

Concussion knowledge among Sport Chiropractic Fellows from the Royal College of Chiropractic Sports Sciences (Canada)

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Objectives: The objective of this study was to investigate the degree of knowledge that sports chiropractors have in regard to concussion diagnosis and management.

Methods: A concussion knowledge survey was administered to Sport Chiropractic Fellows of the Royal College of Chiropractic Sports Sciences – Canada (RCCSS(C)) (n=44) via SurveyMonkey.com.

Results: Sports chiropractors scored statistically higher on the survey when compared to chiropractic residents (mean =5.57 vs. 5.25; t=2.12; p=0.04) and to fourth year chiropractic interns (mean = 5.57 vs 5.2; t=2.45; p=0.02). Additionally, with our modified scoring, the sports chiropractors scored 85.3%. A few knowledge gaps were identified in the sample population.

Conclusion: Sports chiropractors demonstrated the skills and knowledge to diagnose concussion and excel at identifying the definition and mechanism of

Objectif : Cette étude visait à examiner le degré de connaissance des chiropraticiens du sport sur le diagnostic et le traitement de la commotion.

Méthodologie : On a mené un sondage sur les connaissances sur la commotion auprès des chiropraticiens du sport associés du Royal College of Chiropratique Sports Sciences – Canada (RCCSS(C)) (n = 44) via SurveyMonkey.com.

Résultats : Le score des chiropraticiens du sport était statistiquement plus élevé que celui des résidents en chiropratique (moyenne = 5,57 c. 5,25; t = 2,12; p = 0,04) et celui des internes de quatrième année du programme d'étude en chiropratique (moyenne = 5.57 c. 5.2; t = 2,45; p = 0,02). Par ailleurs, en utilisant notre méthode de cotation modifiée, on a obtenu un score de 85,3 % chez les chiropraticiens du sport. Quelques lacunes de connaissances ont été observées dans la population dans l'échantillon de population.

Conclusion : Les chiropraticiens du sport possédaient les connaissances et les compétences nécessaires pour diagnostiquer la commotion et se distinguaient

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The authors have no declarations in the preparation of this manuscript.

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concussion, but knowledge gaps regarding diagnosis and management of concussion were found in the sample population.

(JCCA. 2017;61(3):239-252)

KEY WORDS: chiropractic, concussion, knowledge, specialist

en définissant la commotion et en expliquant son mécanisme. Mais des lacunes de connaissances sur le diagnostic et la prise en charge de la commotion ont été observées dans l'échantillon de population.

(JCCA. 2017;61(3):239-252)

MOTS CLÉS : chiropratique, commotion, connaissances, spécialiste

Introduction

Concussions are one of the most common types of brain injuries. This paper will be mainly focused on sport related concussions, which are defined broadly as representing the immediate and transient symptoms of traumatic brain injury (TBI).¹ It remains pertinent for concussion patients to be appropriately diagnosed, evaluated, and managed by a healthcare professional to determine whether or not it is safe for the patient to return to work, school, or play. The 2016 Berlin recommendations are currently accepted as the best protocol for practitioners when managing a patient with a concussion.¹

Evaluation Tools

After the 2016 Concussion in Sport Group (CISG) Consensus meeting, McCrory *et al.*¹ suggested revisions to the Sport Concussion Assessment Tool 3 (SCAT3)² and introduced the SCAT5 which provides a more complete clinical profile and comprehensive examination for the concussed athlete. Other tools of mention include the Acute Concussion Evaluation (ACE)³, the King-Devick Test (K-D Test)⁴, the Vestibular/Ocular Motor Screening Assessment (VOMS)⁵, variations of the SCAT3² such as the Sport Concussion Assessment Tool for children ages five to 12 years, third edition (Child-SCAT3)⁶, and the Pocket Concussion Recognition Tool (CRT)⁷.

Consensus on a universal concussion protocol and guideline for health practitioners is always evolving as research is still emerging. Currently, the leading authority on current best practice recommendations on the diagnosis and management of concussion is the 2016 Berlin SCAT5 recommendations.¹ Previous to these recommendations the SCAT3² served as a guideline tool for practitioners.

Chiropractors are among the health practitioners that may evaluate, diagnose and manage concussed individuals. Chiropractors receive theoretical and practical training in concussion management with an aim to safely and competently perform physical examination, diagnosis and treatment of these conditions.⁸ The undergraduate program at the Canadian Memorial Chiropractic College (CMCC) touches upon concussion management within the first-year orthopaedics course, second-year neuroscience course, and is studied more thoroughly in third-year.⁸ Furthermore, the chiropractic sports residency program studies concussion in greater detail in the first responder's course and with an additional six hours of lecture on the topic. In addition to this, chiropractic sports residents gain practical experience with concussion management as a part of their sports placement where they are required to act as team chiropractor and first aid provider on average of once per month in their first and second year of the residency program.⁹

Currently, chiropractors are not readily recognized to be at the forefront for diagnosing concussions. However, Crawford¹⁰ claims that after emergency physicians, chiropractors may be the health care profession that sees the next highest number of concussion patients after a motor vehicle accident. As well, Johnson *et al.*¹¹ suggest that chiropractors may actually be the first to interact with an athlete who has sustained a concussion, often because patients are seeking treatment to alleviate symptoms associated with post-concussion syndrome.

