

Concussion knowledge among North American chiropractors

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Objectives: *To investigate the degree of knowledge North American chiropractors have in regards to concussion diagnosis and management.*

Methods: *A Concussion Knowledge Assessment Tool (CKAT) survey was administered to North American chiropractors through SurveyMonkey.com. This survey was sent to all practicing members of the American Chiropractic Association (ACA) and Canadian Chiropractic Association (CCA).*

Results: *1321 surveys were completed and analyzed (response rate of 3.3%). The average score of the CKAT amongst North American Chiropractors was 4.82 out of 9. Using our modified scoring method, chiropractors scored 39.44 out of 48.*

Conclusions: *North American chiropractors who participated in this study demonstrated concussion knowledge and management using the CKAT tool.*

Connaissances des chiropraticiens nord-américains sur la commotion cérébrale

Objectifs : *Examiner le degré de connaissances des chiropraticiens nord-américains sur le diagnostic et la prise en charge de la commotion cérébrale.*

Méthodologie : *On a effectué un sondage sur l'outil d'évaluation des connaissances sur la commotion cérébrale auprès de chiropraticiens nord-américains par SurveyMonkey.com. Ce sondage a été envoyé à tous les membres en exercice de l'American Chiropractic Association (ACA) et de l'Association chiropratique canadienne (ACC).*

Résultats : *1 321 personnes ont répondu au questionnaire (taux de réponse de 3,3 %). Le score moyen obtenu chez les chiropraticiens nord-américains était de 4,82 sur 9. En utilisant notre méthode de notation modifiée, les chiropraticiens ont obtenu un score de 39,44 sur 48.*

Conclusions : *Les chiropraticiens nord-américains qui ont participé à cette étude ont montré qu'ils avaient des connaissances sur la commotion cérébrale et qu'ils utilisaient l'outil d'évaluation pour la prise en charge.*

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Further investigation is recommended in order to address learning gaps and updating the CKAT based on current literature and guidelines.

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KEY WORDS: chiropractic, concussion, diagnosis, knowledge, management, North America

Introduction

Harmon *et al.*¹ describe concussion as, "...a traumatic, transient disturbance of brain function that involves a complex pathophysiological process. Concussion is considered a subset of mild traumatic brain injury (mTBI) and a condition whose symptoms cannot be explained by drugs, alcohol, medication use or other injuries". This type of injury to the brain presents in an array of different symptoms, including headaches, irritability, drowsiness, dizziness, as well as neurological signs.² The expected recovery in the majority of adults (age 19 and above) is about two weeks, whereas in children (age 18 and under) it is about four weeks.² However, not all resolve in this way, and it is essential that chiropractors know how to manage these types of cases.

The research on chiropractors' knowledge of concussions is limited, however, research on the topic is ongoing. Kazemi, Bogumil and Vora³ found that sports chiropractors have the skills and knowledge to correctly manage concussion patients. Kazemi *et al.*⁴ also found that fourth year chiropractic interns and postgraduate chiropractic specialty college residents earned scores that are comparable to fourth year medical students and residents. The researchers noted that there are some knowledge gaps with both chiropractic and medical students when it comes to recognizing concussions.

Evaluation tools

Several methods are used to help recognize concussions in patients. In combination with a thorough history and physical examination, there are several diagnostic tests utilized for concussion recognition. The Glasgow Coma Scale (GCS) differentiates a mild traumatic brain injury

On recommande de poursuivre les recherches afin de combler les lacunes en matière d'apprentissage et de mettre à jour l'outil d'évaluation en fonction de la documentation et des lignes directrices actuelles.

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MOTS CLÉS : chiropratique, commotion cérébrale, diagnostic, connaissances, prise en charge, Amérique du Nord

from a severe traumatic brain injury and defines level of consciousness for all types of acute medical and trauma victims.^{2,5} The GCS score is only one component which may differentiate between TBI subtypes. The Head Injury Severity Scale (HISS) is based on the GCS and is used to grade severity of traumatic brain injuries, also including recommendations based on presence of confounding factors.^{2,5} The Sport Concussion Assessment Tool 5 (SCAT5) is a sideline concussion diagnostic tool used to determine whether a concussion occurred in an athlete aged 13 and above. It is a tool to aid in clinical decision-making regarding sideline concussion presentation. SCAT5 includes an immediate, on-field assessment of cognitive, neurological, and physical function. The SCAT5 was developed to include the GCS. For athletes 12 years old and below, the Child SCAT5 is used.⁶

Current best practice recommendations

Best practice guidelines for treating concussions revolves around initial relative rest from physical and cognitive activities to prevent further injury and prevent second impact syndrome.² However, complete bed rest and complete cognitive rest are not recommended.² After relative rest, an eventual return to activity plan comes into action to ensure that the affected patient can function normally without any concussion symptoms.^{2,5} Among medical professionals there is a noted variability in concussion treatment leading to a subpar treatment plan for concussion patients. Zemek *et al.*⁷ surveyed Canadian paediatric emergency doctors in regards to their knowledge and treatment of concussion. Despite 89% of these emergency physicians diagnosing 20+ concussions per year, only 64% of these physicians implemented proper return-to-

play guidelines.⁷ Cognitive rest from concentration activities which aggravate concussion symptoms was not prescribed as frequently as recommended per best practice guidelines.⁷

