

REVIEW

A retrospective view of concussion in American football, 1900–1959: What was suggested then we now know

Gary Solomon and Allen Kent Sills

Vanderbilt – Neurosurgery, Nashville, TN, USA

Abstract

While published work and media attention about football-related concussion in the USA have increased exponentially in the past few years, these injuries have in fact been written about for over a century. In this work, we undertook a selective review of the PubMed database of the published reports on concussion in football prior to 1960, with attention to the definitions used, physician attitudes, epidemiology, return to play criteria and recommendations and concerns related to long-term outcomes. Search inclusion criteria were English language, publication between the years 1900 and 1959 and studies written by healthcare professionals treating football-related injuries. Twenty-six studies met the inclusion criteria for this review, and the findings are grouped by topic area and detailed chronologically. Early sports medicine physicians struggled with many of the same issues faced today by clinicians such as honest reporting of symptoms by athletes, lack of uniform diagnosis and treatment and ambiguity over maximum 'safe' number of lifetime concussions.

Introduction

With the inaugural meeting of the Concussion in Sport Group in Vienna in 2001, sport-related concussion (SRC) entered the 21st century with a significant new medical focus leading to increased international public awareness [1]. The proclamation by the CDC in the USA in 2003 that concussion in sports had become an 'epidemic' fueled the American public to become more focused on SRC as a public health problem [2]. This focus on SRC in the USA has increased significantly over the past 20+ years, and has led to congressional hearings, the passage of sports concussion-related legislation for youth in all 50 states and the initiation of both class action and individual lawsuits at the high school, collegiate and professional levels [3]. National and international media reports related to concussion in sport have escalated, and the number of published scientific papers and books has proliferated.

The history of concussion in general is a lengthy and frequently controversial one. It has been reported that Rhazes was the first clinician to provide a medical description of concussion [4]. McCrory and Berkovic presented a comprehensive overview of the history of concussion and its conceptual and definitional evolutions over the centuries [5]. Seminal studies of clinical and experimental concussion were reported in the 1940s by Denny-Brown and Russell [6].

Conversely, the history of concussion in football is a much shorter one. The application of clinical neuropsychological testing in the assessment of SRC in collegiate football

Keywords

Concussion, head injury, football, sports

History

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players in the 1980s and 1990s brought SRC to the forefront [7,8]. The National Collegiate Athletic Association studies of concussion in football published in the early 21st century also added significantly to the interest in concussion in collegiate football [9,10]. At the professional level, the creation of the National Football League's Mild Traumatic Brain Injury Committee in the 1990s and the 16 studies produced by the Committee yielded hotly debated findings, but clearly contributed to the interest in and focus on SRC [11]. More recently, Harris published an interesting overview of what she termed the first concussion crisis in football, which dated back to the beginning of the 20th century [12].

It may seem that much of what we know about concussion in football has been a relatively recent phenomenon. However, as with most medical conditions there are numerous early reports about SRC made by medical providers. The goals of this paper are to review the early 20th century literature on SRC in American football, to discern what the early sports medicine physicians concluded about concussion and to contrast their clinical conclusions with the 21st century empirical knowledge base.

Method

A selective review of the MEDLINE PubMed database was performed. Inclusion criteria were English language, publication between the years 1900 and 1959 and studies written by

healthcare professionals treating football-related injuries. Keywords utilized in the search included football, sports, athletics, concussion, head injury and brain injury. Twenty-six studies met the inclusion criteria for the current review (See Table 1), and are grouped by topic area and detailed chronologically below.

Results

Attitudes toward concussion

In early reports, athletes were described as treating football concussions lightly. Nichols and Smith, in reviewing their medical care of the 1905 Harvard University football team, wrote: “Concussion was treated by the players in general as a trivial injury and rather regarded as a joke” [13]. Conversely, sports medicine physicians who wrote on the subject took concussion more seriously. In a 1906 editorial in *JAMA*, it was written “Perhaps the most serious feature of these accidents is the number of concussions of the brain reported” [14]. Landry cited Floyd Eastwood’s survey studies of accidents and deaths in football, which had been presented at the American Football Coaches’ Association meeting in 1933 [15]. According to Landry, one of Eastwood’s conclusions was that concussion was “the most dangerous of all injuries”. Thorndike lamented in 1938 that “The ignorance of the laity of the serious complications that may follow a simple concussion of the brain is to be deplored” [16]. Over 20 years later, Thorndike later wrote “Among other injuries that can be serious are those to the head. Unrecognized cerebral concussion in a player continuing to participate can result in great harm. . .when his mental processes are not operating on the alert, a second blow to the head may have really serious consequences” [17].

