

# Head and Neck Injuries Among Ice Hockey Players Wearing Full Face Shields vs Half Face Shields

Brian W. Benson, MSc

Nicholas G. H. Mohtadi, MD, MSc

M. Sarah Rose, PhD

Willem H. Meeuwisse, MD, PhD

ICE HOCKEY HAS BEEN CHARACTERIZED as the fastest and most violent team sport in the world played with clubs (hockey sticks), a bullet (puck), and knives (skates).<sup>1</sup> The high intensity of the sport results in frequent collisions between players and forceful impacts with the side boards, goal posts, pucks, and hockey sticks. The head and neck are particularly vulnerable to hockey-related injury,<sup>2-10</sup> and the search for improved player safety to prevent these injuries has been an ongoing process for sports governing bodies and researchers.<sup>11</sup>

Ice hockey associations from Canada and the United States have introduced head and neck risk management strategies, the most significant being the mandatory use of full facial protection for athletes across many different age groups and levels of play. These rules, combined with advancements in face shield standards, have been effective in reducing the frequency of facial and eye injuries.<sup>12-14</sup> However, a trend of increasing catastrophic hockey-related injuries to the cervical spine has led to speculation that use of the full face shield may increase players' risk of sustaining a neck injury, possibly due to biomechanical alterations or changes in the style of play.<sup>15-20</sup> To our knowledge, no prospective cohort or experimental research

**Context** Speculation exists that use of a full face shield by ice hockey players may increase their risk of concussions and neck injuries, offsetting the benefits of protection from dental, facial, and ocular injuries, but, to our knowledge, no data exist regarding this possibility.

**Objective** To determine the risk of sustaining a head or neck injury among intercollegiate ice hockey players wearing full face shields compared with those wearing half shields.

**Design, Setting, and Participants** Prospective cohort study conducted during the 1997-1998 Canadian Inter-University Athletics Union hockey season of 642 male hockey players (mean age, 22 years) from 22 teams. Athletes from 11 teams wore full face shields and athletes from 11 teams wore half face shields during play.

**Main Outcome Measure** Reportable injury, defined as any event requiring assessment or treatment by a team therapist or physician or any mild traumatic brain injury or brachial plexus stretch, categorized by time lost from subsequent participation and compared by type of face shield.

**Results** Of 319 athletes who wore full face shields, 195 (61.6%) had at least 1 injury during the study season, whereas of 323 who wore half face shields, 204 (63.2%) were injured. The risk of sustaining a facial laceration and dental injury was 2.31 (95% confidence interval [CI], 1.53-3.48;  $P < .001$ ) and 9.90 (95% CI, 1.88-52.1;  $P = .007$ ) times greater, respectively, for players wearing half vs full face shields. No statistically significant risk differences were found for neck injuries, concussion, or other injuries, although time lost from participation because of concussion was significantly greater in the half shield group ( $P < .001$ ), than in the group wearing full shields.

**Conclusions** These data provide evidence that the use of full face shields is associated with significantly reduced risk of sustaining facial and dental injuries without an increase in the risk of neck injuries, concussions, or other injuries.

JAMA. 1999;282:2328-2332

www.jama.com

has been conducted in the sport of ice hockey to address this issue.

The purpose of this study was to determine the risk of sustaining head or neck injury among intercollegiate ice hockey players wearing full face shields compared with those wearing half shields.

## METHODS

This prospective cohort study was conducted during the 1997-1998 Canadian

Inter-University Athletics Union (CIAU) hockey season. The CIAU is a national league consisting of 4 divisions with identical officiating and player eligibility rules,

**Author Affiliations:** Faculties of Medicine (Mr Benson and Dr Rose) and Kinesiology, Sport Medicine Centre (Drs Mohtadi and Meeuwisse), University of Calgary, Calgary, Alberta.

**Corresponding Author and Reprints:** Willem H. Meeuwisse, MD, PhD, University of Calgary Sport Medicine Centre, 2500 University Dr NW, Calgary, Alberta, Canada T2N 1N4 (e-mail: meeuwiss@ucalgary.ca).

except that each division may mandate use of protective equipment. The Ontario Universities Athletic Association (OUAA) requires that all athletes under its jurisdiction wear full face shields for every practice and game throughout the varsity season. In contrast, the Canada West Universities Athletic Association (CWUAA) and Atlantic Universities Athletic Association (AUAA) require all athletes to wear, at a minimum, half shields (visors) for all practices and games. A half shield is a clear plastic visor that is attached to a helmet and extends down to the tip of a player's nose. A full face shield extends down to the bottom of a player's chin and covers the entire face. For this study, 2 cohorts were defined by their associations' facial protection mandate.

