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# Editorial Board

# JCCA Special Issue December 2016 –Sports Chiropractic

Mohsen Kazemi, RN, DC, MSc, FRCCSS(C), FCCPOR(C), PhD (Candidate)[1]


Mohsen Kazemi, RN, DC, MSc, FRCCSS(C), FCCPOR(C), PhD (Candidate)

Rio's Summer Olympic Games in 2016 were not only an exciting display of the best athletes of the world but also a tremendous display of utilization of chiropractic care. Being part of the Rio Olympics as the Canadian Taekwondo Team doctor, I was excited to see several chiropractors working with various teams as their national sports organization's team chiropractor or at the polyclinics. However, hearing what other health professionals on the teams had to say about those chiropractors was even more exciting. There was a feeling of appreciation and acceptance that I have not seen during my previous Olympic Games experiences. This is a testimony to our hard work towards integrative care. As our integration into sports injury management teams increases, so does our need for solid scientific evidence. We have been blessed for the last seven years to publish such evidence for sports chiropractic in the annual JCCA Sports Chiropractic issue. The global popularity and quality of these editions has been steadily improving. However, we need your contribution, support and involvement in sports chiropractic research even more as we move forward.

With this note I present to you our 8th Sports Chiropractic edition, overflowing with great manuscripts from practical case reports and history to original research. I hope that you not only enjoy this edition but will also be encouraged and excited to get involved in sports chiropractic research.

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# Concussion assessment and management knowledge among chiropractic fourth year interns and residents

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Objectives: *To investigate the degree of knowledge chiropractic fourth year interns and post-graduate chiropractic residents have in regard to concussion diagnosis and management.*

Methods: *A survey modified from a study conducted by Boggild and Tator (2012), was administered to fourth year chiropractic interns and post-graduate residents via SurveyMonkey.com.*

Results: *Chiropractic fourth year interns and post-graduate chiropractic specialty college residents scored 5.2 and 5.25 out of 9 respectively, which compares well with Bogglid and Tator's reports on medical students and residents. Several knowledge gaps were identified in the sample population.*

Conclusion: *The results from this survey show that the concussion knowledge among Canadian fourth year*

Objectifs : *Enquêter sur le niveau de connaissances en diagnostic et gestion de commotion cérébrale des stagiaires de quatrième année et des résidents de troisième cycle en chiropratique.*

Méthodologie : *Une enquête modifiée d'une étude menée par Boggild et Tater (2012) a été réalisée auprès des stagiaires de quatrième année et des résidents de troisième cycle en chiropratique via SurveyMonkey.com.*

Résultats : *Les stagiaires de quatrième année et les résidents du troisième cycle des collèges de spécialités en chiropratique ont obtenu respectivement 5,2 et 5,25 sur 9, ce qui se compare aux rapports de Bogglid et Tator sur les étudiants et les résidents en médecine. Plusieurs lacunes ont été identifiées dans les connaissances de la population étudiée.*

Conclusion : *Les résultats de cette enquête montrent que les connaissances en diagnostic et gestion de commotion cérébrale des stagiaires de quatrième année*

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*chiropractic interns and specialty college residents compares favorably with the knowledge of fourth year medical students and residents in diagnosing and managing concussions. Chiropractors appear to possess the skills and knowledge to diagnose and manage concussion equal to their medical counterparts. However, knowledge gaps regarding concussion diagnosis and management were found among chiropractic students and residents.*

(JCCA. 2016;60(4):273-285)

KEY WORDS: concussion, chiropractic, student, resident, knowledge

*et des résidents du troisième cycle des collèges de spécialités en chiropratique sont comparables à celles des étudiants de quatrième année et des résidents en médecine. Les chiropraticiens semblent posséder les compétences et les connaissances nécessaires pour diagnostiquer et gérer la commotion cérébrale aussi bien que leurs homologues en médecine. Toutefois, des écarts de connaissances sur le diagnostic et la gestion de commotion cérébrale ont été constatés parmi les étudiants et les résidents en chiropratique.*

(JCCA. 2016;60(4):273-285)

MOTS CLÉS : commotion cérébrale, chiropratique, étudiant, résident, connaissance

## Introduction

Concussions represent one of the most common types of brain injuries in sport.[1] While often sustained in motor vehicle accidents, sports injuries or falls, concussions can occur at any age.[1] According to discussions held at the 4th International Consensus Conference on Concussion in Sport in Zurich[1], concussion is described as "a brain injury and is defined as a complex of pathological process affecting the brain, induced by biomechanical forces." [1] The majority of concussions (80-90%) tend to resolve themselves typically in 7-10 days.[1] Nevertheless, it remains pertinent for patients to be diagnosed with a concussion if present, and evaluated to determine when it is safe for them to return to certain activities.

Concussion management has evolved through the decades as research is consistently guiding mangement.[1-6] Those changes include moving from the American Academy of Neurology's 1997 practice parameters, to the 2002 Vienna guidelines, to the 2008 Zurich guidelines, and, most recently, to the 2012 Zurich guidelines, which are currently accepted as the best protocol for practitioners to take when managing a patient with a concussion[1-3]. Broshek *et al*.[4] report that 56% of members of the Child Neurology Society still use the American Academy of Neurology's 1997 parameters, whereas only 8.2% used the Zurich guidelines. Lebrun *et al*.[5] report slightly higher figures, with 9.4% of those US physicians involved in their study using the Zurich guidelines.

Tools for managing a concussion have also changed over the years. Guskiewicz *et al*.[6] have suggested revision to the Sport Concussion Assessment Tool 2 (SCAT2) and have introduced the SCAT3, which may provide a more complete clinical profile and comprehensive examination for the athlete with a suspected concussion. McCrory *et al*.[1] recommend that the initial assessment of an injured athlete should involve the use of the SCAT3. Most of the examinations done at the hospital (if an athlete is taken to the emergency room) are already included in the SCAT3 assessment.

The current guidelines and tools that are available for practitioners, such as those found in the SCAT3, are not always accepted and/or implemented in the practitioner's diagnosis and management of concussions. Lebrun *et al*.[5] surveyed and compared American versus Canadian practicing family physicians and noted many similarities in regards to sport-related concussions. However, one notable difference involved a higher number of US physicians using outdated concussion grading scales with less than 10% of US physicians using the recent Zurich guidelines. In light of this, physicians from both countries indicated their desire for additional education regarding concussions.

Based on evidence founded by Burke *et al*.[7], it seems as though undergraduate medical students receive a limited knowledge base regarding the diagnosis and management of patients with concussions. Of the 14 Canadian medical schools that responded to a survey (of the 17 contacted),

four provided concussion-specific education, six schools offered head injury education that incorporated a concussion component, and four schools reported that there was no concussion education in their curriculum. In contrast, as shown in Boggild and Tator's paper[10], fourth year medical students and neurology residents seem to have a more comprehensive knowledge base with regards to diagnosing and managing concussion, contradicting other research.

Chiropractors receive some theoretical and practical training in concussion management with an aim to safely and competently perform physical examination, diagnosis and treatment of these conditions.[8,9] The chiropractic undergraduate program in Canada provides principles of concussion management throughout all four years of the curriculum.[8,9] The Graduate Studies Programs provide more chance for the chiropractic residents to learn about concussion and even manage concussions during their placements.[8,9]

There has been research conducted to examine the concussion knowledge of medical students and residents as well as an examination of the curriculums of various medical schools across Canada.[10] In a study conducted by Boggild and Tator[10] at the University of Toronto, the knowledge, awareness and attitude towards concussion management among medical students and neurology and neurosurgery residents were examined via a "25 item survey through literature review, expert review and pilot testing to assess medical trainee's knowledge of concussion, sources of information, learning needs and educational preferences on this topic". The survey was administered to these medical trainees via SurveyMonkey.com. Section Two of the survey consisted of nine concussion-related questions testing the students' understanding of the condition. The fourth year medical students scored an average of 4.1 correct answers (out of nine) and the residents scored an average of 5.8 (out of nine).

Crawford[11] claims that after emergency physicians, chiropractors may be the health care professionals that see the next highest amount of concussion patients. In fact, Johnson *et al*.[12] 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, commonly treated by chiropractors, associated with post-concussion syndrome.

Past studies have examined the knowledge of concussions among medical students and residents in Canada.[5,7,10] However, knowledge of concussions among chiropractic students, and chiropractic residents have not yet been investigated. The purpose of this study is to assess the current knowledge in diagnosis and management of concussion among Canadian chiropractic fourth year interns and post-graduate residents.

## Methods

Upon permission from the authors, a similar survey was distributed via email (linked to SurveyMonkey.com) amongst the fourth year interns and chiropractic residents at the Canadian Memorial Chiropractic College (CMCC) in the summer of 2014. A complete class list was obtained from the chiropractic college Registrar Office to avoid missing anyone within the sample. Compliance was assessed through the survey software, which immediately determined whether the participants had completed, not completed, or withdrawn themselves from the survey. The survey was composed of objectively directed questions with slight modifications from the original survey from Boggild and Tator[10] to make questions more appropriately addressed to chiropractic students. (Please refer to appendix B for the modified survey) These modifications took place in Part 1 and Part 3 of the survey and will be discussed later. The study received ethics approval from a Research Ethics Board.

The demographic data collected in Section One included the following subjects: program and place of study, gender, participation in sports and recreation, and a personal history of concussion. The original survey was modified in Part 1 and Part 3 so that questions could be properly addressed to chiropractic students instead of medical students. In question 2, instead of asking which medical school students attended, students were asked "Which *chiropractic* college are you currently attending? If you have currently completed your *chiropractic* undergraduate degree, which college did you receive this at?". Question 18 was replaced by "In your *chiropractic* education, how did you learn about concussions?". The survey used in this study did not include any clerkship rotation options as this does not apply to chiropractic students. Question 23 was replaced by "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 *chiropractic* curriculum?". All other questions were the same as those in the original survey by Boggild and Tator.[10]

The data involving the knowledge of concussion definitions and management considerations collected from Section Two involved nine questions to assess three areas of interest. The first three of nine questions assessed the respondent's ability to correctly identify the definition of a concussion and to recognize that loss of consciousness is not a required symptom of concussion. The next three questions tested the respondent's 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 respondent's 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. For further details, please refer to Appendices A and B.

Similar to the Boggild and Tator[10] study, each question of Section Two 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 permitted to be selected and none of the incorrect options would be given the one point.

Descriptive statistics were used to summarize the sample and any of the variables described in the outcome measurement. When appropriate, Chi Square tests, T tests and regression analysis tests were used to assess the similarities and differences between chiropractic students (interns and residents) and medical students (fourth year students and residents) in respect to their knowledge of concussions and concussion-related clinical experience.[13-15] Data that was extracted from the results of the Boggild and Tator study were compared to data generated from this study, when appropriate.[10] Graphpad.com was used for statistical analysis. A two-tailed T test was used to compare the concussion knowledge scores in Part Two between chiropractic interns and fourth year medical students.[13] Another two-tailed T test was used to compare scores between chiropractic residents and medical residents.[13] A Yates corrected Chi Square test was used to compare lifestyle, educational background, and responses to individual questions in Part Two between chiropractic residents and interns and between chiropractic students and medical students.[14] A linear regression was used to compare the chiropractic students' self ranked knowledge about concussions and compare it with their actual concussion knowledge score in Part Two.[15] All P Values less than 0.01 were considered to be statistically significant in this study.

