Mechanisms of Injury for Concussions in University Football, Ice Hockey, and Soccer

A Pilot Study

J. Scott Delaney, MDCM,† Vishal Puni, PT,† and Fabrice Rouah‡*

Objective: To examine the mechanisms of injury for concussions in university football, ice hockey, and soccer.

Design: Prospective analysis.

Setting: McGill University.

Patients: All athletes participating in varsity football, ice hockey, and soccer.

Main Outcome Measures: Athletes participating in university varsity football, ice hockey, and soccer were followed prospectively to determine the mechanisms of injury for concussions, whether certain mechanisms of injury causing concussions were more common in any of the three sports, whether different areas of the body seem to be more vulnerable to a concussion after contact, and whether these areas might be predisposed to higher grades of concussion after contact.

Results: There were 69 concussions in 60 athletes over a 3-year period. Being hit in the head or helmet was the most common mechanism of injury for all 3 sports. The side/temporal area of the head or helmet was the most probable area to be struck, resulting in concussion for both football and soccer. When examining the body part or object delivering the concussive blow, contact with another player's helmet was the most probable mechanism in football.

Conclusion: The mechanisms of injury for concussions in football are similar to previously published research on professional football players. The mechanisms of injury for concussions in soccer are similar to past research on Australian rules football and rugby.

Key Words: concussion, football, ice hockey, mechanisms, soccer

(*Clin J Sport Med* 2006;16:162–165)

Received for publication October 12, 2005; accepted October 25, 2005.
From the *Department of Emergency Medicine, McGill University Health Centre 2; †McGill Sport Medicine Clinic; and ‡Faculty of Management, McGill University, Montreal, Quebec, Canada.
Reprints: J. Scott Delaney, MDCM, McGill Sport Medicine Clinic, 475 Pine Avenue, West Montreal, Quebec, Canada H2W 1S4 (e-mail: j.delaney@mcgill.ca).

This study was undertaken to better understand the mechanisms of concussive impacts in university-level football, ice hockey, and soccer. This was done in the hopes of determining which injury mechanisms were more common in each of the 3 sports, whether certain areas of the body seem to be more vulnerable to a concussion after contact, and whether these areas might be predisposed to higher grades of concussion after contact. This study was not undertaken to identify individual variables that might predispose an athlete to concussion, such as previous concussions, position played, gender of the athlete, and so on, because this has been well documented previously.[1,2]

METHODS

McGill University is located in Montreal, Canada. It has men's and women's varsity soccer teams, men's and women's varsity ice hockey teams, as well as a men's varsity football team. We present data prospectively gathered from the 2001 fall season to the spring of 2004 inclusively.

Concussion diagnosis and grading was based on the McGill Concussion Grading System[3] and was decided by the treating physician. Information was also prospectively gathered on the mechanism of injury, the presence of loss of consciousness (LOC), the location of the concussive impact, where and how the concussed athlete was struck, and with what body part or object the concussed athlete was struck. The information was based on interviewing the concussed player and teammates, visualization by the team therapists and sideline physician, and/or review of the game film. When a game film had to be viewed to determine the mechanism of injury, all 3 observers (2 therapists and the lead author) had to agree on each question regarding the mechanism of injury; otherwise, that answer was listed as "unable to determine." The location of the concussive impact could be the head, neck, back, thorax, other, or unable to determine. For the head, the location was further specified to be the top, side/temporal area, frontal/forehead area, or face mask, mandible, or occiput. The side/temporal area was considered to begin at the area of the head lateral to the lateral orbital bone prominence and is usually covered with hair. For helmeted athletes, the side/temporal area was considered to be the area of the helmet starting lateral

TABLE 1. Characteristics of Concussions for Each Sport

Variable	Football (n = 39 concussions)*	Ice Hockey (n = 12 concussions)†	Soccer (n = 18 concussions)‡
Age of the concussed athlete, y ± SD	20.6 ± 2.2	20.2 ± 2.9	20.5 ± 2.5
Gender of the concussed athlete			
Male	39 concussions in 33 athletes*	6	6
Female	0	6 concussions in 5 athletes†	12 concussions in 10 athletes‡
Grade of concussions§			
IA	1	0	0
IB	6	2	1
IC	27	9	14
II	5	0	3
III	0	1	0
Loss of consciousness	3	0	2

