fatalities

There were eight fatalities directly related to football during the 2013 football season: all fatalities were in high school football (1 in the spring and 7 in the fall) (Table I). There were no direct fatalities reported in college, professional, semi-professional, or sandlot levels.

For the approximately 4,200,000 participants in 2013, the rate of direct fatalities was 0.19 per 100,000 participants (95% confidence interval: 0.06 to 0.32). The rate of direct fatalities in 2013 for high school (grades 9-12) was 0.73 per 100,000 participants (95% CI: 0.22 to 1.23) (Table III).

Half of direct fatalities in 2013 occurred during competition; two occurred in regularly scheduled games, two occurred in playoff games, and two occurred in a scrimmage (n=2), while two occurred during practice (n=2). The football activities attributed to the direct fatalities were

tackling drills (n=2), being tackled (n=2 – helmet to helmet collision and contact with ground after being tackled), making a tackle (n=1), and unknown activities (n=3) (Table V). Of direct fatalities, 75% were brain injuries and 25% were cervical fractures (Table VI).

Indirect Fatalities

In 2013 there were nine indirect fatalities among football players (Table II). Eight fatalities (88%) were associated with high school football (seven heart-related and one stroke) and one with middle/junior high school football (anaphylactic shock) (Table VIII). Six occurred during football-related activities (4 game and 2 practice), two occurred during other exertional activities (team weight training and pick-up basketball), and one occurred at home (Table IX).

DISCUSSION

Fatalities in the sport of football are rare but tragic events. A total of seventeen direct and indirect fatalities were recorded for the 2013 football season. Even though the rate of direct fatal injuries was very low on a 100,000 participant basis, most 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 2013 report continues a downward trend with eight total direct fatal events at an overall rate of 0.19 per 100,000 football participants (FIGURE II). The 2012 data reported no direct football fatalities in high school, college, or youth football; however, there were two at the semi-professional level. 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.

The data illustrates the importance of data 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 injuries have been in double figures since 1999 with the exception of 2003 and 2007. Since the 1990, indirect fatalities have outnumbered direct fatalities on average 2 to 1 (FIGURE II). In 2013 there were fewer indirect fatalities when compared to 2012. An important observation is that the college level has not recorded a fatality 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. Cardiac events were the primary cause of indirect death in 2013 which is consistent with published research (Harmon et al. 2011).

Head and Neck Injuries

Past efforts have been successful in reducing fatalities to the levels indicated in 1990 and 2012. There have been fewer than 10 head or 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 the new 2005 definition in the rules “intentional” has been dropped. The new rule states “spearing is the use of the helmet (including the face mask) in an attempt to punish an opponent”. A 2006 point of emphasis covers illegal helmet contact and defines spearing, face tackling, and butt blocking. High school rule changes effective during 2006-07 stated that at least a 4-point chinstrap shall be required to secure the helmet, and all mouth guards must be colored, not white or clear. Also

rule revisions regarding illegal helmet contact were made in February 2007. The committee placed butt blocking, face tackling, and spearing under the heading of “Helmet Contact – Illegal” to place more emphasis on risk-minimization concerns. 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. **Coaches who are teaching helmet or face to the numbers tackling and blocking are not only breaking the football rules, but are placing their players at risk for permanent paralysis or death. This type of tackling and blocking technique was the direct cause of 36 football fatalities and 30 permanent paralysis injuries in 1968. In addition, if a catastrophic football injury case goes to a court of law, there is no defense for using this type of tackling or blocking technique.** Since 1960 most of the direct fatalities have been caused by brain and neck injuries, and in fact since 1990 all but seven of the head and neck deaths have been brain injuries (72). We must continue to reduce head and neck injuries.

Another important effort has been and continues to be the improvement of football protective equipment. It is imperative that old and worn equipment be properly reconditioned by manufacturer standards or discarded. A good rule of thumb is to budget for rotating out a specified number of helmets each year. In addition, helmets 10 years or older will not be recondition or returned to the team. Manufacturers, coaches, athletic trainers, and physicians should continue their joint and individual efforts in preventing head and neck trauma.