Research that has examined the knowledge of concussions among medical students and medical residents in Canada¹² and among chiropractic students, chiropractic residents¹³ and those with chiropractic fellowships is nascent. The purpose of this study is to investigate the degree

of knowledge that sports chiropractors have in regard to concussion diagnosis and management, and to identify any knowledge gaps.

Methods

Boggild and Tator¹² developed a 25-item survey tool using literature review, expert review and pilot testing to assess the knowledge, awareness and attitudes of medical trainees about concussion and its management. They administered the survey tool to fourth year medical students and neurosurgery residents via SurveyMonkey.com. The survey also asked about sources of information, learning needs and education preferences on the topic of concussion. With permission of the original authors, a similar survey was distributed via email (linked to SurveyMonkey.com) by Kazemi *et al.*¹³ to fourth year chiropractic interns and chiropractic residents studying at Canadian Memorial Chiropractic College in the summer of 2014. In November 2015, a similar survey was distributed via email (linked to SurveyMonkey.com) at The Annual Sports Conference of The Royal College of Chiropractic Sports Sciences (Canada) (RCCSS(C)) in Toronto, ON. Additionally, the survey was sent out through the RCCSS(C) email listserv to registered sport chiropractic fellows. This survey was directed at fellows who had completed the RCCSS(C) Sports Sciences Residency Program (SSRP) with the designation FRCCSS(C) (n = 99). The sample size was limited to the number of sport chiropractic fellows who currently have an email registered with the RCCSS(C).

All responses were recorded anonymously and completion was assessed through the survey software. The original survey from Boggild and Tator¹² was modified in Part 1 and Part 3 so that questions could be properly framed to the sport chiropractic community instead of medical students (See Appendices A and B to see the modified and original surveys). The study received ethical approval from a designated Ethics Research Committee at the CMCC.

The survey sent out consisted of three parts. Part 1 involved eleven questions pertaining to demographic data, as well as chiropractic education and lifestyle. Part 2 contained nine questions to assess knowledge of concussion definitions and management. The questions were designed by Boggild and Tator¹² to test respondents' knowledge of definitions and management considerations as described

Table 1.
Proportion of male and female sports chiropractors.

	Study Population	Sample Population	Response Rate
Sports chiropractors	99	44	44.4%
Male	79	36	45.6%
Female	20	8	40.0%

in the conference on concussion in sport held in Zurich in 2008¹⁴. Lastly, Part 3 asked ten questions based on past learning experiences on the topic and preferred learning formats.

The data involving the knowledge of concussion definitions and management considerations collected from Part 2 involved nine questions to assess three areas of interest. The first three of nine questions assessed the respondents' ability to correctly identify the definition of a concussion and to recognize that loss of consciousness is not a required symptom of concussion. The next three questions tested the respondents' ability to correctly identify the symptoms of a concussion, the number of symptoms required to make a diagnosis of a concussion and the mechanism of injury. The last three questions tested the respondents' ability 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. After evaluation of this section, a score from 0 to 9 was recorded for each participant reflecting the number of correct answers out of nine.

Similar to the Boggild and Tator¹² study, each question in this survey was marked as either correct or incorrect. A score of one point was given to a correct answer and no point was given to incorrect answers. No partial points were given. If a question required a respondent to "select all that apply", all the correct options were required to be selected and none of the incorrect options could be selected in order to be given the one point. Additionally, to account for true knowledge of concussion we also scored the results individually by total correct answers (out of 35), excluding "Age" from Question 16.

Survey results were analyzed using IBM SPSS software.¹⁵ Descriptive statistics were used to summarize the

Table 2.
Concussion Knowledge Survey Results (correct selections in bold)
 Section 1 (Q13-15,18): Definition and mechanism of concussion.

Questions	Answer Choices	Correct Responses
Q13.	What is the definition of concussion? Select the best answer. <ul style="list-style-type: none"> • A complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces • Loss of consciousness for <5 mins after an impact to the head • A structural brain injury caused by mild traumatic force that transiently decreases cerebral blood flow 	95.50%
Question 13 Total		95.50%
Q14.	Is a concussion a brain injury? Select the best answer. <ul style="list-style-type: none"> • Yes, as there is a functional disturbance that cannot be seen on standard neuroimaging • No, as there is no abnormality seen on standard structural neuroimaging • No, as symptoms are only psychological in nature • Yes, as there is structural abnormality seen on standard neuroimaging 	93.20%
Question 14 Total		93.20%
Q15.	Which one of the following is true? <ul style="list-style-type: none"> • Less than 1/3 of all concussions involve loss of consciousness (LOC) • A period of unconsciousness is necessary for the diagnosis of a concussion • Over 2/3 of all concussions involve loss of consciousness (LOC) • 1/3 to 2/3 of all concussions involve loss of consciousness (LOC) 	95.50%
Question 15 Total		95.50%
Q18.	Which of the following is true regarding the mechanism of concussion? Select the best answer. <ul style="list-style-type: none"> • A whiplash effect to the brain caused by an impact to any part of the body may cause a concussion • Direct physical contact to the head is necessary to sustain a concussion • Localized damage to the brainstem is the cause a concussion • Localized damage to the prefrontal cortex is the cause of a concussion • Localized damage to the hippocampus is the cause of a concussion 	100.00%
Question 18 Total		100.00%

sample and any of the variables described in the outcome measurements. Where appropriate, Chi-square tests, T, and one-way ANOVA tests were used to assess the association of the variables of interest.