Health care practitioner education

It has been stated in the literature that there are gaps in knowledge in regards to concussions. This trend is seen in medical doctors, chiropractors, medical students and residents, chiropractic students and residents, physiotherapists, occupational therapists, athletic trainers, pediatricians and neurology and neurosurgery residents.^{3,4,7-10} Donaworth *et al.*¹¹ stated that many of the American medical students who took part in their survey reported never having any formal lectures about concussions. They also reported that they did not have adequate clinical experience dealing with concussions. This has resulted in an inability to recognize symptoms, diagnose and manage concussions effectively.¹¹ Interestingly, Burke *et al.*¹² surveyed Canadian medical schools in 2012 and found that only four schools out of the fourteen who participated in the survey included concussion related information in the curriculum. Six included information about general head injuries in the curriculum and four did not have any concussion information in the curriculum. Four medical schools did not participate in the study.¹² Mathieu, Ellis and Tator in a follow-up study of the same fourteen Canadian medical schools, received responses from 13 Canadian medical schools. Eleven of those 13 schools reported providing concussion-specific education and all 13 respondents offered head injury education which included a concussion component. Two Canadian medical schools as part of this study did not provide any training in concussion diagnosis, prognosis or management.¹³ Salisbury *et al.*¹⁰ surveyed concussion knowledge among 561 rehabilitation professionals including physiotherapists, occupational therapists and athletic trainers in America. They found that although these professionals were able to identify the basics of how concussions present, there was a large variability when it came to diagnosis, prognosis and recovery duration of a concussed patient, potentially leading to suboptimal care.^{10,13} Physiotherapists scored on average 63.7% (n=252), occupational therapists scored on average 57.4% (n=47) and athletic trainers scored on average 72.1% (n=112) correct responses for their survey. They did not use the concussion knowledge assessment

tool developed by Boggild and Tator⁹ for their study. Their survey was designed using information from the fourth International Conference on Concussion in Sport as well as from six neuropsychologists and a literature search on concussion. Their survey featured two sections totalling 20 questions clarifying the health care practitioner's experiences with concussion in the first section and knowledge on concussion diagnosis, treatment and recovery in the second section.¹⁴ Keenan, Bratton and Dixon¹⁵ surveyed pediatricians' understanding of concussion and found that many pediatricians were unaware of potential long-term consequences of concussion. Over one-third of pediatricians surveyed were unsure of possible attention difficulties as a result of complications from a concussion.¹⁵ They did not use the concussion knowledge assessment tool developed by Boggild and Tator⁹ for their survey. Boggild and Tator surveyed fourth year medical students, neurology and neurosurgery residents in 2010 using the original version of the CKAT they designed.⁹ They found that more than half of the residents sampled were not able to identify post-concussion syndrome and chronic traumatic encephalopathy as potential long-term consequences of concussion.⁹ Fourth year medical students scored on average 4.2 out of 9 whilst residents scored on average 5.8 out of 9 on the CKAT.⁹ Transfer of knowledge is necessary to fill this gap and improve correct diagnosis and management of concussions. To the authors' knowledge, there has not been any investigation into North American Chiropractors' level of concussion knowledge. As such, the aim of this study was to investigate the actual and self-ranked level of concussion knowledge with regards to diagnosis and management among North American chiropractors.

Methods

Study design

We conducted a cross-sectional study of all currently practicing North American chiropractors within the Canadian Chiropractic Association (CCA) and American Chiropractic Association (ACA), during the Spring of 2019. The CCA and ACA members received three emails over the month of March 2019.

Participants and recruitment

Three groups of participants were contacted for this study:

English speaking chiropractors who were members of the ACA, English speaking chiropractors who were members of the CCA and French speaking chiropractors who were members of the CCA. Participants were recruited via an email sent by ACA and CCA to their current practicing chiropractors. Participants were emailed a SurveyMonkey link that led to our survey. A total of 40,580 surveys were sent to the three groups of participants.

Measures

A 30-question survey originally created by Boggild and Tator⁹ which was modified for a chiropractic population by Kazemi *et al.*³ was uploaded to SurveyMonkey. The survey consisted of three sections. Section 1 consisted of eleven questions and collected information on demographic data of the participant, chiropractic education and lifestyle. Section 2 consisted of nine questions and collected information on concussion knowledge and management. Section 3 consisted of ten questions and collected information on past learning experiences on concussions and preferred learning formats.

Changes to the original survey by Boggild and Tator⁹ included modifications to the language used in the questions to make the survey more applicable to a chiropractic population.³ For example, question 2 was modified from originally asking, “what medical school...” to “what chiropractic college...”. Question 18, “what is the appropriate management of concussion? Select all that apply”, a response option was changed from “every concussed individual should see a physician” to “every concussed individual should see a healthcare professional”. Question 19, “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?”, response “age” was changed to “younger age” in order to avoid ambiguity. The complete questionnaire is available within Appendix 1.

The main outcome measure of interest from this survey came from the information collected in section 2; which measured the knowledge of concussion management of the participant- Concussion Knowledge Assessment Tool (CKAT). Original scoring of the CKAT as described by Boggild and Tator⁹ involves scoring section 2 from 0 to 9 with each question in section 2 being worth one point. Question 15, 18, 19 and 20 involves selecting the multiple correct answers and not selecting any

of the incorrect answers in order to be awarded a point for that question. For example, question 18 consists of ten possible responses with six of those being correct responses. In order to be awarded a correct response for that question, the six correct responses must be chosen and none of the incorrect responses can be chosen. For this study, an alternative scoring method was utilized where one point is possible for each of the compound questions. Responses are recorded as either correct or incorrect, the correct responses were then summed. This yielded a scoring range of 0 to 49, opposed to the original method of scoring 0 to 9. The revised method of scoring the CKAT is favorable as it shows fair test-retest reliability opposed to the original having poor test-retest reliability. Utilizing the old scoring method of 0 to 9 resulted in an intra-class correlation coefficient of test-retest reliability of 0.56 whilst the new scoring method of 0 to 49 yielded an intra-class correlation coefficient of test-retest reliability of 0.68 when comparing first year chiropractic students, fourth year chiropractic interns and sport chiropractic Fellows of the Royal College of Chiropractic Sports Sciences (Canada) [FRCCSS(C)].¹⁶ However, when implementing the Survey Monkey, question 12 which asks “Which of the following is a sign or symptom of a concussion? Select all that apply.”, vertigo and amnesia were set as one correct response instead of being separate correct answers. As such, our alternative scoring range became 0-48 instead of 0-49. Another measure from this survey, included in our study, was in section 3 where participants were asked to self-rank their knowledge about concussions on a scale of 0 to 10. In this instance with 0 representing inadequate and 10 representing completely adequate.