The authors of this research are convinced 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 the National Operating Committee on Standards for Athletic Equipment (NOCSAE), excellent player physical conditioning, proper

medical intervention and care, and an independent data collection system have played the major role in reducing fatalities and serious brain and neck injuries in football. This is best illustrated by Table X and FIGURE I which shows the increase in both brain and cervical spine fatalities during the decade from 1965-1974. This time period was associated with blocking and tackling techniques that involved the head as the initial point of contact. The reduction in brain and cervical spine injuries is shown in the decade from 1975-1984. This decade was associated with the 1976 rule change that eliminated the head as the initial contact point in blocking and tackling. There is no doubt that the 1976 rule change has made a difference and that a continued effort should be made to keep the head out of the fundamental skills of football. Data from the decade 1985-1994 continues to illustrate the reduction in brain and neck fatalities. A concern is that the data from 1995-2004 show an increase in brain fatalities over that of 1985-1994. There has been an increase of 11 brain deaths during the decade 1995-2004, which is an increase of 33% over 1985-1994. This time period also coincides with improved detection and medical care for concussion. Through nine years of this current decade from 2005-2013, 25 brain deaths have been recorded.

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

1. **Conditioning:** Athletes must be given proper conditioning exercises that will strengthen their necks in order to combat late game fatigue enabling players to hold their heads in proper position when tackling and to absorb impact energy to control head movement. Players should also have appropriate flexibility and range of motion of the shoulder and neck complex.
2. **Skills:** Coaches should drill the athletes in the proper execution of the fundamental skills, particularly blocking and tackling. Player should keep their head up while tackling and running with the ball. Contact should never with the top 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 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.

5. Brain Injury and Concussion:

a. Signs & Symptoms: When a player has experienced or shown signs of head trauma (loss of consciousness, visual disturbance, headache, inability to walk correctly, obvious disorientation, memory loss), he 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.

b. Reporting & Care: Some cases associated with brain trauma reported that players complained of headaches 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 above mentioned signs of brain trauma.

- c. Management & Return to Play: 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. A concern is raised when an athlete who has not recovered from a concussion is returned to play and receives another severe hit leading to 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/concussion/policies.html>.

For the most up to date information on concussion management please refer to the updated Consensus Statement on Concussion in Sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012 (McCrory et al. 2013).

Over the last decade, sport governing bodies have adopted new or modified playing rules for football to protect defenseless players, 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, (1982-2013). Available at:

<http://www.nfhs.org/SportsMed.aspx>

NCAA changes to minimize risk of injury (2009). Available at:

<http://fs.ncaa.org/Docs/NCAANewsArchive/2009/Association-wide/ncaa+changes+to+minimize+risk+of+injury+-+12-10-09+-+ncaa+news.html>

NFL timeline of rule changes related to health and safety, (2013). Available at:

<http://www.nflevolution.com/nfl-timeline/index.html>

Heat Stroke

A continuous effort should be made to eliminate heat stroke deaths associated with football. Since the beginning of the survey through 1959 there were five cases of heat stroke death reported. However, these events were not routinely monitored during this period. From 1960 through 2012 there have been 133 heat stroke cases that resulted in death (Table IV). In 2011 there were five cases of heat stroke death at the high school level and none in youth, professional or college football. In the last two years (2012-2013) there has been only one heat stroke fatality. This is a positive trend that could continue due the efforts at the state and national levels. Authors believe that heat stroke deaths are preventable with the proper precautions. Since 1995, 52 football players have died from heat stroke (41 high school, 8 college, 2 professional, and one sandlot). In the past ten years (2003-2012) there have been 31 heat stroke deaths as

compared with the previous ten years (1993-2002) when there were 21. Ninety percent of recorded heat stroke deaths occurred during practice. Every effort should be made to continuously educate coaches, players, and parents concerning the proper procedures and precautions when practicing or playing in the heat.

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://www.nata.org/sites/default/files/attr-44-03-332.pdf>). (Casa & Cisslan, 2009) 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 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.
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. Use of a sling psychrometer is recommended to measure the relative 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 frequently throughout a practice session. Athletes should drink water before, during, and after practice. 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 sweatsuits.
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: www.nfhs.org 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. Heat stroke victims, contrary to popular belief, may sweat profusely as athletes are exercising. If heat illness is suspected, seek a physician's immediate 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. 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, and 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.