Results

A total of 99 surveys were emailed out to the sport chiropractic fellows (20 female, 79 male) from the Royal College of Chiropractic Sports Sciences – Canada (RCCSS(C)) in November 2015, of which a total of 49 surveys were returned, with five (5.05%) discarded due to incompleteness, yielding 44 completed surveys (response

rate 44.4%) (Table 1). Out of the 44 respondents, 32 attended CMCC to complete their sports residency program through the Royal College of Chiropractic Sports Sciences – Canada (RCCSS(C)) (72.7%), 12 attended colleges and universities outside of CMCC (27.3%). Of these 12 respondents, the colleges and universities attended included the Sports Sciences Residency Program (SSRP) through the RCCSS(C), the Field Practitioner Program (FPP) through the RCCSS(C), or the Canadian Chiropractic Sports Academy, which is now known as the Royal College of Chiropractic Sports Sciences – Canada.

In the concussion knowledge section of the survey,

sports chiropractors scored an average of 5.57 out of 9 (standard deviation (SD) = 1.0; 95% confidence interval (CI) = 5.25, 5.86). Gender ($t = 1.0$; $p = 0.32$; CI = -0.4, 1.18), personal concussion history ($t = -0.08$; $p = 0.93$; CI = -0.65, 0.60) and previous acutely concussed patient experience ($t = -1.65$; $p = 0.11$; CI = -2.15, 0.21), post concussive patient syndrome experience ($t = -0.08$; $p = 0.93$, CI = -0.65, 0.60) were not predictive of the number of questions answered correctly (two-tailed t-test). Additionally, there was no correlation between self-rating of concussion knowledge and survey concussion knowledge (Pearson correlation, $r = 0.24$, $p = 0.113$). In a previous study by Kazemi *et al.*¹³, the same survey was administered to fourth year chiropractic interns and to chiropractic residents at the CMCC in Toronto. In comparison between the three groups, sports chiropractors scored slightly higher than both chiropractic residents (mean = 5.57 vs. 5.25; $t = 2.12$; $p = 0.04$) and fourth year chiropractic interns (mean = 5.57 vs 5.2; $t = 2.45$; $p = 0.02$); which is statistically significant. Additionally, when the results were scored individually by total correct answers (excluding “Age” from Question 16), the average score of the respondents was 29.8 out of 35 or 85.3% (SD = 2.93, 95% CI = 28.9, 30.7).

With an average score of 5.57 out of nine questions, a few knowledge gaps could be identified. In the first section of the knowledge survey when asked about the definition and mechanism of concussion (questions 13, 14, 15, 18; see Appendix A), sports chiropractors scored exceptionally well. See Table 2 for results of Questions 13-15, and 18.

The second section of the knowledge survey included two questions (questions 16, 17; see Appendix A) that identified some knowledge gaps among the sample regarding diagnosing concussion. For question 16, based on original scoring system¹² in order to be given the point for this question, respondents had to correctly select all of the appropriate signs and symptoms out of the fifteen that were listed. See Table 3 for results to Questions 16-17.

The third section of the knowledge survey included items about management and “red flags” (questions 19, 20, 21, see Appendix A) which identified several knowledge gaps associated with concussion. The following rule applied to all the questions in this section: in order to be given a point for each question, respondents had to correctly choose all of the appropriate selections that were

Table 3.
Concussion Knowledge Survey Results
(correct selections in bold)
Section 2(Q16-17): Diagnosing concussion.

Questions	Answer Choices	Correct Responses
Q16.	Which of the following is a sign or symptom of concussion? Select all that apply.	
	• Headache	100.00%
	• Hemiparesis	90.91%
	• Dizziness	100.00%
	• Confusion	97.73%
	• Fixed dilated pupil	84.09%
	• Nausea and/or vomiting	100.00%
	• Vertigo	75.00%
	• Amnesia	93.18%
	• Tinnitus	75.00%
	• Emotional or personality changes	95.45%
	• Papilledema	90.91%
	• Intention tremor	88.64%
	• Fatigue	93.18%
	• Temporary loss of consciousness	93.18%
	• Prolonged coma	88.64%
Question 16 Total*		27.27%
Q17.	How many symptoms of a concussion are required to diagnose a concussion? Options:	
	• One or more symptoms	84.09%
	• Three or more symptoms	
	• Five or more symptoms	
Question 17 Total		84.09%
*All correct selections must have been made to be awarded the point (original scoring)		

listed. For question 20, the response option “age” was not included in the scoring as the wording was unclear; this selection was also excluded in the previous surveys.^{12,13} See Table 4 for results to Questions 19-21.

