Concussions Among University Football and Soccer Players

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Abstract

Objective: A study to examine the incidence and characteristics of concussions amongst Canadian university athletes during one full year of football and soccer participation

Design: Retrospective survey

Participants: 380 Canadian university football and 240 Canadian university soccer players reporting to 1999 fall training camp. Of these, 328 football and 201 soccer players returned a completed questionnaire.

Main Outcome Measures: Based on self-reported symptoms, calculations were made to determine the number of concussions experienced during the previous full year of football or soccer participation, the duration of symptoms, the time for return to play and any associated risk factors for concussions.

Results: Of all the athletes who returned completed questionnaires, 70.4% of the football players and 62.7% of the soccer players had experienced symptoms of a concussion during the previous year. Only 23.4% of the concussed football players and 19.8% of the concussed soccer players realized they had suffered a concussion. More than one concussion was experienced by 84.6% of the concussed football players and 81.7% of the concussed soccer players. When examining symptom duration, 27.6% of all concussed football players and 18.8% of all concussed soccer players experienced symptoms for at least one day or longer. Tight ends and defensive lineman were the positions most commonly affected in football, while goalies were the players most commonly affected in soccer. Variables which increased the odds of suffering a concussion during the previous year for football players included a history of a traumatic loss of consciousness or a recognized concussion in the past. Variables which increased the odds of suffering a concussion during the previous year for soccer players included a past history of a recognized concussion while playing soccer and being female.

Conclusion: University football and soccer players seem to be experiencing a significant amount of concussions while participating in their respective sports. Variables which seem to increase the odds of suffering a concussion during the previous year for football and soccer players include a history of a recognized concussion. Despite being relatively common, many players may not recognize the symptoms of a concussion.

Introduction

Football has historically been considered a high risk sport for concussion [1-4]. Although equipment and rule changes have occurred over the years in an attempt to make the game safer for its participants, football is still believed to be responsible for the majority of sports related concussions today [5-9]. Soccer, on the other hand, has historically not been considered to be a high risk sport for concussion [5, 7, 10-12]. Recently, however, there has been a growing awareness of the dangers of head injuries in soccer. Recent research has documented the significant risk of concussions while playing soccer [13] [14]. Studies have documented abnormalities on CAT scans and Magnetic Resonance Imaging (MRI) of the brains of soccer players [15] [16] [17] [18]. Neuropsychologic testing has shown deficits in attention, concentration, memory and judgement in soccer players as compared to controls [18] [19]. Electroencephalograph (EEG) tracings of the brain have shown abnormalities in more soccer players as compared to non-soccer players [20]. The American Academy of Pediatrics now defines soccer to be a "contact/collision" sport, in the same category as football and hockey [21].

In 1998, a pilot study examining concussions amongst 44 Canadian university football and 52 Canadian university soccer players was conducted using athletes from McGill University in Montreal, Canada [22]. This pilot study was undertaken to compare the incidence, recognition and variables that increased the odds of sustaining a concussion during one fall season of participation for these athletes. The results of this study have been published previously [22]. The results revealed that a significant proportion of both football and soccer players had suffered symptoms of a concussion after being hit in the head during participation in their respective sports. Variables that increased the odds of suffering a concussion for both groups of players included a past history of a recognized concussion.

Changes from the Pilot Study

The present study was much larger, as it was conducted using universities from across Canada with the help and approval of the Canadian Interuniversity Athletic Union (CIAU). A few changes were made to the pilot questionnaire in an effort to expand the amount of information obtained pertaining to concussions.

Canadian university athletes not only play Canadian football or soccer during the fall university season, but also during many other months of the year. Spring and summer football camps, where full contact in pads occur, are now more prevalent than in the past. As well, the majority of Canadian university soccer players participate in winter indoor and summer outdoor leagues [22]. As such, the questionnaire was amended to include any symptoms which occurred in the last 12 months after being hit in the head during participation in their respective sport, i.e. not just those that occurred during the fall season. Players were also asked about mouthguard use, including the type worn and frequency of use.

Methods

CIAU universities with both Canadian football and soccer teams were approached to participate in the study. In the CIAU, soccer teams usually dress 15-20 players per game, and each team fields 11 players, so there are 22 players on the field in total at any one time. For both the men's and women's soccer teams, the 1998 fall outdoor season consisted of 4 preseason games, 10 regular season games and up to 5 playoff games, for a total of 19 possible games.

In the CIAU, football teams usually dress 35-40 players per game, and in Canadian football rules, each team fields 12 players, so there are 24 players on the field at any given time. For each team, the 1998 season consisted of 8 regular season games and up to 4 playoff games, for a total of 12 possible games.