RECOMMENDATIONS

Specific recommendations resulting from the 2013 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 Athletic Association. Most state associations require the use of their own medical examination form.
2. All personnel concerned 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 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 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 page 11 of report).
12. When a player has experienced or shown signs of head trauma (loss of consciousness, visual disturbance, headache, inability to walk correctly, obvious disorientation, memory loss), he 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 indirect heart related deaths has increased over the years and it is recommended that schools have an emergency action plan and automated external defibrillators (AED) available for emergency situations.
14. A more recent concern for indirect deaths in football players is sickle cell trait. Research has mentioned that up to 13 college football players have died after an on

field collapse due to complication of sickle cell trait. 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.

REFERENCES

- Boden, B.P., Breit, I., Bechler, J.A., Williams, A., & Mueller, F. O. (2013). Fatalities in High School and College Football Players. *Am J Sports Med*, 41(5):1108-16.
- Cantu, R.C. & Mueller, F.O. (2002). Brain Injury-Related Fatalities in American Football, 1945-1999. *Neurosurgery* 52:846-853.
- Casa, D., & Csillan, D. (2009). Preseason heat-acclimatization guidelines for secondary school athletics. *J Athl Train*, 44(3), 332-333. doi: 10.4085/1062-6050-44.3.332
- Casa, D., Guskiewicz, K., Anderson, S., Courson, R., Heck, J., Jimenez, C., et al. (2012). National athletic trainers' association position statement: preventing sudden death in sports. *J Athl Train*, 47(1), 96-118.
- Harmon, K.G., Asif, I.M., Klossner, D., & Drezner J.A. (2011). Incidence of Sudden Cardiac Death in National Collegiate Athletic Association, *Circulation*, 123(15):1594-600.
- Harmon, K.G., Drezner, J.A., Klossner, D., & Asif I.M. (2012). Sickle cell trait associated with a RR of death of 37 times in National Collegiate Athletic Association football athletes: a database with 2 million athlete-years as the denominator. *Br J Sports Med*, 46(5):325-30.
- Inter-Association Task Force on Sickle Cell Trait and the Athlete. (2007). *Consensus Statement: Sickle Cell Trait and the Athlete* (pp. 5). Dallas, TX: National Athletic Trainers' Association.
- Mueller, F.O. & Cantu, R.C. (2011). *Football Fatalities & Catastrophic Injuries, 1931-2008*. Carolina Academic Press. Durham, NC.
- Mueller, F.O. & Schindler, R.D. (1991). *Annual Survey of Football Injury Research: 1931-1990*. American Football Coaches Association, National Collegiate Athletics Association, & National Federation of State High School Associations. Waco, TX, Indianapolis, IN.
- Mueller, F.O. & Colgate, B. (2011). *Annual Survey of Football Injury Research: 1931-2010*. American Football Coaches Association, National Collegiate Athletics Association, & National Federation of State High School Associations. Waco, TX, Indianapolis, IN.
- Mueller, F.O. & Colgate, B. (2012). *Annual Survey of Football Injury Research: 1931-2011*. American Football Coaches Association, National Collegiate Athletics Association, & National Federation of State High School Associations. Waco, TX, Indianapolis, IN.
- Mueller, F.O. & Colgate, B. (2013). *Annual Survey of Football Injury Research: 1931-2012*. American Football Coaches Association, National Collegiate Athletics Association, & National Federation of State High School Associations. Waco, TX, Indianapolis, IN.

CASE SUMMARIES

All summaries compiled from publicly available media sources.

DIRECT FATALITIES

HIGH SCHOOL

A male 17 year old high school junior running back sustained a fractured cervical vertebrae during spring football team tackling drills. Reports indicate he was carrying the football and was tackled. He was unable to get up after the tackle. He was transported by ambulance to the hospital and was placed on life support shortly after. He was taken off life support four days later after being declared brain dead.

A male 16 year old high school junior (5'11, 164 pound) football corner back collapsed after making a "routine" tackle during a scrimmage (witnesses reported head was up). Coaches and adults responded and called emergency medical services (EMS) (took 15 minutes to arrive at city suburb school; EMS not present at scrimmages). Autopsy confirmed C3 cervical fracture.

