

Concussion Knowledge among Medical Students and Neurology/Neurosurgery Residents

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ABSTRACT: Background and Objectives: Concussion is a prevalent brain injury in the community. While primary prevention strategies need to be enhanced, it is also important to diagnose and treat concussions expertly and expeditiously to prevent serious complications that may be life-threatening or long lasting. Therefore, physicians should be knowledgeable about the diagnosis and management of concussions. The present study assesses Ontario medical students' and residents' knowledge of concussion management. **Methods:** A survey to assess the knowledge and awareness of the diagnosis and treatment of concussions was developed and administered to graduating medical students (n = 222) and neurology and neurosurgery residents (n = 80) at the University of Toronto. **Results:** Residents answered correctly significantly more of the questions regarding the diagnosis and management of concussions than the medical students (mean = 5.8 vs 4.1, t = 4.48, p < 0.01). Gender, participation in sports, and personal concussion history were not predictive of the number of questions answered correctly. Several knowledge gaps were identified in the sample population as a whole. Approximately half of the medical students and residents did not recognize chronic traumatic encephalopathy (n = 36) or the second impact syndrome (n = 44) as possible consequences of repetitive concussions. Twenty-four percent of the medical students (n = 18) did not think that "every concussed individual should see a physician" as part of management. **Conclusions:** A significant number of medical students and residents have incomplete knowledge about concussion diagnosis and management. This should be addressed by targeting this population during undergraduate medical education.

RÉSUMÉ: Les connaissances sur la commotion cérébrale chez les étudiants en médecine et les résidents en neurologie/neurochirurgie. Contexte et objectifs : La commotion cérébrale est un traumatisme cérébral relativement fréquent. Non seulement les stratégies de prévention doivent-elles être renforcées, mais encore il est important de diagnostiquer et de traiter rapidement et adéquatement la commotion cérébrale afin de prévenir les complications sérieuses qui peuvent mettre la vie en danger ou avoir des répercussions à long terme. Les médecins doivent donc savoir en poser le diagnostic et la traiter. Cette étude évalue les connaissances des étudiants et des résidents en médecine en Ontario. **Méthode :** nous avons procédé à une enquête auprès des finissants en médecine (n = 222) et des résidents en neurologie et en neurochirurgie (n = 80) de l'Université de Toronto pour évaluer leurs connaissances sur le diagnostic et le traitement de la commotion cérébrale. **Résultats :** Les résidents ont répondu correctement à un plus grand nombre de questions sur le diagnostic et le traitement de la commotion cérébrale que les étudiants en médecine et la différence entre ces deux groupes était significative au point de vue statistique (moyenne = 5,8 vs 4,1; t = 4,48; p < 0,01). Le sexe, la participation à des sports et une histoire personnelle de commotion cérébrale n'étaient pas des facteurs de prédiction du nombre de bonnes réponses. Nous avons identifié plusieurs lacunes dans les connaissances des répondants en général. Environ la moitié des étudiants en médecine et des résidents ne savaient pas reconnaître l'encéphalopathie traumatique chronique (n = 36) ou le syndrome du second impact (n = 44) comme conséquences de commotions cérébrales répétées. Vingt-quatre pour cent des étudiants en médecine (n = 18) ne pensaient pas que « chaque individu qui a subi une commotion cérébrale devrait être examiné par un médecin ». **Conclusions :** Un nombre important d'étudiants en médecine et de résidents manquent de connaissances sur le diagnostic et le traitement de la commotion cérébrale. Cette lacune devrait être comblée au cours du premier cycle des études en médecine.

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Concussion is a prevalent brain injury in the community that is currently drawing much attention from the medical, legal, and media communities¹⁻⁴. In 2000, there were 11,068 reported head injuries in public schools in Ontario, of which 1861 were concussions⁵. The Center for Disease Control and Prevention estimates that up to 75% of the 1.5 million traumatic brain injuries in the United States each year are concussions⁶. Brain injuries including concussions often occur in children and young adults – such as athletes – and therefore have the potential to cause substantial quality of life years lost⁷⁻⁹.

With the high prevalence of concussion, every physician is likely to be called upon to manage a concussion at least once in

his/her career¹⁰. Unfortunately, there is no Class I evidence to guide clinical decision making¹¹, and therefore, how concussions will be managed by a physician is dependent on his/her knowledge of current guidelines such as the consensus statement

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from the International Conference on Concussion in Sport in Zurich in 2008⁷. It has previously been shown that there are several misconceptions about concussion among the public and health care professionals, such as the mistaken requirement for loss of consciousness^{4,12-14}.