Prior to the 1999 fall season, all players reporting to soccer and football tryouts/training camp were asked to complete a questionnaire based on their personal history, sports history and symptoms pertaining to the 1998 sports year. The questionnaires were anonymous, voluntary and as stated above, were almost identical to the questionnaires used in the pilot study a year earlier, save a few changes. These questionnaires were also very similar to those answered by the players in the Canadian Football League (CFL) who had recently taken part in a similar study [23].

The questionnaire inquired about general background information as well as past football or soccer history. Data was collected pertaining to the number of years each player had participated in organized tackle football or soccer, and the different positions played. Information was obtained about

past recognized concussions and losses of consciousness, and whether these had occurred during participation in football or soccer, or whether they had occurred during other activities. The players were then questioned more specifically about the 1998 football or soccer year, including different positions and the number of games played during the fall university season. Although players were asked to include symptoms which may have occurred at any point in the previous 12 months, the number of games the player played in the fall university season was felt to be a good indicator of the possible exposures to concussions over that period of time. It is believed, at least for football, that most concussions occur during game situations [24]. Players were then asked,“ Last year, after being hit in the head playing soccer/football, did you ever suffer a concussion?”. If players answered yes, they were asked to:

a) List the number of times they had a concussion during the year.

b) List the longest duration they experienced symptoms from a concussion during the year.

c) List the longest duration they were unable to play soccer/football (had to “sit out”) because of the concussion.

d) Indicate who usually decided they were unable to play soccer/football because of the concussion (ex. trainer, team doctor, decided yourself, etc.).

It should be noted that the soccer players were instructed that “*After being hit in the head playing soccer”* refers to any contact with your head; either from another player, the ground, the goal posts, or the ball itself (includes heading). This was done to avoid confusion and assure that any symptoms that occurred after heading would be included.

The players were then asked a series of questions pertaining to the commonly recognized symptoms of a concussion. They were asked if, after being hit in the head playing soccer/football during the 1998 year, they had been knocked unconscious; felt confused or disoriented (got “dinged” or had your “bell rung”); experienced headaches; dizziness; memory difficulties; blurred or abnormal vision; felt nauseous or vomited; or experienced any other symptoms which affected their ability to play

soccer/football (ex. hearing problems, inability to tolerate bright lights). If players answered yes to one of the above questions, they were asked to:

a) List the number of times they experienced this symptom after being hit during the year.

b) List the number of times they experienced a concussion when having this symptom after being hit during the year.

c) List the longest duration they experienced this symptom after being hit during the year.

d) List the longest duration they were unable to play soccer/football because of this symptom during the year.

The soccer players were also asked a series of questions pertaining to heading the ball. They were asked if they considered themselves someone who heads the ball frequently (a "header"), how often on average they head the ball per game, and which types of soccer did they play in the last 12 months (fall outdoor, winter indoor, summer outdoor, summer indoor).

In 1997, the American Orthopedic Society for Sports Medicine Concussion Workshop Group defined a concussion as any alteration in cerebral function caused by a direct or indirect (rotation) force transmitted to the head resulting in one or more of the following acute signs or symptoms: a brief loss of consciousness, light-headedness, vertigo, cognitive and memory dysfunction, tinnitus, blurred vision, difficulty concentrating, amnesia, headache, nausea, vomiting, photophobia or a balance disturbance. Delayed signs and symptoms may also include sleep irregularities, fatigue, personality changes, an inability to perform usual daily activities, depression or lethargy [25]. This definition has provided a more practical definition than some suggested previously, and has been used as a basis for even more comprehensive definitions which have been proposed more recently [26] [27]. Similarly, for the purposes of our study, a concussion was considered to have occurred if an athlete reported a loss of consciousness (LOC), confusion or disorientation, or any of the other most commonly recognized concussion symptoms (headaches, dizziness, memory difficulties, blurred or abnormal vision, nausea, hearing problems or light sensitivity) after being hit in the head playing soccer or football[6] [28]. The

number of concussions was conservatively estimated to be the maximum number of times any one sign or symptom was experienced and not the cumulative number of all signs and symptoms experienced.

Descriptive analyses were created for all study variables using means, standard deviations, medians, ranges and percentages where appropriate. Two by two tables correlating concussions with various potential predictors were created to investigate these relationships. Logistic regression models were constructed to examine the multivariate relationships between potential predictors of concussions and a wide variety of risk factors. These risk factors included the athlete's age, the number of games played during the 1998 fall season, the total number of years playing soccer/football, past concussions in soccer/football, past concussions outside of soccer/football, past losses of consciousness in soccer/football, past losses of consciousness outside of soccer/football, mouthguard use, alcohol intake and other sports played by the athlete. In all cases, final models were selected using the Bayesian Information Criterion (BIC) [29]. The BIC improves over the conventional backwards or forwards model selection techniques in that the model need not be nested, and the final model is selected independent of the order in which they are estimated.