### Subjects and Data Collection

The study population included 642 consenting male ice hockey players from 11 CIAU university teams competing in the OUAA, 7 teams in the CWUAA, and 4 teams in the AUAA. Thus, athletes from the 11 OUAA and 11 CWUAA/AUAA teams formed the cohorts wearing full and half face shields, respectively.

The 11 OUAA teams were selected based on geographic proximity to a pre-season meeting in Toronto, Ontario, between the investigator and team therapists. The 7 CWUAA team therapists had been collecting data for the Canadian Intercollegiate Sport Injury Registry (CISIR), Calgary, Alberta, during the previous 3 seasons, and the 4 AUAA teams were selected based on geographic proximity to a pre-season meeting in Halifax, Nova Scotia. The purpose of the meetings was to discuss the data collection protocol with team therapists so that they would have a thorough understanding of what was required of them in terms of data collection.

Approved by the University of Calgary's institutional review board, this study required team therapists to obtain informed verbal consent from all players prior to participation. Previous injury status was documented for each CWUAA player using a standardized medical form during a manda-

tory preseason medical examination with the team physician. Because no standardized form was uniformly used by team physicians of institutions participating in the OUAA and AUAA, athletes competing in these divisions completed an injury history questionnaire with their team therapist during a pre-season meeting. The injury information recorded on these forms served as a baseline for the 1997-1998 hockey season. From the first practice of the season, team therapists used a standardized weekly exposure sheet<sup>21</sup> to record the level of individual participation (full, partial, or none) and the type of face shield worn for every practice and game throughout the season. If a player sustained an injury that met the reportable injury definition, team therapists, physicians, or both were required to complete an injury report form.<sup>21</sup> A subjective assessment of whether an injury was the result of an illegal action during a game and subsequently whether a penalty was called by a referee was included on the injury report form so that a descriptive comparison could be made with respect to style of play between facial protection divisions. The completed forms were sent to the CISIR, where they were checked, coded, and entered into a database using a dual entry system to minimize data entry errors.<sup>21</sup>

### Team Therapists

Athletic therapists were important members of the investigative team because of their medical orientation and diagnostic skills; their relationships with athletes, coaches, and team physicians; and their daily presence at both practices and games. Canadian Athletic Therapist certification requires: (1) enrollment in a university undergraduate degree program in kinesiology or physiotherapy, (2) the completion of 1200 hours of practical experience (600 clinical and 600 field hours), and (3) successful completion of a national examination consisting of both written and practical components. During training, student athletic therapists are under the direct supervision of certified Canadian

Athletic Therapists. Each participating coordinating athletic therapist received a small honorarium for overseeing data collection throughout the 1997-1998 season.

### Outcome Variables and Statistical Analysis

The main outcome (dependent) variable measured in this study was an injury defined as "any event requiring assessment or treatment by a team therapist or physician" and "any mild traumatic brain injury or brachial plexus stretch (ie, burner/stinger)." Reportable injuries were then categorized by the amount of time lost from subsequent participation. To avoid potential injury reporting biases between institutions, the following injury definition was used for data analyses: (1) any injury received during an organized practice or game during the 1997-1998 CIAU hockey season that required assessment or treatment by a team therapist or physician and resulted in at least 1 missed participation, or (2) any facial laceration/fracture, dental injury, eye injury, traumatic brain injury, or brachial plexus stretch (regardless of playing-time lost).

The independent variable of interest was full face shield vs half facial shield. Individual athlete-participation (*exposure*), defined as 1 player participating in 1 practice or game in which the athlete was exposed to the possibility of injury, was measured to determine the amount of time under the different exposure conditions during which each individual was at risk of injury. Athlete-exposures were calculated by weighting a full session of participation as "1," a partially missed session as "0.5," and a completely missed session as "0." Goal tender exposure and injury information was not included in the analyses so that a true comparison could be made between players wearing full face shields vs half shields. For example, 20 athletes fully participating in 10 games would yield 200-game athlete exposures. In addition, several potential confounding or effect-modifying variables were assessed, including player posi-

tion (forward vs defense), injury status (new vs recurrent), and injury setting (game vs practice).

