Concussion Incidences and Severity in Secondary School Varsity Football Players

SUSAN GOODWIN GERBERICH, PhD, RN, JAMES D. PRIEST, MD, JAMES R. BOEN, PhD, CONRAD P. STRAUB, PhD, and ROBERT E. MAXWELL, MD

Abstract: The head coaches and players of 103 secondary school football teams in Minnesota were asked to respond to mail questionnaires. Information about injury incidence and concomitant health care provision was elicited. Responses from 3,063 players (81 per cent) yielded a total injury rate of 78 injuries/100 players; 19/100 players reported a concussion experience characterized by loss of consciousness and/or loss of awareness. Of the players who experienced a loss of consciousness, 69 per cent were returned to play the same day. Persistent concussion symptoms were reported as long as six to nine months following the end of the season; six cases involved permanent disabilities. Continued use of illegal techniques of butt-blocking and face-tackling by as many as 40 per cent of the players was associated with apparent increased risks of concussions and concussion symptoms. Players with a prior history of loss of consciousness had a risk of loss of consciousness four times that of the player without a prior history. (Am J Public Health 1983; 73:1370–1375.)

Introduction

Between 1970 and 1980, an average of 12 directly-related* high school football fatalities per year was reported in the United States, accounting for a rate of one fatality per 100,000 participants.1 Most of these fatalities resulted from trauma to the head or neck with head trauma being the most frequent.1-2 Reported non-fatality injuries have varied widely depending upon the methodologies and definitions utilized in past studies; published rates range from 20 to 81 injuries per 100 players in any one season.3-7

In 1976, a pilot study17 of 300 football players in five Minnesota high school teams yielded an injury rate of 72 injuries per 100 players; one or more injuries was experienced by 48 per cent of the players. Concussions accounted for 21 per cent of the reported injuries. While earlier studies1-3,18,19 contained statistics relevant to concussion incidence, the data are not comparable since the methodologies and/or case inclusions varied.

The need for identification, careful assessment, and management of individuals with concussions or suspected concussions8-10 has been addressed by several authorities; in particular, the mild concussion, involving no loss of consciousness, is exceedingly common; yet, it is brought to medical attention infrequently.21 Individuals with a suspected mild concuss must not be permitted to resume contact or regular activity until they can move with usual dexterity and speed and are perfectly oriented as to the time, place, and their own identity22 and are able to identify the activities in which they were engaged just prior to the injury incident.23 Because of the potential for progressive neurological debilitation,22-27 continued observation of these cases for persistent and/or changing symptoms is essential. Individuals who experience a definite loss of consciousness must be removed from activity and not permitted to re-enter.22,28-30 In cases involving a loss of consciousness for less than five minutes, hospital admission for observation is recommended;21,32 immediate hospitalization and neurosurgical consultation is indicated in severe cases where there is an initial loss of consciousness for five minutes or more.22

In this paper, a portion of the comprehensive epidemiological study conducted among Minnesota high school football teams,33 is presented relevant to concussion incidence and severity.

Materials and Methods

Following the end of the 1977 Fall football season, a retrospective study of 103 Minnesota secondary school teams was begun. A stratified random sample was drawn from the 499 schools offering interscholastic football.** From the selected schools, a total of 3,802 varsity football players comprised the sample. Based on data from the pilot study,17 the sample size was chosen to provide 95 per cent confidence intervals.

Following initial communication with the participants about the purpose of the study, separately designed comprehensive questionnaires were distributed to individual participants by mail through the schools' athletic directors. Supporting letters from the Minnesota State High School League, responsible for coordination of secondary school interscholastic activities, were included in this mailing. Information relevant to injuries and illnesses incurred as a result of participation during the 1977 season was requested from individual players; brain concussion data represented a portion of the total data collection. In the initial portion of the player questionnaire, participants were asked, "Did you have any injuries or illnesses as a result of your participation in the Fall 1977 football season which prevented you from

*Detailed data available on request to author.

**These techniques both involve driving a blow, with the head as a primary point of contact, into the opponent, and since 1976 have commanded a 15-yard penalty when called by an official.42,43
participating in any regular activity, practice, or game following the day of injury or illness? Include, also, any dental injuries, concussions, or heat stroke, regardless of time lost.' This constituted the basic injury definition. If players responded yes to this question, they were instructed to complete all of the questions incorporated into a grid format under the relevant body parts injured. Across the top of the grid, 11 body parts, including the head, were identified. A total of 19 questions, at the left side of the grid, requested information about the nature of and follow-up of the injury; diagnoses including concussion and the individual diagnosing the injury (e.g., physician) were included in these variables.