Some of the questionnaires did not list a primary position (4 football and 7 soccer questionnaires). The rest of the data from these questionnaires was entered and used in the study. The study was approved by the CIAU and the Ethics Review Board of the McGill University School of Medicine.

Results

There were 380 questionnaires sent out to football teams and 240 questionnaires sent out to soccer teams participating in the 1999 CIAU fall season. The response rate was 86% for football and 84% for soccer, as a total of 328 questionnaires were returned from the football teams, while 201 (82 males, 110 females and 9 undetermined) were returned from the soccer teams. There were 203 football players and 121 soccer players who had played in the CIAU in 1998. The other 125 responding football players and 80 responding soccer players had played in a league other than the CIAU in 1998.

The average player profiles are listed in Table 1. The average football player had over 2 years of university football experience and had been playing organized tackle football for over 7 years. The

average soccer player also had over 2 years of university soccer experience. On average, the soccer players had started playing organized soccer at a younger age than the football players and thus had been playing organized soccer for longer (over 14 years). The breakdown of primary positions played are listed in Table 2. While many players played several positions, they were asked to pick only one primary position. Any other positions they may have played were considered secondary positions.

While 12.4% (25/201) of all soccer players recognized they had experienced at least one concussion during the 1998 year, 62.7% (126/201) of all players reported signs or symptoms of at least one concussion. In other words, of the 126 soccer players who actually experienced a concussion, only 19.8% (25/126) of these realized the symptoms they had experienced represented a concussion. Of all football players, 16.5% (54/328) recognized they had experienced at least one concussion during the 1998 year, but 70.4% (231/328) of all football players, however, reported signs or symptoms of at least one concussion. Of the 231 football players who experienced a concussion, only 23.4% (54/231) of these players realized the symptoms they had experienced represented a concussion. For those athletes who did experience at least one concussion, the conservative estimates for the number of concussions (the maximum number of any one symptom *only*, not all symptoms combined) are listed in Table 3.

When examining factors which increased the odds for a concussion during the 1998 year, a number of variables were examined (see Table 4). Soccer players were found to have over 3 times greater chance of suffering a concussion during the 1998 year if they had sustained a previous recognized concussion while playing soccer ($p<0.05$). Female soccer players were more than 2.5 times as likely to suffer a concussion during the 1998 year as male soccer players ($p<0.05$). Football players who had suffered a previous recognized concussion outside of football were over 3 times as likely to suffer a concussion, while those with a past recognized concussion occurring during football were almost twice as likely to sustain a concussion ($p<0.05$). The percentage of players from each position who suffered at least one concussion during the 1998 year are listed in Table 5.

Duration of symptoms for the concussion episodes are listed in Table 6. It refers to the length of time that the longest symptom persisted. The duration of symptoms can be used to grade the concussion and as a guide for return to play [1, 6, 12] [23] [30] [31] [32] [33]. The data also reveals that 27.6% of

football players who sustained a concussion had their longest symptoms last one day or longer. This compares with 18.8% of all soccer players who sustained a concussion and had symptoms persist for at least one day.

The individual symptoms experienced by athletes who sustained a concussion in either football or soccer are listed in Table 7. Headache was the most common symptom for both sports followed by confusion/disorientation.

Discussion

Utilizing self-reported symptoms of concussions, the study revealed that 70.4% of all football players had experienced at least one concussion during the 1998 year as compared to 62.7% of all soccer players. Of these concussed players, only 23.4% of the football players realized that the symptoms they had suffered represented a concussion, as compared to 19.8% of the soccer players. The fact that an athlete does not realize he or she has suffered a concussion makes it unlikely that the athlete sought medical attention. Thus, the chances these players would continue to play while still symptomatic are probably greater than those players who had recognized they had suffered a concussion. Although there are many different guidelines for return to play after a concussion, most, if not all, agree that no player should return to play the same day if that player has had a loss of consciousness or is still experiencing symptoms from a concussion [8] [26] [30] [34] [35] [36] [37] [38]. In fact, in our study, there were 9 episodes of loss of consciousness after being hit in the head which were not recognized as a concussion in football players and 5 episodes in soccer players.