When asked about how the respondents learned about concussion during their residency program, 35 answered that they learned through small group (79.6%), 28 through clinical experience (63.6%), 35 through self-study (79.6%). Ninety-three percent of the sports chiropractors

Table 4.
Concussion Knowledge Survey Results (correct selections in bold)
 Section 3 (Q19-21): Management of concussion.

Questions	Answer Choices	Correct Responses
Q19.	What is the appropriate management of a concussion? Select all that apply.	
	<ul style="list-style-type: none"> • Every concussed individual should see a physician • A concussed player can return to play in the same game or practice if examined by a physician • A stepwise increase in exercise and activity if symptomatic • Physical rest is always recommended after a concussion • Mental rest is always recommended after a concussion • Signs and symptoms should be monitored for increased severity • Full neurological exam at initial assessment is recommended • The standard mini mental status exam at initial assessment as an adequate cognitive test for concussion • MRI of the brain is mandatory • CT of the brain is mandatory 	<p>54.55%</p> <p>100.00%</p> <p>45.45%</p> <p>93.18%</p> <p>93.18%</p> <p>97.73%</p> <p>93.18%</p> <p>63.64%</p> <p>97.73%</p> <p>100.00%</p>
	Question 19 Total*	11.36%
Q20.	What are some “red flags” that may predict the potential for more prolonged symptoms and may influence your investigation and management of concussion?	
	<ul style="list-style-type: none"> • Nose bleed • Prolonged loss of consciousness • Number and duration of symptoms • Age • Repeated concussions occurring with progressively less impact force • Slower recovery after each successive concussion • Repeated concussions over time • Concussions close together in time • Being hit on the left side of the head 	<p>75.00%</p> <p>88.64%</p> <p>77.27%</p> <p>52.27%</p> <p>95.45%</p> <p>90.91%</p> <p>95.45%</p> <p>90.91%</p> <p>97.73%</p>
	Question 20 Total*	43.18%
Q21.	What are the long-term consequences of repetitive concussive injury? Select all that apply.	
	<ul style="list-style-type: none"> • Dementia • Depression • Headaches • Increased risk of hemorrhagic stroke • Death or disability with second concussion before recovery from a first concussion • Increased risk of schizophrenia • Prolonged fatigue • Impairment of concentration and memory • Parkinsonism • Chronic traumatic encephalopathy 	<p>70.45%</p> <p>93.18%</p> <p>90.91%</p> <p>72.73%</p> <p>65.91%</p> <p>97.73%</p> <p>65.91%</p> <p>88.64%</p> <p>22.73%</p> <p>79.55%</p>
	Question 21 Total*	6.82%
*All correct selections must have been made to be awarded the point (original scoring)		

(n=41) answered that they have seen a concussed patient in the acute phase. Thirty-nine respondents (92.8%) said they have seen a patient with post-concussive syndrome, three (7.1%) said they had not, and two (4.5%) responded, "I don't know." Additionally, sports chiropractors were asked about which tools they have used in practice (see Figure 1).

When asked to self-rank themselves on a scale of 1-10 (with 1 being 'inadequate' and 10 being 'completely adequate') about their knowledge about concussions, the average ranking was 7.71 out of 10. When asked to rank themselves on a scale of 1-10 (with 1 being 'not at all' and 10 being 'very much') about whether concussions are something they want to learn more about as part of their continuing education, the average score was 8.27 out of 10. Finally, when asked about their preferred format for physician learning material, 37 preferred seminars (84.1%), 28 preferred lectures (63.6%), and 16 preferred informational emails (36.4%).

Discussion

The objective of this study was to investigate the degree of knowledge that sports chiropractors have in regard to concussion diagnosis and management, and to identify any knowledge gaps. Although the sample size for this study was small (n = 44 respondents, 20 females, 24 males), the response rate was fair (44.4%) from the pool of 99 emailed sports chiropractors. The total years in practice varied from as little as 0 to as many as 34 years, representing a diverse pool of participants. Half of the respondents reported suffering from a past concussion. Many of the chiropractors had learned about concussions through undergraduate curriculum, residency and clinical experience. Gender, personal concussion history and previous acutely concussed patient experience, and post concussive patient syndrome experience were not predictive of the number of questions answered correctly.