Epidemiology

From a research and methodological perspective, it is of interest to note that none of the studies reviewed actually defined concussion. We found three early studies of high school and six studies of collegiate concussions. As with more modern works, early authors suspected that players underreported symptoms. As an example, in 1906 Nichols and Smith, in their ‘List of injuries received while playing football prior to 1905’, reported a total of seven prior, pre-collegiate concussions among active players of the Harvard football team [13]. In a footnote to the table, the authors commented “Judging from this year’s experience and from conversations with the players, we believe that the figure under concussion is much too small”. Burnett and O’Brien, in their 1933 survey of concussion among Massachusetts high school athletes, commented that “Many of these are very difficult, even for a doctor familiar with them to diagnose—so many times boys are capable of fooling one” [18]. This trend of underreporting concussion may yet continue today (see Meehan and Bachur [19] for a review of studies related to underreporting).

Regarding the early prevalence of concussion at the high school level, Horan reported in 1934 that a total of eight concussions were incurred by boys playing football at the

Cranbrook School, Bloomfield Hills, Michigan, during the 1930–1932 seasons, with none occurring in 1933 [20]. Burnett reported in 1940 on football concussions in the Boston secondary schools across several time periods [21]. In the 1939–1940 season, there were three ‘major’ concussions (accounting for 12.5% of major injuries) and two ‘very slight’ concussions (accounting for 0.05% of minor injuries). For ‘Football injuries sustained by boys seen at the Boston City Hospital, 1939’, one of the 29 (3.4%) was due to concussion. The age of the athlete was not reported and it cannot be discerned whether this athlete participated in organized or sandlot football. Matthews, in his survey of 34 Massachusetts high school football programs during the 1949 season, reported 18 concussions among the 333 injuries (5%) [22].

The prevalence of concussion in collegiate football was first reported by Wilbur in 1906 [23]. In his review of 5 years’ experience treating members of the Stanford University football team, he reported a total of two concussions. One concussion involved brief loss of consciousness, and one involved a basilar skull fracture which resulted from “. . .two men coming together full tilt with heads down – one with head gear and the other without it”. Nichols and Richardson reported on concussions among the Harvard football team during the 1905–1908 seasons [24]. In 1905, there were 19 reported concussions. According to Nichols and Richardson, rule changes were implemented prior to the 1906 season eliminating ‘mass plays’, which were described as ‘uninteresting’ and said to be related to increased rate of injury. A typical mass play included 10 of 11 players on one team moving forward in the same direction simultaneously, trying to score, while the defensive players moved simultaneously in the same direction, trying to tackle the ball carrier. In the case of the ‘flying wedge’, one ball carrier would line up behind the other players (who formed a wedge) and would try to advance the ball by jumping over the wedge. The defense sent a man flying over their wedge in an attempt to tackle the ball carrier. Concussions for the 1906–1908 seasons subsequent to the rule change were reported as 5, 5 and 3. Cook reported one concussion during the 1924 football season at Yale [25]. Hobart, in his 1936 report of the injuries sustained at Northwestern University from 1930 to 1934, listed concussion as an ‘unusual’ injury, reporting that he had seen ‘several’ during the course of the five seasons [26]. He did believe that skull fracture should keep an athlete from returning to play for the season and typically for a year. Landry reported football injuries sustained by the Tulane squad in the 1934 season in a table, and no concussions were listed [15].

Thorndike reported 3923 injuries at Harvard during the 1932–1937 seasons [16]. One hundred six were ‘mild brain concussions’. This represents 2.7% of all injuries and averages 17.67 per season. Three of the concussed athletes underwent lumbar puncture and all were normal.

Gonzales, from the Office of the Chief Medical Examiner of New York City, reported on fatalities due to sports during the period 1918–1950 [27]. Of the 104 cases, nearly half were from baseball (43), which outnumbered deaths from football (22) or boxing (21) by a nearly 2–1 margin. Among the football players, infection accounted for 10 fatalities,

Table 1. Studies reviewed.