The percentage of each group that suffered symptoms of a concussion after being hit in the head during sports participation was greater for this larger study as compared to our pilot study. When comparing an entire year of participation in their respective sports to only the fall season (pilot study), the percentage of concussed players involved in each sport increased dramatically. Football climbed from 34.1% of players suffering symptoms of a concussion after being hit in the head playing football during the fall season, to 70.4% of all players when they were asked to include the entire year. Soccer climbed from 46.2% of players suffering symptoms of a concussion after being hit in the head playing

soccer during the fall season, to 62.7% of all players when they were asked to include the entire year. Obviously players are at risk for concussions during the entire year and not only during the fall university season. Whether it be football players participating in spring camps and summer municipal leagues, or soccer players playing winter indoor and summer outdoor soccer, these young athletes are likely sustaining concussions 12 months of the year. This becomes an important point that must be addressed at preseason medicals, especially when one considers that most return to play guidelines for concussions base their decisions on not only the severity of the concussion in question, but also on the number and severity of previous concussions [8] [30] [34] [35] [36] [37] [38].

Similar to previous studies headache and confusion/disorientation ("dinged") were the two most common symptoms for each group[6] [23] [28]. Dizziness was the third most common symptom in each group.

When examining the positions most likely to suffer a concussion during the 1998 year, the results reveal that tight ends and defensive lineman were most likely to be affected in football, while similar to the pilot study, goalies were the most likely in soccer. In our pilot study, quarterbacks and running backs were the position most at risk for concussion in football. This difference may be due to the fact that there were no tight ends responding in the pilot study, and there were many more quarterbacks responding (n=21) in this larger study as compared to the pilot study. This means that it is likely there were a greater number and percentage of backup quarterbacks responding in the larger study. These backups would not have played as often as the starter in game situations and thus would be at less risk for concussion, at least during the fall university season.

Similar to previous studies, players with a past history of a recognized concussion were at increased odds of suffering a concussion [22] [23] [31]. Football players who suffered a loss of consciousness after being hit in the head playing football were more likely to suffer a concussion during the 1998 season (OR=2.44, $p<0.05$). This independent variable was also found to be significant in a similar study on professional football players [23]. As in the pilot study, no correlation was found between concussions and soccer players who considered themselves to be a "header" (head the ball frequently in games). There was also no relationship between the average number of headings per game

and concussions. These findings are in keeping with previous work which has shown that heading the ball is unlikely to be a significant mechanism for concussions in soccer [14] [39].

For soccer players, being female was associated with 2.6 times greater odds of having suffered a concussion during the 1998 season (p,0.05). Why this might have been the case cannot be ascertained by this study. Besides occurring randomly, possible reasons include different techniques, styles of play and anatomy. The average male university soccer player would likely have a stronger neck and torso area as compared to the average female university soccer player. A strong neck and torso may help dissipate forces transmitted to the head by transmitting the energy down across the neck and upper torso, as compared to the forces being absorbed solely by the skull and brain [20] [26] [27, 39] [40] [41].

The use of mouthguards in football players was not found to be protective or associated with a decreased odds for a concussion. In fact, although not statistically significant, there was a trend towards increased odds of suffering a concussion for those football players who reported wearing a mouthguard (OR= 2.46, p=0.373). While any association which is not statistically significant should not be relied upon as definitive evidence, the trend was contrary to what many people believe to be true, i.e. mouthguards provide protection against concussions [42] [43] [44] [45]. Although this study was designed to only examine associations and not determine causality, possible explanations for the trend seen in mouthguard users may have included chance, players with a past history of concussion being more likely to wear mouthguards, players playing at high-risk positions for concussions being more likely to wear mouthguards, and those players wearing mouthguards somehow being more susceptible to concussions. As stated in the Table 4, only 4 soccer players reported wearing a mouthguard and thus odds ratios were not calculated.

Unexpectedly, playing basketball was associated with increased odds of suffering a concussion during the 1998 season for both football and soccer players. This study cannot determine why that occurred. Possible explanations may have include chance, players who also played basketball may have been more likely to have sustained a recognized concussion in the past, or players who also played basketball may have been more likely to play high-risk positions for concussions in football or soccer.

Among football players, 70.4% of those responding experienced a concussion during the 1998 year. Of these concussed players, 84.7% had more than one episode, 27.2 experienced more than 5 episodes and one athlete responded that he had been "dinged" 99 times during football participation in 1998 year. For the soccer players responding, 62.7% experienced a concussion during the 1998 year. Of these concussed players, 81.7% experienced more than one episode and 11.9% experienced more than five episodes. The number of players who experienced more than one concussion is important to note because multiple concussions may result in longer and more severe episodes of functional disability[11] [19]. Repeated concussions may also result in progressive and cumulative neurologic and neuropsychologic impairment [20] [32] [46].