Players who reported they did not experience an injury were referred directly to the second portion of the questionnaire, completed by all players. In this second portion, data collection included equipment worn, use of illegal techniques, and education in prevention received. In addition, questions, more specific to concussion incidence as a result of their participation, were posed to the players. These included: "Did you lose consciousness following a blow to the head?" "Did you have any of the following symptoms/problems after a blow to the head, even though you may not have been unconscious...? 1) a brief loss of awareness (for example, not knowing the time, not knowing the place, not remembering what play you had just made, or perhaps not remembering what you were assigned to do on the field); 2) dizziness; 3) headaches; 4) blurred vision; 5) double vision; 6) other (specify)?"

For purposes of analyses, a concussion included those concussion diagnoses designated by physicians and/or a loss of consciousness or a loss of awareness following a blow to the head. This definition was based on the definition established by the Committee on Head Injury Nomenclature of the Congress of Neurological Surgeons and elaborated upon by Maroon.22,34 Severity of concussion related to the type and length of symptoms following a blow to the head: with a mild concussion there is no loss of consciousness, but there is a loss of awareness—short-term memory loss that can occur as long as 10 to 15 minutes following a blow or loss of intermediate21,22,34 and old memories24; a moderate concussion21,22,34 involves a loss of consciousness with recovery occurring in less than five minutes; severe concussions25,34 involve a loss of consciousness for five minutes or more. Retrograde amnesia and varying combinations of symptoms, including headache, auditory, visual or olfactory hallucinations,37 a sensation of "being dinged,"38 and poor coordination of body movements are also often associated with a concussion episode.***

In accordance with the guidelines of the University Committee on the Use of Human Subjects in Research, informed consent was provided to the participants; parents were required to read the player questionnaire and cover letters and sign the consent form. Return, first class envelopes were enclosed for each participant to maintain confidentiality of individual replies. Follow-up, incorporating four questionnaire mailings, was utilized to minimize non-respondents to this question. They were instructed to concuss as defined above were followed up with a more comprehensive questionnaire. Four mailings were incorporated in the follow-up of 112 cases with loss of consciousness, two mailings in the remaining cases. Telephone follow-up of the six permanent-loss cases plus a 15 per cent sampling of the 1,356 cases reporting concussions and/or concussion symptoms was also utilized to verify and clarify information.

Validation of physician diagnoses was conducted on all players reporting severe injuries plus two randomly selected players from each school team who identified injuries diagnosed by physicians. This sample accounted for 23 per cent of the total physician diagnosis (930). A follow-up form identifying the injury and diagnoses, as reported by the player, was sent to the player requesting the name of the physician involved in the case; this required signed permission from the parent to contact the physician. Subsequently, these forms and a form requesting the diagnosis and details surrounding the treatment and rehabilitation of the injury were sent to the physician. These data were then compared with the data collected from the players.

Computer analyses were conducted on the total sample and according to the three school strata (Rural-Suburban-Urban; Public-Private; and Football Class). Independent variables relative to the game, the player, the environment, and overall health care were analyzed with respect to injuries/illnesses utilizing a variety of statistical techniques. Players experiencing injuries or illnesses were compared with those not experiencing injuries or illnesses under similar conditions.39-41 In all statistical tests, the significance level of 0.05 was used.

Results

Responses from 3,063 players (81 per cent) were received and used in the final analyses. The total injury rate was 78 injuries/100 players, representing multiple injuries incurred throughout the football season by 51 per cent of the players. For the individual team classifications, the total injury rates ranged from 64 to 94 injuries/100 players.

Concussion Incidence

In addition to the 74 concussion diagnoses reported in conjunction with a head injury, an additional 507 players reported loss of consciousness and/or loss of awareness. This resulted in a rate of 19/100 players with at least one possible concussion per player (Figure 1); at least 24 per cent of all injuries were concussions.†

Unless the player had been told he had a "concussion", he did not associate the symptoms of loss of awareness/ transient amnesia, or loss of consciousness with the word concussion. For example, following a loss of consciousness: "The athletic director took me out of the game to see if I had a concussion but I did not."