Table 1.
*Proportion of male and female interns and residents.*

| | Study Population | Sample Population | Response Rate |
|---|---|---|---|
| **Chiropractic Interns** | 186 | 36 | 19.4% |
| Female | 97 | 19 | 19.6% |
| Male | 89 | 17 | 19.1% |
| **All Chiropractic Residents** | 33 | 8 | 24.2% |
| Female | 14 | 2 | 14.3% |
| Male | 19 | 6 | 31.6% |
| **Sports Science Residents** | 26 | 6 | 23% |
| Female | 9 | 0 | 0% |
| Male | 17 | 6 | 35.3% |
| **Clinical Science Residents** | 5 | 2 | 40% |
| Female | 3 | 2 | 67% |
| Male | 2 | 0 | 0% |
| **Total Chiropractic Students and Residents** | 219 | 44 | 20.1% |
| Female | 111 | 21 | 18.9% |
| Male | 108 | 23 | 21.3% |

The sample size was limited to the number of fourth year chiropractic interns and residents who completed the survey through SurveyMonkey.com.

## Results

A total of 219 surveys were emailed to fourth year chiropractic interns and chiropractic residents in the chiropractic clinical sciences, chiropractic sports sciences and chiropractic diagnostic imaging programs. Thirty-six surveys were returned from fourth year chiropractic interns (19.4% response rate), two from the chiropractic clinical sciences program, six from chiropractic sports sciences program and none were returned from diagnostic imaging program (24.2% response rate for all residents). The number of surveys returned from fourth year chiropractic interns that were females and males were comparable. As for chiropractic residents, all respondents were male from the sports sciences program, and all respondents were female from the clinical sciences program (See Table 1). Three residents completed their undergraduate chiroprac-

tic education at a college outside of Canada (37.5%). The response rate of chiropractic interns (19.4%) was comparable to the response rate of medical students (23.0%), while the response rate of chiropractic residents (24.2%) was comparable to the response rate of medical residents (31.3%). However our sample size was much smaller than that of Boggild and Tator.[10]

Fourth year chiropractic interns scored an average of 5.2 out of 9 (standard deviation [SD] = 1.17, 95% confidence interval (CI) = 4.8-5.6) in Section 2: Knowledge Questions About Concussions. Chiropractic residents scored an average of 5.25 out of 9 (SD = 0.89, 95% CI = 4.6-5.9). There were no significant factors in the knowledge score of the fourth year chiropractic interns and chiropractic residents in regards to a personal history of concussion, gender or time spent participating in sports and recreation (Yates corrected Chi Square, $p>0.01$). In the study conducted by Boggild & Tator[10], fourth year medical students received a mean score of 4.1 out of 9 in Section Two. Medical residents answered correctly significantly more of the questions on the survey than the fourth year medical students with a mean score of 5.8 out of 9 (mean = 5.8 vs. 4.1; $t = 4.65$; $p<0.01$).

A two tailed t-test comparing study groups revealed that fourth year chiropractic interns answered correctly significantly more of the questions on the survey than the graduating fourth year medical students (mean = 5.2 vs. 4.1; $t=3.94$; $p<0.01$). Chiropractic residents showed no statistically significant difference in their scores on the survey when compared to medical residents (mean = 5.25 vs. 5.80; $t = 0.87$; $p>0.01$) or to fourth year chiropractic interns (mean = 5.25 vs 5.2; $t= 0.06$; $p>0.01$).

Fifty percent of all fourth year chiropractic interns and chiropractic residents in this study did not recognize chronic traumatic encephalopathy as a possible outcome of repeated concussions, and 57% did not recognize second impact syndrome, but all chiropractic interns and residents were able to recognize that the mechanism of concussion involves a whiplash effect to the brain caused by an impact to any part of the body. Only 2.7% of fourth year chiropractic interns (1 out of 36) thought that a concussion was not a brain injury as there is no abnormality seen on structural neuroimaging. None of the chiropractic respondents answered that a period of unconsciousness was necessary for the diagnosis of a concussion. Seventy-five percent of chiropractic interns were able to correctly answer that less than one-third of all concussions involve loss of consciousness. Thirty-six percent of fourth year chiropractic interns (n=16) did not believe that every concussed individual should see a physician.

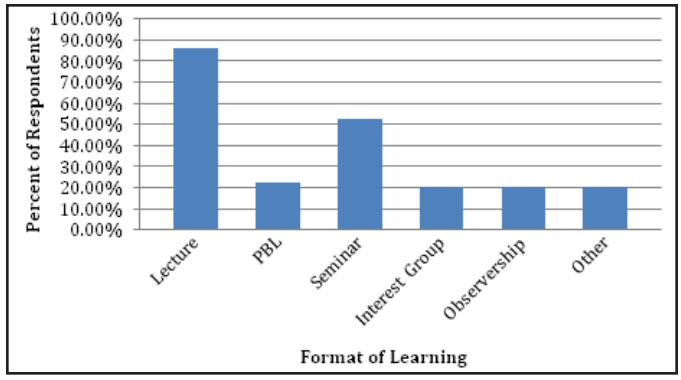


Figure 1.
*How chiropractic trainees learned about concussions during their undergraduate chiropractic education. PBL = Problem Based Learning.*

Sixty-four percent of the fourth year chiropractic interns in this study were able to correctly answer that only one symptom is required to diagnose a concussion. When the same question was asked of the chiropractic residents in this study, 50% of them (n=4) were able to correctly answer this.

Chiropractic residents were significantly more likely to have seen a concussion patient when compared to fourth year chiropractic interns (Yates corrected chi square, $p<0.01$). There was no statistical correlation between chiropractic trainees (both interns and residents) who had seen an acute or chronic concussion patient in the past and the number of correct concussion knowledge questions in Section Two of the survey (two tailed t-test, mean = 5.47 [have seen] vs 5.11 [have not seen], $p = 0.33$).

The majority of chiropractic trainees (both interns and residents) reported that they had learned about concussion in their undergraduate chiropractic education through lecture (86%) and/or seminar (52%) (see Figure 1). When chiropractic trainees were asked what resource they were most likely to use to retrieve information about concussions, 48% answered "Pubmed" would be their preferred source, 32% answered "Google", 11% answered "Other", 5% answered an "Agency Website", 2% answered "Think-First.ca", and 2% answered "Up-to-Date". In terms of learning preferences, the majority (67%) responded that

a seminar or workshop would be their preferred option. The second-highest learning preference option was lecture (28%), followed by informational email (2%).

One of the questions in the survey required chiropractic trainees to self-rank their concussion knowledge on a scale of 1 to 10. This data was compared to their actual concussion knowledge scores using a bubble graph with the corresponding trend line (see Figure 2). Those that self-ranked their knowledge about concussions as poor were slightly more likely to have a lower concussion knowledge score in Part Two of the survey (linear regression, r = 0.40).

The chiropractic trainees in this study were also asked (in the form of an open-ended question) what challenges they feel chiropractors in general face when diagnosing and managing a concussion. The responses to these questions were organized according to theme (see Table 2).

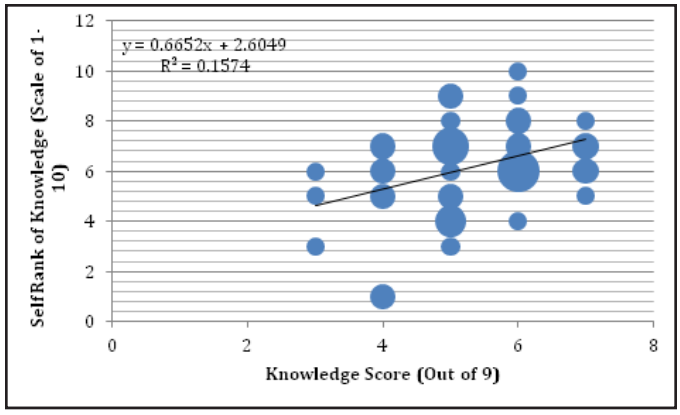


Figure 2.
*Relationship between chiropractic trainees' self-ranking of knowledge about concussions and their assessment. The area of points is proportional to the number of respondents when plotted to the same coordinate.*

Table 2.
*Challenges faced by medical doctors and chiropractors when diagnosing and managing a concussion as reported by chiropractic interns and residents.*

| **Theme** | **Representative Quote** |
|---|---|
| Appropriate plan of management | "The uncertainty surrounding the management of concussions. Treatment is often subjective, also there are so many conflicting views of the best way the manage concussions."<br><br>"The variety of ways they can present is vast, and not all concussions resolve in the same way or time frame." |
| Continuous evolution of guidelines and protocol | "There is an abundance of information currently out in the field and it is constantly evolving and difficult to keep up with. For example: one of your questions asked about long-term consequences (including Parkinsons, CTE and dementia). Some of the recent systematic reviews are showing there is no conclusive relation between concussion and those disorders however most studies should be done to confirm this and the media plays on the few cases. Having an abundance of information can be helpful but also very confusing. Guiding our education by utilizing the best level of evidence is recommended."<br><br>"Being aware of changes in the guidelines for diagnosing and managing concussion" |
| Determining safe return to play | "Not knowing the proper protocol/return to play." |
| Lack of knowledge about patient's baseline testing results prior to concussion | "Baseline testing is often not done for athletes so that the SCAT become invalid." |
| Lack of imaging findings | "Lack of physical findings on CT or MRI" |
| Subtleties of the clinical diagnosis | "The complexity of individuality. No two cases are the same: the signs and symptoms are different, the pathology, ability to heal, response to treatment."<br><br>"The main one is diagnosing one and the degree of severity."<br><br>"The consequences of missing a more severe diagnosis (e.g. intracranial bleed)."<br><br>"The variability of signs and symptoms from person to person"<br><br>"Separating confounding variables from the underlying cause." |

## Discussion

The objective of this study was to examine CMCC's fourth year chiropractic interns' and chiropractic residents' knowledge of concussion diagnosis and management. Chiropractic fourth year interns correctly answered significantly more of the questions on the survey than the graduating fourth year medical students (mean = 5.20 vs. 4.10; t = 3.94; $p<0.01$). However, since our study was conducted four years after Boggild and Tator's[10], dissemination of knowledge during the intervening time may account for at least some of this difference. Chiropractic residents showed no statistically significant difference in their scores on the survey when compared to medical residents (mean = 5.25 vs. 5.80; t = 0.87; $p>0.01$) or to fourth year chiropractic interns (mean = 5.25 vs 5.20; t = 0.06; $p>0.01$). These results suggest that chiropractic students have equivalent knowledge to their medical peers, though none may have enough at graduation to engage in optimal concussion management. Concussion patients may not be the biggest population in a physician's practice, but if chiropractors manage (or co-manage) concussed patients, it may reduce the stress on busy physicians, as 95% of family physicians see, assess, and treat concussions[5].

Boggild and Tator[10] reported that medical students and residents did not recognize Chronic Traumatic Encephalopathy (48%) or Second Impact Syndrome (57%) as possible outcomes of repetitive concussive injury. Chiropractic interns and residents had similar results, with half of them not recognizing chronic traumatic encephalopathy (50%) or second impact syndrome (57%) as possible consequences for individuals sustaining recurrent concussions. It is highly pertinent that a clinician be aware of these when working with concussion patients. Second Impact Syndrome (SIS) involves a second concussion occurring before the individual has recovered from their first concussion. Numerous studies have shown that even after the initial post-concussion symptoms disappear, the athlete is still extremely vulnerable, and the likelihood of re-activating symptoms hours or even days later with possible accompanying neurological deficit is highly likely.[16] Marshall[16] explains that it is not only return to play that can cause further damage, but even premature return to strenuous exercise can cause a prolonging of symptoms and possibly lead to a worsened outcome. Even more serious than this are the consequences of chronic concussions, which include: Post-Concussion Syndrome (PCS) and Chronic Traumatic Encephalopathy (CTE).[10] It is therefore important to get an accurate diagnosis for a concussion as soon as possible.