As in our previous studies, this study used what, in the past, may have been considered a liberal definition of inclusion in that a concussion was considered to have occurred if an athlete reported a loss of consciousness, confusion or disorientation, or any of the other most commonly accepted symptoms of a concussion (headaches, dizziness, memory difficulties, blurred or abnormal vision, nausea, hearing problems or light sensitivity) after being hit in the head playing football or soccer. Although the players were asked to include only those common concussion symptoms that occurred immediately after being hit in the head, it is possible that the inclusion criterion over estimated the number and severity of concussions. In particular, the symptom of headaches may be difficult to attribute solely to concussions, especially since recent research has shown that around 20% of athletes who play football in high school and college may experience headaches during games [47]. If a more limited definition of a concussion was used to include only those players who experienced a loss of consciousness or confusion, 39.0% (128/328) of the football players and 36.3% (73/201) of the soccer players would still be considered to have experienced a concussion.

The study is retrospective in nature, and thus not ideal because athletes can forget symptoms and are often less accurate with respect to duration and frequency of symptoms. It does however allow an athlete the opportunity to reveal symptoms that may not have been identified prospectively. This may occur if the athlete is unaware that his or her symptoms are secondary to a concussion, or if the athlete is

afraid to mention his or her symptoms to a trainer or physician, for fear of being prevented from returning to play [31] [33] [48] [49].

The questionnaires were answered anonymously. While this makes it impossible to confirm or gather further data from a player, it was decided that players would be less inhibited in answering an anonymous questionnaire. In a similar study done on professional football players, athletes remarked on their reluctance to answer truthfully about concussions for fear it would jeopardize their chances of making or remaining with a team [23]. The anonymity allowed them to answer truthfully without fear of negative repercussions.

The study does not account for possible confounding variables such as the different equipment worn by individual players. The use of different football helmets, the proper inflation of these helmets or the wearing of soft cervical football collars ("cowboy collars") was not addressed in the questionnaire.

Conclusion

University football and soccer players seem to be experiencing a significant number of concussions while participating in their respective sports. Variables which seem to increase the odds of suffering a concussion during the previous year for football and soccer players include a history of a recognized concussion. Despite being relatively common, many players may not recognize the symptoms of a concussion.

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References

1. Cantu, R.C., *When to return to contact sports after cerebral concussion.* Sports Med Digest, 1988. **10**: p. 1-2.

2. Cantu, R.C., *Head injuries in sport.* Br J Sports Med, 1996. **30**(4): p. 289-96.

3. Mueller, F.O., *Fatalities from head and cervical spine injuries occurring in tackle football: 50 years' experience.* Clin Sports Med, 1998. **17**(1): p. 169-82.

4. Collins, M.W., et al., *Relationship between concussion and neuropsychological performance in college football players.* Jama, 1999. **282**(10): p. 964-70.

5. Cantu, R.C., *Athletic head injuries.* Clin Sports Med, 1997. **16**(3): p. 531-42.

6. Guskiewicz, K.M., et al., *Epidemiology of concussion in collegiate and high school football players.* Am J Sports Med, 2000. **28**(5): p. 643-50.

7. Powell, J.W. and K.D. Barber-Foss, *Traumatic brain injury in high school athletes.* Jama, 1999. **282**(10): p. 958-63.

8. Torg, J.S., *Epidemiology, pathomechanics, and prevention of athletic injuries to the cervical spine.* Med Sci Sports Exerc, 1985. **17**(3): p. 295-303.

9. Torg, J.S., et al., *The National Football Head and Neck Injury Registry. 14-year report on cervical quadriplegia, 1971 through 1984.* Jama, 1985. **254**(24): p. 3439-43.

10. Cantu, R.C., *Diagnosis and management of concussion.*, in *American College of Sports Medicine's Essentials of Sports Medicine*, R.E. Sallis and F. Massimino, Editors. 1997, Mosby: St. Louis. p. 345-347.

11. Lindsay, K.W., G. McLatchie, and B. Jennett, *Serious head injury in sport.* Br Med J, 1980. **281**(6243): p. 789-91.

12. Schmidt-Olsen, S., et al., *Injuries among young soccer players.* Am J Sports Med, 1991. **19**(3): p. 273-5.

13. Barnes, B.C., et al., *Concussion history in elite male and female soccer players.* Am J Sports Med, 1998. **26**(3): p. 433-8.

14. Boden, B.P., D.T. Kirkendall, and W.E. Garrett, Jr., *Concussion incidence in elite college soccer players.* Am J Sports Med, 1998. **26**(2): p. 238-41.