Analysis

Descriptive statistics were used to summarize the data. Counts and percentages were used for categorical variables and means and standard deviations were used for continuous variables. CKAT scores were quantified using boxplots, means and 95% confidence intervals (CI). Scatterplots and Pearson correlation coefficients (*r*) with 95% CI were utilized to compare participants self-reported rank of concussion knowledge to their CKAT score. CKAT data was collected to represent all North American chiropractors and to compare American trained chiropractors against Canadian trained chiropractors. The

analysis for this study was generated using SAS software v9.4.

Sample size

This study planned for all current practicing members of the ACA and CCA.

Ethics

The authors of this study were blinded to the names of the participants or any identifying information of the participants since the members were contacted by ACA and CCA via email. This study was approved by the research ethics board of Canadian Memorial Chiropractic College.

Results

A total of 40 580 surveys were emailed out to current practicing members of the ACA and CCA in March of 2019. 1321 completed surveys were returned yielding a 3.3% response rate. 1184 respondents were English speaking chiropractors and 118 respondents were French speaking chiropractors. 748 respondents graduated from American Chiropractic colleges and 573 respondents graduated from Canadian Chiropractic colleges. The average for concussion knowledge of North American chiropractors was 4.82 out of 9 on the original CKAT and 39.44 out of 48 on the revised CKAT.

In the concussion knowledge section of the survey, English speaking chiropractors scored an average of 4.88 standard deviation (SD = 1.20); 95% confidence interval (95% CI = 4.82-4.95) and an average of 39.54 (SD = 3.40; 95% CI = 39.35-39.73) for original and revised scoring respectively. English speaking chiropractors self-ranked their concussion knowledge an average of 6.29 out of 10, (SD = 1.87; 95% CI = 6.18-6.40). French speaking chiropractors scored an average of 4.18 (SD = 1.14; 95% CI = 3.98-4.39) and an average of 38.40 (SD = 3.40; 95% CI = 37.78-39.01) respectively. French speaking chiropractors self-ranked their concussion knowledge an average of 6.01 out of 10, (SD = 1.68; 95% CI = 5.70-6.31).

American educated chiropractors scored an average of 4.72 (SD = 1.22) and an average of 39.38 (SD = 3.37) respectively. American educated chiropractors self-ranked their concussion knowledge an average of 6.26 out of 10, (SD = 1.95). Canadian educated chiropractors scored an average of 4.65 (SD = 1.17) and an average of 39.33

Table 1.

Self ranking and scores of concussion knowledge by graduates of various chiropractic colleges across North America

School	N	Self-Rank (out of 10)		Original CKAT Scoring		Revised CKAT Scoring	
		Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
CMCC	578	6.21	1.80	4.97	1.17	39.58	3.39
Life	47	6.28	2.20	4.51	1.30	39.02	3.11
Logan	40	6.24	2.17	4.73	1.18	39.50	3.27
NYCC	68	5.98	1.86	4.57	1.07	39.38	2.93
NUHS	48	6.34	1.98	4.88	1.41	38.83	3.45
NWHSU	70	6.03	1.64	4.96	1.28	40.27	3.45
Palmer	155	6.41	1.90	4.74	1.19	38.90	3.79
Parker	36	6.51	2.08	4.61	1.20	39.36	3.34
UQTR	78	6.05	1.73	4.33	1.16	39.09	2.83
UWS	108	6.27	1.75	4.80	1.09	39.80	2.93

Legend: Canadian Memorial Chiropractic College (CMCC), New York Chiropractic College (NYCC), National University of Health Sciences (NUHS), Northwestern Health Science University (NWHSU), Université du Québec à Trois-Rivières (UQTR) and University of Western States (UWS)

(SD = 3.11). Canadian educated chiropractors self-ranked their concussion knowledge an average of 6.18 out of 10, (SD = 1.77). Male chiropractors scored an average of 4.87 (SD = 1.22; 95% CI = 4.8-5.0) and an average of 39.41 (SD = 3.56; 95% CI = 39.17-39.66). Whereas female chiropractors scored an average of 4.74 (SD = 1.19; 95% CI = 4.63-4.84) and an average of 39.48 (SD = 3.17; 95% CI = 39.20-39.75).

The chiropractic colleges which were a part of this study are as follows: Canadian Memorial Chiropractic College (CMCC), Life, Logan, New York Chiropractic College (NYCC), National University of Health Sciences (NUHS), Northwestern Health Science University (NWHSU), Palmer, Parker, Université du Québec à Trois-Rivières (UQTR) and University of Western States (UWS). Table 1 summarizes the self-rank and scoring for each school.