Four hundred thirty-nine players (14 per cent of all respondents) had experienced at least one previous episode of unconsciousness. Two and three episodes were reported by 3 and 1 per cent of the players, respectively. Of the 112 players reporting a loss of consciousness during 1977, 40 per cent had experienced previous loss of consciousness; the risk of experiencing a loss of consciousness during 1977, for a player with at least one prior

***Garrick, James G., MD, personal communication, July 20, 1982.

†In the postcard follow-up study of fourth mailing non-respondents with a 57 per cent response, the rates of loss of awareness and loss of consciousness were within 2 per cent of the original respondents.
experience, was over four times as great as for the player with no such prior experience.

In addition to questions about loss of consciousness and loss of awareness, following a blow to the head, players were asked about other symptoms experienced during the season following a blow to the head. Single, as well as multiple incidents, of dizziness, headaches, blurred vision, and double vision, were reported by the players (Figure 1). More severe symptoms of blurred vision and/or double vision were noted by 14 and 3 per cent of the players, respectively. Other unsolicited symptoms reported by 3.4 per cent of the respondents included descriptions of déjà-vu phenomena and of visual and auditory hallucinations, indicative of temporal lobe involvement.

Follow-up of Concussion Reports

Of the 112 players who originally reported a loss of consciousness, 90 per cent responded to follow-up; 60 per cent of the 403 players who experienced a loss of awareness and 40–45 per cent of players who experienced other concussion symptoms responded.

In the follow-up study of players who experienced concussions and concussion symptoms, the players were asked to identify those people who examined them for their symptoms. Of players rendered unconscious, 41 per cent reported they were examined by coaches, 33 per cent by physicians, and 18 per cent by athletic trainers; of those who experienced a loss of awareness, 58 per cent were not examined at all (Table 1). Five players reported being unconscious six minutes or more, two of them from one to 24 hours. The reported duration of concussion symptoms experienced are given in Table 2.

Players who reported persistent head trauma symptoms in the follow-up study six to nine months following the end of the football season were asked to indicate its severity on a scale from one to six (Table 3). Three noted great discomfort that interfered with some regular activity some of the time. Permanent disabling conditions, consequent to head trauma, were reported by six players; these confirmed disabilities included episodic seizure activity, blurred vision, double vision, hearing loss, and vertigo.

On the first questionnaire, 77 of the 112 players who reported a loss of consciousness and 393 of the 485 players who reported a loss of awareness were returned to play the same day. In response to the question posed in the follow-up study, "Who made the decision to send you back to play?", 60 per cent stated self, 29 per cent coach, 5 per cent athletic trainer, 3 per cent physician, and 2 per cent a parent. A repeated theme reported by several players with potentially serious symptoms was the fact that they wanted to play so they did not tell anyone about the symptoms. Beyond this, there was concern for the ridicule that would follow if they did tell anyone. Among the three strata of school teams, return rates varied from a high of 89 per cent to a low of 59 per cent, suggesting that "ridicule" operated differentially among schools.

While no statistically significant differences in loss of

![Concussive Experience](image)

**FIGURE 1**—Incidence of Selected Concussion Symptoms and Total Apparent Concussions in Minnesota Secondary School Varsity Football Players, 1977

---

**TABLE 1**—Percentage Distribution of Individuals Who Examined Minnesota Secondary School Varsity Football Players with Apparent Concussions, 1977

<table>
<thead>
<tr>
<th>Individuals Who Examined Players</th>
<th>Loss of Consciousness (N:101)*</th>
<th>Loss of Awareness* (N:242)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coach</td>
<td>41</td>
<td>20</td>
</tr>
<tr>
<td>Physician</td>
<td>33</td>
<td>12</td>
</tr>
<tr>
<td>Athletic Trainer</td>
<td>18</td>
<td>6</td>
</tr>
<tr>
<td>Teammate(s)</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Parent(s)</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Chiropractor</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Nurse</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>No one</td>
<td>—</td>
<td>58</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

*Respondents to follow-up study

†††Physician diagnoses were consistent with diagnoses reported by players in a minimum of 95 per cent of the cases included in the validation study of all injuries; all severe injuries including permanent disabilities were validated.
Concussion, according to the position played, were noted for defensive team players, among the offensive players 8 per cent of running backs versus 3 per cent or less among other positions reported loss of consciousness.

Linebackers reported a significantly greater loss of awareness than the linemen or secondaries. Of the offensive players, quarterbacks (24 per cent), running backs (22 per cent) and wide receivers (21 per cent) reported the highest incidence of loss of awareness, while tight ends (8 per cent) reported the lowest incidence.