Chiropractic interns and medical students equally identified that less than one-third of concussions involve loss of consciousness. When examining a patient, red flags such as loss of consciousness make diagnoses stand out more, but those red flags aren't always present.[10] Practitioners need to be mindful of concussions as a possible diagnosis in situations where trauma is sustained and there is no loss of consciousness.

Chiropractic interns and medical students correctly identified that only one symptom is required to diagnose a concussion or to examine a patient for a possible concussion, as only one may be present even if they do have a concussion.[7]

All of the chiropractic residents and interns 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. In comparison, 33% of fourth year medical students and 24% of neurology and neurosurgery residents believed that a direct blow to the head was necessary to sustain a concussion.[10] A very small percentage of chiropractic interns (2.7%) incorrectly answered that a concussion was not a brain injury due to the absence of abnormalities seen on structural neuroimaging, whereas 1.9% of fourth year medical students incorrectly answered the same way.[10] All chiropractic respondents correctly answered that a period of unconsciousness was not necessary for the diagnosis of a concussion, while 6% of fourth year medical students incorrectly answered this question.[10]

Boggild and Tator[10] stated that 24% of respondents did not select "every concussed individual should see a physician", whereas 36% of fourth year chiropractic interns (n=16) did not believe that every concussed individual should see a physician. It is important to emphasize that, on the survey, when asking this question to a chiropractic intern or resident, it would make sense that their first inclination would be not to select this option since chiropractors are not physicians by definition, nor do they believe that physicians are the only ones capable of managing such a condition.[8] However, selecting this option was a correct answer according to Boggild and Tator[10].This may act as a source of bias within the survey, which was

developed for medical students. This was an oversight by the authors not to modify this question prior to administration of the survey to chiropractic population.

Question 25 in Part 3 of the survey questioned chiropractic residents and interns about what they believed the challenges faced by medical doctors and chiropractors were when diagnosing and managing a concussion. The most frequent responses to this question involved subtleties of the clinical diagnosis, and determining the appropriate plan of management for the patient. It seems that chiropractic interns and residents believe that most challenges arise due to the complexity and uniqueness of concussion cases, inconsistency in protocols used in concussion management across the board, and continuously evolving research that clinicians are not always up-to-date with.

It is important to consider the time at which this question was answered by medical students compared to chiropractic students as literature and guidelines have been subject to change over the three year since this survey had first been completed (medical students in 2011 vs chiropractic students in 2014). This in itself could mean that the participants in this study could have had greater exposure to information relating to the diagnosis and management of concussion when compared to the participants in the original study conducted by Boggild and Tator[10]. As such, comparing the knowledge of current chiropractic students and residents to that of medical students and residents of three years ago is not justified. In the future, such comparative studies should incorporate the chiropractic and medical students at the same time in order for a fair comparison of knowledge.

### *Limitations*

This study has a number of limitations. One of the main limiting factors of this study was that there was limited access to the raw data from the survey conducted by Boggild and Tator[10]. This made it difficult to make a true comparison of results.

Another limitation considered relevant in translating these results into professional practice is the format in which knowledge was evaluated. A multiple choice answer format was used, which may be somewhat different from how a chiropractor or a medical doctor would apply their knowledge in a real life setting where decisions must be made without "recognizing" the correct answer from a list of options. Yet another limitation is that 44 Canadian chiropractic students cannot be generalized to the population of students attending all other chiropractic colleges in the world. The cumulative response rate of 21.8% is a major limitation of generalizing this study's results to all chiropractic residents and interns. A small sample size may be another source of limit bias in this study.

Boggild and Tator[10] were the first to analyze concussion knowledge among medical students and residents in Canada. However, our study is the first study which analyzes the knowledge of concussion within the chiropractic interns and residents. Evidently, the research is still in its infancy. It is imperative that more research is done to guage the knowledge chiropractic students have regarding the management of concussion. It would also be interesting to look into the knowledge of practicing chiropractors (and of other health care professionals who have not been included in this study who also manage concussion).

The survey scores of chiropractic interns and residents (5.20 and 5.25, respectively) indicate some knowledge gaps. In order to rectify this situation, we suggest incorporating more focused lecture material regarding concussion as well as hands on group learning sessions where the SCAT 3 and return to play protocols can be reviewed. This was determined with the help of question 24 of our survey, which asked, "What is your preferred format for physician learning material?" The participants of this study reported their preferred learning format was through seminar or workshop, with lecture being the second most popular choice.

Further research should examine the knowledge of concussion management among chiropractors with special interest in concussion for example among sports chiropractors.

## Conclusion

The results from this survey show that knowledge about concussion among fourth year chiropractic interns and residents is comparable to the knowledge of fourth year medical students and residents in diagnosing and managing concussions. As such, this may suggest that chiropractors maybe able to play a role in diagnosis and management of concussion alongside their medical counterparts. However, knowledge gaps were found in concussion diagnosis and management among chiropractic students

and residents. Hence we recommend additional lecture and workshop hours on concussion material to be added to the chiropractic undergraduate curriculum to fill knowledge gaps identified.

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## Appendix A.
*Table with Summary of Results.*

| Test Question Comparison | Chiropractic Interns | Chiropractic Residents | Medical Students | Medical Residents | Statistically significant score between chiropractic Interns and 4th year Medical Students | Statistically significant score between Chiropractic Residents and Medical Residents? | Statistically significant score between Chiropractic Interns and Residents? |
|---|---|---|---|---|---|---|---|
| Mean Overall Test Score | 5.20 | 5.25 | 4.10 | 5.80 | Yes, t=3.94 p<0.01 | No, t=0.87 p>0.01 | No, t=0.06 p>0.01 |
| Which of the following are TRUE regarding concussion and loss of consciousness (LOC)? | 75% correctly identified that less than 1/3 of all concussions involve LOC.<br><br>100% correctly answered that a period of unconsciousness is not necessary for the diagnosis of concussion | 100% correctly answered that a period of unconsciousness is not necessary for the diagnosis of concussion | 66% correctly identified that less than 1/3 of all concussions involve LOC.<br><br>6% incorrectly answered that a period of consciousness is necessary for the diagnosis of concussion | | No, Yates corrected chi square p>0.01<br><br>No, Yates corrected chi square p>0.01 | | |
| Which of the following is TRUE regarding the mechanism of concussion? | 100% correctly identified that a whiplash effect to the brain caused by an impact to any part of the body may cause a concussion | | 33% incorrectly identified that a direct blow to the head was necessary to sustain a concussion | 24% incorrectly identified the same answer as medical students | Yes, Yates corrected chi square p<0.01 | No, Yates corrected chi square p>0.01 | |
| Is a concussion a brain injury? | 2% incorrectly answered that a concussion was not a brain injury due to the absence of abnormalities on structural neuroimaging | | 6% incorrectly answered that a concussion was not a brain injury due to the absence of abnormalities on structural neuroimaging | | No, Yates corrected chi square p>0.01 | No, Yates corrected chi square p>0.01 | |
| What are the long term consequences of repetitive concussive injury? | 50% of both chiropractic interns and residents did not recognize chronic traumatic encephalopathy, nor did 57% of them recognize that second impact syndrome are consequences of recurrent concussions | | | 48% of both medical students and residents did not recognize chronic traumatic encephalopathy, nor did 57% of them recognize that second impact syndrome are consequences of recurrent concussions | No, Yates corrected chi square p>0.01 | No, Yates corrected chi square p>0.01 | |
| What is the appropriate management of concussion? | 42% incorrectly believed that not every concussed individual should see a physician | | 24% incorrectly believed that not every concussed individual should see a physician | | No, Yates corrected chi square p>0.01 | No, Yates corrected chi square p>0.01 | |

## Appendix B.
*Survey sent to chiropractic students in this study.*

**Part 1. ID questions and Sports and Recreation background.**

1. What is your gender?

2. Which chiropractic college are you currently attending? If you have currently completed your chiropractic undergraduate degree, which college did you receive this at?

3. What residency program and year are you in? (question only in survey to residents)

4. Have you done any of the following in the past 2 years? Mark all that apply.
   Thirty-one options of sports and activities given, including the option "other"

5. Last week, how many times did you participate in sports or physical activity?
   Options for 1 time to 7 times given

6. About how much time did you spend on each occasion?
   Options: 1 to 15 minutes, 16 to 30 minutes, 31 to 60 minutes, More than one hour

7. In the past, have you ever suffered a concussion? You may have been "knocked out", knocked unconscious, confused, or had your "bell rung". You may have felt lightheaded, not known where you were, etc.
   Options: Yes – once, Yes – 1-5 times, Yes – more than 5 times, No

8. If you answered yes to the previous question, how did your concussion(s) occur? Please select all that apply.
   Options: Work related, Motor Vehicle Crash, Sport or recreational activity, Fall, Other

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

9. What is the definition of concussion? Select the best answer.
   a. Loss of consciousness for <5 mins after an impact to the head
   *b. A complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces*
   c. A structural brain injury caused by mild traumatic force that transiently decreases cerebral blood flow

10. Is a concussion a brain injury? Select the best answer.
    a. No, as there is no abnormality seen on standard structural neuroimaging
    b. No, as symptoms are only psychological in nature
    *c. Yes, as there is a functional disturbance that cannot be seen on standard neuroimaging*
    d. Yes, as there is structural abnormality seen on standard neuroimaging

11. Which one of the following is true?
    a. A period of unconsciousness is necessary for the diagnosis of a concussion
    b. Over 2/3 of all concussions involve loss of consciousness (LOC)
    c. 1/3 to 2/3 of all concussions involve loss of consciousness (LOC)
    *d. Less than 1/3 of all concussions involve loss of consciousness (LOC)*

12. Which of the following is a sign or symptom of a concussion? Select all that apply.
    Options: *Headache*, Hemiparesis, *Dizziness*, *Confusion*, Fixed dilated pupil, *Nausea and/or Vomiting*, *Vertigo*, *Amnesia*, *Tinnitus*, *Emotional or personality changes*, Papilledema, Intention tremor, *Fatigue*, *Temporary loss of consciousness*, Prolonged coma

13. How many symptoms of a concussion are required to diagnose a concussion?
    Options: *One or more symptoms*, three or more symptoms, five or more symptoms

14. Which of the following is true regarding the mechanism of concussion?
    a. Direct physical contact to the head is necessary to sustain a concussion
    b. Localized damage to the brainstem is the cause a concussion
    c. Localized damage to the prefrontal cortex is the cause of a concussion
    d. Localized damage to the hippocampus is the cause of a concussion
    *e. A whiplash effect to the brain caused by an impact to any part of the body may cause a concussion*

15. What is the appropriate management of concussion? Select all that apply
    *a. Every concussed individual should see a physician*
    b. A concussed player can return to play in the same game or practice if examined by a physician
    *c. A stepwise increase in exercise and activity if symptomatic*
    *d. Physical rest is always recommended after a concussion*
    *e. Mental rest is always recommended after a concussion*
    *f. Signs and symptoms should be monitored for increasing severity*
    *g. Full neurological exam at initial assessment is recommended*
    h. The standard mini mental status exam at initial assessment as an adequate cognitive test for concussion
    i. MRI of the brain is mandatory
    j. CT of the brain is mandatory

16. What are some "red flags" that may predict the potential for more prolonged symptoms and may influence your investigation and management of concussion? Select all that apply:
    a. Nose bleed
    *b. Prolonged loss of consciousness*
    *c. Number and duration of symptoms*
    *d. Age*
    *e. Repeated concussions occurring with progressively less impact force*
    *f. Slower recovery after each successive concussion*
    *g. Repeated concussions over time*
    *h. Concussions close together in time*
    i. Being hit on the left side of the head