A male 16 year old high school football player collapsed on sidelines after coming off the field from a JV scrimmage. He had a seizure and never regained consciousness. School's athletic trainer and coaches attended to the injured player prior to the arrival of paramedics. A CT scan showed trauma to the right side of the head and swelling and bleeding in the brain; surgery performed to reduce swelling and bleeding. Official cause of death is awaiting autopsy.

A male 16 year old high school junior football running back suffered a head injury during a helmet to helmet collision during third quarter of the game. He lost consciousness and collapsed on the field. [The game was called off.] He was transported to the hospital where he died 3 days later. Official cause of death is awaiting autopsy. Update: the team has cancelled their season.

A male 17 year old high school senior football wide receiver suffered a brain injury during the game. He walked off the field and collapsed on sidelines. He was taken from the field by ambulance midway through the fourth quarter. At the hospital he had brain surgery to remove a blood clot. He died ten days after the injury. Official cause of death is awaiting autopsy.

A male 15 year old high school sophomore football middle linebacker (5-foot-11, 215 pounds) collapsed during practice while going through team drills. He was transported by helicopter to the Medical Center, where he died later that day. It is reported that he recently had sustained a concussion during a game and was cleared to play for a subsequent game. After consultation with the player's parents, the player did not play in the game. He collapsed a few days after that during practice. No other details are available. Official cause of death is awaiting autopsy.

A male 17 year old high school junior football wide receiver was injured with 6 minutes left in a playoff game. He was taken to the hospital by ambulance with a brain injury. He died 16 days later from his injuries. Official cause of death is awaiting autopsy.

A male 17 year old high school senior football running back caught a pass and was tackled in what officials report was a typical tackle. On the way down, athletes head hit the ground hard.

Athlete got back up and played two more plays before collapsing on the field. He was conscious when the ambulance arrived but was declared critical en route to the hospital. He died two days later from traumatic brain injury.

SANDLOT

NONE IN 2013

COLLEGE

NONE IN 2013

PROFESSIONAL

NONE IN 2013

INDIRECT FATALITIES

HIGH SCHOOL

A male 17 year old high school senior football running back collapsed due to cardiac arrest during a summer weightlifting session at school. He was taken to the hospital and put on life support. He died two months later. He had cardiomyopathy.

A male 16 year old high school junior football defensive end (6 foot 1 inch 210 pounds) reported he couldn't catch his breath and collapsed after finishing practice at 12 PM (86 degrees with a heat index of 94). Hospital reported he died of cardiac arrest. Preparticipation physical examination (PPE) performed confirmed history of sickle cell trait. Official cause of death is awaiting autopsy.

A male 14 year old high school freshman football player (5 foot 9 inches) collapsed at practice after warm-up at 4 pm. Adult responders began cardiopulmonary resuscitation (CPR) and EMS was called. He died at the hospital. Medical history reported by the parent included mitral valve prolapse for which athlete was under doctor's care.

A male 15 year old high school sophomore football lineman (6 foot 2 inches 230 pounds) died at home while taking bath between the morning and evening football practices. EMS was called and he could not be resuscitated. Official cause of death is awaiting autopsy.

A male 17 year old high school junior football linebacker (6 foot 0 inches and 180 pounds) collapsed on track area after running laps during football practice. Coaches responded and CPR administered till EMS arrived. He was rushed to the hospital where he died of cardiac arrest. He had ventricular cardiomyopathy.

A male 17 year old high school senior football wide receiver (6 foot 1 inch 180 pounds) suffered a stroke after scoring on a 63-yard touchdown pass in a game. He got a drink of water on the sideline and was trying to sit on the bench when he became disoriented. He was treated by 2 athletic trainers and an MD. EMS was called and he was taken to the hospital where a blood clot was found during surgery. He died 1 day later. Official cause of death is awaiting autopsy.

A male 14 year old high school freshman football lineman collapsed during a pickup basketball game. CPR was administered and he was taken to the hospital. He died the next day. Official cause of death is awaiting autopsy.

A male 16 year old high school junior football running back collapsed and stopped breathing after running a touchdown in a JV game. EMS was called and arrived within 5 minutes. He was taken to the hospital and was transferred to another hospital to be examined by a brain injury specialist. He died 2 days after the incident. Official cause of death was determined to be cardiac failure or sudden cardiac event. Had been previously diagnosed with hypertrophic cardiomyopathy.