Higher education degrees for the purpose of this study

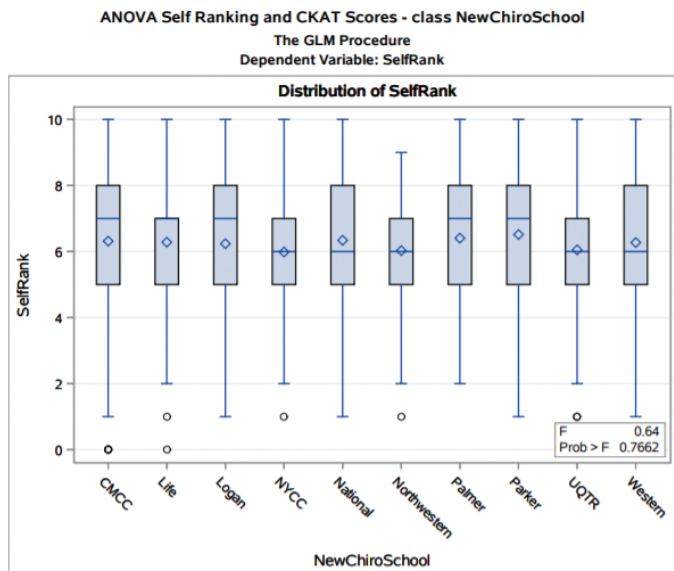


Figure 1.

Self-ranking of concussion knowledge by graduates of various chiropractic colleges across North America. Canadian Memorial Chiropractic College (CMCC), New York Chiropractic College (NYCC), National University of Health Sciences (National), Northwestern Health Science University (Northwestern), Université du Québec à Trois-Rivières (UQTR) and University of Western States (Western)

were limited to MSc and PhDs. Chiropractors of recognized residencies and Fellowships were also ranked in separate categories. Table 2 summarizes the concussion knowledge of chiropractors who completed higher education (MSc and PhDs), chiropractic residency and chiropractic Fellowship showing self-rank, original CKAT scoring and revised CKAT scoring. Chiropractors who completed a Fellowship in sport, rehabilitation, or neurology performed the best, scoring 5.24 (SD = 1.27) on the original scoring for the CKAT, 40.46 (SD = 3.27) on the revised scoring for the CKAT, and self-ranked their concussion knowledge an average of 7.63 out of 10, (SD = 1.59). The group that performed the poorest was chiropractors who were not complete Fellows, scoring 4.79 (SD = 1.20), 39.36 (SD = 3.43) on the revised scoring for the CKAT, and self-ranked their concussion knowledge an average of 6.15 out of 10, (SD = 1.85).

Table 3 summarizes North American Chiropractors'

Table 2.

Concussion knowledge of chiropractors who completed higher education (MSc and PhDs), chiropractic residency and chiropractic Fellowship.

Level of Education	Self-Rank (out of 10)		Original CKAT Scoring		Revised CKAT Scoring	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Higher Education (MSc, PhDs)	6.38	1.82	4.87	1.16	39.52	3.21
No Higher Education	6.25	1.86	4.81	1.21	39.42	3.44
Chiropractic Residents	6.76	2.03	4.92	1.26	39.88	2.57
No Chiropractic Residency	6.25	1.86	4.82	1.21	39.42	3.43
Chiropractic Fellows	7.07	1.77	5.05	1.25	39.93	3.30
No Chiropractic Fellowship	6.15	1.85	4.79	1.20	39.36	3.43
Chiropractic Fellows in Sport, Rehabilitation, or Neurology	7.63	1.59	5.24	1.27	40.46	3.27

Legend: CKAT Concussion Knowledge Assessment Tool, SD = Standard deviation

preferred methods of learning, showing self-rank, original CKAT scoring and revised CKAT scoring. Chiropractors who preferred pamphlet-based learning self-ranked the lowest with a mean of 5.83 out of 10, (SD = 1.56), whereas chiropractors who preferred seminars or workshops self-ranked the highest with a mean of 6.38 out of 10, (SD = 1.85). Chiropractors who preferred letters scored the lowest on the original and revised CKAT with a mean score of 4.07 (SD = 1.22) and 37.40 (SD = 5.89), respectively. Chiropractors who preferred seminars and workshops scored the highest on the original and revised CKAT with a mean score of 4.88 (SD = 1.22) and 39.57 (SD = 3.41), respectively.

Female chiropractors self-ranked their concussion knowledge an average of 6.02 out of 10, (SD = 1.87; 95% CI = 5.86-6.19) and scored an average of 4.74 (SD = 1.19; 95% CI = 4.63-4.84) and 39.48 (SD = 3.17; 95% CI = 39.20-39.75), whereas male chiropractors self-ranked their concussion knowledge an average of 6.42 out of 10, (SD = 1.84; 95% CI = 6.29-6.54) and scored an average of 4.87 (SD = 1.21; 95% CI = 4.79-4.96) and 39.41 (SD = 3.56; 95% CI = 39.17-39.66).

Those who participated in contact sports self-ranked

Table 3.

North American Chiropractors' preferred methods of learning – self-rank, original CKAT and revised CKAT scores

Preferred method of learning	N	Self-Rank (out of 10)		Original CKAT Scoring		Revised CKAT Scoring	
		Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Informational E-mail	190	5.93	1.82	4.71	1.17	39.16	3.18
Lecture	131	6.05	1.90	4.74	1.06	39.48	3.32
Letter	15	5.87	2.61	4.07	1.22	37.40	5.89
Pamphlet	30	5.83	1.56	4.20	1.10	38.10	3.46
Seminar or workshop	936	6.38	1.85	4.88	1.22	39.57	3.41

Legend: CKAT Concussion Knowledge Assessment Tool

their concussion knowledge higher than those who did not participate in contact sports. Non-contact sport participants self-ranked their concussion knowledge an average of 5.64 out of 10, (SD = 1.94; 95% CI = 1.74-2.2) and scored an average of 4.56 (SD = 1.21; 95% CI = 1.10-1.36) and 39.00 (SD = 4.17; 95% CI = 3.74-4.72). Contact sport participants self-ranked their concussion knowledge an average of 6.34 out of 10, (SD = 1.83; 95% CI = 1.76-1.91) and scored an average of 4.85 (SD = 1.20; 95% CI = 1.16-1.25) and 39.50 (SD = 3.31; 95% CI = 3.18-3.45). Using the original and revised CKAT scoring method,

Table 4.