17. What are the long term consequences of repetitive concussive injury? Select all that apply.
    *a. Dementia*
    *b. Depression*
    *c. Headaches*
    d. Increased risk of hemorrhagic stroke
    *e. Death or disability with second concussion before recovery from a first concussion*
    f. Increased risk of schizophrenia
    *g. Prolonged fatigue*
    *h. Impairment of concentration and memory*
    *i. Parkinsonism*
    *j. Chronic traumatic encephalopathy*

**Part 3. Learning needs about concussions.**

18. In your undergraduate chiropractic education, how did you learn about concussions? Select all that apply.
    Options: Lecture, PBL (problem based learning), Seminar, Interest Group, Shadowing/Observership, Other, Never, I can't remember

19. In your residency to date, how did you learn about concussions? Select all that apply.
    Options: Clinical experience, Self-study, Lecture, Never, I can't remember, Other

20. To date, have you seen a patient with:
    – concussion in the acute phase? Yes, No, I don't know (select one)
    – post-concussive syndrome? Yes, No, I don't know (select one)

21. How would you self-rank your knowledge about concussions?
    Inadequate Completely adequate
    1 2 3 4 5 6 7 8 9 10

22. What resource would you most likely use to find information about concussions?
    Options: Google, Wikipedia, Up-to-date, Textbook, Pubmed, an agency website, Thinkfirst.ca, other

23. Are concussions something you want to learn more about as part of your medical curriculum?
    Not at all Very much
    1 2 3 4 5 6 7 8 9 10

24. What is your preferred format for physician learning material?
    Options: Pamphlet, letter, seminar or workshop, lecture, informational email

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

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# Exercise prescription: perceptions and physical activity habits in chiropractic students at CMCC

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Background: *Health care practitioner's physical activity (PA) habits are associated with their likelihood to recommend PA to their patients. The intent of this project is to better understand the Canadian Memorial Chiropractic College (CMCC) students' perceptions and practices of PA and exercise prescription as this may predict exercise counselling they will provide to future patients.*

Methods: *A 27-item survey was distributed to Canadian Memorial Chiropractic College (CMCC) students (N = 744). The survey determined the proportion of CMCC students that meet the (2012) Canadian Physical Activity Guidelines. Additionally the survey recorded students' perceptions of PA counselling during patient visits and their own example of maintaining a healthy lifestyle.*

Results: *The response rate for the survey was*

Contexte : *Les habitudes liées à l'activité physique (AP) des professionnels de la santé sont associées à leur probabilité de recommander des AP à leurs patients. L'objectif de ce projet est de mieux comprendre les perceptions et les pratiques des étudiants du Canadian Memorial Chiropractic College (CMCC) quant aux activités physiques et à la prescription d'exercices, car cela peut être indicatif des conseils en matière d'exercices qu'ils fourniront aux futurs patients.*

Méthodologie : *Un questionnaire comportant 27 points a été distribué aux étudiants du Canadian Memorial Chiropractic College (CMCC) (N = 744). L'enquête a déterminé la proportion d'étudiants du CMCC qui respectent les Directives canadiennes en matière d'activité physique (2012). En outre, l'enquête a permis de noter les perceptions des étudiants concernant les conseils en matière d'AP pendant les visites des patients et leur propre exemple de maintien d'un mode de vie sain.*

Résultats : *Le taux de réponse pour l'enquête était de*

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*46% (N = 343). By using average estimates, it was determined that 72% of the respondents meet the (2012) Canadian Physical Activity Guidelines. 86% of the respondents perceived PA counselling to be usually or always relevant during patient interactions, and approximately 73% believed that exercise counselling is highly relevant to chiropractic practice. Furthermore, at least 88% percent believed that chiropractors must adhere to a healthy lifestyle in order to effectively model a healthy lifestyle to their patients.*

Conclusions: *A high proportion of CMCC students meet PA guidelines, and perceive PA counselling to be highly relevant and important to patient encounters.*

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KEY WORDS: exercise, prescription, physical activity, chiropractic, survey, student

*46 % (N = 343). En utilisant des estimations moyennes, on a déterminé que 72 % des répondants se conforment aux Directives canadiennes en matière l'activité physique (2012). 86 % des répondants ont perçu que les conseils en matière d'AP étaient habituellement ou toujours pertinents pendant les interactions avec les patients, et environ 73 % ont estimé que les conseils en matière d'exercice sont très pertinents pour la chiropratique. En outre, au moins 88 % pour cent estiment que les chiropraticiens doivent adopter un mode de vie sain afin de donner l'exemple à leurs patients.*

Conclusions : *Une proportion élevée des étudiants du CMCC respectent les directives en matière d'AP et perçoivent que les conseils en matière d'AP sont très pertinents et importants pendant les consultations avec les patients.*

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MOTS CLÉS : exercice, prescription, activité physique, chiropratique, enquête, étudiant

## Introduction

It is well known that physical activity (PA) has a plethora of health benefits among which is a significant reduction in the risk of developing noncommunicable diseases (NCD) such as cancer, cardiovascular disease (CVD), hypertension and diabetes.[1] However, globally one in three adults are not physically active (bodily movements that increase heart rate and breathing rate) enough to achieve these benefits.[1] Physical inactivity, defined as less than three and a half hours of exercise per week, are cited as a key risk factor for common chronic NCDs.[2,3] NCDs, although preventable, are cited as the fourth leading risk factor for death worldwide resulting in 3.2 million people deaths each year.[4]

Reflective of the global shift towards physical inactivity, obesity rates in Canada have doubled between 1981 and 2007, resulting in an increased prevalence of NCDs.[5] In 2011, Statistics Canada revealed that one in four Canadian adults and 9% of children between the ages of six and 17 years old were obese.[6] Obesity and its associated conditions have cost the Canadian economy approximately $4.6 billion in 2008, an increase of $735 million or approximately 19% since 2000.[6] Research has identified a number of determinants associated with obesity, including PA, diet, socioeconomic status, ethnicity, immigration and environmental factors. When studying these determinants, physical inactivity emerged as the most strongly associated with obesity at the population level for both men and women after adjusting for age and other behavioral and social determinants of health.[2] Specifically, an American based study found excess weight, defined as a body mass index (BMI) of 25 or greater, and physical inactivity, defined as less than three and a half hours of exercise per week, could collectively account for 31% of all premature deaths, 59% of deaths from CVD and 21% of deaths from cancer among nonsmoking women.[2] Furthermore, sedentary lifestyle is responsible for roughly one third of deaths due to coronary heart disease, colon cancer and diabetes three diseases for which physical inactivity is an established causal factor.[7] Results from the Canadian Community Health Survey showed that from 2003 to 2007/2008, the prevalence of diabetes mellitus in those from 12 years and older rose from 1.22 to 1.67 million.[6]

Regular PA is associated with a range of health benefits,

including a markedly reduced risk of chronic disease morbidity and premature mortality.[8,9] In addition to these preventative aspects physical activity may also be considered as a therapeutic intervention unto itself. While physical activity and exercise are often used interchangeable it is widely understood that exercise is planned, structured and purposeful. Exercise therapy, as it is often referred to in the literature, is not only helpful for the prevention of chronic NCD's, but has also been shown to be effective in increasing function and decreasing pain for a wide range of chronic musculoskeletal (MSK) disorders.[10] In addition to the breadth of global health benefits noted with movement, robust evidence shows that exercise itself can have a profound effect on analgesia and pain reduction in MSK conditions.[11,12] The effectiveness of PA and its transferability into the healthcare system as a therapeutic intervention has led the American College of Sports Medicine (ACSM) to establish the "Exercise is Medicine" (EIM) movement.[13] With the goal of transitioning into a preventative healthcare model, this global health initiative encourages mainstream and complementary healthcare providers to understand and promote active lifestyles in their patients and clients. EIM extolls the belief that physical activity is integral in the prevention and treatments of diseases and should be regularly assessed and recommended as part of all healthcare. The Canadian Society for Exercise Physiology (CSEP) is the host organization for EIM in Canada (EIMC) and chairs the multidisciplinary advisory council which provides leadership in promoting physical activity in Canada. Lifestyle modifications are fundamental to managing chronic disease risk, and there is some evidence that exercise counseling by medical doctors can help patients increase their PA levels.[2]

The ACSM recommend that men over 45 years of age and women over 55 who currently have or at risk for any chronic health problems should consult a physician prior to beginning any vigorous physical activity regimen.[14] Furthermore, advertisements for commercial health and fitness products commonly advise people to consult their physician prior to exercise participation. However, few physicians report including advice on PA in their history taking or report process.[15] When asked about their ability to provide such advice, they cite insufficient time, lack of reimbursement and inadequate training in PA counseling as reasons they fail to discuss exercise.[15] Therefore, despite the well-established health benefits of PA and the effectiveness of PA prescribed by doctors, rates of exercise counseling by doctors remain unfortunately low.[16-19]

Studies have shown that 64% of Canadian medical students and 61% of American medical students meet the ACSM guidelines for weekly PA.[20] While almost two thirds of Canadian medical students meet the recommended weekly guidelines for PA, approximately 75% percent do not regularly engage in exercise counseling with patients.[21] Evidence also reveals that physicians who are physically active may be up to 5.7 times more likely to recommend PA to patients[21-24] and it is suggested that active physicians are not only more likely to prescribe exercise and lifestyle advice, but their patients are also more likely to follow the advice[8]. Thus, despite the low exercise prescription rates in both active and inactive doctors, it appears that there is a greater chance of active physicians discussing it with their patients during a medical consultation.

This current study was conducted to determine if the medical student findings are similar for Canadian chiropractic students. Specifically, the purpose of this study was to evaluate the proportion of chiropractic students at the Canadian Memorial Chiropractic College (CMCC) engaging in at least 150 minutes of moderate to vigorous physical activity (MVPA) per week (as recommended for adults aged 18-64 years of age by the Canadian Physical Activity Guidelines).[25] MVPA includes activities such as running, biking, brisk walking and even yard work akin to raking. The Canadian guidelines aim to reduce disease and achieve greater health benefits by giving specific activity tips to accumulate more exercise. Exercise bouts of ten minutes or more and strengthening activities at least 2 days per week are also suggested. Additionally this study attempts to evaluate the perceptions of chiropractic students as to the importance of exercise counseling during patient encounters. Finally, the association between PA and personal psychological well-being or mental health amongst chiropractic students themselves will be considered as previous studies have noted high stress in medical students to be important to PA habits.[1,20]

## Methods

### *Study Population*

The population eligible for sampling included all students enrolled in the CMCC undergraduate Doctor of Chiropractic program as of September 1st, 2013. The undergraduate

program at CMCC is a four year program and includes students from a diverse educational background provided they meet the prerequisite grade point average and have at least three years of undergraduate studies by Canadian standards. Students registered in postgraduate chiropractic studies, such as the CMCC residency Programs, were excluded from the study population as the intent was to capture a cross-sectional study of the entire undergraduate CMCC student population. Participants were contacted through the CMCC student email database as well as through cohort-wide social media forums. The surveys were completed anonymously and submitted online in the months of March and April 2014. Ethics approval was obtained from the CMCC Research Ethics Board.

### *Survey Tool*

Data were drawn from a 41 item survey that was created based on a modified 27 item template originally published by Ng and Irwin[20], reconfigured to be applicable to a chiropractic study population. The specific validity and reliability of the chiropractic survey was not tested. The Ng survey was created by utilizing Erica Frank's[26] questionnaire, which was used to determine medical students' perception of the relevance and frequency of PA counseling during patient visits. Furthermore, to determine PA habits, Ng and Irwin[20] combined Frank's questionnaire[26] with a condensed version of the International Physical Activity Questionnaire (IPAQ) validated and published by Craig *et al*.[27] The survey used in this study is simply a reworded version of the survey used by Ng and Irwin[20] in order for the vocabulary used to have greater applicability/readability to chiropractic students as opposed to medical students. Survey responses were scored and numerical data was generated using a 3-5 point Likert-type scale (ranging from nothing, somewhat, highly for 3 points or from strongly agree, agree, neutral, disagree, and strongly disagree for 5 points), and simply scored from 1-3 or 5 (options A, B, C, D, E). The survey was posted to, and issued through, the Survey Monkey program (www.surveymonkey.com, LLC) for ease of completion and data collection. CMCC years 1 through 4 class representatives sent out the survey invitation to their respective years with 3 follow up reminders 2 weeks apart. An additional verbal request from the researchers was also made to a class of each year in the final week that the survey was open to optimize response rates.