*There were 39 concussions in 33 athletes (4 athletes sustained 2 concussions each and 1 athlete sustained 3 concussions).
†There were 12 concussions in 11 athletes (1 female athlete suffered 2 concussions).
‡There were 12 concussions in 10 athletes (2 female athletes each suffered 2 concussions).
§The McGill Concussion Grading System: grade I, no loss of consciousness (LOC) or posttraumatic amnesia (PTA); grade IA, no postconcussion symptoms (PCSs), only seconds of confusion; grade IB, PCS and/or confusion resolved in less than 15 minutes; grade IC, PCS and/or confusion not resolved in 15 minutes; grade II, PTA less than 30 minutes and/or LOC less than 5 minutes; grade III, PTA more than 30 minutes and/or LOC more than 5 minutes. PCSs include blurred vision, nausea, vomiting, headache, dizziness, photophobia, hearing problems, and so forth.

to the facial opening for the helmet but above the ear hole. For any impact on the helmet below the ear hole, the area of impact was considered to be the face or mandible.

For each outcome of interest (impact location, and so forth), we constructed tables corresponding to the proportion of players in each sport with the outcome. We also examined each outcome across sports to determine whether the proportion of players experiencing each outcome was the same. We used the χ^2 test to detect differences among the proportions.

The study was approved by the ethics review board of the McGill University School of Medicine.

RESULTS

Over 3 years, there were 69 concussions in 60 athletes. Table 1 lists the characteristics of the concussions, Table 2 lists the location of contact for each concussive impact, Table 3 lists the person or objects causing the concussive impacts, and Table 4 lists the body part or object delivering the concussive blow.

When trends were examined, it was found that being hit in the head for soccer or being hit in the helmet for football and ice hockey was the most common mechanism of impact that resulted in concussions for all 3 sports (soccer, $P < 0.0001$; football, $P < 0.0001$; ice hockey, $P = 0.0067$). The side/temporal of the head or helmet was the most probable area of the head or helmet to be struck resulting in a concussion for both football ($P = 0.0001$) and soccer ($P = 0.0032$).

Being struck by an opponent was the most probable mechanism of injury in football ($P < 0.0001$). There was a trend toward this in soccer, but it did not reach statistical significance with the numbers involved ($P = 0.15$). Contact with another player's helmet was the most probable mechanism in football ($P < 0.0001$). Although contact with another player's head was the most common mechanism in soccer, this value did not reach statistical significance ($P = 0.15$).

TABLE 2. Location of Contact for Concussive Impacts

Contact Location	Football (n = 39 concussions)	Ice Hockey (n = 12 concussions)	Soccer (n = 18 concussions)
Head	33	10	18
Top	1	2	0
Side/temporal	15	1	10
Frontal/forehead	11	1	1
Face or face mask	3	2	1
Mandible	1	2	2
Occiput	2	2	4
Thorax	0	1	0
Back	2	0	0
Unable to determine	4	1	0

TABLE 3. Person or Objects Causing Concussive Impacts

Concussed Athlete Struck by	Football (n = 39 concussions)	Ice Hockey (n = 12 concussions)	Soccer (n = 18 concussions)
Opponent	31	8	12
Own player	3	0	0
Self	0	0	0
Other*	4	4	6
Unable to determine	1	0	0

*These included the ground for football and soccer, the ball for soccer, and the ice and boards for ice hockey.

There is currently no statistically significant association between the grade of concussion and the location of impact, person or object causing the concussion, and body part or object delivering the concussive blow.

DISCUSSION

Similar to recent National Football League (NFL) research,[4] our data revealed that being hit on the side of the helmet by an opposing player's helmet was the most probable way to sustain a concussion in university football. Although no previous studies have addressed which contact areas on the head and body are most at risk for concussion in soccer, research has been done in Australian rules football (ARF) and rugby.[5] ARF, rugby, and soccer all involve running on grass or turf, where collisions occur without helmets. Similar to our university soccer results, research on ARF and rugby have also shown that the side/temporal region of the head is the most common location of concussive impacts.[5]

Previous research on soccer concussions has listed contact with the ball as the second most common mechanism, after head-to-head contact.[6] In our study, although head-to-head contact was similarly the most common mechanism for concussion, contact with the ground or an elbow more commonly resulted in concussions compared with contact with the ball.