Number of concussions and Chiropractors' reported self-rank, original CKAT and revised CKAT scores

Number of Concussions	Self-Rank (out of 10)		Original CKAT Scoring		Revised CKAT Scoring	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
0	6.01	1.94	4.71	1.19	39.12	3.61
1	6.34	1.77	4.83	1.27	39.56	3.36
2-5	6.47	1.80	4.92	1.16	39.66	3.21
>5	7.11	1.37	5.30	1.13	40.63	2.68

Legend: CKAT Concussion Knowledge Assessment Tool

chiropractors who participated in contact sports performed better than chiropractors who did not participate in contact sports. It is important to note that the sample size of chiropractors who participated in contact sports was much larger than the sample size of chiropractors who did not participate in contact sports – 1176 and 145 respectively.

Discussion

The purpose of this study was to investigate the extent of knowledge that North American chiropractors have regarding concussion diagnosis and management, and to identify any knowledge gaps present. The study population was large (n = 40 580); however, the response rate was low (n = 1321 respondents: 3.3%). From the pool of respondents, 506 identified as male (38%), and 815 identified as female (62%). When comparing both groups' knowledge of concussions, they performed similarly using both the original and revised CKAT scoring methods.

Results from our study were compared to previous studies which have utilized the CKAT to compare against other healthcare practitioners to identify areas where chiropractors excel and where they are deficient in managing a concussed patient. Section 1 involved asking the definition of a concussion and the mechanisms of concussions. The majority of chiropractors were able to correctly identify the characteristics of concussions. These findings suggest that the chiropractors who participated in this study have concussion knowledge similar to other healthcare practitioners who have taken the CKAT and are possible first contact practitioners to a concussed patient.

In the second section, chiropractors were asked to correctly identify symptoms of concussion. Chiropractors' scores varied and showed lower scores compared to section 1. This trend is common among other healthcare fields, including medical residents, medical students, chiropractic interns and chiropractic residents.^{3,4,9,11} Sport chiropractors scored the highest amongst all healthcare fields mentioned above.³ Section 3 asked about management of concussions. Results were similar to those in section 2, where all healthcare fields showed a decrease in scores except for the sport chiropractor population.^{3,4,9,11}

English-speaking chiropractors self-ranked higher compared to French-speaking chiropractors. When comparing the self-ranking scores and original CKAT

scores, all chiropractors self-ranked higher than their actual scores, with English-speaking chiropractors having higher scores. English speaking chiropractors also scored higher on the revised CKAT than the original CKAT when compared to their French-speaking counterparts. It is unknown whether the higher scores in the English-speaking population are due to increased concussion knowledge or merely due to the accuracy of the translation of the survey from English to French, resulting in poorer scores in the French-speaking population in self-rank, original CKAT and revised CKAT scores. To the authors' knowledge no other study has compared these two groups.

All schools' graduates self-ranked their concussion knowledge similarly and scored similarly using the original CKAT scoring method. Using the revised CKAT scoring method, graduates of NWHSU scored the best (40 out of 48), followed by CMCC, Life, Logan, NYCC, Parker, UWS, and UQTR all scoring 39 out of 48. Graduates of NUHS and Palmer scored 38 out of 48. To the authors' knowledge no other study has investigated this in the past.

133 respondents reported that they hold an advanced degree (MSc or PhD). Chiropractors who hold an advanced degree only scored slightly higher on the original and revised CKAT scoring methods, when compared to chiropractors who do not hold an advanced degree. One possible explanation for the similarity between groups could be linked to the fact that their advanced degrees were not related to learning that involved concussion education.

In Canada, available residencies include Clinical Sciences, Diagnostic Imaging, and Sports Sciences programs offered at the Canadian Memorial Chiropractic College.¹⁷ In the United States, Radiology and Rehabilitation residency programs are available at multiple colleges. The Clinical Sciences residency offered by CMCC is a two year program focusing on advanced clinical knowledge and critical thinking, through interactive experiences, in a multidisciplinary environment. CMCC's Sports Sciences two year residency program involves thorough academic and clinical preparation for the participation in a multidisciplinary sports injury care environment. The Canadian Diagnostic Imaging residency program follows a three year curriculum guided by the American College of Chiropractic Radiology.¹⁷ Similarly, the American radiology residency features a three year curriculum of in-depth diagnostic imaging, where residents are eligible for the examination by the American Chiropractic Board

of Radiology (DABCR).¹⁸ The Rehabilitation residency features a three year intensive clinical experience with a focus on neuromusculoskeletal rehabilitation in an interdisciplinary setting, where residents are eligible for the Diplomate in Chiropractic Rehabilitation (DACRB).¹⁹

Once again, North American chiropractic residents were found to have nearly the same concussion knowledge as those not enrolled in a residency program with residents scoring slightly higher compared to non-residents. Chiropractic residents in our population of study scored 4.92 out of 9 on the original scoring and 39.88 out of 48 on the revised scoring; comparatively in a previous study by Kazemi *et al.*⁴ Canadian chiropractic residents scored 5.25 out of 9. In the study by Kazemi *et al.*⁴ the residents surveyed were only from Canadian Memorial Chiropractic College and were not indicative of the entire North American population of chiropractors and residents from different chiropractic institutions across Canada and the United States. In a study by Boggild and Tator⁹, neurology and neurosurgery residents scored 5.8 out of 9. The difference in scores can be attributed to the differences in population between their study and ours. In their study, neurosurgery and neurology residents were found to be more likely to have experience treating patients with concussions and similar brain injuries. In our study, chiropractic residents include those who are clinical science, rehabilitation, radiology, orthopaedics and neurology; some of whom have differing experiences with seeing concussed patients.