### *Outcome Measures*

In order to assess the attitudes and exercise habits of chiropractic students, questions involving frequency, intensity, and type of exercise performed along with exercise perceptions were created to assess if students met the recommended 150 minutes of PA per week (for 18-64 yrs. old), as recommended in the most recent Physical Activity Guidelines outlined by the Canadian Society of Exercise Physiologists (CSEP).[25] To assess chiropractic students' attitudes toward PA counseling, specific questions were asked with regard to their perceptions of credibility and authenticity in counseling and the influence in prescribing PA to patients. To consider the influence of mood on exercise habits additional questions were included that specifically asked about mental health and stress.

### *Statistical Analysis*

Self reported habits and attitudes towards exercise and exercise prescription were compared to a determination of whether chiropractic students meet the weekly minimum amount of exercise as determined by the Canadian Society of Exercise Physiologists (150 minutes of MVPA).[25] Analysis of frequency and count data were determined using Microsoft Excel and through Survey Monkey. We then further organized the data based on specific subject responses, and compared those answers to a set of questions e.g., "How relevant do you think exercise counseling is during patient encounters?" Survey responses were scored and numerical data was generated using a 3-5 point Likert-type scale, all variables were categorical with chi-square tests of independent variables used to assess association with outcomes. P-values $\leq 0.05$ were considered statistically significant. Additionally, a difference of proportions test was utilized to assess the difference between the number of chiropractic students who met the exercise guidelines versus the previously reported[20] medical student data. Statistical analysis of the impact that mental health of chiropractic students has on exercise habits was conducted in atwo-step manner. A mental status latent score was estimated using the Rizopoulos item response theory based on summing the three questions asked about stress and mental health. A t-test for the difference in the means of the latent score between those that met exercise guidelines and those that did not was calculated.

Table 1.
*Characteristics of chiropractic students and comparison between physical activity levels.*

| | Meets Physical Activity Levels | | |
|---|---|---|---|
| | No (<150 min per week) | Yes (>150 min per week) | P Value |
| | N=85 | N=247 | |
| **Current Year of Chiropractic School** | | | |
| 1st | 18 | 73 | 0.047 |
| 2nd | 22 | 57 | |
| 3rd | 36 | 71 | |
| 4th | 9 | 46 | |
| **Sex** | | | |
| Male | 37 | 121 | .368 |
| Female | 48 | 125 | |
| **Undergraduate Program of Study** | | | |
| Health Sciences | 12 | 31 | .009 |
| Basic Sciences | 15 | 28 | |
| Kinesiology | 46 | 173 | |
| General Arts | 4 | 9 | |
| Other | 8 | 5 | |
| **Frequency on counseling exercise during patient interaction** | | | |
| Rarely | 2 | 3 | .00001 |
| Sometimes | 13 | 14 | |
| Usually | 50 | 98 | |
| Always | 20 | 132 | |
| **Relevance of exercise counseling to intended specialty** | | | |
| Not at all | 0 | 2 | .004 |
| Somewhat | 30 | 45 | |
| Highly | 55 | 199 | |
| **To effectively encourage a patient, a chiropractor must also adhere to a healthy lifestyle** | | | |
| Strongly agree | 47 | 181 | .006 |
| Agree | 33 | 59 | |
| Neutral | 4 | 2 | |
| Disagree | 1 | 2 | |
| Strongly disagree | 0 | 2 | |
| **Provide more credible and effective counseling if I exercise and stay fit** | | | |
| Strongly agree | 48 | 184 | .001 |
| Agree | 29 | 56 | |
| Neutral | 7 | 3 | |
| Disagree | 1 | 2 | |
| Strongly disagree | 0 | 2 | |
| **I currently exercise enough** | | | |
| Strongly agree | 0 | 86 | <.0001 |
| Agree | 11 | 100 | |
| Neutral | 15 | 33 | |
| Disagree | 42 | 26 | |
| Strongly disagree | 17 | 1 | |

## Results

The survey was sent out to 744 participants with 344 students responding, representing a response rate of 46%. The respondents were represented across the four years of study with approximately ¼ of each class responding. Of the respondents 332 (96.5%) provided answers for the exercise questions such that the number of minutes of MVPA could be calculated and used for interpretation. All respondents of this survey were students at CMCC.

To correspond to this study's main purpose, Table 1 shows characteristics of the study population and whether or not the study population meets the Canadian Physical Activity Guidelines of at least 150 of MVPA per week. This study found that 74% (247/332) of chiropractic students at CMCC meet the Canadian Physical Activity Guideline for recommended MVPA per week (Table 1). Considering the previously reported 64% (969/1510) of medical students that meet the guidelines our test for difference in proportions shows a significantly higher proportion of chiropractic students to meet the physical activity guidelines (P = 0.000416).

Table 1 also corresponds to the study's second purpose in exploring the association between PA and personal psychological well-being or mental health amongst chiropractic students themselves. No differences were noted between male (158) and female (173) respondents. A significant finding from Table 1 showed 99% of students saw exercise counseling as "somewhat" or "highly" relevant to their intended practice style (P = 0.004). Furthermore, additional significant findings from Table 1 revealed 96% of students either agree or strongly agree that a chiropractor must adhere to a healthy lifestyle in order to effectively encourage patients to exercise (P = 0.006). When asked about their intended frequency of exercise counseling, approximately 90% of students will usually offer counsel promoting exercise (P = 0.00001). When presented with the statement "I will be able to provide more credible and effective counseling if I exercise and stay fit, 95% of students either agree or strongly agree (P = 0.01). When assessing respondent's current level of exercise, 59% of students either agree or strongly agree that their current exercise level is adequate (P = 0.0001).

Stress in the last 2 weeks, last 12 months and number of days with bad mental health in the last 30 days were combined to estimate a mental status latent score. The mean latent score for those who meet exercise guidelines

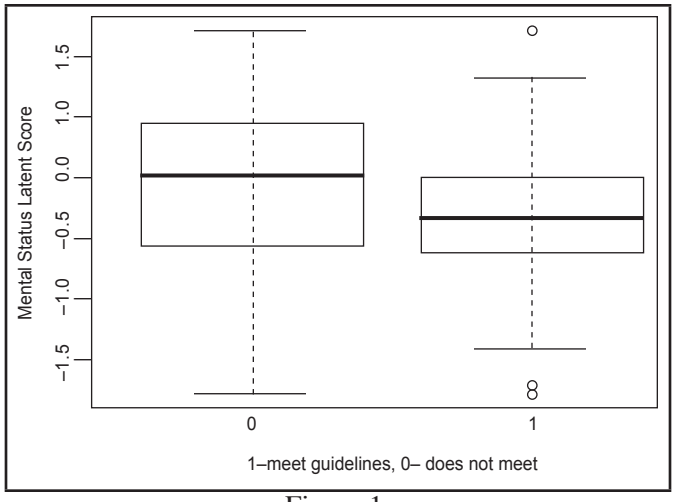


Figure 1.

*Box Plot – Mental Health Status and Physical Activity.*

is -0.0782 while the mean latent score for those that do not meet the exercise guidelines is 0.2207 (Figure 1 Box Plot). The t-test shows a significant difference between the two groups with the students who do not meet the guidelines having a significantly higher mental health latent score, suggesting higher stress (t test stats = 3.007298, P = 0.00284).

## Discussion

To our knowledge, this is the first study to examine the PA levels and intended counseling practices of chiropractic students. Comparing adherence to PA recommendations with previous American (61%) and Canadian (64%) medical student studies, our (74%) Canadian chiropractic students PA participation compares exceedingly well.[20,26] As in the previous medical study by Ng and Irwin, the percentages of chiropractic students who met PA guidelines were stable throughout their chiropractic education. This finding was not surprising given that 79% of our respondents had undergraduate degrees in health science or kinesiology and likely developed their PA habits earlier. Beyond improving fitness, PA has also been identified as playing a role in prevention and therapy for mental health, and given the known stress associated with professional education this aspect was considered.[1,20] Similar to medical student findings those students who met PA requirements also reported less stress or better mental health and this might provide another avenue for research in student success and education satisfaction. While we recognize the inherent validity/reliability issues in creating a latent score to quantify mood we are confident this approach could prove useful in future research.

Approximately 99% of the chiropractic students saw exercise counseling as relevant to their intended practice style which was similar to the medical student findings of Ng and Irwin (93%). Chiropractic and medical students were both in line with the notion put forth by Erica Frank that a healthy doctor equates to healthy patients (95% of chiropractic students and 94% of medical students) agree that advice is more credible and authentic by staying fit themselves. Additionally, chiropractic students (96%) are in greater agreement that they must adhere to PA guidelines in order to effectively encourage patients to do the same versus only 80% of medical students saying the same.[20]

### *Limitations*

There are a variety of limitations and potential sources of bias that may have caused for lower responses and over representation of the actual habits and perceptions of exercise and counseling amongst chiropractic students at CMCC. One such source of bias that may exist is the presence of social desirability bias. Social desirability bias can result when respondents systematically alter questionnaire responses in the direction they perceive to be desired leaving undesirable results to be underreported.[28] In this investigation, social desirability bias could have manifested in respondents reporting higher PA levels than they actually perform as well as a higher value for exercise prescription. This can be explained by the social role of a chiropractor to patients' wellness being more important than they would otherwise perceive. Another source of bias that is inherently associated with the utilization of self-directed surveys is the presence of a self-selection bias. Due to the nature of this investigation being based on volunteer participation, only those willing to fill out the study were included instead of all individuals of the target population.[29] Unfortunately we did not capture the responses of the entire student body at CMCC as the response rate in our study was only 46%. Although the response rate was greater than the 24% response rate of the Ng and Irwin study, these response rates limit the overall interpretation.

As indicated in the methods, the survey tool used in this investigation is an amalgamation of a previously validated International Physical Activity Questionnaire, and the questionnaire used by Frank *et al*.[22] that was changed to apply to a chiropractic audience. It is a major limitation that the modified survey used in this investigation was not previously validated nor was the reliability assessed. Test-retest reliability was not assessed and it can be argued that the results from this study do not adequately answer the question sought by the authors.

Finally, a cross-sectional study does not allow us to determine if this cohort of students change their level of PA or exercise counselling as they progress through their medical training or upon graduation however important conclusions can still be drawn.

## Conclusion

This study provides a baseline understanding of Canada's future chiropractors' current PA behaviors, attitudes and counseling habits. It is becoming more apparent in mainstream healthcare that a paradigm shift is underway towards a more preventative model of health. Engaging in 150 minutes of MVPA per week is the minimum amount required to attenuate morbidity and ultimately prevent disease.[25] One way to encourage greater participation in PA is through health practitioners actively counseling patients. Previous studies show that personal activity behavior is a strong predictor of whether healthcare providers value PA counseling as a part of routine patient visits.[8]

It has been demonstrated that nearly three-quarters of chiropractic students at CMCC that completed our survey meet the Canadian Physical Activity Guidelines for PA along with almost all of them perceiving PA counseling as somewhat to highly relevant in patient encounters. This compares with previous research that shows 64% of medical students meet the Canadian Physical Activity Guidelines[20], whereas this preliminary study reveals 74% of chiropractic students met the Canadian Physical Activity Guidelines, which is significantly more (p=0.000416). Overwhelmingly CMCC students plan on implementing exercise counseling in their patient visits (90%). In accordance with this, 96% percent of chiropractic students at CMCC believe chiropractors must adhere to a healthy lifestyle to encourage/model healthy lifestyles effectively in their patients and to further demonstrate authenticity and credibility. It was also found that while 59% of student's view their current level of exercise as adequate, over 40% would like to do more. Given the chiropractic and university undergraduate education of CMCC students we were not surprised that these results did not change regardless of the students' years of study.