Most individuals who have a concussion have an excellent prognosis; but, in some cases, the recovery from a concussive injury does not follow the typical progressive improvement¹⁵. There are a variety of circumstances in which there is an increased risk of prolonged morbidity associated with a concussion, including: repeated concussions occurring with progressively less impact force; slower recovery after each successive concussion; repeated concussions over a short time; and concussions with very prolonged time to recovery, or incomplete recovery. All of these should raise the concern of clinicians to the possible development of catastrophic or long-term sequelae³. One acute catastrophic sequel of concussion is the second impact syndrome which may be fatal^{16,17}. Serious long-term sequelae include post-concussion syndrome and chronic traumatic encephalopathy which can be severely disabling^{18,19}.

Physicians need to be well equipped with the knowledge of how to assess whether or not a concussion has occurred, how to minimize the burden of injury, and how to prevent the development of long-term sequelae¹⁰. Currently, it is strongly recommended that all concussed individuals should seek medical attention^{7,20}. The knowledge and awareness about concussion by the physician is an important factor in the secondary prevention of post-concussive sequelae by insuring that signs of concussive brain injury are recognized, that symptoms are monitored, and that second blows to the head before full recovery and premature return-to-activity are avoided.

Previous studies have assessed the awareness about concussions of coaches, the public and athletic trainers^{4,13,14}. However, knowledge of concussions among medical students and neurology and neurosurgery residents has not been previously studied in Canada. Paediatric residency programs in the United States were studied in 2003 and concluded that 24% of the programs did not include formal teaching about concussions in their curriculum²¹. A study by Ryu et al²² published in this journal suggested that mild traumatic brain injuries (mTBI) - of which concussion is the most frequent type - are often missed entirely or given an incorrect diagnosis by physicians in Ontario emergency departments and family practice offices. Indeed, 124 of 876 mTBI in the study were missed and not correctly diagnosed by the physician²². The aim of the present study was to assess medical students' and neurology and neurosurgery residents' knowledge of concussions to identify learning needs that may exist. A secondary objective was to study whether there is a relationship between the student's gender, personal history of concussion, participation in sports and recreation, and knowledge of concussion. How medical students and residents learned about concussions, their preferences for methods to learn about the topic, and their perceived challenges were also studied.

METHODS

To assess the knowledge and attitude about concussions among medical trainees, we surveyed fourth year medical students and neurology and neurosurgery residents at the University of Toronto. Fourth year medical students were included in the study population as they are finishing undergraduate medical education within the year and would have already had most of the topic-specific didactic lectures and seminars. Also, the fourth year class would include medical students who will become a variety of specialists and not necessarily those with a subsequent career that would focus on brain injury. Residents in all years of the neurology and neurosurgery programs at the University of Toronto were included in the study population as it was expected that they are knowledgeable about concussion management, as brain injury is highly relevant to their field of practice. It should be noted that knowledge and attitude about concussion has not been previously studied among Canadian medical students and neurology and neurosurgery residents. Three-hundred and two surveys were sent via two consecutive emails (initial and reminder) to all fourth year medical students ($n = 222$) and neurology and neurosurgery residents ($n = 80$) enrolled at the University of Toronto during the latter part of the academic year of 2010-2011. Neurology and neurosurgery residents in all years of the program, including fellowships, were included in the study population. Of the 302 surveys, 222 went to fourth year medical students, 44 to neurology residents, and 36 to neurosurgery residents. All responses were anonymous. The study received ethics approval from a Designated Ethics Research Committee of the University of Toronto.

The authors developed a 25-item survey (see Appendix) through literature review, expert review and pilot testing to assess medical trainee's knowledge of concussion, sources of information, learning needs, and educational preferences on this topic. The survey was hosted by SurveyMonkey.com (Menlo Park, CA). The survey consisted of three sections: section one contained eight questions on demographic data, medical education, and lifestyle; section two included nine questions to assess knowledge of concussion definitions and management; and section three asked questions on past learning experiences on the topic and preferred learning formats.