The sample size chosen for this study was calculated based on injury data from the CISIR database during the previous CWUAA varsity season, which showed that neck injuries accounted for approximately 7% of the total reported player injuries wearing half shields. Using a 2-sided test ( $\alpha = .05$ ,  $\beta = .20$ ), it was estimated that 300 subjects in each group would be required to achieve 80% power to detect a relative risk of 2.0 or greater between the 2 study groups. The test-based method of Miettinen<sup>22</sup> was used to calculate 95% confidence intervals (CIs) for relative risks based on incidence density ratios<sup>23</sup> and *Epi Info 6* (Version 6.04a, Centers for Disease Control and Prevention, Atlanta, Ga) was used for all *P* value computations (2-tailed tests).

## RESULTS

### Athletes and Athlete-Exposures

All 642 varsity athletes from the 22 participating teams consented to have data collected and sent to the CISIR. In addition, athlete-exposure information was 100% complete throughout the 1997-1998 CIAU hockey season. Furthermore, the weekly exposure sheets were verified when they were received at the CISIR for any indication that a player had missed time due to an injury. In all cases but 1, an injury report form was sent to the CISIR (99.9% completion rate). It was not possible to determine the completion rate for injuries that did not result in time lost from participation.

The median age for athletes in both categories was 22 years (range, 17-29 years, full face shield division; range, 18-29 years, half face shield division). Of the 319 athletes wearing full face shields, 195 players (61.1%) were injured during the 1997-1998 season compared with 204 (63.2%) of the 323 athletes wearing half face shields. In addition, the 2 study groups, classified as rookies, had a similar level of playing experience, with 118 (41.9%) of the 281 players wearing full face shields, compared with 116 (39.5%) of 294 players

wearing half shields. Furthermore, 280 (95.2%) of the 294 athletes competing in half shield divisions had 1 or more injuries prior to the study compared with 247 (87.9%) of 281 players competing in the full shield division. Of note, 38 athletes (11.9%) competing in the full shield and 29 athletes (9%) competing in half shield divisions did not have medical forms or injury history questionnaires returned to the CISIR. These individuals participated for a minimal amount of time as varsity players or joined a team later in the season.

Excluding goal tenders, players wearing full face shields accumulated 24 147.5 athlete-exposures during the 1997-1998 varsity season, while players wearing half shields amassed 26 823.0 athlete-exposures.

### Injury Risk

Crude relative risk estimates of head and facial injuries, neck injuries, concussions, and other types of injuries sustained by players from each cohort are shown in TABLE 1. Although we found a significant difference in rates of head and facial injuries between the 2 groups ( $P < .001$ ), there was no significant difference in risk of sustaining a concussion, neck, or other injury (overall) for athletes wearing half shields compared with those wearing full face shields. Determined by multivariate (stratified) analysis, these findings were not confounded or modified by injury setting (game vs practice), injury status (new vs recurrent), or position (forward vs defense), which were recorded on the in-

jury report forms by the team therapists and physicians. The same differences between face shield types were found across all strata. The incidence rates of head injuries sustained for each cohort are shown in FIGURE 1. There were no significant differences in the number of concussions sustained between the 2 study groups ( $P = .90$ ).

### Facial Lacerations and Dental Injuries

The risk of sustaining a facial laceration was 2.31 times greater for players wearing half shields compared with those wearing full face shields (95% CI, 1.53-3.48;  $P < .001$ ). Based on the absolute number of facial lacerations sustained during the 1997-1998 season (half shield, 77; full shield, 30), an average of 7 facial lacerations per team are expected during any given season for athletes wearing half face shields, compared with 2 to 3 injuries per team for athletes wearing full face shields.

The incidence rates for various types of facial lacerations sustained by athletes in the 2 study groups are presented in FIGURE 2. The lip and eyebrow are 2 areas of the face that receive the most lacerations among players wearing half shields. The majority of lacerations sustained by athletes wearing full face shields were to the chin. Although there was a higher incidence of chin lacerations among players wearing full face shields, the incidence was not significantly greater than for players wearing half shields ( $P = .25$ ).

**Table 1.** Crude Relative Risk Estimates of Injury for Players Wearing Full Face Shields Compared With Half Shields

Variables	Half Shield		Full Shield		Relative Risk	95% Confidence Interval	<i>P</i> Value
	No. of Injuries	Injury Rate*	No. of Injuries	Injury Rate*			
Head and face injuries†	95	3.54	34	1.41	2.52	1.73-3.68	<.001
Concussions‡	41	1.53	38	1.57	0.97	0.61-1.54	.90
Neck injuries§	9	0.34	7	0.29	1.16	0.43-3.16	.77
Other injuries	202	7.53	150	6.21	1.21	0.98-1.49	.07

\*Per 1000 athlete-exposures.