It is well understood that exercise is effective in preventing chronic disease.[1] Chiropractors are well positioned to contribute and take on a leadership role in the "Exercise is Medicine" movement of health promotion and disease prevention in Canada, and the profession should take on an influential role in encouraging its implementation. Future research efforts should investigate the health habits and counseling practices of chiropractors in the field within Canada, the United States, Europe and Australia to further solidify this notion and enhance the global "Exercise is Medicine" movement.

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# Atypical presentation of axillary web syndrome (AWS) in a male squash player: a case report

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*Axillary Web Syndrome (AWS), also known as lymphatic cording, refers to a condition in which a rope-like soft-tissue density develops in the axilla. It usually appears in the 5 to 8 week period following breast cancer surgery and can lead to shoulder pain and restricted motion. We present a case of AWS in a male squash player with no history of breast cancer or surgery following a period of intense exercise. This case highlights the rare presentation of AWS in a male patient and raises awareness for the health care practitioner who may not suspect this condition in this population.*

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KEY WORDS: chiropractic, axillary web syndrome, lymphatic cording

*Le syndrome des cordelettes axillaires (AWS), également connu sous le nom de thromboses lymphatiques, se réfère à une condition dans laquelle des tissus mous denses comme une corde se forment dans la région de l'aisselle. Ceci apparaît généralement dans 5 à 8 semaines après une chirurgie du cancer du sein et peut entraîner des douleurs à l'épaule et limiter les mouvements. Nous présentons un cas d'AWS chez un joueur masculin de squash, sans antécédents de cancer du sein ou de chirurgie du sein, après une période intense d'exercice. Ce cas met en évidence la rare présentation de l'AWS chez un patient masculin et sert à sensibiliser le professionnel de la santé qui ne pourrait pas soupçonner cette condition chez cette population.*

(JCCA. 2016;60(4):294-298)

MOTS CLÉS : chiropratique, syndrome des cordelettes axillaires, thromboses lymphatiques

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Patient consent was obtained for the use of clinical information and imaging with respect to this case report.

## Introduction

Axillary Web Syndrome (AWS), also known as lymphatic cording, refers to a condition in which a rope-like soft-tissue density develops in the axilla.[1] A systematic review by Yeung et al. reported many synonymous names for AWS including axillary variant of Mondor disease, cording, lymphatic cord, cording lymphoedema, webbing, axillary web cord, vascular string, lymphatic thrombosis, axillary string, and fiddle-string phenomenon, among others.[2] The cording can extend further down into the arm and forearm and is made taut and painful by shoulder abduction.[1] AWS is typically the result of surgical treatment for breast cancer such as sentinel lymph node biopsy (SLNB) or axillary lymph node dissection (ALND), however the exact pathophysiology is currently not well established.[2,3] While AWS is often self-limiting, it can cause psychological and physical morbidity up to and beyond the typical resolution period of 5 to 8 weeks.[4] There are several risk factors for AWS which include type and extent of surgery, age, BMI, ethnicity, oncological treatment and healing complications.[2] We present an atypical presentation of AWS in a male patient with no history of breast cancer or surgery in which the cording appeared following an intense round of squash. To our knowledge, this is the first case in the literature to report this syndrome following a bout of high intensity exercise. We will also highlight the signs, symptoms, and risk factors associated with AWS to raise awareness of this condition as it is not commonly seen in general practice, and briefly discuss treatment options for manual therapists.

## Case Presentation

A 38-year-old competitive squash player and commercial pilot presented to our clinic noting the recent appearance of a subcutaneous cord along the medial portion of his right arm extending into the axilla, approximately 10cm in length (Figure 1). He did not relate any other contributing factor to the appearance of this cord. The cord appeared 8 days earlier following a particularly aggressive game of squash 24 hours prior. The cord was only visible with the arm abducted to at least 60 degrees and he described it as moderately tender to touch and mildly uncomfortable at rest, and did not cause him any functional limitations. The tissue appeared to be adhered to the skin at the distal end and deformed the skin in a crinkling appearance when the arm was moved (Figure 2). The patient related an active lifestyle including competitive squash, kite sailing, jogging, and beach volleyball. He has a family history of renal cancer in his father, hepatic cancer in his paternal grandmother, and metastatic cancer

Figure 1.
*Thin, compressible cord of soft tissue within the subcutaneous tissue of the axillary region.*

in his maternal grandmother. He was normotensive, does not take medications for any condition, and has a history of minor knee, back injuries, and cervicogenic dorsalgia that were managed conservatively. The patient reported no significant history of right shoulder or arm injury. He does not use recreational drugs or drink alcohol to excess. Upon physical examination, the patient is 5'4" tall with a medium athletic build and normal posture. He had normal distal pulses, and bilaterally symmetrical sensation, motor response, and reflexes of the upper limbs. He did not have any signs or symptoms of thoracic outlet syndrome. On abduction of the right arm to 90 degrees, a fibrous subcutaneous cord was observed extending 10 cm from the axilla along the medial aspect of the arm. On palpation, the cord was extremely thin, like butcher's string, and collapsed under minimal pressure.

The patient underwent one treatment of manual therapy including soft-tissue mobilization and friction-type myofascial release as well as advice on how to perform self-massage at home, which he only completed a few times by his account. The soft-tissue therapy was applied over the skin of the cord, while the patient brought the shoulder into extension at 90 degrees of abduction. The patient was travelling for the subsequent 4 weeks and could not return for further treatment. At 2 weeks, the patient contacted the practitioner and noted no longer feeling any discomfort from the cording. One month later the cord was no longer visible at rest however a small amount of cording was still visible when the patient flexed his biceps muscle in an abducted position (Figure 3).

## Discussion

The diagnosis of AWS is primarily made based on reported symptoms of pain and restricted motion, visual inspection and palpation of the axilla, upper extremity, and trunk for signs of cording.[3] A prospective study by Lacomba *et al*. reported an incidence rate of 48.3% in patients undergoing ALND however the range of incidences reported in the literature span from 0.6%-85.4%.[2] There are no reports of incidence rates available for males not undergoing breast cancer treatment. The natural history of this condition is reported to range from 3 weeks to 3 months,[5,6] although persistent symptoms have also been reported up to one year later.[7] Although it is not currently well understood, the most commonly cited pathophysiological process reported in the literature is damage to the lymphatic and venous systems during removal of lymph nodes for the treatment of breast cancer.[1,2,8] During the

Figure 2.
*The tissue appeared to be adhered to the skin at the distal end and deformed the skin in a crinkling appearance when the arm was moved.*

surgical process, increased lymphatic fluid coagulation may result in lymphatic thrombosis, which will lead to an accumulation in the lymphatic vessels, forming visible cords.[2] Lymphatic fluid has the capacity to spontaneously coagulate, although this process is increased in the presence of thrombokinase, a plasma protein. Thrombokinase is elevated post-surgery, but can also be present due to inflammation from tissue damage.[9] The present patient did not have breast cancer or surgery so the inciting mechanism is not clearly understood. One plausible explanation was a particularly intense bout of squash the day prior to the appearance of cording. The high force associated with overhead motions in his dominant racquet hand may have lead to damage of the venous and lymphatic vessels, as it has been suggested that external compression can lead to localized lymphatic thrombosis.[10] The patient is also a commercial pilot with a flight log of 54 hours in the month preceding the onset of cording at 35,000 feet with the cabin pressurised to 6000 feet. As it is known that high altitude travel can disrupt the venous system[11] It is possible that this may also have contributed to disruption of the lymphatic system, however this is purely speculative.

There are several risk factors reportedly associated with AWS including the type of surgery, BMI, age, ethnicity, axillary metastasis, oncology treatment, and healing complications.[2] Surgically, it appears that more aggressive surgical techniques such as ALND increase the incidence rate of AWS.[2,3,8] Studies have reported that a higher BMI is protective against AWS,[4,8] however it has been suggested that excess subcutaneous adipose tissue makes the visual diagnosis of AWS more difficult[4], therefore making it appear to be a protective effect. Since being older is often associated with a greater BMI, this may explain the association between AWS and younger age. Being a younger female also appears to increase your risk of AWS, however, this population is more likely to be undergoing breast cancer treatment.[3,4,8] Finally, one study reported increased prevalence of symptomatic AWS in African-American patients compared to caucasian patients.[4] Other than a low BMI and young age, the present patient did not demonstrate any of the associated risk factors for AWS, highlighting the rarity of his presentation.

The primary symptoms of AWS are pain, feelings of tightness in the axilla, and associated restricted range of motion, particularly in abduction, although not all patients with AWS will be symptomatic.[2] Our patient had mild pain at rest and moderate tenderness of the cord and due to his low percentage body fat, the visual inspection

Figure 3.
*One month later, without further intervention beyond the first visit of soft-tissue mobilization and advice on stretching and self massage.*

made for a clear diagnosis. His symptoms did not lead to any functional limitations or restrictions of activities of daily living.

In a systematic review by Yeung *et al*., the authors noted nine level IV studies for manual therapy techniques including myofascial release, scar massage, and manual lymphatic drainage.[2] Myofascial release treatments involving manual fixing of the cord while stretching the tissue resulted in increases in range of motion and decreases in pain.[12,13] It was also often reported that a painless audible "popping" sound would be heard during treatment, which is hypothesized to be the breakdown of the lymphatic cording.[13] Our patient underwent one treatment consisting of myofascial release and soft-tissue mobilization as well as weekly self-massage. He noted a 50% improvement in reduction of cording and perceived tightness after one treatment. After one month the cording was no longer visible at rest with only slight visualization during active biceps contraction. Due to the wide range of reported natural resolution periods in the literature[5–7], it is uncertain whether the treatment expedited recovery or if the condition spontaneously resolved. Low-level evidence has suggested between 5-10 treatments over 3-10 weeks[13,14], however, more high quality research is needed to make stronger manual therapy recommendations.

## Summary

This case highlights the rare presentation of AWS in a competitive squash player with low risk factors for developing this condition. While it is plausible that frequent air travel combined with an intense bout of overhead exercise may have caused damage to the lymphatic vessels and subsequent cording, the exact mechanism cannot be determined. This case illustrates an unusual and potentially confusing patient presentation of a benign condition that was managed with manual therapy and self-massage. An awareness and understanding of this condition will provide the practitioner with confidence in providing effective conservative care.