TABLE 4. Body Part or Object Delivering the Concussive Blow

Concussed Athlete Struck With	Football (n = 39 concussions)	Ice Hockey (n = 12 concussions)	Soccer (n = 18 concussions)
Head	22	0	6
Shoulder	3	2	0
Upper arm	0	0	0
Elbow	1	4	3
Forearm	0	0	0
Hand	0	0	0
Upper leg	0	0	0
Knee	7	0	1
Lower leg	0	0	0
Foot	0	0	2
Thorax/trunk	1	1	0
Ground or ice	4	2	4
Goal	0	0	0
Ball or puck	0	0	2
Other	0	2*	0
Unable to determine	1	1	0

*Two female players struck their heads on ice hockey boards causing concussions.

In 2 of the 3 sports we examined, and in the studies on concussions in the NFL, ARF, and rugby, the side/temporal area of the head was the most common area of impact resulting in concussion.[4,5] Although there are 2 sides of the head, perhaps resulting in more opportunity for injury because there is more surface area that may be struck, it may also be true that the side of the head is more susceptible for other reasons. It may be that athletes cannot see an impending contact to the side of the head and, as such, they may not be able to prepare for contact. It has been suggested that if an athlete is able to contract his or her neck muscles in anticipation of contact to the head, this may lessen the amount of acceleration experienced by the head.[7] It may also be true that, for a given force, the side/temporal area of the brain is more biomechanically susceptible to a concussion than other parts of the head.

It should be noted that the study was designed and started recruiting before the Concussion in Sport Group published its first consensus statement on concussions, which abandoned the use of concussion grading systems.[8] The current study was also originally designed to document the presence of LOC in concussions. Recent research has indicated that LOC may have little prognostic use in predicting the duration or severity of concussion symptoms.[9]

In conclusion, the data presented here reveal that being hit in the head is the most common mechanism of injury for concussions for university football, ice hockey, and soccer. Impact to the side/temporal area of the head was the most probable location of the head to result in a concussion for football and soccer.

We are continuing to collect data for all 3 sports. In an effort to keep up to date with the latest concussion literature, we will prospectively classify the concussions as simple or complex as recommended by the latest meeting of the Concussion in Sport Group.[10]

ACKNOWLEDGMENTS

The authors thank the athletes and team therapists at McGill University for their help in collecting data, especially Lynn Bookalam, Laura Abbatiello, and Penny Lee. They also thank Tracy Troutman Delaney and Mary Mooney for their work in preparing the manuscript.

REFERENCES

1. Delaney JS, Lacroix VJ, Leclerc S, et al. Concussions during the 1997 Canadian Football League season. *Clin J Sports Med.* 2000; 10:9–14.
2. Delaney JS, Lacroix VJ, Leclerc S, et al. Concussions among university football and soccer players. *Clin J Sports Med.* 2002;12: 331–338.
3. Leclerc S, Lassonde M, Delaney JS, et al. Recommendations for grading of concussion in athletes. *Sports Med.* 2001;31:629–636.
4. Pellman EJ, Viano DC, Tucker AM, et al. Concussion in professional football: location and direction of helmet

impacts—part 2. *Neurosurgery*. 2003;53:1328–1340. Discussion. *Neurosurgery*. 2003;53:1340–1341.
5. McIntosh AS, McCrory P, Comerford J. The dynamics of concussive head impacts in rugby and Australian rules football. *Med Sci Sports Exerc*. 2000;32:1980–1984.
6. Boden BP, Kirkendall DT, Garrett WE Jr. Concussion incidence in elite college soccer players. *Am J Sports Med*. 1998;26: 238–241.
7. Queen RM, Weinhold PS, Kirkendall DT, et al. Theoretical study of the effect of ball properties on impact force in soccer heading. *Med Sci Sports Exerc*. 2003;35:2069–2076.
8. Aubry M, Cantu R, Graf–Baumann T, et al. Summary and agreement statement of the 1st International Symposium on Concussion in Sport, Vienna 2001. *Clin J Sports Med*. 2002; 12:6–11.
9. Collins MW, Iverson GL, Lovell MR, et al. On-field predictors of neuropsychological and symptom deficit following sports-related concussion. *Clin J Sports Med*. 2003;13:222–229.
10. McCrory P, Johnston K, Meeuwisse W, et al. Summary and agreement statement of the 2nd International Conference on Concussion in Sport, Prague 2004. *Clin J Sports Med*. 2005;15: 48–55.