Chiropractic Fellows in rehabilitation, sport sciences and neurology are graduates from programs that potentially cover concussion and brain injuries topics in more details than other programs. Furthermore, these Fellows may also see more concussed patients in their practices. Sport sciences programs are available in Canada, while rehabilitation and neurology are offered in the United States.¹⁹ These fellows scored 5.24 out of 9 on the original scoring and 40.46 out of 48 on the revised scoring, considerably higher than other sub-populations analyzed for this study. Compared to the rehabilitation, sport sciences and neurology residents, the neurology and neurosurgery residents in the study by Boggild and Tator scored 5.8 out of 9 on the CKAT.⁹ This elevated score can possibly be attributed to the fact that both respective fields have more education dealing with conditions pertaining to head trauma and concussion. Surveying sports chiropractors

Table 5.
Concussion survey results comparison

	Current study North American Chiropractors	Kazemi 2017 Sports Chiropractors ³	Donaworth 2016 Medical Students ¹¹	Kazemi 2016 Chiropractic Interns ⁴	Kazemi 2016 Chiropractic Residents ⁴	Boggild 2012 Medical Students ⁹	Boggild 2012 Medical Residents ⁹
Mean Overall Score	4.82	5.57	NS	5.2	5.25	4.1	5.8
Correctly identified that less than 1/3 of all concussions involve LOC	85%	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	86%	100%	68%	100%	100%	67%	76%
Correctly answered that a concussion is a brain injury with no abnormalities on structural neuroimaging	84%	93%	84%	98%	NS	94%	100%
Correctly identified that it is only necessary to have one or more symptoms to diagnose a concussion	52%	84%	37%	64%	50%	60%	72%
Correctly recognized chronic traumatic encephalopathy as long-term consequences of repetitive concussive injury	67%	80%	56%	50%	50%	52%	52%
Correctly recognized that second impact syndrome are consequences of recurrent concussions	47%	95%	86%	43%	43%	43%	43%
Believed that every concussed individual should see a physician as appropriate management of concussion	81%	55%	73%	64%	NS	76%	76%
Legend: NS – not explicitly stated in article.							

solely, they scored the highest among chiropractors with a score of 5.57 out of 9.³

In a study by Salisbury *et al.*¹⁰ assessing concussion knowledge among rehabilitation staff across US hospitals, a general trend was found that rehabilitation professionals were able to accurately recognize some signs of a concussion, however, there was a great deal of variability, and thus lack of consistency, when it came to best care, recovery and long-term consequences of concussions. Consistent with our research, chiropractors were able to correctly identify concussions in patients and variability in answers when queried about the nuances of managing these patients. These findings suggest that chiropractors are capable of being a source of first line care for patients who have suffered a concussion.

Self-rank of concussion knowledge increased with the amount of concussions that the chiropractor experienced. The same pattern can be seen with the scores of the original and revised CKAT, where chiropractors who have had no prior concussion scored poorest and chiropractors who have suffered more than five concussions performed the best. It can be theorized that chiropractors who themselves

have suffered concussions have sought out a better understanding of concussions as a result of their injury which could account as to why with increased amount of concussions, self-rank and CKAT scores increased subsequently.

Chiropractors who indicated that they participated in contact sports self-ranked their knowledge of concussions higher than those who indicated that they did not participate in contact sports. Chiropractors who indicated that they participated in contact sports outperformed those who did not in both original and the revised CKAT scoring method. This finding suggests that chiropractors who participated in contact sports were further exposed to concussion knowledge due to inherent risk of concussion in these sports. It is reasonable to assume that chiropractors who have not had personal experience or experience assessing/treating concussions may have been less likely to participate in this survey or may have scored lower compared to other clinicians.

Table 5 demonstrates the results of this study and other studies which used CKAT.³ Several knowledge gaps were presented by chiropractors who participated in this study. Only 52% of chiropractors correctly identified that it is

necessary to have a minimum of one symptom to diagnose a concussion, 67% correctly recognized chronic traumatic encephalopathy as a long-term consequence of repetitive concussive injury and 47% correctly recognized that second impact syndrome is a consequence of recurrent concussions. Interestingly, low scores in these categories were reported in all populations who took the CKAT except sport chiropractors who scored the highest amongst North American chiropractors, medical students, chiropractic interns, chiropractic residents and medical residents.³ This result may be due to the limitations of observational studies and the lack of a consensus on causal association between mTBI and neurodegenerative disease. As such, the removal of Parkinsonism, chronic traumatic encephalopathy and dementia from question 18 is recommended.