15. Autti, T., et al., *Brain lesions in players of contact sports.* Lancet, 1997. **349**(9059): p. 1144.

16. Jordan, S.E., et al., *Acute and chronic brain injury in United States National Team soccer players.* Am J Sports Med, 1996. **24**(2): p. 205-10.

17. Matser, J.T., et al., *Chronic traumatic brain injury in professional soccer players.* Neurology, 1998. **51**(3): p. 791-6.

18. Tysvaer, A.T. and E.A. Lochen, *Soccer injuries to the brain. A neuropsychologic study of former soccer players.* Am J Sports Med, 1991. **19**(1): p. 56-60.

19. Matser, E.J., et al., *Neuropsychological impairment in amateur soccer players.* Jama, 1999. **282**(10): p. 971-3.

20. Tysvaer, A.T. and O.V. Storli, *Soccer injuries to the brain. A neurologic and electroencephalographic study of active football players.* Am J Sports Med, 1989. **17**(4): p. 573-8.

21. Pediatrics, T.A.A.o., *A policy statement.* The Physician and Sportsmedicine, 1988. **16**: p. 165-169.

22. Delaney, J.S., et al., *Concussions among university football and soccer players: a pilot study.* Clin J Sport Med, 2001. **11**(4): p. 234-40.

23. Delaney, J.S., et al., *Concussions during the 1997 Canadian Football League season.* Clin J Sport Med, 2000. **10**(1): p. 9-14.

24. McCrea, M., et al., *Standardized assessment of concussion in football players.* Neurology, 1997. **48**(3): p. 586-8.

25. Wojtys, E.M., et al., *Current concepts. Concussion in sports.* Am J Sports Med, 1999. **27**(5): p. 676-87.

26. Aubry, M., et al., *Summary and agreement statement of the 1st international symposium on concussion in sport, Vienna 2001.* Clin J Sport Med, 2002. **12**(1): p. 6-11.

27. Johnston, K.M., et al., *Evidence-Based review of sport-related concussion: clinical science.* Clin J Sport Med, 2001. **11**(3): p. 150-9.

28. Maddocks, D.L., G.D. Dicker, and M.M. Saling, *The assessment of orientation following concussion in athletes.* Clin J Sport Med, 1995. **5**(1): p. 32-5.

29. Kass, R.E. and A.E. Raftery, *Bayes factors.* J Amer Statistical Assoc, 1995. **90**: p. 773-795.

30. Leclerc, S., et al., *Recommendations for grading of concussion in athletes.* Sports Med, 2001. **31**(8): p. 629-36.

31. Gerberich, S.G., et al., *Concussion incidences and severity in secondary school varsity football players.* Am J Public Health, 1983. **73**(12): p. 1370-5.

32. Warren, W.L., Jr. and J.E. Bailes, *On the field evaluation of athletic neck injury.* Clin Sports Med, 1998. **17**(1): p. 99-110.

33. Yarnell, P.R. and S. Lynch, *The 'ding': amnestic states in football trauma.* Neurology, 1973. **23**(2): p. 196-7.

34. Cantu, R.C., *Guidelines for return to contact sports after a cerebral concussion.* The Physician and Sportsmedicine, 1986. **14**: p. 75-83.

35. Cantu, R.C., *Return to play guidelines after a head injury.* Clin Sports Med, 1998. **17**(1): p. 45-60.

36. Ommaya, A.K. and T.A. Gennarelli, *Cerebral concussion and traumatic unconsciousness. Correlation of experimental and clinical observations of blunt head injuries.* Brain, 1974. **97**(4): p. 633-54.

37. Roberts, W., *Who plays? Who sits? Managing concussion on the sidelines.* The Physician and Sportsmedicine, 1992. **20**(6): p. 66-72.

38. Wilberger, J.E., Jr. and J.C. Maroon, *Head injuries in athletes.* Clin Sports Med, 1989. **8**(1): p. 1-9.

39. Kirkendall, D.T., S.E. Jordan, and W.E. Garrett, *Heading and head injuries in soccer.* Sports Med, 2001. **31**(5): p. 369-86.

40. Tysvaer, A.T., *Head and neck injuries in soccer. Impact of minor trauma.* Sports Med, 1992. **14**(3): p. 200-13.

41. McCrory, P., et al., *Evidence-based review of sport-related concussion: basic science.* Clin J Sport Med, 2001. **11**(3): p. 160-5.

42. Barth, J.T., J.R. Freeman, and J.E. Winters, *Management of sports-related concussions.* Dent Clin North Am, 2000. **44**(1): p. 67-83.

43. Labella, C.R., B.W. Smith, and A. Sigurdsson, *Effect of mouthguards on dental injuries and concussions in college basketball.* Med Sci Sports Exerc, 2002. **34**(1): p. 41-4.