The activities in which these players were engaged at the time of loss of consciousness involved primarily tackling (43 per cent), being tackled (23 per cent), blocking (20 per cent), and being blocked (10 per cent). A similar distribution of activities was reported for loss of awareness.* Time at risk by position and activity is not known, however.

Illegal techniques were reported as associated with 23 per cent of all injuries. Players were asked specifically about the use of butt-blocking during offensive play and face-blocking** during defensive play throughout the season. Butt-blocking was reported as practiced by 33 per cent of the players and 43 per cent reported the use of face-blocking. Of the players using these techniques, 43 per cent were not advised by a coach against the use of the butt-block and 54 per cent were not advised against the use of the face-tackle.

The relative risks of loss of consciousness for players who reported using the butt-blocking and face-tackling techniques were 1.6 and 1.4, respectively. These risks were 1.9 and 1.7, respectively for those who reported loss of awareness. Relative-risks for concussion symptoms of dizziness, headaches, blurred vision, double vision, and temporal lobe symptoms ranged from 1.5 to 1.9 with the use of butt-blocking and face-tackling.* These risks are based on a maximum of one symptom or concussion episode per player even though many players experienced multiple episodes.

Virtually all players reported the type of helmet (internal design) they wore during the season: suspension-type (14 per cent), a padded-type (55 per cent), and a combination padded and suspension-type of helmet (31 per cent). Differences according to the type of helmet were unrelated to players experiencing loss of consciousness or loss of awareness.

Discussion and Conclusion

The rate of 19 players with at least one possible concussion/100 players, and the fact that probable concussions accounted for 24 per cent of all injuries are conservative figures. Only one concussion experience was counted for any one player, and it is known that multiple episodes were experienced by some players. A finding of this many concussion episodes, together with the way they were handled, suggests problems of defining and understanding concussion and differences in diagnosis and diagnostic criteria by medical personnel or other individuals presumably trained in injury assessment. The hesitancy of the player to reveal physical symptoms that might result in restriction of his activity further complicates identification. While retrospective data collection by questionnaires has limitations, the methodology utilized in this study is believed to have facilitated reporting since confidentiality of responses from the players (and parents) was maintained.

Additional study is required to further document this problem. Our findings point up the need for observation and examination of participants in sports that involve head contact; unless the individual is questioned specifically about symptoms experienced and evaluated for recent memory integrity, it is believed that the true incidence and severity of concussions will go undetected. Schneider37 reported that symptoms may not be volunteered and must be elicited aggressively by the examiner. Garrick*** has confirmed the discovery of such cases inadvertently at the end of the season through history-taking, and emphasized the need for ongoing assessment. Yarnell and Lynch38 have also underscored the subtleties in detecting individuals with concussions that do not initially involve a loss of consciousness.

While the increased risk of players with prior concussion may reflect a difference in the activity levels or differences in reporting between the injured and non-injured players.

*Permanent Disabilities Subsequent to Head Trauma = 6.

**These strata, incorporating 30 possible categories, are: Rural-Suburban-Urban: Public-Private; and Football Class AA, A, B, C, and Nine-Man.

***Any concussion was considered a significant injury.
TABLE 3—Degree of Persistent Activity Limitation among Minnesota Secondary School Varsity Football Players Who Reported Concussion Symptoms*

<table>
<thead>
<tr>
<th>Degree of Persistent Activity Limitation</th>
<th>Loss of Awareness</th>
<th>Dizziness</th>
<th>Headaches</th>
<th>Blurred Vision</th>
<th>Double Vision</th>
<th>Other—Temporal Lobe Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Causes mild discomfort (or is bothersome) Some of the Time</td>
<td>7</td>
<td>16</td>
<td>24</td>
<td>6</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2. Causes mild discomfort (or is bothersome) All of the Time</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>3. Causes moderate discomfort and interferes with some regular activities Some of the Time</td>
<td>1</td>
<td>4</td>
<td>10</td>
<td>2</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>4. Causes moderate discomfort and interferes with some regular activities All of the Time</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>5. Causes great discomfort and interferes with some regular activity Some of the time</td>
<td>—</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>6. Causes great discomfort and interferes with some regular activity All of the time</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>1</td>
</tr>
</tbody>
</table>