Individuals who preferred lecture-based learning and seminar/workshops scored higher on the original and revised CKAT scoring method, scoring 4.88 and 39.57 in their respective categories. Individuals who attended seminar/workshops self-ranked the highest compared to all other preferred methods of learning. This could be due to increased adherence and participation during lectures and seminars/workshops. In a previous study by Kazemi *et al.*³ assessing the concussion knowledge of sport chiropractors, their preferred learning method was seminar or workshops where they achieved a CKAT score of 5.57. Comparing this study and our study, it is possible that seminars and workshops promote an environment where learning about concussions occurs the most. In a study by Boggild and Tator⁹, when querying fourth year medical students, neurosurgery and neurology medical residents, their preferred learning methods were workshops or seminars with 43% (n = 33) of their respondents preferring workshops or seminars for learning about concussions. In their study, they did not show a score of how those who preferred seminars/workshops scored on the CKAT. They did find, however, that those who self-ranked their ability to manage concussed patients lower also performed worse on the CKAT.⁹ This possibly suggests that this population recognizes that their ability to manage concussed patients is lackluster and seek out an evidence-based treatment for their patients.²⁰ Perhaps the most effective way for healthcare practitioners to learn about concussion post-graduation, would be through the implementation of seminars or workshops. However, it is the authors' opinion that in-

clusion of concussion in the curriculum of chiropractic colleges would be the best approach to enhance general knowledge of future chiropractors.

Limitations

Despite the large population size, the response rate was low. Furthermore, conducting survey always runs the risk of only attracting those participants who have a vested interest in the topic. As such the result of this study may not be a true presentation of the North American chiropractors' concussion knowledge. Additionally, the large number of chiropractors who have had personal experiences with concussions themselves may have resulted in a general overestimation of chiropractors' knowledge on concussions, which could have influenced the results of the study.

The initial survey⁹ that this study was based on was created utilizing information from the 2008 Zurich consensus statement on concussion.²¹ Since then, there has been new consensus statements every four years with the last one developed in Berlin in 2016.² To enhance CKAT addition of following questions based on the most recent guidelines² are recommended:

- immediate management of the athlete on field with red flags²;
- management of athlete based on return to play and return to school protocols²;
- the eleven Rs² (Recognize; Remove; Re-evaluate; Rest; Rehabilitation; Refer; Recover; Return to sport; Reconsider; Residual effects and sequelae; Risk reduction) in recognition and management of the concussion;
- the effects of past medical history such as depression, headaches, learning disabilities, Attention Deficit Disorder (ADD)/Attention Deficit Hyperactivity Disorder (ADHD);
- baseline testing;
- prevention strategies.

A limitation exists such that in a practical setting, a clinician uses a combination of history, physical and clinical experience in order to evaluate a patient, whereas this study presents a multiple-choice questionnaire to quantify a clinician's knowledge.

When implementing the Survey Monkey, question 12

which asks “Which of the following is a sign or symptom of a concussion? Select all that apply.”, vertigo and amnesia were set as one correct response instead of being separate correct answers. As such, our alternative scoring range became 0-48 instead of 0-49. This could have affected the scoring and validity/reliability of the revised scoring reported by Savic *et al.*¹⁶

Conclusions

Concussions are injuries to the brain that present to chiropractors in practice. It is important for chiropractors to accurately recognize, diagnose and manage concussions. Implementation of best practice concussion guidelines should be increased within a chiropractor’s education in order to be able to manage concussions effectively.

Chiropractors who had experience with concussions showed an increased knowledge of concussions, however, not by a great deal. Chiropractors with Fellowships in sport, neurology and rehabilitation scored on the higher ends of all the different chiropractic populations, as well as chiropractors who have suffered concussions themselves in the past.

The chiropractors participated in this study could accurately identify the basics of concussions in patients, however, the subtle nuances of concussions lead to variability in managing these patients. This trend is consistent with many different rehabilitation practitioners involved with managing concussion patients, including physical therapists, athletic trainers and physicians.¹⁰ Further enhancement and updating of the CKAT based on current literature and guidelines and an item by item construct validity assessment are highly recommended. Education should be designed to address the learning gaps and further investigation is needed to understand what method is most effective in the delivery of concussion knowledge.

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Appendix 1.
Modified CKAT questionnaire

Part 1: ID questions and Sports and Recreation background:	
1.	What is your gender? 1. Male 2. Female
2.	Which chiropractic college did you graduate from?
3.	Do you have any chiropractic speciality Fellowships or diplomate certificate? If so, what are they?
4.	Are you enrolled in any Chiropractic specialty residency program? If so, what program and year are you in?
5.	Have you done any of the following in the past 2 years? Mark all that apply. i. Walking for exercise ii. Jogging or running iii. Swimming iv. Bicycling v. Weight-training vi. Exercise class or aerobics vii. Golfing viii. Baseball or softball ix. Tennis or squash x. Volleyball xi. Basketball xii. Ice hockey or ice skating xiii. Downhill skiing or snowboarding xiv. Boxing martial arts (judo/karate) xv. Wrestling xvi. Football xvii. Soccer xviii. Equestrian xix. Inline skating xx. Gymnastics xxi. Cheerleading xxii. Trampoline xxiii. Diving xxiv. Rugby xxv. Skydiving xxvi. Mountain climbing xxvii. Martial arts xxviii. ATV, Motorcycle, automobile racing, or snowmobiling xxix. Other

Modified CKAT questionnaire – Part 1: ID questions and Sports and Recreation background (<i>continued</i>)	
6.	Last week, how many times did you participate in sports or physical activity? i. 1 time ii. 2 times iii. 3 times iv. 4 times v. 5 times vi. 6 times vii. 7 times
7.	About how much time did you spend on each occasion? i. 1 to 15 minutes ii. 16 to 30 minutes iii. 31 to 60 minutes iv. More than one hour
8.	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 knowing where you are, etc. i. Yes – once ii. Yes – 1-5 times iii. Yes – more than 5 times iv. No
9.	If you answered yes to the previous question, how did your concussion(s) occur? Please select all that apply. 1. Work related 2. Motor Vehicle Crash 3. Sport or recreational activity 4. Fall 5. Other