We compared our results with the previous study done by Kazemi *et al.*¹³ and found significant differences in mean knowledge between sports chiropractors and both chiropractic residents and chiropractic interns. In order to better understand the knowledge gaps in our survey, we analyzed each section of the survey separately as follows. In the first section of the knowledge survey, which asked respondents about the definition and mechanism of concussion, almost all of our respondents correctly de-

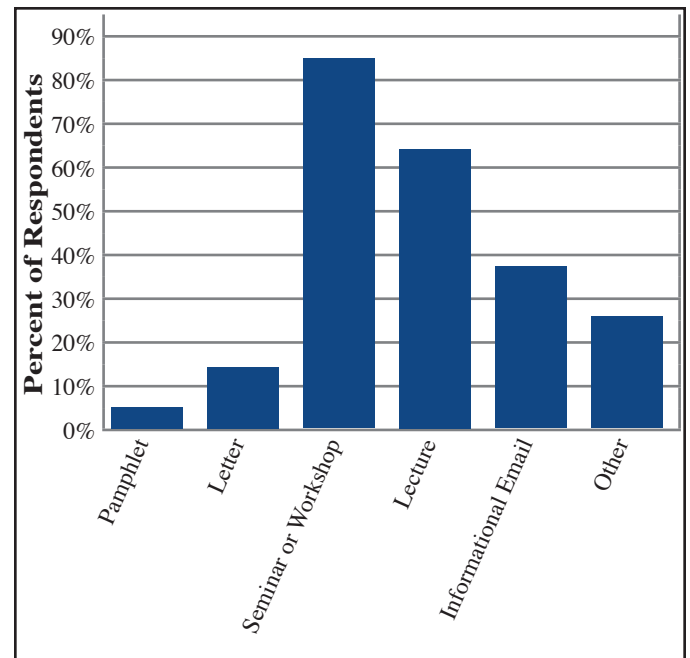


Figure 1.
Format of learning

finer what a concussion was, and that there was a functional disturbance that cannot be seen on standard neuroimaging. They were also able to identify that less than a third of all concussions involved loss of consciousness. All of our respondents correctly identified the mechanism of concussion. This finding suggests the chiropractic profession is capable of being a first line of care for concussed individuals. All of the sports chiropractors were able to correctly recognize that the mechanism of concussion involved a whiplash effect to the brain caused by an impact to any part of the body.

Based on original scoring¹² in the second section we asked respondents about the symptoms of concussion, we found the majority of respondents answered incorrectly in selecting the appropriate symptoms of concussion (total score 55.68%). However, based on the modified scoring system accounting for all correct answers they scored well at 81.97%. Sports chiropractors were able to identify more serious uncommon signs and symptoms that are affiliated with severe brain injury such as hemiparesis, fixed dilated pupil, papilledema, and prolonged coma. Only 75% of the respondents chose tinnitus and vertigo

correctly. Donaworth *et al.*¹⁶ using the same survey¹² in a unique mid-western top 50 medical school in USA surveyed 1st-4th year medical students also reported poor selection of these two symptoms (see Table 5). Although the subjects of Donaworth *et al.*¹⁶ are not comparable to subjects of the current study, it was included here for the lack of literature in this area. Possible explanations of these results are that perhaps the participants associated tinnitus as a result of direct injury to the structures of the internal and external ear. As for vertigo, the sports chiropractors may have considered that as a separate diagnosis rather than a symptom of concussion.

In the third section of the knowledge survey regarding the management of concussion, and based on original scoring, overall performance was poor (total score of 20.45%). Whereas the sports chiropractors scored decently (81.15%) based on the modified scoring system. All three questions in this section were multi-selection answer format in which most respondents were unable to select all the appropriate answers to gain a point according to the scoring scheme of Boggild and Tator¹². There were a few results that we found to be interesting, for example when participants were asked about the appropriate management of a concussion, forty-five percent of the responses did not select “every concussed individual should see a physician.” We believe this may be because the term physician could have been interpreted as ‘medical doctor’ versus a healthcare practitioner trained to manage concussions. This was similar to the result of Kazemi *et al.*¹³ for the same possible reason. With respect to the selection “a stepwise increase in exercise and activity if symptomatic,” almost half of the respondents did not correctly select this answer. We believe this might be due to the fact that there currently is no standardized methodology for practitioners to follow regarding return to exercise and activity after a concussion.

The largest knowledge gap was found when sports chiropractors were asked to select long-term consequences of repetitive concussive injury. Nearly three quarters of our respondents did not recognize parkinsonism symptoms as a result of prolonged concussive symptoms. These results are similar to a study done by Donaworth *et al.*¹⁶ where only 29.3% correctly selected parkinsonism. This may be a knowledge gap that has resulted either from research on parkinsonism and concussion being related is nascent or because much of the research on parkinsonism and sport

Table 5.
Percentage of responses to
“Which of the following is a sign or symptom of a
concussion? Select all that apply.”
(Correct responses are in bold)

Symptom	Current study – Sports Chiropractors	Donaworth 2016 – Medical Students ¹⁶
Headache	100.0%	96.6%
Hemiparesis	9.1%	11.8%
Dizziness	100.0%	94.3%
Confusion	97.7%	98.3%
Fixed dilated pupil	15.9%	22.6%
Nausea and/or vomiting	100.0%	86.5%
Vertigo	75.0%	44.8%
Amnesia	93.2%	73.1%
Tinnitus	75.0%	44.1%
Emotional or personality changes	95.5%	44.1%
Papilledema	9.1%	9.8%
Intention tremor	11.4%	9.1%
Fatigue	93.2%	57.2%
Temporary loss of consciousness	93.2%	94.3%
Prolonged coma	11.4%	12.1%

injuries was in the sports of boxing and wrestling. The term chronic boxer’s encephalopathy, or chronic traumatic brain injury associated with boxing has been used to describe conditions that result from repeated concussive and sub-concussive blows to the head^{1,2}. Another possibility is the current education surrounding concussions is limited and needs to be further expanded and updated to include short-term and long-term results of prolonged symptoms after sustaining concussions. Finally, the respondents may have read the term “parkinsonism” as *Parkinson* and responded accordingly.