The first eight questions focused on demographic data including the following: program and place of study, gender, participation in sports and recreation, and personal history of concussion. Of these eight items, two were adapted from the Canadian Community Health Survey 2001 by Statistics Canada²³ to quantify the respondent's participation in sports and recreation (see questions 5 and 6 in the appendix). Two questions regarding previous history of concussion were adapted from a questionnaire by ThinkFirst Canada²⁴ (see questions 7 and 8 in the appendix). Nine questions to assess knowledge of concussion definitions and management were designed by the authors to test the respondent's knowledge of the definitions and management considerations described in the 2008 Consensus Statement on Concussion in Sport 3rd International Conference on Concussion in Sport Held in Zurich³. Three questions tested the respondent's ability to correctly identify the definition of a concussion and to recognize that loss of consciousness is not a

required symptom of concussion¹¹ (see questions 9,10, and 11 in the appendix). Two questions tested the respondent's ability to correctly identify the symptoms of a concussion and the number of symptoms required to make the diagnosis of a concussion (see questions 12 and 13). Three questions asked the medical trainees to recognize the steps of management, red flags that may indicate an increased risk of post-concussive sequelae, and the potential long-term sequelae of concussion (see questions 15, 16, and 17). Finally, eight questions asked about past learning about concussions in the medical curriculum, sources used to look up information, preferred format for physician learning, self-rank of knowledge about concussions, and motivation to learn more about the topic (see questions 18 to 24). Lastly, an open-ended question asked the medical trainees what challenges, if any, they think physicians face when diagnosing and managing a patient with concussion (see question 25).

Questions 1-24 were analyzed quantitatively; question 25 was analyzed thematically. The themes were analyzed independently by two research team members. When appropriate, t-tests, Chi square tests, and linear regression were used to describe relationships between lifestyle, education background, and awareness of concussion management. For section two of the survey, a score from 0 to 9 was given for the nine knowledge based questions (see questions 9 to 17). Each question was marked as correct or incorrect, one point was given for a correct answer, and no partial marks were given. If a question required the respondent to "select all that apply", all the correct options must have been selected and none of the incorrect options to be given the one point. The only exception was that the option "age" was eliminated from question 8 as the question was unclear (see appendix question 8).

RESULTS

Of the 302 surveys emailed to the students and residents, 81 were returned (26.8% response rate); 52 surveys were returned from the medical students (23% response rate), 17 from the neurology residents (37% response rate), and eight from the neurosurgery residents (22% response rate). There were a proportionate number of surveys returned from males and females in the medical student and resident groups (see Table 1).

Of the neurology and neurosurgery residents who returned the survey, 17 attended universities in Canada for their undergraduate medical education (68%), and eight attended universities outside of Canada (32%). Of the residents who attended a university in Canada for their undergraduate medical education, the University of Toronto and Queens University were the most represented with 41% and 23% of the Canadian responses, respectively. Dalhousie University, University of Calgary, McGill University, University of Alberta, University of Saskatchewan and Sherbrooke University were also represented in the resident population.

The fourth year medical students scored an average 4.2 correct answers out of 9 questions in the knowledge section of the survey (standard deviation (SD) = 1.4, 95% confidence interval (CI) = 3.9, 4.5). The residents scored an average 5.8 out of 9 (SD = 1.7, 95%CI = 5.1, 6.8), and were significantly better than the medical students (two-tailed t-test, mean = 5.8 vs 4.1, $p < 0.01$). Gender, personal history of concussion, and time spent participating in sports and recreation were not significant factors in the knowledge score of the medical students or residents.

Table 1: Study Population and response rate

	Study Population*	Sample Population†	Response rate
Medical students	222	52	23%
Female	126	34	27%
Male	96	18	19%
All Residents ‡	80	25	31.3%
Female	25	5	20%
Male	55	20	36.4%
Neurology residents	44	17	39%
Female	19	4	21%
Male	25	13	52%
Neurosurgery residents	36	8	22%
Female	6	1	17%
Male	30	7	23%
Total Medical Students and residents	302	77	25%
Female	151	39	26%
Male	151	38	25%

* Total number of students in the program, all emailed the survey

† Number of completed surveys

‡ Neurology and Neurosurgery residents

Residents were significantly more likely to have seen a patient with a concussion than the fourth year medical students (Yates corrected chi square, $p < 0.01$). However, previous experience of encountering a patient with a concussion in the acute or chronic phase was not a significant variable in the number of correct knowledge questions (two-tailed t-test, mean = 5 vs 4.3, $p = 0.055$).