†Any facial laceration or fracture, dental, or eye injury (excluding concussions), regardless of time loss.

‡Any concussive head injury including all transient traumatic brain injuries, regardless of time loss.

§Injuries resulting in 1 or more lost participation and all transient brachial plexus injuries, regardless of time loss.

||Only injuries resulting in 1 or more lost participation.

Stick contact to the face was the predominant mechanism of lacerations for athletes wearing half shields, whereas contact with a stick or an opponent via body check or collision caused the majority of lacerations among athletes wearing full face shields (TABLE 2). Six facial lacerations sustained by athletes wearing half shields were caused by a skate.

Eleven players wearing half face shields sustained dental injuries (ie, teeth fractures) during the 1997-1998 varsity season. Nine of the 11 dental fractures sustained by athletes wearing half shields were caused by contact with a hockey stick, 1 resulted from contact with a player's own visor, and the remaining mechanism was unknown. Seven of the 11 players injured in this cohort were wearing mouthguards at the time of injury. Only 1 athlete, who was wearing a full face shield but not a mouth guard, sustained a dental injury when he was punched in the face during an organized practice. The risk of sustaining a dental injury was 9.90 times greater for players wearing half shields than for those wearing full facial shields (95% CI, 1.88-52.1;  $P = .007$ ). One eye injury (traumatic iritis) was sustained by a player wearing a half shield. This injury occurred when an opposing player's elbow struck the injured player's eye during an organized game. No eye in-

juries were reported for players wearing full face shields.

### Concussions and Neck Injuries

We found no statistically significant risk differences in the number of concussions sustained by players in either study group ( $P = .90$ ). However, the time lost from practices and games associated with these injuries was significantly greater for players wearing half shields than for those players wearing full face shields ( $P < .001$ ). Forty-one players who sustained concussions while wearing half shields missed a total of 166.5 sessions, and 38 players who sustained concussions while wearing full face shields missed 64.5 sessions. In addition, 24 of the 41 players who experienced concussions while wearing half shields missed 1 or more complete sessions compared with 13 of the 38 players wearing full face shields. Using a time-lost definition, the injury rate is approximately double for players wearing half face shields. Concussive head injuries were randomly distributed between the participating teams; that is, there was no clustering of concussions on any 1 particular team within either cohort.

Only 5 neck injuries experienced by athletes wearing full face shields resulted in 1 or more completely missed games or practices, compared with 7 for athletes wearing half shields. The risk of

neck injury was not significantly different between the 2 comparison groups ( $P = .78$ ).

### Reported Injury Factors

High sticking, slashing, and checking from behind, respectively, were the 3 most common types of illegal play causing injury reported by therapists of athletes competing in half shield divisions. In comparison, slashing, checking from behind, and cross-checking, respectively, were the top 3 reported types of illegal play causing injury in full face shield divisions.

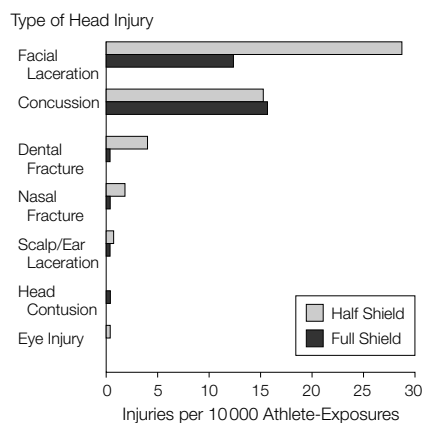
Team therapists from the half shield divisions reported that 41.3% of the injuries sustained during games were caused by an illegal action, compared with 32.2% of the injuries sustained by players competing in the full face shield division. In addition, it was reported that a referee called a penalty after 10% of injuries sustained by players competing in half shield divisions vs 8.5% of injuries of players in the full face shield division.

An accurate assessment of the penalty information reported by team therapists was not possible because official game sheets were not collected for verification.