*The number of cases reflects the cases from Table 2 with identified persistent symptoms which almost exclusively involved the greater (moderate or great discomfort) degrees of persistent activity limitation. In addition, it includes cases from Table 2 with initial shorter durations of symptoms that recurred and involved persistent discomfort and interference with activity some of the time.

players, it also implies a need for careful pre-season history-taking and physical assessment with attention devoted to the identification of previous concussions. There were six confirmed permanent disabilities incurred as a result of head trauma. An average of two cases, with severity ranging from extensive brain dysfunction and/or quadriplegia or death, as a result of head/neck trauma in high school football, had been reported yearly in Minnesota since 1971; the findings of permanent disabilities from the present study extrapolate to an expected number of 29 cases per year in the total Minnesota secondary school varsity football programs, or a rate of one case per 688 players.† While the injuries reported through the study may not be as disabling as those officially reported, these cases involve permanent loss of function.

In addition to the permanent disabilities, the finding of players who reported concussion symptoms which lasted more than one week and involved varying levels of discomfort and interference with activity are a cause for concern. Furthermore, some of these players (including the six players with permanent disabilities) were still experiencing symptoms six to nine months following the end of the season.

The percentages of players who reported that they were returned to play the same day following a loss of consciousness were nearly identical to those of the pilot study. Players who decided, on their own, to return to play appeared to be motivated by a strong desire to play and fear of ridicule, as well as ignorance of the risk of return to play. Better understanding of risks, by both players and coaches, is clearly in order.

Continued widespread use of the butt-block and face-tackle was first reported in the pilot study and further confirmed in the present study. Researchers have repeatedly warned of the consequences of the use of these techniques which have been associated with very serious and fatal injuries.

REFERENCES

44. Schneider RC, Redf E, Croister HO, Oosterbaan BG: Serious and fatal football injuries involving head and spinal cord. JAMA 1961; 177:262–267.

ACKNOWLEDGMENTS

The authors thank the following individuals for their contributions to this study: Susan P. Baker, MPH, Associate Professor, Department of Health Services Administration, Johns Hopkins University, School of Public Health, Baltimore, Maryland; Marvin Helling, Associate Executive Director, Minnesota State High School League, Anoka; Jack S. Mandel, PhD, Associate Professor and Assistant Director, Division of Epidemiology, School of Public Health, University of Minnesota, Minneapolis; John Pearson, BA, Computer Programming Consultant, Health Sciences Computer Center, University of Minnesota, Minneapolis; Richard C. Siebert, MD, Neurosurgeon, Minneapolis Neurological Surgeons, Ltd.

Financial support of this study was provided by: Automated Building Components, Inc., Excelsior, Minnesota; County Seat Stores, Brooklyn Park, Minnesota; Fairview Community Hospitals, Minneapolis, Minnesota; Fairview Hospital—Institute for Athletic Medicine, Minneapolis; General Mills Foundation, Minneapolis; Group Health Plan, Inc., St. Paul; Minnesota State Health Planning and Development Agency, St. Paul; Minnesota State High School League, Anoka; Naegle Outdoor Advertising Company of the Twin Cities, Inc., Minneapolis; Orthopaedic Consultants, P.A., Minneapolis; Mendon F. Schutt Foundation, Minneapolis; University of Minnesota Computer Center, Minneapolis; University of Minnesota Health Sciences Computer Center, Minneapolis.

Portions of this paper were presented before the American Orthopaedic Society for Sports Medicine, Forty-Eighth Annual Meeting, Las Vegas, Nevada, February 26–March 3, 1981.

NIH Symposium on Reducing Risks of Laboratory Infections

The Division of Safety, National Institutes of Health, announces the 1983 NIH Research Safety Symposium to be held on December 1–2 at the Twin Bridges Marriott Hotel in Arlington, Va. The topic of this seventh symposium is “Reducing the Risk of Infection in Biomedical Laboratories.” These annual symposia provide researchers and safety professionals with a forum to exchange state-of-the-art information on safety issues in biomedical research.

The 1983 symposium will review approaches and methods for conducting risk assessments of work activities involving infectious agents and will also address safeguards for control of hazards associated with this work. The Centers for Disease Control/National Institutes of Health publication, Biosafety in Microbiological and Biomedical Laboratories, will serve as the resource document for this symposium.

For information, contact:
1983 NIH Research Safety Symposium
8630 Fenton Street, Suite 508
Silver Spring, MD 20910
(301) 585-7400

AJPH December 1983, Vol. 73, No. 12