SANDLOT

NONE IN 2013

COLLEGE

NONE IN 2013

PROFESSIONAL

NONE IN 2013

MIDDLE SCHOOL (JR HIGH)

A male 13 year old middle school football player suffered anaphylactic shock after he was bitten by ants at half-time during a game (the field reportedly had several fire ant hills). He collapsed on field. Coaches administered CPR with an automatic external defibrillator (AED) till EMS arrived. He was taken to the hospital where he died four days later.

TABLE I: FATALITIES DIRECTLY DUE TO FOOTBALL – 1931-2013*

Year	Sandlot Direct	Pro & Semi-pro Direct	High School Direct	College Direct	Total Direct
**1931-1965	134	72	348	54	608
1966	4	0	20	0	24
1967	5	0	16	3	24
1968	4	1	26	5	36
1969	3	1	18	1	23
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	15	0	18
1977	1	0	8	1	10
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	0	9
1983	0	0	4	0	4
1984	1	0	4	1	6
1985	2	0	4	1	7
1986	0	0	11	1	12
1987	0	0	4	0	4
1988	0	0	7	0	7
1989	0	0	4	0	4

TABLE I (CONTINUED): FATALITIES DIRECTLY DUE TO FOOTBALL – 1931-2013*

Year	Pro &				Total Direct
	Sandlot Direct	Semi-pro Direct	High School Direct	College Direct	
1990	0	0	0	0	0
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
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	2	1	4
2012	0	2	0	0	2
2013	0	0	8	0	8
TOTALS:	180	80	686	89	1035
Percent	17.4%	7.7%	66.3%	8.6%	100%

*No study was made in 1942.

**Yearly totals available from past reports.

TABLE II: FATALITIES INDIRECTLY DUE TO FOOTBALL – 1931-2013*

Year	Sandlot Indirect	Pro & Semi-pro Indirect	High School Indirect	College Indirect	Total Indirect
**1931-1965	85	15	159	40	299
1966	0	0	6	2	8
1967	0	0	4	1	5
1968	2	0	8	2	12
1969	3	1	8	3	15
1970	0	0	12	2	14
1971	2	1	7	2	12
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	7	2	10
1977	0	0	6	0	6
1978	0	0	8	1	9
1979	1	0	8	1	10
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	0	0	4	3	7
1988	1	0	10	0	11
1989	0	0	9	2	11

TABLE II (CONTINUED): FATALITIES INDIRECTLY DUE TO FOOTBALL – 1931-2013*

Year	Sandlot Indirect	Pro & Semi-pro Indirect	High School Indirect	College Indirect	Total Indirect
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	1	0	7	1	9
1996	0	1	10	1	12
1997	1	0	7	0	8
1998	1	0	6	1	8
1999	1	0	11	0	12
2000	0	0	11	2	13
2001	0	2	10	3	15
2002	1	0	7	3	11
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	1	12
2012	0	0	9	4	13
2013***	0	0	9	0	9
TOTAL:	115	23	502	119	759
Percent	15.2%	3.0%	66.1%	15.7%	100%

*No study was made in 1942.

**Yearly totals available from past reports.

***One occurred at home, one occurred during pick-up basketball.

TABLE III: DIRECT FATALITIES INCIDENCE PER 100,000 PARTICIPANTS – 1931-2013*

Year	High School	College
1960	1.78	1.53
1961	1.62	9.23
1962	1.94	0.00
1963	1.94	3.04
1964	2.23	4.56
1965	2.00	1.33
1966	2.00	0.00
1967	1.60	4.00
1968	2.60	6.60
1969	1.64	1.33
1970	1.92	4.00
1971	1.25	4.00
1972	1.33	2.67
1973	0.58	0.00
1974	0.83	1.33
1975	1.08	1.33
1976	1.00	0.00
1977	0.53	1.33
1978	0.60	0.00
1979	0.23	1.33
1980	0.69	0.00
1981	0.38	2.67
1982	0.54	0.00
1983	0.30	0.00
1984	0.30	1.33
1985	0.30	1.33
1986	0.84	1.33
1987	0.30	0.00
1988	0.46	0.00
1989	0.27	0.00