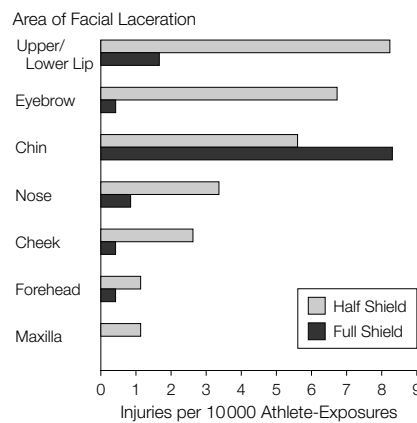
### COMMENT

Public and professional concern about the number of head and neck injuries occurring in ice hockey is increasing. There is speculation that while full face shield use reduces facial, dental, and ocular injuries,<sup>24</sup> it may increase injury rates to other anatomic regions such as the neck, brain, and spinal cord, possibly due to biomechanical alter-

**Figure 1.** Incidence Density of Head and Facial Injury Outcome by Facial Shield Worn at Time of Injury



**Figure 2.** Incidence Density of Facial Lacerations by Area of Face and Facial Shield Worn at Time of Injury



**Table 2.** Mechanism of Facial Lacerations by Type of Face Shield Worn at Time of Injury: Absolute Numbers

Mechanisms of Facial Laceration	Half Shield	Full Shield
Stick contact	45	12
Boards or glass contact	12	2
Player contact	8	11
Skate contact	6	0
Puck contact	5	1
Ice contact	3	3
Unknown	1	1

ations<sup>25,26</sup> or changes in the style of play.<sup>27</sup> In this study, the risk of injury was prospectively evaluated in a natural experimental setting using 2 groups similar in every respect, apart from face shields use. There were no differences between sites, league divisions, or physicians and therapists in their threshold to decide to remove a player or limit a player's participation in a game or practice, and there was no differences in player skill levels or training. Furthermore, the data were collected using a previously validated system of injury surveillance,<sup>21</sup> and data collection was nearly 100% complete.

For intercollegiate ice hockey players wearing half shields compared with full face shields, we found that the risk of sustaining a head injury (excluding concussions), facial laceration, and dental injury was 2.52, 2.31, and 9.90 times greater, respectively. We found no evidence in this study to support the speculation that full face shield use increases players' risk of sustaining a neck injury or concussion. Furthermore, the overall risk of injury to an anatomic region other than the head or neck was not significantly different between the 2 comparison groups.

Several other findings warrant comment. First, a significant number of facial lacerations in the half shield group were to periorbital regions, which carries a risk of catastrophic eye injury. This concern is compounded when the evidence shows that stick and skate related facial injuries are far higher in this group.

Second, the finding that 7 of the 11 athletes who sustained dental injuries in the half shield group were wearing mouth guards at the time of injury suggests that the use of such protective equipment in combination with half shields is not enough to offer protection from these injuries. The use of full face shields significantly reduces players' risk of sustaining a dental injury.

Third, concussions sustained by players wearing half shields resulted in significantly greater time lost from competition than for players wearing full face shields ( $P < .001$ ). Possible explanations

for this finding may be that many players wearing half shields place their helmets in a manner such that the visors are raised above the level of their nose in order to get a clearer view of the ice and surrounding area. Since the helmet is placed further back on the head, the protective effect of the padding is minimized on the forehead area. In addition, a loose chin strap may allow a properly fitted helmet and half shield unit to shift from its original position during impact with an opposing player, thereby decreasing its protective effect. Furthermore, a direct blow to the exposed jaw of players wearing half shields may increase concussion severity compared with the full facial shield, which because of its chin piece may cushion the jaw. The chin piece of the full face shield also helps hold the helmet in place during impact, thereby maintaining maximum player-protection from brain injury. However, data or detailed evaluations of concussions, such as grade or associated or persistent neurologic deficits, were not collected, so the relative severity of injury between the groups could not be determined.

Finally, these findings are based on data from collegiate hockey players and may not be generalizable to high school and younger, skeletally immature players.

In this study, use of full face shields was associated with significant reductions in the risk of facial and dental injuries without increasing the risk of neck injuries, mild traumatic brain injuries, or other injury rates (overall). Sports governing bodies at the intercollegiate level of competition should seriously consider mandating full facial protective equipment for all participants under their jurisdiction.

**Funding/Support:** Funding for this project was provided by the Canadian Hockey Association and Olympic Oval Research Fund, Calgary, Alberta.

#### REFERENCES

1. Sim FH, Simonet WT, Melton LJ, Lehn TA. Ice hockey injuries. *Am J Sports Med.* 1987;15:30-40.
2. Bjorkenheim J, Syvahuoko I, Rosenberg PH. Injuries in competitive junior ice-hockey: 1437 players followed for one season. *Acta Orthop Scand.* 1993;64:459-461.
3. Deady B, Brison RJ, Chevrier L. Head, face and neck injuries in hockey: a descriptive analysis. *J Emerg Med.* 1996;14:645-649.