While the average scores of 4.2 and 5.8 out of nine questions for students and residents, respectively, indicates knowledge gaps, there were also specific misconceptions. Approximately half the medical students and residents did not select chronic traumatic encephalopathy (48%, $n = 37$) or second impact syndrome (57%, $n = 44$) as possible consequences of repetitive concussive injury. When asked to select all points in the appropriate management of a concussion, 24% ($n = 18$) did not select "every concussed individual should see a physician". Twenty-four percent of the neurology and neurosurgery residents ($n = 6$) and 33% of the fourth year medical students ($n = 17$) think direct physical contact to the head is necessary to sustain a concussion. Three of the 52 fourth year medical students (6%) think concussions are not a brain injury as there is no abnormality seen on standard structural neuroimaging. Six percent ($n = 5$) thought a period of unconsciousness is necessary for the diagnosis of a concussion but 66% ($n = 52$) correctly identified that less than one third of all concussions involve loss of consciousness. The majority of the respondents (72% of the residents and 60% of the medical students) knew that it is only necessary to have one or more symptoms to diagnose a concussion.

Thirty-three percent ($n = 26$) of the respondents have had one or more concussions in the past, and 90 percent were sports or

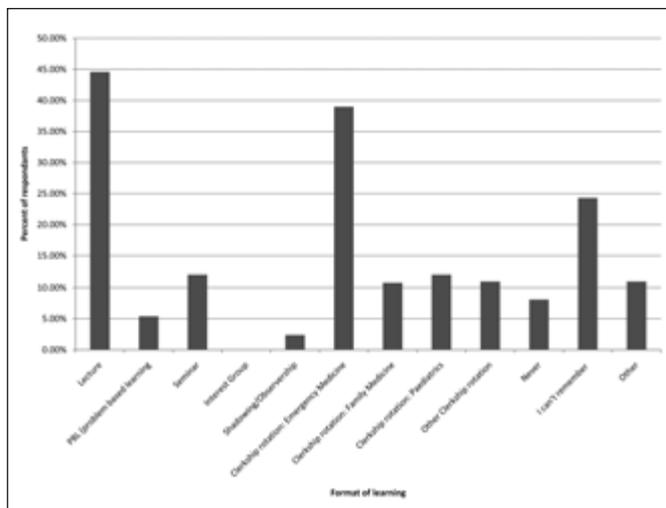


Figure 1: How respondents learned about concussions during their undergraduate medical education

recreation related. When asked how they learned about concussions in their undergraduate medical education, the two most frequent answers were lecture and emergency medicine rotation at 45% (n = 33) and 38% (n = 28) respectively (see Figure 1). Eight percent (n = 6) of the students and residents answered that they had never learned about concussions during their medical education (see Figure 1).

When asked what resource they would most likely use to find information about concussions, 66% (n = 49) answered that they would use Up-To-Date (22); 15% (n = 11) answered that they would use Pubmed. The subjects were also asked to select their preferred format of physician learning material from the options listed that included pamphlet, letter, workshop or seminar, lecture or informational email (see question 24). Thirty-three out of 76 (43%) indicated their preference for workshop or seminar and 34% (n = 26) indicated lecture. Letter was the least popular selection at 2.6 % (n = 2).

Despite the knowledge gaps about concussions, those who scored poorly were slightly more likely to rank their knowledge about concussions as low (linear regression, r = 0.44) (see Figure 2). This may suggest that they would recognize that their knowledge was deficient when confronted with a concussed patient and prompt them to look for evidence-based information.

The last question of the survey was an open-ended question that asked “what challenges, if any, do you think physicians face when diagnosing and managing a concussion?” The responses to this question were analyzed thematically; the themes were independently reviewed by two research team members, and five themes were developed from the data (see Table 2). Lack of physician and public knowledge and awareness of concussion, and the subtleties of the clinical diagnosis of concussion were the two themes that were most frequent.