Additionally, we compared our results with the previous studies’ results that were published in the articles by Kazemi *et al.*¹³ Boggild and Tator¹², and Donaworth *et*

Table 6.
Concussion knowledge survey result comparison.

	Current study – Sports Chiropractors	Donaworth 2016 – Medical Students ¹⁶	Kazemi 2016 – Chiropractic Interns ¹³	Kazemi 2016 – Chiropractic Residents ¹³	Boggild 2012 – Medical Students ¹²	Boggild 2012 – Medical Residents ¹²
Mean Overall Score	5.57	NS	5.2	5.25	4.1	5.8
Correctly identified that less than 1/3 of all concussions involve LOC	95%	60%	75%	NS	66%	NS
Correctly identified that a whiplash effect to the brain caused by an impact to any part of the body may cause a concussion	100%	68%	100%	100%	*67%	*76%
Correctly answered that a concussion is a brain injury with no abnormalities on structural neuroimaging	93%	84%	98%	NS	94%	100%
Correctly identified that it is only necessary to have one or more symptoms to diagnose a concussion	84%	37%	64%	50%	60%	72%
Correctly recognized chronic traumatic encephalopathy as long-term consequences of repetitive concussive injury	80%	56%	50%	50%	52%	52%
Correctly recognized that second impact syndrome are consequences of recurrent concussions	95%	86%	43%	43%	43%	43%
Believed that not every concussed individual should see a physicians as appropriate management of concussion	55%	73%	64%	NS	76%	76%
Legend: NS– not explicitly stated in article. * – 33% of the fourth year medical students and 24% medical residents think direct physical contact to the head is necessary to sustain a concussion.						

*al.*¹⁶ (see Table 6). Overall, sports chiropractors responded better than the various groups on these individual questions with the exception of not believing that “every concussed individual should see a physician” which we have previously discussed possible reasons for this result. They were also slightly less inclined to correctly answer that “a concussion was a brain injury as there is a functional disturbance that cannot be seen on standard neuroimaging” in comparison to the other groups. However, it should be noted that not all the relevant data could be found in the previous studies for a complete comparison.

Among the respondents surveyed, most sports chiropractors have used at least one concussion assessment tool in practice. Of those surveyed, almost 80% have

used SCAT3. At the time of the survey the SCAT3 was the latest standardized tool that was developed to assist healthcare practitioners in the diagnosis of concussion. In comparison Lebrun *et al.*¹⁷ reported that only 34% of Canadian and 27% of American medical physicians used SCAT1 or SCAT2 at time of their study, which predated SCAT3. In addition, most sports chiropractors reported the use of SCAT2, SCAT1, Child-SCAT3, and CRT, instead of or in combination with the SCAT3. All of these assessment tools have been recognized worldwide as the most valid and reliable tools for concussion assessment. It is noted within the SCAT5¹ and SCAT3² that practitioners should use the tool with caution as an athlete may score normal but may still be concussed. Research has shown

subjects who have suffered a previous concussion are at a higher risk of suffering another^{1,2}. Therefore, it is important for practitioners to be able to diagnose a concussed individual in a timely manner.

In our opinion, one of the major shortcomings of Bog-gild and Tator¹² survey scoring is their requirement for choosing all right answers for multi-answer questions to get a point. As an alternative method to their scoring, we tried scoring Part 2 of the questionnaire (concussion knowledge) by giving a point for each correct selection. We believe that this method measures the level of knowl-edge better than the original way of attaining all correct answers per question to get a point. The average score of the respondents was 29.84 out of 35 or 85.26% (SD = 2.93, 95% CI = 28.97, 30.71). With this method of scor-ing, the sports chiropractors did well. It would be interest-ing to calculate the scores of the last two studies^{12,13} with this method for comparison.