Atsatt R. The high school football team physician. <i>Calif Med.</i> 1957 [35]
Burnett J. Football: A review of injuries in Boston secondary schools. <i>N Engl J Med</i> 1940 [21]
Burnett J, O'Brien F. Survey of football injuries in the high schools of MA. <i>J Health Phys Ed.</i> 1931 [18]
Condon R. Athletic trauma and incidental disease. <i>N Engl J Med</i> 1955 [29]
Cook R. Medical and surgical supervision of competitive athletics. <i>Am Phys Ed Rev.</i> 1924 [25]
Daly J. Treatment of athletes. <i>Calif Med.</i> 1958 [31]
Editorial. Surgical aspects of football. <i>JAMA</i> 1906 [14]
Farnsworth D. Health in colleges. <i>N Engl J Med</i> 1953 [41]
Gonzales T. Fatal injuries in competitive sports. <i>JAMA</i> 1951 [27]
Harkness J. Physical fitness for sports. <i>Am J Surg.</i> 1959 [32]
Hobart M. Athletic injuries. <i>JAMA</i> 1936 [26]
Horan T. Analysis of football injuries. <i>JAMA</i> 1934 [20]
Landry L. Injuries peculiar to modern football. <i>Am J Surg.</i> 1935 [15]
Martland H. Punch drunk. <i>JAMA</i> 1928 [40]
Matthews, R. <i>A survey of football injuries occurring in MA high schools during 1949.</i> Thesis, Boston University School of Education, 1950 [22]
Nichols E, Richardson F. Football injuries of the Harvard squad for three years under the revised rules. <i>Boston Med Surg J.</i> 1909 [24]
Nichols E, Smith H. The physical aspect of American 594 football. <i>Boston Med Surg J.</i> 1906 [13]
Patton R. Football injuries in a "Big Ten" university. <i>Tort Med YB 2.</i> 1962 [36]
Rachun A, Kavanagh F. Protective football equipment. <i>Am J Surg.</i> 1959 [30]
Reid S, Swan V. Varsity football injuries. <i>Q Bull Northwest U Med Sch</i> 1952 [28]
Thorndike A. Trauma incident to sports and recreation. <i>N Engl J Med</i> 1938 [16]
Thorndike A. Serious recurrent injuries of athletes: contraindications to further competitive participation. <i>N Engl J Med</i> 1952 [39]
Thorndike A. Prevention of injury in athletics. <i>JAMA</i> 1956 [38]
Thorndike A. Frequency and nature of sports injuries. <i>Am J Surg.</i> 1959 [17]
Thurber P. Athletic injuries. <i>Cal West Med.</i> 1936 [17]
Wilbur R. Personal experiences with football injuries. <i>Cal State J Med.</i> 1906 [23]

while head injury accounted for 4 of the deaths. Two cases were acute subdural hemorrhages, one case was a delayed onset subdural, and the fourth was due to skull fracture with epidural hematoma 'when the player ran into a wall on one side of the playing field'.

Reid and Swan, in their analysis of the 120 injuries sustained among the 70 football players during the 1950–1951 Northwestern University season, reported four head injuries [28]. In 1955, Condon reported 10 concussions among Boston College varsity athletes over a 5-year period, which included football, hockey, baseball and basketball [29].

In 1959, Rachun and Kavanagh noted the increased probability of future concussions in previously concussed football players: "Then, too, it is well known that some athletes are more concussion-prone, usually a residuum of injuries to the head received in pre-college years" [30].

Assessment of concussion

Loss of consciousness and amnesia surrounding the concussive event were considered hallmark clinical signs and symptoms of concussive injury, and many early sports medicine clinicians utilized loss of consciousness as a primary indicator of concussion severity [31,32]. Of the five concussions incurred by the members of the 1907 Harvard football team, one was described as 'severe', and involved loss of consciousness. "This man still complains of difficulty in studying and concentrating his mind and of almost constant headaches" [24]. In 1934, Horan described the importance of noting clinically the 'dazed and bewildered state' along with retrograde amnesia as hallmark signs of concussion [20]. Two years later, Thurber suggested the use of the 'Rhomberg' and eye reflex assessment in evaluating concussion [33]. Thurber presaged Maddocks' Questions [34] in his description of

on-field assessment of the concussed athlete when he recommended "...asking questions pertinent to the particular athletic endeavor in which they were engaged at the time of the injury". Thorndike focused on the symptomatic assessment of disorientation to time and place, dizziness, amnesia and headache [16]. In 1957, Atsatt recommended x-rays for an athlete who received a concussion and 'lied perfectly still' [35].