44. McCrory, P., *Do mouthguards prevent concussion?* Br J Sports Med, 2001. **35**(2): p. 81-2.

45. Maroosis, G., *Back to basics: making a vacuum-formed, custom-fitted intraoral mouthguard using the "dry model" technique.* J Can Dent Assoc, 1999. **65**(2): p. 90-1.

46. Kelly, J.P. and J.H. Rosenberg, *Diagnosis and management of concussion in sports.* Neurology, 1997. **48**(3): p. 575-80.

47. Sallis, R.E. and K. Jones, *Prevalence of headaches in football players.* Med Sci Sports Exerc, 2000. **32**(11): p. 1820-4.

48. Grindel, S.H., M.R. Lovell, and M.W. Collins, *The assessment of sport-related concussion: the evidence behind neuropsychological testing and management.* Clin J Sport Med, 2001. **11**(3): p. 134-43.

49. Schneider, R.C., *Head and neck injuries in football.* 1973, Baltimore: Williams and Wilken.

Tables

Table 1- Average player profile

Football

Age at time of the survey	21.1 ± 2.1
Age started organized tackle football	13.6 ± 2.7
Years played organized tackle football	7.6 ± 2.9
Years played university football	2.5 ± 1.4
Games played in the 1998 CIAU fall football season	7.7 ± 3.0
Average number of recognized concussions from football	0.2 ± 0.6

Soccer

Age at time of the survey	20.9 ±2.0
Age started organized soccer	7.3 ± 3.0
Years played organized soccer	14.2 ± 3.9
Years played university soccer	2.4 ± 1.3
Games played in the 1998 CIAU fall soccer season	13.4 ± 5.5
Average number of recognized concussions from soccer	0.4 ± 1.9
Played Soccer Fall Outdoor	98.2%
Played Soccer Winter Indoor	99.4%
Played Soccer Summer Outdoor	99.5%
Played Soccer Summer Indoor	76.9%

Table 2- Primary position played by responding athletes

Football

Position	Percentage of total responders
Offensive lineman	16.9% (55/324)
Cornerback/safety	15.7% (51/324)
Defensive lineman	14.5% (47/324)
Linebacker	13.6% (44/324)
Wide receiver/slot back	13.6% (44/324)
Running back	0.8% (35/324)
Quarterback	6.5% (21/324)
Special teams player	4.6% (15/324)
Punter/kicker	1.9% (6/324)
Tight end	1.9% (6/324)

* 4 questionnaires had no answer for position

Soccer

Position	Percentage of total responders
Midfield	36.6% (71/194)
Defence	29.4% (57/194)
Forward	24.2% (47/194)
Goalie	9.8% (19/194)

* 7 questionnaires had no answer for position

Table 3- Number of concussions per concussed players

Football

Number of concussions	Percentage of all concussed players
1	15.3% (35 /228)
2	23.6% (54/228)
3	17.1% (39/228)
4	11.0% (25/228)
5	5.7% (13/228)
6-10	17.1% (39/228)
>10*	10.1% (23/228)

*One player (ID=264) reported having been ”dinged” 99 times

Soccer

Number of concussions	Percentage of all concussed players
1	18.3% (23/126)
2	27.0% (34/126)
3	18.3% (23/126)
4	9.5% (12/126)
5	15.1% (19/126)
6-10	9.5% (12/126)
>10	2.4% (3/126)

Table 4- Odds Ratios for concussions during the 1998 season

Football

Variable	Odds Ratio	p Value
Previous recognized concussion not during football	3.09	p=0.002 [b]
Previous LOC [a] not during football	2.95	p=0.027 [b]
Previous LOC [a] during football	2.44	p=0.045 [b]
Previous recognized concussion during football	1.94	p=0.037 [b]
Participation in other sports (basketball)	1.72	p=0.034 [b]
Current age in years	1.46	p=0.048 [b]
Mouthguard use	2.46	p=0.373 [c]
Each extra game played in the fall season	0.97	p=0.612 [c]
Years played organized tackle football	0.99	p=0.992 [c]
Years played university football	0.75	p=0.186 [c]
Age started organized tackle football	0.97	p=0.793 [c]
Increased alcohol intake (# beers/week)	1.04	p=0.170 [c]

Note: **a:** Loss of Consciousness (after being hit in the head)
b: considered to be statistically significant
c: not considered to be statistically significant