Limitations

While this data is important to begin to understand the knowledge gaps that are present in the sports chiroprac-tors' understanding of concussion, the study has several limitations. The sample size was small (n = 44) which may present a limiting bias. However, it is important to note the total number of sports chiropractors in Canada registered under the RCCSS(C) was 99 at the time of this study. Additionally when comparing the sports chiroprac-tors (n = 44) to the chiropractic interns (n = 36) and chiro-practic residents (n = 8) the sample sizes were varied. Due to these differences, when statistically comparing the mean scores of the chiropractic residents to sports chiro-practors there was a violation of assumptions as the results would imply sports chiropractors did exceptionally well. Another limitation was that in a real life setting health practitioners would apply their knowledge of concussion through a thorough history and physical examination. This survey was constructed as a multiple choice question-naire; however, in a real life setting a sports chiropractor would apply his or her knowledge with clinical expertise instead of selecting all correct answers. This survey was based on 2008 Zurich Consensus statement on concus-sion¹⁴, although the knowledge with regards to diagnosis and management has not drastically changed the survey should be updated to reflect the current knowledge. With recent media coverage surrounding concussion, one can

assume the recent survey respondents were more likely to be exposed to concussion information outside of clinical practice. Therefore, this may have a “positive” effect on their results, thereby inflating the concussion knowledge results on this survey compared to the previous surveys.

Conclusion

As sports chiropractors are likely to see a concussed patient in their clinic, it is important that they are adept at recognizing, diagnosing and managing concussions. Overall the sports chiropractors performed well in the sur-vey. They were successfully able to identify a few knowl-edge gaps within concussion diagnosis and management. Further investigations should be conducted in order to produce a standardized guideline as best practice of con-cussion management and additional concussion curricula and/or workshops for chiropractors. In our sample, most sports chiropractors indicated they preferred to receive learning material in the following formats from most preferred to least: seminar or workshop, lecture, informa-tional email, and pamphlet. However, it should be further investigated as to what is the best delivery of such infor-mation to future and current chiropractors. Finally, this paper helps confirm the solid knowledge foundation that sports chiropractors have to be part of the collaborative healthcare environment required for concussion care in Canada.

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Appendix A.
Concussion Knowledge Among Sports Chiropractors Survey

1. Do you consent to participate in this study?
 - Yes
 - No
- Part 1:**
ID Questions and Sports/Recreation Background
2. What is your gender?
 - Male
 - Female
 - Other
 3. Where did you complete your undergraduate chiropractic degree?
 - Canadian Memorial Chiropractic College
 - University of Quebec at Trois-Rivières
 - Other (please specify)
 4. Where did you complete your sports residency program?
 - Canadian Memorial Chiropractic College
 - University of Quebec at Trois-Rivières
 - Other (please specify)
 5. Which residency program and year did you complete? Select all that apply.
 - Sports Science, Year 1
 - Sports Science, Year 2
 - Sports Science (Non-CMCC), Year 1
 - Sports Science (Non-CMCC), Year 2
 - Sports Science (Non-CMCC), Year 3
 - Clinical Science, Year 1
 - Clinical Science, Year 2
 - Diagnostic Imaging, Year 1
 - Diagnostic Imaging, Year 2
 - Diagnostic Imaging, Year 3
 - Other (please specify)
 6. How many years have you been in practice as a qualified Sports Chiropractor? Please type a numerical answer (in years).
 7. Have you done any of the following in the past 2 years? Select all that apply.

• Walking for exercise	• Wrestling
• Jogging or running	• Football
• Swimming	• Soccer
• Bicycling	• Equestrian
• Weight-training	• Inline skating
• Exercise class or aerobics	• Gymnastics
• Golfing	• Cheerleading
• Baseball or softball	• Trampoline
• Tennis or squash	• Diving
• Volleyball	• Rugby
• Basketball	• Skydiving
• Ice hockey or ice skating	• Mountain climbing
• Downhill skiing or snowboarding	• Martial arts
• Boxing or martial arts (judo/karate)	• ATV, motorcycle, automobile racing, or snowmobiling
	• Other (please specify)
 8. Last week, how many times did you participate in sports or physical activity?

• 0 times	• 5 times
• 1 time	• 6 times
• 2 times	• 7 times
• 3 times	• 8 or more times
• 4 times	
 9. About how much time did you spend on each occasion?
 - 0 minutes
 - 1 to 15 minutes
 - 16 to 30 minutes
 - 31 to 60 minutes
 - More than one hour
 10. In the past, have you ever suffered a concussion?
 - Yes
 - No
 - Prefer not to answer
 11. If you answered yes to the previous question, how did your concussion(s) occur? Please select all that apply.
 - Work related
 - Motor Vehicle Crash
 - Sport or recreational activity
 - Fall
 - Not applicable
 - Other (please specify)
 12. Which of the following signs and symptoms did you experience? Select all that apply.
 - Headache
 - Dizziness
 - Nausea
 - Feeling unsteady
 - Feeling “dinged” or “stunned” or “dazed”
 - Feeling like their “bell was rung”
 - Seeing stars or other visual disturbances
 - Ringing in the ears
 - Double vision
 - Simply “not feeling right”
 - Loss of consciousness or impaired consciousness
 - Poor coordination or balance
 - Easy distractibility and poor concentration
 - Slowness answering
 - Questions and following directions
 - Confusion
 - Amnesia
 - Disorientation
 - Poor concentration
 - Memory disturbance
 - Feeling of depression or moodiness
 - Vomiting
 - Looking “glassy eyed”
 - Photophobia
 - Slurred
 - Speech
 - Personality or behavior changes (including inappropriate playing behavior such as skating or running in the wrong direction) and significantly decreased performance or playing ability)
 - Other (please specify)

Part 2:
Knowledge Questions about Concussions

Correct answers in bold.