4. Goodwin-Gerberich S, Finke R, Madden M, Priest J, Aamoth G, Murray K. An epidemiological study of high school ice hockey injuries. *Childs Nerv Syst.* 1987;3:59-64.
5. Montelpare WJ, Pelletier RL, Stark RM. Ice Hockey. In: Caine DJ, Caine CG, Lidner KJ. *Epidemiology of Sports Injuries.* Windsor, Ontario: Human Kinetics Publishers Inc; 1996:247-267.
6. Pelletier R, Montelpare W, Stark R. Intercollegiate ice hockey injuries: a case for uniform definitions and reports. *Am J Sports Med.* 1993;21:78-82.
7. Pettersson M, Lorentzon R. Ice hockey injuries: a 4-year prospective study of a Swedish elite ice hockey team. *Br J Sports Med.* 1993;27:251-254.
8. Rampton J, Leach T, Therrien SA, Bota GW, Rowe BH. Head, neck, and facial injuries in ice hockey: the effect of protective equipment. *Clin J Sport Med.* 1997;7:162-167.
9. Reilly M. The nature and causes of hockey injuries: a five year study. *Athl Train.* 1982;17:88-90.
10. Voaklander DC, Saunders LD, Quinney HA, Macnab RB. Epidemiology of recreational and old-timer ice hockey injuries. *Clin J Sport Med.* 1996;6:15-21.
11. Watson RC, Singer CD, Sproule JR. Checking from behind in ice hockey: a study of injury and penalty data in the Ontario University Athletic Association Hockey League. *Clin J Sport Med.* 1996;6:108-111.
12. Pashby T. Eye injuries in Canadian amateur hockey. *Can J Ophthalmol.* 1985;20:2-4.
13. Pashby T. Eye injuries in Canadian amateur hockey: still a concern. *Can J Ophthalmol.* 1987;22:293-296.
14. Pashby T. Eye protection in ice hockey: an historical review. In: Castaldi CR, Bishop PJ, Hoerner EF, eds. *Safety in Ice Hockey.* Philadelphia, Pa: American Society for Testing and Materials; 1993:159-163.
15. Brukner P. Sport medicine: concussion. *Aust Fam Physician.* 1996;25:1445-1448.
16. Cantu RC. Cerebral concussion in sport: management and prevention. *Sports Med.* 1992;14:64-74.
17. Tator C. Spinal injuries due to hockey. *CMAJ.* 1982;127:1077.
18. Tator CH, Ekong CEU, Rowed DW, Schwartz ML, Edmonds VE, Cooper PW. Spinal injuries due to hockey. *Can J Neurol Sci.* 1984;11:34-41.
19. Tator CH, Edmonds VE, Lapczak L, Tator IB. Spinal injuries in ice hockey players, 1966-1987. *Can J Surg.* 1991;34:63-69.
20. Tator CH, Carson JD, Edmonds VE. New spinal injuries in hockey. *Clin J Sport Med.* 1997;7:17-21.
21. Meeuwisse WH, Love EJ. Development, implementation and validation of the Canadian intercollegiate sport injury registry. *Clin J Sport Med.* 1998;8:164-177.
22. Miettinen O. Estimability and estimation in case-referent studies. *Am J Epidemiol.* 1976;103:226-235.
23. Kleinbaum DG, Kupper LL, Morgenstern H. *Epidemiologic Research: Principles and Methods.* New York, NY: Van Nostrand Reinhold; 1982.
24. LaPrade RF, Burnett QM, Zazour R, Moss R. The effect of the mandatory use of face masks on facial lacerations and head and neck injuries in ice hockey: a prospective study. *Am J Sports Med.* 1995;23:773-775.
25. Bishop P, Norman R, Wells R, Ranney D, Skleryk B. Changes in the center of mass and moment of inertia of a head form induced by a hockey helmet and face shield. *Can J Appl Sport Sci.* 1983;8:19-25.
26. Smith AW, Bishop PJ, Wells RP. Alterations in head dynamics with the addition of a hockey helmet and face shield under inertial loading. *Can J Appl Sport Sci.* 1985;10:68-74.
27. Walsh S. A proposal for the use of the half face, clear plastic visor for national collegiate athletic association hockey. In: Castaldi CR, Hoerner EF, eds. *Safety in Ice Hockey.* Philadelphia, Pa: American Society for Testing and Materials; 1989:55-57.