DISCUSSION

The objective of this study was to investigate medical students’ and residents’ knowledge of concussion

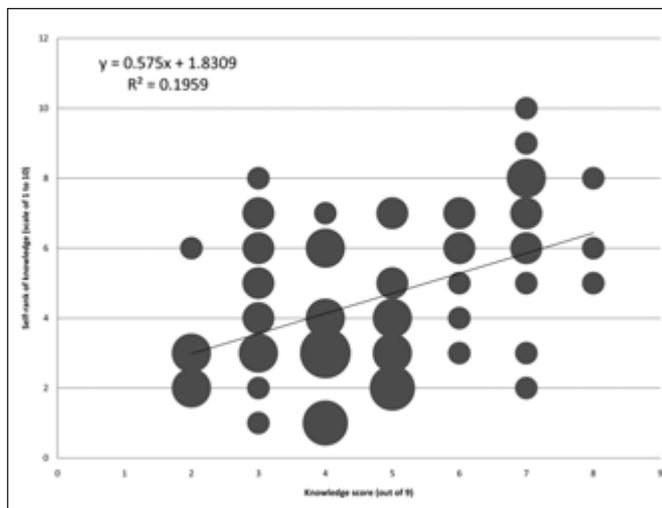


Figure 2: Relationship between self-rank of knowledge about concussions and knowledge assessment in the study survey. The area of the points is proportional to the number of respondents who plotted to the same coordinate.

symptomatology and management. The secondary objectives included determining if there is any association between the students’ and residents’ knowledge and their gender, participation in sports and recreation, exposure to concussions in medical education, and personal concussion history. Lastly, the learning needs of the medical students and residents were explored.

While residents answered significantly more questions correctly about the diagnosis and management of concussion

Table 2: Challenges faced by physicians when diagnosing and managing a concussion reported by medical students and residents

Theme	Representative quote
Pressure from athletes/coaches to return to play	“Discouraging athletes from returning to risky physical activity too soon” (is a challenge)
Lack of physician knowledge and awareness	“Little in medical curriculum since it is assumed that students know about this common condition” “Lack of physician awareness and education about consequences and outcomes”
Lack of public knowledge and awareness	“The fact that patients often don't come in to see you when they get a concussion, not understanding the severity of the injury”
Subtleties of the clinical diagnosis	“Initial non-specific symptoms with a suspicious history may present challenges in diagnosis” “Signs and symptoms are different in many people” “Not recognizing mild symptoms”
Lack of imaging findings	“Reliance on imaging for other reasons make(s) it difficult to diagnose without reassurance of medical imaging”

than the medical students, both groups lacked knowledge in specific areas. It is interesting to note that approximately half the students and residents did not recognize chronic traumatic encephalopathy or second impact syndrome as possible consequences of repetitive concussive injury. Both chronic traumatic encephalopathy and second impact syndrome have been previously described in the literature¹⁶⁻¹⁹ and are important factors in why return-to-play guidelines recommend against return to play while still symptomatic^{4,7}. Also, 24% (n = 18) did not think that “every concussed individual should see a physician” as part of appropriate management (see Appendix, question 15). This suggests many medical professionals do not think concussion is a serious injury that warrants management by a physician. This is troubling because examination by a health care professional is an essential step to ensuring safe management of concussion^{1,7}. Continuing efforts to educate physicians is vital to ensure they understand why and how patients with a possible concussion should be managed by a health care professional.

This survey describes a need for learning materials for new physicians that is not being fully met. Eight percent (n = 6) of the students and residents answered that they never learned about concussions during their undergraduate medical education and 24% (n = 18) could not remember if they have learned about concussions during their undergraduate medical education. As such, there is an opportunity to increase concussion awareness of graduating physicians by targeting them during undergraduate medical education and residency. The authors recommend that this be addressed by making curriculum changes to include specific teaching about concussions. This was recently instituted at the University of Toronto in the spring of 2011 after the completion of the present study, with the addition of a specific lecture about concussions during the first year of medical school. This survey identified that the preferred format of physician learning material is seminar, workshop or lecture (77%, n = 59) and the least preferred is a letter (2.6%, n = 2). This should be taken into consideration when planning continuing medical education. The present study also indicates the need to enhance knowledge of concussion among residents in training in neurology and neurosurgery, and it should be the responsibility of the relevant Royal College specialty committees to examine the need for action. It is highly likely, based on personal observation of the author CH Tator, that this need for enhanced concussion education is also present in other specialties involved in the care of concussed patients, especially family medicine, emergency medicine, and paediatrics.

It was of interest to note that the challenges about concussion identified by the students and residents included lack of knowledge and awareness about concussion on the part of the public and physicians. There are several attempts to rectify this being made by governmental organizations like the Centers for Disease Control in the United States²⁵ and by non-governmental agencies in Canada such as ThinkFirst²⁶, especially through websites. There should be greater attempts made to make the public and health care professionals aware of these readily available resources on concussion.