At the other end of the spectrum, hospitalization for concussion was considered necessary by several sports medicine physicians. Nichols and Richardson referred all concussed football players for hospitalization "to avoid the possibility of delayed middle meningeal artery hemorrhage or a recurrence of excitement or delirium" [24]. These athletes were treated with 'a milk diet and a saline cathartic', and were typically discharged within 1–3 days. Condon reported that all 10 cases of concussion were hospitalized and underwent neurosurgical consultation and electroencephalography [29]. Patton recommended hospitalization for any athlete with 'prolonged unconsciousness or prolonged sequel or with any physical sign' [36]. Of note, an early report [37] alludes to a case of a football athlete who sustained a subdural hematoma without skull fracture during a scrimmage and after a 'free interval' (now referred to as the 'lucid phase') was treated surgically and successfully by Dr. Harvey Cushing, the father of neurosurgery.

Rest after a concussion & return to play

In 1938, Thorndike wrote "I believe that in any case exhibiting residual symptoms of amnesia, headache, dizziness or a lack of orientation as to time and place, the patient must not resume athletic competition or exercise until recovery is complete" [16]. Twenty years later, Daly wrote about his 10 years' experience caring for high school and collegiate athletes.

"It is a good policy, I believe, to forbid body contact scrimmage for at least a week to any athlete who has had a short period of unconsciousness from a blow on the head" [31]. Daly also felt that "Persistent headache often results from participation too soon after mild concussion".

Regarding return to play after a concussion, in 1956 Thorndike wrote "The permitting of a player with cerebral concussion to continue play should not be tolerated" [38]. Two years later, Daly foreshadowed today's recommendations for no activity until the patient is asymptomatic with his policy: "The period of restriction from strenuous activity and body contact should be determined by the severity of the initial blow and subsequent examination of the patient. It is difficult to lay down hard and fast rules governing the return to unrestricted participation following brain trauma, but it is well to keep decisions on the cautious side" [31]. A less conservative view was espoused by Atsatt [35]. In discussing his 25 years of experience at Santa Barbara High School, Atsatt recommended that an athlete receiving a blow to the head without loss of consciousness should be 'watched but not necessarily taken out'. Atsatt recommended that an athlete rendered 'semiconscious' only and who was revived with 'aromatic spirits of ammonia' should have 'cold towels placed on his head'. If, after 15 minutes the athlete passed a brief cognitive examination ('his mother's maiden name or some such question'), then he should be allowed to return to play.

Permanent disqualification due to concussion

The notion of three concussions leading to disqualification may have its origin in Thorndike's 1952 paper when he wrote "Patients with cerebral concussion that has recurred more than 3 times or with more than momentary loss of consciousness at any one time should not be exposed to further body-contact trauma" [39]. Thorndike referenced Martland's seminal work on punch-drunk boxers [40], and insisted on neurological/neurosurgical evaluation in such cases.

In 1953, Farnsworth echoed Thorndike's recommendation when he wrote "No student should return to body-contact sports who has had...three cerebral concussions of moderate degree" [41].

Condor, in his 5-year summary of accidental trauma and incidental disease at Boston College from 1950 to 1955, reported that 11 varsity athletes were disqualified from participation during the study period [29]. One athlete was a football player who sustained two concussions in a season and had a history of a concussion in high school, thus triggering the three concussion rule for disqualification.

Patton, in a review of injuries sustained at Ohio State University from 1947 to 1957, reported that 8 of the 20 players disqualified due to injuries had experienced 'repeated minor head trauma' [36]. Although clinical examination was normal in all eight athletes, "...it was simply observed that they were more sensitive than normal to the usual head trauma in football". There was no report of specific the number of concussions sustained by these athletes.

In 1959, Harkness wrote that "There is a rule of thumb among athletic physicians that three concussions should

negate contact sports. This seems dogmatic" [32]. He suggested that the focus be on the length of loss of consciousness in each concussion as a determinant of disqualification.

The possibility of long-term adverse effects from concussive injury

The question of potential adverse, long-term effects from repeated SRC was posed over a century ago. In an editorial in *JAMA* in 1906, titled "Surgical aspects of football", it was written "At the present time no one is ready to say whether concussion of the brain may or may not have serious consequences in after life" [14]. Twenty years later, in a paper read before the 52nd meeting of the American Neurological Association, non-sports neurologists Osnato and Giliberti stated: "Anatomic and clinical investigations seem to show definitely that our conception of concussion of the brain must be modified. It is no longer possible to say that 'concussion is an essentially transient state which does not comprise any evidence of structural cerebral injury'. Not only is there actual cerebral injury in cases of concussion but in a few instances complete resolution does not occur, and there is a strong likelihood that secondary degenerative changes develop" [42].