Part 2: Knowledge questions about concussions (Answers that were considered correct are bolded):	
10.	What is the definition of concussion? Select the best answer. 1. Loss of consciousness for <5 mins after an impact to the head 2. A complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces 3. A structural brain injury caused by mild traumatic force that transiently decreases cerebral blood flow
11.	Is a concussion a brain injury? Select the best answer. i. No, as there is no abnormality seen on standard structural neuroimaging ii. No, as symptoms are only psychological in nature iii. Yes, as there is a functional disturbance that cannot be seen on standard neuroimaging iv. Yes, as there is structural abnormality seen on standard neuroimaging

Modified CKAT questionnaire – Part 2: Knowledge questions about concussions (continued)	
12.	<p>Which one of the following is true?</p> <ul style="list-style-type: none"> i. A period of unconsciousness is necessary for the diagnosis of a concussion ii. Over 2/3 of all concussions involve loss of consciousness (LOC) iii. 1/3 to 2/3 of all concussions involve loss of consciousness (LOC) iv. Less than 1/3 of all concussions involve loss of consciousness (LOC)
13.	<p>Which of the following is a sign or symptom of a concussion? Select all that apply.</p> <ul style="list-style-type: none"> 1. Headache 2. Hemiparesis 3. Dizziness 4. Confusion 5. Fixed dilated pupil 6. Nausea and/or Vomiting 7. Vertigo, Amnesia 8. Tinnitus 9. Emotional or personality changes 10. Papilledema 11. Intention tremor 12. Fatigue 13. Temporary loss of consciousness 14. Prolonged coma
14.	<p>How many symptoms of a concussion are required to diagnose a concussion?</p> <ul style="list-style-type: none"> 1. One or more symptoms 2. three or more symptoms 3. five or more symptoms
15.	<p>Which of the following is true regarding the mechanism of concussion?</p> <ul style="list-style-type: none"> i. Direct physical contact to the head is necessary to sustain a concussion ii. Localized damage to the brainstem is the cause a concussion iii. Localized damage to the prefrontal cortex is the cause of a concussion iv. Localized damage to the hippocampus is the cause of a concussion v. A whiplash effect to the brain caused by an impact to any part of the body may cause a concussion
16.	<p>What is the appropriate management of concussion? Select all that apply.</p> <ul style="list-style-type: none"> i. Every concussed individual should see a healthcare professional ii. A concussed player can return to play in the same game or practice if examined by a healthcare professional iii. A stepwise increase in exercise and activity if symptomatic iv. Physical rest is always recommended after a concussion v. Mental rest is always recommended after a concussion vi. Signs and symptoms should be monitored for increasing severity vii. Full neurological exam at initial assessment is recommended viii. The standard mini mental status exam at initial assessment as an adequate cognitive test for concussion ix. MRI of the brain is mandatory x. CT of the brain is mandatory

Modified CKAT questionnaire – Part 2: Knowledge questions about concussions (<i>continued</i>)	
17.	<p>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:</p> <ul style="list-style-type: none"> i. Nose bleed ii. Prolonged loss of consciousness iii. Number and duration of symptoms iv. Younger Age v. Repeated concussions occurring with progressively less impact force vi. Slower recovery after each successive concussion vii. Repeated concussions over time viii. Concussions close together in time ix. Being hit on the left side of the head
18.	<p>What are the long-term consequences of repetitive concussive injury? Select all that apply.</p> <ul style="list-style-type: none"> i. Dementia ii. Depression iii. Headaches iv. Increased risk of hemorrhagic stroke v. Death or disability with second concussion before recovery from a first concussion vi. Increased risk of schizophrenia vii. Prolonged fatigue viii. Impairment of concentration and memory ix. Parkinsonism x. Chronic traumatic encephalopathy

Part 3: Learning needs about concussions::	
19.	<p>In your undergraduate chiropractic education, how did you learn about concussions? Select all that apply.</p> <ul style="list-style-type: none"> i. Lecture ii. PBL (problem-based learning) iii. Seminar iv. Interest Group v. Shadowing/ Observership vi. Other vii. Never, I can't remember
20.	<p>In your residency to date, how did you learn about concussions? Select all that apply.</p> <ul style="list-style-type: none"> 1. Clinical experience 2. Self-study 3. Lecture 4. Never, I can't remember 5. Other

Modified CKAT questionnaire – Part 3: Learning needs about concussions (<i>continued</i>)										
21.	To date, have you seen a patient with: – concussion in the acute phase? (select one) 1. Yes, 2. No, 3. I don't know – post-concussive syndrome? (select one) 1. Yes, 2. No, 3. I don't know									
22.	How would you self-rank your knowledge about concussions? Inadequate Completely adequate 1 2 3 4 5 6 7 8 9 10									
23.	What resource would you most likely use to find information about concussions? 1. Google 2. Wikipedia 3. Up-to-date 4. Textbook 5. Pubmed 6. an agency website 7. Thinkfirst.ca 8. other									
24.	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									
25.	What is your preferred format for healthcare professional learning material? 1. Pamphlet 2. letter 3. seminar or workshop 4. lecture 5. informational email									
26.	What challenges, if any, do you think healthcare professionals face when diagnosing and managing a concussion?									
27.	This concussion assessment tool was created from knowledge extracted from the 2008 Zurich Consensus Statement on Concussion. Given that there have been recent advances in concussion research since 2008, are there any changes you recommend to the assessment tool, as a result of newer research?									