While this data is important to begin to understand the barriers and needs of physician understanding of concussion, the study has several limitations. The sample size is small (n=81,

27% response rate). It is possible that there was a selection bias and that our results cannot be generalized to the entire fourth year medical class and neurology and neurosurgery residents in Toronto or to other schools and provinces. Another important limitation is that the survey used to assess the knowledge of key management points was not previously validated. In order to ask questions that were up-to-date and relevant to this population, we did not use any of the previously validated surveys used to assess the knowledge of other populations, including the general public, athletes, and coaches because the questions were not specific enough to test the knowledge of concussion needed for physicians^{4,13,27}. Questions from previous surveys assessing the knowledge of primary care physicians and athletic trainers were not used as the questions focused on out-of-date guidelines such as the Colorado guidelines^{12,14,28}. However, these previous surveys were used as models for the development of the present survey.

Another limiting factor is that it is difficult to infer the clinical significance of the results, such as how the lack of knowledge demonstrated by this survey would impact the care and outcome of patients managed by these physicians. Also, it cannot be concluded that the respondents would actually do what they selected as the most appropriate management of concussions. However, the authors believe it is valuable to know what physicians think is the ideal management of concussions.

As this is the first study of medical students' and residents' understanding and awareness of concussion management in Canada, there are many opportunities to build upon this research. Next steps would include a larger study population and a design that could have a higher response rate. Only neurology and neurosurgery residents were included in this study; it would be important to expand the study to residents in family medicine and emergency medicine programs, who also treat many concussed patients. Also, differing methodologies could be used to confirm or refute the challenges that this study described. For example, focus groups could be used to build upon the themes described from our qualitative analysis of responses to the open-ended question.

We recommend that all medical schools ensure their students are exposed to specific teaching sessions about concussions in their undergraduate medical education. Lastly, as new educational opportunities are integrated into the curriculum, as is being done at University of Toronto, medical trainees' understanding before and after should be examined to study the effectiveness of such implementations.

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REFERENCES

1. Tator CH. Let's standardize the definition of concussion and get reliable incidence data. *Can J Neurol Sci.* 2009;36(4):405-6.
2. Engrossed Substitute House Bill 1824, 61st Legislature, 2009 Regular Session. (2009).