Discussion

The 26 studies reviewed revealed that sports medicine physicians have been concerned about concussion in football at least since the beginning of the 20th century. Players underreported concussion then and likely continue to do so. The sparse epidemiological data available indicated an approximate rate of 2.6 concussions annually among the two individual high schools (Michigan and Boston) from the 1930s, 0.53 concussions among 34 Massachusetts high schools in 1949 and an approximate rate of one concussion annually among the five colleges (Boston, Stanford, Northwestern, Tulane, Yale). Harvard was clearly a statistical outlier with a reported annual rate of up to 17.67 concussions. We suspect that Thorndike, the Harvard team physician, was more sensitive to and aware of concussion, as he published more papers on the subject than any author in the time period reviewed. We also note that no study of concussion in professional football was reported pre-1960.

It is quite clear that concussions in football are diagnosed much more frequently now at the high school [43] and collegiate [44] levels than in the time period reviewed for this paper. This is likely due (at least) to definitional factors, as no definition of concussion was presented in any of the early studies reviewed, which likely led to variable diagnoses by physicians. Also, the underreporting and/or unawareness of symptoms by athletes were probably contributing factors.

Regarding the clinical evaluation of concussion, it was clear from the studies reviewed that no consensus diagnostic evaluation or treatment protocol for concussion was utilized, but loss of consciousness and amnesia were considered central clinical features. However, the 1906 editorial in *JAMA* is quite noteworthy, as it is the earliest report that loss of consciousness was not a prerequisite for a diagnosis of

concussion in football. This fact was said to be ‘well recognized’ by 1959. The notion that a football player sustaining a concussion was more likely to sustain further concussions was noted in the 1950s. It appears that many of the early sports medicine physicians employed careful clinical observation of the concussed athlete while others hospitalized athletes (routinely or selectively) and obtained neurosurgical consultation.

It would appear that significant progress has been made in the clinical evaluation and treatment of concussion, as standardized assessment strategies (e.g., SCAT3) and treatment protocols are available [45]. Also, it is clear that advances in modern football helmet design and construction materials have had a positive impact on reducing the number of football-related skull fractures and hematomas, although these injuries still occur, though infrequently today [46].

Withholding concussed football players from competition and allowing for complete symptom resolution before clearance for return to play was first recommended in 1938. This maxim is now a clinical rule across all levels of football, and is state law at the high school level in the USA. Atsatt’s (1958) recommendation of a potential clearance for return to play after a 15 min period of observation and Daly’s 1959 mention of a week’s rest post-concussion were the first evidence found of: a specific recommended sideline period for clinical observation and possible clearance for return to play, and a prescribed period of rest post-concussion [1,45].

The possibility exists that these recommendations were the basis for the early return to play guidelines of the late 20th century [47–49]. The concept of exertion leading to provocation of symptoms in the acute post-concussive phase was first noted for cognitive functions and headaches in 1909. The probability of incurring additional concussions after the index event had been sustained was first noted in 1959. Thorndike may have been describing what was to be later conceptualized by some as malignant brain edema [50] or Second Impact Syndrome [51] as early as 1959.

The ‘3 concussions rule’ leading to disqualification appears to have been proclaimed by Thorndike in 1952. This clinical maxim may have been the basis for inclusion in the late 20th century return to play criteria mentioned previously [47–49]. This notion may yet remain embedded in clinical lore to this date. The current international guidelines for concussion have not incorporated this rule (or any particular number of concussions as a condition of disqualification) specifically [46].

The concern about potential long-term effects from concussion in football was first noted in 1906. This remains a contentious topic, and is likely to be answered with any degree of certainty only with well-controlled, prospective, longitudinal studies. Despite numerous case and cohort reports [52–54], the relationship between SRC and dementia remains unproven [46].

Our study is not without limitations. First, it is possible that we failed to use sufficiently comprehensive search criteria or keywords and have subsequently missed relevant studies. Second, only one author reviewed the studies to ensure that the inclusion criteria were met; it would have been ideal methodologically to have a second author cross-check the

findings. Third, our own biases cannot be ignored and may have played a role in the studies selected and data/quotes emphasized.

Conclusion

In summary, our review indicates that many of the guidelines published in the latest iteration of the Concussion in Sport Group’s consensus statement and guidelines [46] were first noted clinically in the first half of the 20th century. Many of these guidelines now have gained empirical support with retrospective, prospective and cross-sectional studies of concussed athletes. Although significant progress has been made, much remains to be done. It is our hope that progress in the diagnosis, treatment and management of concussion in football (and other sports) will grow exponentially in the near future.

Declaration of interest

Dr. Solomon receives consulting fees from the Nashville Predators and the Tennessee Titans. G Solomon is on the advisory board for ImpACT. The authors have no other relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript apart from those disclosed.

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