Soccer

Variable	Odds Ratio	p Value
Previous recognized concussion during soccer	3.15	p=0.010 [b]
Female Sex	2.60	p=0.004 [b]
Participation in other sports (basketball)	2.16	p=0.018 [b]
Previous recognized concussion not during soccer	8.02	p=0.134 [c]
Previous LOC [a] during soccer	0.65	p=0.796 [c]
Previous LOC [a] not during soccer	0.74	p=0.734 [c]

Each extra game played in the fall season	1.12	p=0.057[c]
Years played organized soccer	0.98	p=0.864 [c]
Years played university soccer	0.78	p=0.490 [c]
Current age in years	0.85	p=0.066 [c]
Age started organized soccer	0.93	p=0.649 [c]
Increased alcohol intake (# beers/week)	0.98	p=0.768 [c]
Female sex	4.74	p=0.070 [c]
Increased average number of headings per game	1.02	p=0.843 [c]
Considering oneself a header	1.63	p=0.548 [c]
Mouthguard use	N/A[d]	N/A [d]

Note: **a:** Loss of Consciousness (after being hit in the head)
b: considered to be statistically significant
c: not considered to be statistically significant
d: not calculated as only n=4 responded affirmatively

Table 5- Primary position and % of players that suffered at least 1 concussion

Football

Primary position	Percentage with concussions
Tight end	100.0% (6/6)
Defensive lineman	80.9% (38/47)
Special teams player	80.0% (12/15)
Wide receiver/slot back	77.3% (34/44)
Cornerback/safety	70.6% (36/51)
Linebacker	70.4% (31/44)
Offensive lineman	69.1% (38/55)
Running back	65.7% (23/35)
Quarterback	52.4% (11/21)
Punter/kicker	0.0% (0/6)
Unknown	50.0% (2/4)
Overall	***70.4% (231/328)***

Soccer

Primary position	Percentage with concussions
Goalie	78.9% (15/19)
Defence	70.2% (40/57)
Midfield	57.7% (41/71)
Forward	57.4% (27/47)
Unknown	42.9% (3/7))
Overall	***62.7% (126/201)***

Table 6- Maximum duration of symptoms

Football

Symptom duration	Percentage of concussed players
Less than or equal to: **5 sec**	**5.5%**
Less than or equal to: **1 min**	**12.4%**
Less than or equal to: **2 min**	**15.7%**
Less than or equal to: **5 min**	**22.1%**
Less than or equal to: **10 min**	**25.4%**
Less than or equal to: **20 min**	**28.1%**
Less than or equal to: **1 hour**	**39.6%**
Less than or equal to: **2 hrs**	**48.4%**
Less than or equal to: **1 day**	**72.4%**
Less than or equal to: **2 days**	**83.0%**
Less than or equal to: **3 days**	**87.1%**
Less than or equal to: **1 week**	**95.4%**
Less than or equal to: **2 weeks**	**96.8%**
Less than or equal to: **1 month**	**98.6%**
Less than or equal to: **1 year**	**100.0%**

Soccer

Symptom duration	Percentage of concussed players
Less than or equal to: **5 sec**	**4.1%**
Less than or equal to: **1 min**	**12.3%**
Less than or equal to: **2 min**	**17.2%**
Less than or equal to: **5 min**	**20.5%**
Less than or equal to: **10 min**	**26.2%**
Less than or equal to: **20 min**	**30.3%**
Less than or equal to: **1 hour**	**45.9%**
Less than or equal to: **2 hrs**	**55.7%**
Less than or equal to: **1 day**	**81.2%**
Less than or equal to: **2 days**	**89.3%**
Less than or equal to: **3 days**	**92.6%**
Less than or equal to: **1 week**	**95.9%**
Less than or equal to: **2 weeks**	**99.2%**
Less than or equal to: **1 month**	**100.0%**

Table 7- Symptoms experienced by concussed players

Symptoms	Football [b]	Soccer [b]
	Percentage of all concussed players with symptoms [a]	
Loss of Consciousness	4.4% (10/226)	4.8% (6/126)
Confusion/Disorientation	55.0% (126/229)	55.6% (70/126)
Headache	70.0% (159/227)	72.6% (90/124)
Dizziness	40.7% (92/226)	55.3% (68/123)
Memory Difficulties	10.6% (24/226)	6.5% (8/124)
Blurred/Abnormal Vision	26.3% (59/224)	27.8% (35/126)
Nausea	8.8% (20/226)	8.0% (10/125)
Other Symptoms	13.0% (29/223)[c]	6.5% (8/123)[d]

Note: **a**: all players who suffered at least one concussion
b: questions pertaining to some symptoms may have been left unanswered so the total may be different for individual symptoms
c: included photophobia, sensitivity to noise and tinnitus
d: included photophobia and sensitivity to noise