3. Tator CH. Concussions are brain injuries and should be taken seriously. *Can J Neurol Sci.* 2009;36(3):269-70.
4. Cusimano M. Canadian minor hockey participants' knowledge about concussion. *Can J Neurol Sci.* 2009;36(3):315-20.
5. Willer B, Dumas J, Hutson A, Leddy J. A population based investigation of head injuries and symptoms of concussion of children and adolescents in schools. *Inj Prev.* 2004;10:144-8.
6. Centers for Disease Control and Prevention (CDC), National Center for Injury Prevention and Control. Report to Congress on mild traumatic brain injury in the United States: steps to prevent a serious public health problem. Atlanta (GA): Centers for Disease Control and Prevention; 2003.
7. McCrory P, Meeuwisse W, Johnston K, et al. Consensus statement on concussion in sport 3rd international conference on concussion in sport held in Zurich, November 2008. *Clin J Sport Med.* 2009;19:185-200.
8. Tator CH. Brain injury is a major problem in Canada and annual incidence is not declining. *Can J Neurol Sci.* 2010;37(6):714-15.
9. Colantonio A, Saverino C, Zagorski B, et al. Hospitalizations and emergency department visits for TBI in Ontario. *Can J Neurol Sci.* 2010;37(6):783-90.
10. Ropper A, Gorson K. Concussion. *N Engl J Med.* 2007;356:166-72.
11. Practice parameter: the management of concussion in sports. Report of the Quality Standards Subcommittee. *Neurology.* 1997;48(3):581-5.
12. Bazarian J, Veenema T, Brayer A. Knowledge of concussion guidelines among practitioners caring for children. *Clin Pediatr.* 2001;40:207-12.
13. Guilmette T, Malia L, Mcguiggan M. Concussion understanding and management among New England high school football coaches. *Brain Inj.* 2007;21(10):1039-47.
14. Covassin T, Elbin R, Stiller-Ostrowski JL. Current sport-related concussion teaching and clinical practices of sports medicine professionals. *J Athl Train.* 2009;44(4):400-4.
15. King NS, Kirwilliam S. Permanent post-concussion symptoms after mild head injury. *Brain Inj.* 2001;25(5):462-70.
16. Cantu RC, Voy R. Second impact syndrome: a risk in any contact sport. *Phys Sportsmed.* 1995;23:27-34.
17. Wetjen N, Pichelmann M, Atkinson J. Second impact syndrome: concussion and second injury brain complications. *J Am Coll Surg.* 2010;211:553-7.
18. McQuillen J, McQuillen E, Morrow P. Trauma, sport, and malignant cerebral edema. *Am J Forensic Med Pathol.* 1988;9:12-15.
19. Gavett B, Stern R, McKee A. Chronic traumatic encephalopathy: a potential late effect of sport-related concussive and subconcussive head trauma. *Clin Sports Med.* 2010;30:179-88.
20. Zafonte R, Discussant DO. Diagnosis and management of sports-related concussion. *JAMA.* 2011;306(1):79-86.
21. Demorest RA, Bernhardt DT, Best TM, Landry GL. Pediatric residency education: is sports medicine getting its fair share? *Pediatrics.* 2005;115(1):28-33.
22. Ryu WHA, Feinstin A, Colantonio C, Streiner DL, Dawson DR. Early identification of mild TBI in Ontario. *Can J Neurol Sci.* 2009;36:429-35.
23. Statistics Canada [Internet]. Government of Canada [updated 2011 June 28; cited 2011 July 6]. Canadian Community Health Survey Questionnaire for Cycle 1.1. Government of Canada 2000. Available from: http://www.statcan.gc.ca/imdbbmdi/instrument/3226_Q1_V1-eng.pdf
24. Delaney J, Johnston K [Internet]. Toronto: ThinkFirst Canada [cited November 17 2010] ThinkFirst Concussion Questionnaire; [7 pages]. Available from: <http://www.thinkfirst.ca/downloads/concussion/concussion-Questionnaire.pdf>
25. CDC.org [Internet]. Atlanta: Centers for Disease Control and Prevention [updated 2011 September 9; cited 2011 September 10]. Available from: <http://www.cdc.gov/>
26. ThinkFirst.ca [Internet]. Toronto: ThinkFirst Canada [cited 2011 August 24]. Available from: <http://www.thinkfirst.ca>
27. Guilmette T, Paglia M. The public's misconceptions about traumatic brain injury: a follow up survey. *Arch Clin Neuropsychol.* 2004;19:183-9.
28. Ferrara M, McCrea M, Peterson C, Guskiewicz K. A survey of practice patterns in concussion assessment and management. *J Athl Train.* 2001;36:145-9.

Appendix: Survey

Part 1: ID questions and Sports and Recreation background:

1. What is your gender?
2. What medical school did you go to for undergraduate medical education? Residency?
3. What residency program and year are you in? (question only in survey to residents)
4. Have you done any of the following in the past 2 years? Mark all that apply.
Thirty-one options of sports and activities given, including the option "other"
5. Last week, how many times did you participate in sports or physical activity?
Options for 1 time to 7 times given
6. About how much time did you spend on each occasion?
Options: 1 to 15 minutes, 16 to 30 minutes, 31 to 60 minutes, More than one hour
7. In the past, have you ever suffered a concussion? You may have been "knocked out", knocked unconscious, confused, or had your "bell rung". You may have felt lightheaded, not known where you were, etc.
Options: Yes – once, Yes – 1-5 times, Yes – more than 5 times, No
8. If you answered yes to the previous question, how did your concussion(s) occur? Please select all that apply.
Options: Work related, Motor Vehicle Crash, Sport or recreational activity, Fall, Other

Part 2 Knowledge questions about concussions (Answers that were considered correct are in italic):