13. What is the definition of concussion? Select the best answer.
- Loss of consciousness for <5 minutes after an impact to the head
 - **A complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces**
 - A structural brain injury caused by mild traumatic force that transiently decreases cerebral blood flow.
14. Is a concussion a brain injury? Select the best answer.
- No, as there is no abnormality seen on standard structural neuroimaging
 - No, as symptoms are only psychological in nature
 - **Yes, as there is a functional disturbance that cannot be seen on standard neuroimaging**
 - Yes, as there is structural abnormality seen on standard neuroimaging
15. Which one of the following is true?
- A period of unconsciousness is necessary for the diagnosis of a concussion
 - Over 2/3 of all concussions involve loss of consciousness (LOC)
 - 1/3 to 2/3 of all concussions involve loss of consciousness (LOC)
 - **Less than 1/3 of all concussions involve loss of consciousness (LOC)**
16. Which of the following is a sign or symptom of concussion? Select all that apply.
- **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
17. 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
18. Which of the following is true regarding the mechanism of concussion? Select the best answer.
- Direct physical contact to the head is necessary to sustain a concussion
 - Localized damage to the brainstem is the cause of a concussion
 - Localized damage to the prefrontal cortex is the cause of a concussion
 - Localized damage to the hippocampus is the cause of a concussion
 - **A whiplash effect to the brain caused by an impact to any part of the body may cause a concussion**
19. What is the appropriate management of a concussion? Select all that apply.
- **Every concussed individual should see a physician**
 - A concussed player can return to play in the same game or practice if examined by a physician
 - **A stepwise increase in exercise and activity if symptomatic**
 - **Physical rest is always recommended after a concussion**
 - **Mental rest is always recommended after a concussion**
 - **Signs and symptoms should be monitored for increased severity**
 - **Full neurological exam at initial assessment is recommended**
 - The standard mini mental status exam at initial assessment as an adequate cognitive test for concussion
 - MRI of the brain is mandatory
 - CT of the brain is mandatory
20. 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.
- Nosebleed
 - **Prolonged loss of consciousness**
 - **Number and duration of symptoms**
 - **Age**
 - **Repeated concussions occurring with progressively less impact force**
 - **Slower recovery after each successive concussion**
 - **Repeated concussions over time**
 - **Concussions close together in time**
 - Being hit on the left side of the head
21. What are the long-term consequences of repetitive concussive injury? Select all that apply.
- **Dementia**
 - **Depression**
 - **Headaches**
 - Increased risk of hemorrhagic stroke
 - **Death or disability with second concussion before recovery from a first concussion**
 - Increased risk of schizophrenia
 - **Prolonged fatigue**
 - **Impairment of concentration and memory**
 - **Parkinsonism**
 - **Chronic traumatic encephalopathy**

Part 3:

Learning Needs About Concussions

22. In your undergraduate chiropractic education, how did you learn about concussions? Select all that apply.
- Lecture
 - Problem based learning (PBL)
 - Seminar
 - Interest Group
 - Shadowing/Observership
 - Self-study
 - Never
 - I can't remember
 - Other (please specify)
23. In your residency to program, how did you learn about concussions? Select all that apply.
- Small Group Discussion/Lecture
 - Clinical experience
 - Self-study
 - Never
 - I can't remember
 - Other (please specify)

24. To date, have you seen a patient with concussion in the acute phase? Select one.
 - Yes
 - No
 - I don't know
25. To date, have you seen a patient with post-concussive syndrome? Select one.
 - Yes
 - No
 - I don't know
26. What are the tools you have used in practice? Please Select all that apply.
 - Sport Concussion Assessment Tool (SCAT)
 - Sport Concussion Assessment Tool 2 (SCAT2)
 - Sport Concussion Assessment Tool 3 (SCAT3)
 - Sport Concussion Assessment Tool for children ages 5 to 12 years, 3rd Edition (Child-SCAT3)
 - Pocket Concussion Recognition Tool
 - Concussion Recognition Tool (CRT)
 - None of the above
 - Other (please specify)
27. On a scale of 1-10 (with 1 being 'inadequate' and 10 being 'completely adequate') how would you self rank your knowledge about concussions?
28. What resource would you most likely use to find information about concussions? Select all that apply.
 - Google
 - Wikipedia
 - UpToDate
 - Textbook
 - Pubmed
 - An agency website
 - Thinkfirst.ca
 - Other (please specify)
29. On a scale of 1-10 (with 1 being 'not at all' and 10 being 'very much') are concussions something you want to learn more about as part of your continuing education?
30. What is your preferred format for physician learning material? Select all that apply.
 - Pamphlet
 - Letter
 - Seminar or workshop
 - Lecture
 - Informational email.
 - Other (please specify)
31. What challenges, if any, do you think Sports Chiropractors face when diagnosing and managing a concussion. Please answer below.