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# Delayed diagnosis of an isolated posterolateral corner injury: a case report

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Introduction: *Isolated injuries to the posterolateral corner of the knee are a rare and commonly missed injury associated with athletic trauma, motor vehicle accidents, and falls. Delayed or missed diagnoses can negatively impact patient prognosis, contributing to residual instability, chronic pain, and failure of surgical repair to other ligaments.*

Case Presentation*: A 44-year-old male CrossFit athlete presented with a history of two non-contact hyperextension injuries to his left knee while walking on ice. The only positive finding was the Dial Test at 30 degrees of knee flexion, indicative of an isolated posterolateral corner injury. After a delay in diagnosis, the patient underwent a reconstruction of the posterolateral corner and subsequent rehabilitation. Early recognition of this injury is important as this can affect the prognosis and activities of daily living of the patient.*

Introduction: *Les lésions isolées du point d'angle postéro-externe du genou sont une blessure rare et fréquemment manquée associée à un traumatisme sportif, à des accidents de véhicule automobile et à des chutes. Les diagnostics tardifs ou ambigus peuvent avoir un impact négatif sur le pronostic du patient, ce qui contribue à l'instabilité résiduelle, à la douleur chronique et à l'échec de la réparation chirurgicale à d'autres ligaments.*

Exposé de cas : *Un athlète CrossFit masculin de 44 ans s'est présenté avec deux lésions d'hyperextension sans contact de son genou gauche qui se sont produites alors qu'il marchait sur la glace. Le seul résultat positif a été le test d'hypermobilité externe (Dial test) à 30 degrés de flexion du genou, indiquant une lésion isolée du point d'angle postéro-externe. Après un retard dans le diagnostic, le patient a subi une reconstruction du point d'angle postéro-externe et une réadaptation subséquente. Le diagnostic précoce de cette lésion est important, car cela peut affecter le pronostic et les activités de la vie quotidienne du patient.*

Résumé : *Ce cas traitera du tableau clinique, des*

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Patient consent was obtained for the use of clinical information and imaging with respect to this case report.

Summary: *This case will discuss the clinical presentation, diagnostic procedures, and management of an isolated posterolateral corner injury and highlight the importance of early recognition and referrals from primary contact healthcare practitioners.*

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KEY WORDS: chiropractic, knee, posterolateral corner injury, rehabilitation, Dial test

*procédures diagnostiques et de la prise en charge d'une lésion isolée du point d'angle postéro-externe et soulignera l'importance du diagnostic précoce et des références des professionnels de soins de santé primaires.*

(JCCA. 2016;60(4):299-304)

MOTS CLÉS : chiropratique, genou, lésion du point d'angle postéro-externe, réadaptation, test d'hypermobilité externe

## Introduction

Injuries to the posterolateral corner (PLC) of the knee occur in 16% of knee injuries[1] and are most commonly associated with athletic trauma, motor vehicle accidents, and falls[2]. Isolated injury to the PLC occurs in 2% of acute knee injuries.[1] The PLC is comprised of numerous muscular and ligamentous structures, making this a complex anatomical region,[3] however it is most commonly cited that the 3 primary structures which comprise the PLC are the fibular collateral ligament (FCL), popliteus tendon, and popliteofibular ligament (PFL).[4,5] Biomechanically, the PLC structures primarily restrain tibial varus, external rotation, and posterior translation movement. Accordingly, injury to this area of the knee occurs with blows to the anteromedial thigh, contact and non-contact hyperextension, a valgus force to a flexed knee, and severe tibial external rotation with a flexed knee.[6] Delayed or missed diagnoses can negatively impact patient prognosis, contributing to residual instability, chronic pain, and failure of surgical repair to other ligament grafts.[7,8] This report highlights the clinical presentation, diagnostic procedures, and necessity of early recognition in an isolated PLC injury.

## Case Presentation

A 44-year-old male CrossFit athlete presented with a history of two non-contact hyperextension injuries to his left knee while walking on ice. The patient complained of intermittent instability and decreased confidence while descending stairs. On initial presentation, there was full range of motion (ROM) of the knee, mild pain in the posterolateral aspect of the knee, and no joint effusion. The only orthopaedic finding was mild laxity of the posterior drawer test compared to the contralateral limb. Tests for tibial rotational laxity were not performed at the initial assessment. The mechanism of injury and initial examination had lead to a diagnosis of a mild knee sprain.

At 3 months into his rehabilitation, the patient had noted muscle weakness and atrophy of the quadriceps; symptoms of instability since the onset of injury; decreased confidence descending stairs and walking on uneven ground; and the inability to engage in Olympic lifting. At that point, magnetic resonance imaging (MRI) was performed which showed high signal intensity in the anterior aspect of the lateral femoral condyle, suggestive of bone marrow edema. The FCL, PFL, popliteus tendon, and all other osseous and soft tissue structures were reported to be normal. Due to continued symptoms of instability and functional disability, the patient requested referral to an orthopaedic surgeon. Upon physical examination, the surgeon noted a mild varus angulation of the patient's legs. Range of motion revealed full knee flexion and extension. There was no varus thrust gait, effusion, or joint line tenderness present, however, there was tenderness over the FCL when the knee was placed in the combined flexion, abduction, and external rotation position. There was increased tibial posterior translation and external rotation on the affected side at 30 degrees of knee flexion, constituting a positive Dial test. The Dial test at 90 degrees was negative. Reverse Lachman and reverse pivot shift tests also demonstrated posterolateral laxity compared to the contralateral limb. His posterior cruciate ligament (PCL), anterior cruciate ligament (ACL), and medial collateral ligament (MCL), were within normal limits during ortho-

paedic testing. Varus stress radiographs performed at 20 degrees of knee flexion did not reveal any coronal plane instability of the FCL, as there was no side-to-side difference in joint gapping. Plain radiographs were within normal limits.

Based on the history and physical examination, the patient was diagnosed with PLC deficiency. The patient underwent a knee arthroscopy, which confirmed the presence of laxity in the PLC. The grading of the injury at the time of the surgery was not provided, however the surgeon commented that due to the time since the injury, the PFL and popliteal tendon had healed but continued to demonstrate laxity, seen as increased space in and around the posterolateral corner during the arthroscopy. The LCL was completely intact. He received a popliteus graft and common peroneal nerve neurolysis and transposition. The surgical procedure occurred 15 months after the initial injury. Post-surgical rehabilitation followed an approach similar to a PCL protocol[9] with touch weight bearing for six weeks, pain and edema management, and progressive strengthening. The patient reported gradual improvements in strength over a 6-month period, but he continued to experience some difficulties returning to Olympic lifting.

## Discussion

It has previously been suggested that the incidence of PLC knee injuries is under-reported.[6,10] In a prospective MRI study by LaPrade *et al*.[1], the authors investigated the incidence of various ligamentous injuries in knees presenting with hemarthrosis. It was found that 16% of PLC injuries occur in combination with other ligamentous injuries. The most common other ligaments injured with the PLC are the PCL, followed by the ACL. The PLC will be injured in isolation only 2% of the time[1], highlighting the rare presentation in this case.

There are many signs and symptoms associated with injuries to the PLC. Specifically, there are five signs and symptoms that can be noted before a hands-on examination is performed, including mechanism of injury, location of pain, involvement of the common fibular nerve, complaints of knee instability, and abnormal gait.[2]

The mechanisms most commonly associated with injury to the PLC include posterolateral forces to the anteromedial thigh, contact and non-contact hyperextension, a valgus force to a flexed knee, and severe tibial external rotation with a flexed knee.[6] Different structures in the PLC will be affected depending on the degree of knee flexion at the time of injury. Contact and non-contract sports involving pivot motions are most likely to encounter PLC injuries. An injury to the PLC should also be considered in the presence of injuries to the PCL and ACL.[2]

Upon initial injury to the PLC, patients may report lateral or medial joint line tenderness, however there is commonly a diffuse tenderness over the posterolateral knee and the fibular head due to irritation of the PLC structures, knee capsule, and common fibular nerve. Patients may also present with neurological symptoms as it has been reported that the common fibular nerve is injured in 13% of PLC injuries.[6] Therefore, clinicians need to perform a thorough examination of the deep and superficial fibular nerves for both sensory and motor function.[11] PLC injury may lead to patient complaints of instability. The patient may describe a "give-way" sensation into hyperextension with stairs or hill walking and have apprehension to pivoting or cutting motions.

Due to the rotary instability of the knee, an abnormal gait pattern may develop which the patient cannot compensate for. During the initial contact and loading phase of gait, the knee may suddenly angulate in a varus direction (known as a varus thrust gait), which also loads the medial compartment of the knee. Over time, this continued stress on the medial compartment may expedite the degenerative process in the knee.[12,13]

A heightened index of suspicion for a PLC injury should be considered when the above-mentioned signs and symptoms are present. A complete physical examination of the knee should be included to rule out other intra-articular and cruciate ligament injuries. However, the following procedures should be used to assess posterolateral rotational laxity. The Dial Test is a measure of posterolateral rotational laxity of the knee.[2,14] The patient is placed in the supine position, hips and knees flexed to 90 degrees, ankle in dorsiflexion, and the foot is used to rotate the tibia until a hard end-range is felt (Figure 1). A positive test is indicated when there is an increase in rotational laxity on the affected side. In a cadaveric study investigating tibial rotation laxity, a 10-15 degree difference is significant between legs with specific sectioning of the three PLC structures.[15] Furthermore, a positive Dial Test at 30 degrees suggests an isolated PLC injury, while at 90 degrees suggests involvement of the PCL. To date, no

Figure 1.
*Dial test performed in the supine position. In this image, increased laxity into tibial external rotation of the subject's right leg indicates a positive dial test at 30 degrees of knee flexion, suggestive of an isolated posterolateral corner injury. If the dial is also positive at 90 degrees of knee flexion, this suggests involvement of the PCL.*

study has investigated the sensitivity or specificity values of this test.[2] The accuracy of this test can also be affected by injury to the MCL which resists anteromedial rotation of the knee[16], so the possibility of injury to this ligament must also be considered. Other tests of rotational laxity of the knee include the external rotation recurvatum test, reverse-pivot shift, posterolateral drawer, and standing apprehension test.[2] While this case highlights an isolated PLC injury, it is important to consider potential damage to the anterior and posterior cruciate ligaments as 87% of PLC tears occur as part of multi-ligament injury spectrums.[1] MRI should be utilized for suspected cases of PLC injury. Coronal oblique planes should be included in order to adequately display the PLC structures.[2] In this case, the FCL was fully intact (Figure 2) and due to inadequate visualization of the PFL and popliteus tendon, the diagnosis of PLC deficiency was delayed. It has been previously reported that the sensitivity of MRI to detect PLC injuries is low, with values of 57.58% for detecting FCL injury and 24.24% for detecting popliteal tendon injury.[17] Furthermore, a second opinion of the MRI in this case was also inconclusive for PLC injury, which was not detected until the arthroscopy was performed. This highlights that the absence of positive findings on MRI do not confirm the absence of pathology.[17] To obtain better visualization of the PLC, specific protocols should be used including coronal oblique and sequence views, and the scans should be performed in the acute injury phase, which may increase the accuracy of the study.[17]