9. What is the definition of concussion? Select the best answer.
 - a. Loss of consciousness for <5 mins after an impact to the head
 - b. *A complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces*
 - c. A structural brain injury caused by mild traumatic force that transiently decreases cerebral blood flow
10. Is a concussion a brain injury? Select the best answer.
 - a. No, as there is no abnormality seen on standard structural neuroimaging
 - b. No, as symptoms are only psychological in nature
 - c. *Yes, as there is a functional disturbance that cannot be seen on standard neuroimaging*
 - d. Yes, as there is structural abnormality seen on standard neuroimaging
11. Which one of the following is true?
 - a. A period of unconsciousness is necessary for the diagnosis of a concussion
 - b. Over 2/3 of all concussions involve loss of consciousness (LOC)
 - c. 1/3 to 2/3 of all concussions involve loss of consciousness (LOC)
 - d. *Less than 1/3 of all concussions involve loss of consciousness (LOC)*
12. Which of the following is a sign or symptom of a concussion? Select all that apply.
Options: *Headache, Hemiparesis, Dizziness, Confusion, Fixed dilated pupil, Nausea and/or Vomiting, Vertigo, Amnesia, Tinnitus, Emotional or personality changes, Papilledema, Intention tremor, Fatigue, Temporary loss of consciousness, Prolonged coma*
13. How many symptoms of a concussion are required to diagnose a concussion?
Options: *One or more symptoms, three or more symptoms, five or more symptoms*
14. Which of the following is true regarding the mechanism of concussion?
 - a. Direct physical contact to the head is necessary to sustain a concussion
 - b. Localized damage to the brainstem is the cause a concussion
 - c. Localized damage to the prefrontal cortex is the cause of a concussion
 - d. Localized damage to the hippocampus is the cause of a concussion
 - e. *A whiplash effect to the brain caused by an impact to any part of the body may cause a concussion*
15. What is the appropriate management of concussion? Select all that apply
 - a. *Every concussed individual should see a physician*
 - b. A concussed player can return to play in the same game or practice if examined by a physician
 - c. *A stepwise increase in exercise and activity if symptomatic*
 - d. *Physical rest is always recommended after a concussion*

Appendix: Survey continued

- e. *Mental rest is always recommended after a concussion*
- f. *Signs and symptoms should be monitored for increasing severity*
- g. *Full neurological exam at initial assessment is recommended*
- h. *The standard mini mental status exam at initial assessment as an adequate cognitive test for concussion*
- i. *MRI of the brain is mandatory*
- j. *CT of the brain is mandatory*

16. What are some “red flags” that may predict the potential for more prolonged symptoms and may influence your investigation and management of concussion? Select all that apply

- a. *Nose bleed*
- b. *Prolonged loss of consciousness*
- c. *Number and duration of symptoms*
- d. *Age*
- e. *Repeated concussions occurring with progressively less impact force*
- f. *Slower recovery after each successive concussion*
- g. *Repeated concussions over time*
- h. *Concussions close together in time*
- i. *Being hit on the left side of the head*

17. What are the long term consequences of repetitive concussive injury? Select all that apply.

- a. *Dementia*
- b. *Depression*
- c. *Headaches*
- d. *Increased risk of hemorrhagic stroke*
- e. *Death or disability with second concussion before recovery from a first concussion*
- f. *Increased risk of schizophrenia*
- g. *Prolonged fatigue*
- h. *Impairment of concentration and memory*
- i. *Parkinsonism*
- j. *Chronic traumatic encephalopathy*

Part 3 Learning needs about concussions:

18. In your undergraduate medical education, how did you learn about concussions? Select all that apply.

Options: Lecture, PBL (problem based learning), Seminar, Interest Group, Shadowing/Observership, Clerkship rotation: ER, Clerkship rotation: Family Medicine, Clerkship rotation: Paediatrics, Other Clerkship rotation, Other, Never, I can't remember

19. In your residency to date, how did you learn about concussions? Select all that apply.

Options: Clinical experience, Self-study, Lecture, Never, I can't remember, Other

20. To date, have you seen a patient with:

concussion in the acute phase? Yes, No, I don't know (select one)

post-concussive syndrome? Yes, No, I don't know (select one)

21. How would you self-rank your knowledge about concussions?

Inadequate Completely adequate

1 2 3 4 5 6 7 8 9 10

22. What resource would you most likely use to find information about concussions?

Options: Google, Wikipedia, Up-to-date, Textbook, Pubmed, an agency website, Thinkfirst.ca, other

23. Are concussions something you want to learn more about as part of your medical curriculum?

Not at all Very much

1 2 3 4 5 6 7 8 9 10

24. What is your preferred format for physician learning material?

Options: Pamphlet, letter, seminar or workshop, lecture, informational email

25. What challenges, if any, do you think physicians face when diagnosing and managing a concussion?