TABLE III (CONTINUED): DIRECT FATALITIES INCIDENCE PER 100,000 PARTICIPANTS – 1931-2013*

Year	High School	College
1990	0.00	0.00
1991	0.20	0.00
1992	0.14	0.00
1993	0.20	1.33
1994	0.00	1.33
1995	0.27	0.00
1996	0.33	0.00
1997	0.40	1.33
1998	0.40	1.33
1999	0.27	1.33
2000	0.20	0.00
2001	0.46	0.00
2002	0.20	0.00
2003	0.13	0.00
2004	0.27	0.00
2005	0.13	0.00
2006	0.07	0.00
2007	0.20	0.00
2008	0.47	0.00
2009	0.13	0.00
2010	0.13	2.66
2011	0.18	1.33
2012	0.00	0.00
2013	0.73	0.00

*No study was made in 1942.

**Yearly totals available from past reports.

Rates based on 1,100,000 players grades 9-12, and 75,000 college players.

TABLE IV: HEAT STROKE FATALITIES 1931-2013*

Year	Total
**1931-1954	0
1955	1
1956-1958	0
1959	4
1960-1964	15
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	0
1986	0
1987	1
1988	2
1989	2
1990	1
1991	0
1992	1
1993	0
1994	0
1995	4
1996	2
1997	1
1998	4
1999	2

TABLE IV (CONTINUED): HEAT STROKE FATALITIES 1931-2013*

Year	Total
2000	5
2001	3
2002	0
2003	0
2004	3
2005	2
2006	5
2007	2
2008	5
2009	4
2010	4
2011	5
2012	1
2013	0
Total since 1995:	52
TOTAL:	138

*No study was made in 1942.

**In 2010 two were a combination of heat and sickle cell trait.

TABLE V: DIRECT FATALITIES 2013: TYPE OF ACTIVITY ENGAGED IN

Type of Activity	Pro &		High	College	Total (%)
	Sandlot	Semipro	School		
Tackled while carrying ball, struck head on ground	0	0	1	0	1 (12.5)
Helmet to helmet collision	0	0	1	0	1 (12.5)
Tackle drills	0	0	2	0	2 (25.0)
Making a tackle	0	0	1	0	1 (12.5)
Unknown	0	0	3	0	3 (37.5)
Type of Session					
Game - regular season	0	0	2	0	2 (25.0)
Game - playoff	0	0	2	0	2 (25.0)
Scrimmage	0	0	2	0	2 (25.0)
Practice	0	0	2	0	2 (25.0)
TOTAL (%)	0	0	8 (100)	0	8 (100)

TABLE VI: DIRECT FATALITIES 2013: SUSPECTED CAUSE OF DEATH

Causes	Pro &		High	College	Total (%)
	Sandlot	Semipro	School		
Head/brain	0	0	6	0	6 (75.0)
Neck	0	0	2	0	2 (25.0)
TOTAL (%)	0	0	8 (100)	0	8 (100)

TABLE VII: DIRECT FATALITIES 2013: POSITION PLAYED

Position	Pro &		High	College	Total (%)
	Sandlot	Semipro	School		
Running back	0	0	3	0	3 (37.5)
Wide receiver	0	0	1	0	1 (12.5)
Line backer	0	0	1	0	1 (12.5)
Defensive back	0	0	2	0	2 (25.0)
Unknown	0	0	1	0	1 (12.5)
TOTAL	0	0	8 (100)	0	8 (100)

TABLE VIII: INDIRECT FATALITIES 2013: SUSPECTED CAUSE OF DEATH

Causes	Pro &		High	Total	
	Sandlot	Semipro	School	College	(%)
Heart Related	0	0	7	0	7 (77.8)
Stroke	0	0	1	0	1 (11.1)
Anaphylactic shock	0	0	1	0	1 (11.1)
TOTAL	0	0	9 (100)	0	9 (100)

TABLE IX: INDIRECT FATALITIES 2013: TYPE OF SESSION OR ACTIVITY

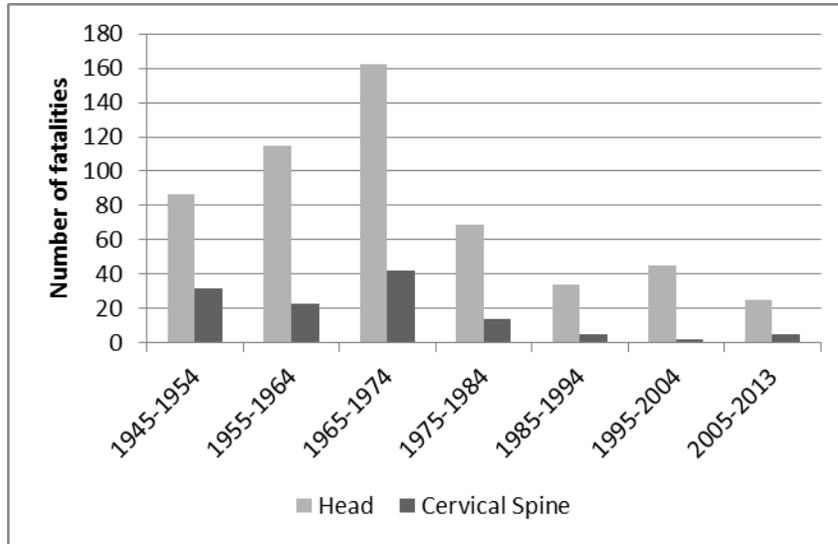
Type of Session	Pro &		High	College	Total (%)
	Sandlot	Semipro	School		
Game - regular season	0	0	3	0	3 (33.3)
Practice	0	0	4	0	4 (44.4)
Personal conditioning	0	0	1	0	1 (11.1)
At home	0	0	1	0	1 (11.1)
TOTAL (%)	0	0	9 (100)	0	9 (100)

TABLE X: HEAD AND CERVICAL SPINE FATALITIES BY DECADE, 1945-2013

Year	Head		Cervical Spine	
	Frequency	Percent	Frequency	Percent
1945-1954	87	16.2%	32	26.0%
1955-1964	115	21.4%	23	18.7%
1965-1974	162	30.2%	42	34.1%
1975-1984	69	12.8%	14	11.4%
1985-1994	34	6.3%	5	4.1%
1995-2004	45	8.4%	2	1.6%
2005-2013*	25	4.7%	5	4.1%
TOTALS	537	100.0%	123	100.0%

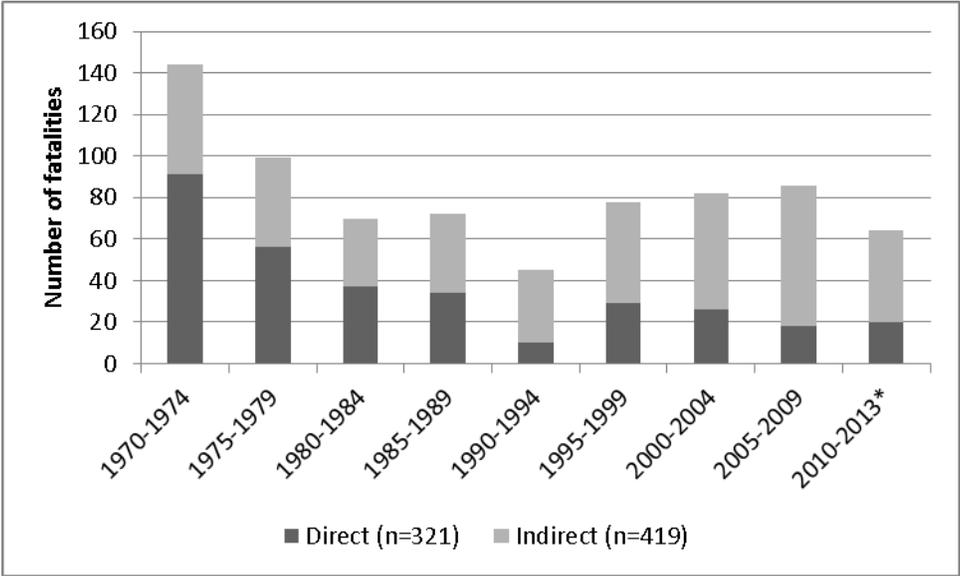
*Note: nine year period

FIGURE I: HEAD AND CERVICAL SPINE FATALITIES BY DECADE, 1945 to 2013*



*Note: nine year period for 2005-2013

FIGURE II: NUMBER OF DIRECT AND INDIRECT FATALITIES BY 5-YEAR PERIOD,
1970 to 2013



*Note: Four year period 2010-2013