The time between initial injury and surgery was 15

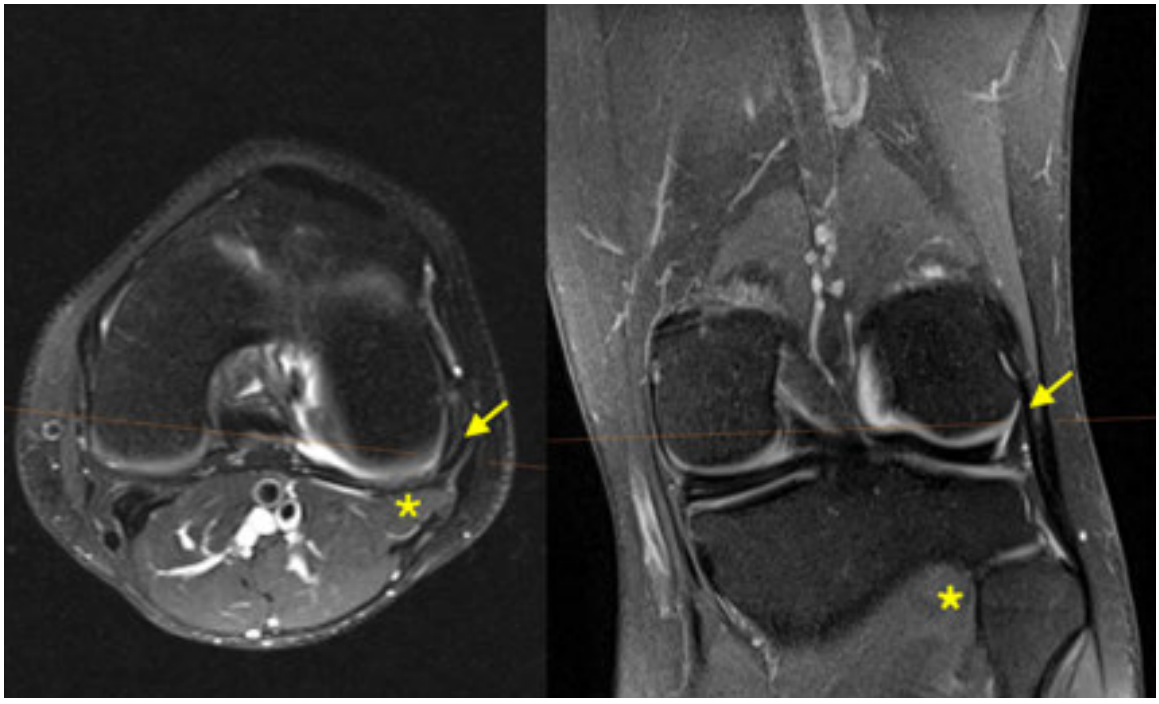

Figure 2.
*Axial (left) and coronal (right), proton-density, fat-suppressed image of the patient's left knee unremarkable for posterolateral corner injury. A positive finding would be high intensity signal at the FCL (arrow) and popliteus tendon (asterisk).*

months due to a combination of low index of suspicion clinically, inconclusive MRI results, and lack of access to a knee specialist. This delay caused the patient significant functional disability and muscle atrophy, which may have been avoided with early clinical recognition. While a recent systematic review suggests that acute and chronic PLC injury repairs have similar success rates at 83% and 90% respectively, there is an increase risk of injury to other ligamentous structures in the pre-surgical period.[18,19] Noyes and Westin[8] reported that 40% of PCL injuries occurred due to deficiencies of the PLC, therefore recognizing an injury to the PLC may decrease the likelihood of causing further damage to other structures in the knee.

Classification of PLC tears is based on the Fanelli Scale with increased grades indicating increased number of structures involved.[2] While most Grade III tears to the FCL are managed surgically due to better outcomes[7], Grade I and II tears may be managed conservatively. There is inadequate evidence highlighting surgical repairs to the popliteal tendon in the absence of tears of the FCL. There is also a paucity of literature supporting the conservative management of isolated PLC tears due to its low prevalence. PLC injuries that occur with other ligament tears typically follow the rehabilitation protocol of the primary ligament that has been damaged. Experts advocate standard pain and edema management initially, followed by progressive rehabilitation based on anthropometrics, function, and symptom resolution.[2]

## Summary

This case highlights the need for a high index of suspicion for a PLC injury when the mechanism and clinical findings support the diagnosis, even in the absence of MRI findings. While the evidence supports surgical methods for Grade III tears, further research on rehabilitation in conservative cases is needed.

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# Septic olecranon and prepatellar bursitis in hockey players: a report of three cases

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*Septic bursitis (SB) is an important differential diagnosis in athletes presenting with an acute subcutaneous swelling of the elbow or knee. Prompt recognition is essential to minimize recovery time and prevent the spread of infection. Due to the significant overlap in clinical features, it is often difficult to differentiate SB from non-septic bursitis (NSB) without bursal aspirate analysis. SB is commonly not considered unless the bursitis is accompanied by a local skin lesion or fever. This study describes two cases of septic olecranon bursitis and one case of septic prepatellar bursitis in adult hockey players presenting to a sports medicine clinic. None of the cases presented with an observable skin lesion and only one case developed a fever. It is therefore essential that clinicians maintain a high index of suspicion and monitor for signs of progression when presented with an acute bursitis even in the absence of these features.*

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KEY WORDS: chiropractic, bursitis, olecranon, prepatellar, infection, hockey

*La bursite septique (BS) est un diagnostic différentiel important chez les athlètes souffrant d'un œdème sous-cutané aigu du coude ou du genou. Le diagnostic rapide est essentiel pour réduire au minimum la période de convalescence et prévenir la propagation de l'infection. En raison du chevauchement important des caractéristiques cliniques, il est souvent difficile de distinguer entre la BS et la bursite non septique (BNS) sans analyse de l'aspiration de la bourse. La bursite septique n'est couramment envisagée que si elle est accompagnée d'une lésion cutanée locale ou de fièvre. Cette étude décrit deux cas de bursite rétro-olécranienne septique et un cas de bursite prérotulienne septique chez les joueurs de hockey adultes qui se présentent à une clinique de médecine sportive. Aucun des cas ne présentait une lésion cutanée observable et un seul cas a présenté de la fièvre. Il est donc essentiel que les cliniciens maintiennent un haut indice de suspicion et surveillent les signes de progression lorsqu'on leur présente une bursite aiguë même en l'absence de ces caractéristiques.*

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MOTS CLÉS : chiropratique, bursite, olécrane, prérotulien, infection, hockey

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Patient consent was obtained for the use of clinical information and imaging with respect to these case reports.

## Introduction

Septic bursitis (SB) is characterised by inflammation secondary to bursal infection and most commonly involves the olecranon and prepatellar bursa due to their superficial locations.[1] The condition is frequently initiated by direct trauma with resultant transcutaneous bacterial contamination, most often through a traumatic or dermatologic skin lesion.[2,3] Although the prevalence is unknown, SB accounts for one third of acute bursitis cases presenting to community hospitals with approximately 85% of cases occurring in young to middle-aged men.[2]

While non-septic bursitis (NSB) has been widely observed among athletes, to our knowledge only one case of SB resulting from sport participation has been reported in the literature.[4] The purpose of this paper is to describe three cases of SB in young adult hockey players presenting to a multidisciplinary sports medicine clinic and provide an overview of the clinical features differentiating SB and NSB.

## Case Reports

### *Patient A*

A 19-year-old male hockey player presented to a sports medicine clinic with localized swelling over the right olecranon process one day after striking his elbow on the ice. The patient reported that his elbow padding had temporarily shifted leaving the area unprotected during impact. Due to minimal pain and full functionality, the patient was able to continue playing. Swelling reportedly began within two hours of injury. Physical examination revealed a mildly tender, localized, subcutaneous swelling overlying the right olecranon process (Figure 1). No skin lesions were observed. Elbow ranges of motion were full, though mild pain was reported at the end-range of flexion. Blood pressure, heart rate, and respiratory rate were normal and oral temperature measured 36.9 degrees Celsius. The patient was diagnosed with an acute traumatic olecranon bursitis and advised to apply ice and avoid aggravation.

The following day, the patient returned to the clinic due to progression of pain and swelling. Upon examination, there was diffuse tenderness, warmth, erythema, and swelling extending into the extensor surface of the forearm (Figure 2). Ranges of motion of the elbow were full though moderate pain was reported beyond 90 degrees of flexion with maximal pain at end-range. Oral temperature

Figure 1.
*Upon initial presentation, the patient demonstrated a tender, localized, subcutaneous swelling overlying the olecranon process consistent with an acute traumatic olecranon bursitis. No skin lesion was observed. Vitals were normal.*

Figure 2.
*On the second day, diffuse swelling, warmth, and erythema developed over the extensor surface of the forearm indicating peribursal cellulitis. Vital examination revealed fever (38.3 °C). Patient was referred to urgent care with suspected septic olecranon bursitis.*

measured 38.3 degrees Celsius. Blood pressure, heart rate, and respiratory rate were normal. The patient was referred to a local urgent care centre with suspected septic olecranon bursitis.

Bursal fluid aspiration yielded gram-positive bacteria, elevated leukocytes, and reduced fluid glucose. Blood analysis including complete blood count (CBC) and blood culture were normal. The diagnosis of septic olecranon bursitis was confirmed and the patient was prescribed Cephalexin (500mg 4x/day) and Naproxen (375mg 2x/day) for seven days and instructed to rest and ice. Over the course of treatment, the swelling continued to progress, travelling distally to the wrist and proximally to the middle of the arm. The patient returned to the urgent care centre and was immediately prescribed home-based parenteral antibiotics for an additional seven days. Fourteen days following initial presentation, the patient made a full recovery and gradually returned to play by the third week.

### *Patient B*

A 20-year-old male hockey player presented to the above clinic with swelling over the left olecranon process two days after bumping his elbow on the boards. The patient reported wearing protective elbow padding at the time of impact and was able to continue playing with mild discomfort. Within three hours, a localized swelling developed over the olecranon process and over the course of two days, the swelling progressed into the extensor surface of his arm and forearm.

Physical examination revealed an erythematous, tender, warm, and diffuse swelling extending from the extensor surface of the proximal third of the forearm to the distal third of the arm most prominent over the olecranon process. No skin lesions were observed. Elbow ranges of motion were full with moderate pain at the end-range of flexion and extension. Vitals were normal and oral temperature measured 37.0 degrees Celsius. The patient was referred to an urgent care centre with suspected septic olecranon bursitis.

Bursal fluid analysis was consistent with SB and blood analysis (CBC and culture) was normal. Radiographic examination was negative for osseous pathology and diagnostic ultrasound revealed an avascular septated hypoechoic mass overlying the olecranon process. The patient was diagnosed with septic olecranon bursitis and prescribed Cephalexin (500mg 4x/day) and Naproxen (375mg 2x/day) for seven days and instructed to rest and ice. The patient made a full recovery over the course of five days and returned to play on the seventh day.

Figure 3.
*Diffuse swelling, warmth, erythema, and tenderness along the anteromedial aspect of the right knee was observed with extension beyond the joint margins superomedially. Tenderness and swelling were most pronounced over the prepatellar bursa. An associated skin lesion was absent and vitals were normal. The involved area was outlined with a black marker prior to referral.*

### *Patient C*

A 19-year-old male hockey player presented to the above clinic with a swollen and painful knee one day after receiving a lateral impact from an opponent player and striking his knee against the boards. The patient reported wearing knee protection though he was unable to continue playing due to pain. Upon physical examination, diffuse tenderness, warmth, erythema, and swelling along the anteromedial aspect of the right knee was observed with extension beyond the joint margins superomedially (Figure 3). The swipe test for intra-articular effusion was

Figure 4.
*A significant reduction in the involved area was observed the following day (red marking). The weave pattern of the kinesiotape can be visualized on the skin.*

negative. Palpation revealed maximal tenderness over the prepatellar soft-tissues and over the area of the MCL. Bony tenderness was absent at the patella, tibial plateaus, and femoral condyles. Range of motion of the knee was full with mild discomfort at the end-range of flexion and extension. Medial knee pain was reproduced with valgus testing at 30 degrees of flexion, though no laxity was observed. Orthopedic testing of the cruciate ligaments and menisci were negative. Vitals were within normal limits and oral temperature measured 36.4 degrees Celsius.

An acute MCL sprain was diagnosed clinically and septic prepatellar bursitis was confirmed by bursal aspiration at the urgent care centre. Blood analysis including CBC and culture was normal. The patient was prescribed Cephalexin (500mg 4x/day) and Naproxen (375mg 2x/day) for seven days and instructed to rest and ice. Prior to referral, a black marker was used to outline the affected area as shown in Figure 2A.

The patient returned to the sports clinic the same day and immediately began pain and edema reduction strategies including 30 minutes of ice and compression using a Game Ready machine and a lymphatic drainage kinesiotape technique. In addition to taking the prescribed medications, the patient was instructed to apply ice every hour at home. The response to treatment was examined the following day by outlining the area of warmth and tenderness with a marker. A three to five centimetre reduction was observed in all directions (Figure 4). This treatment protocol was continued and by the fourth day, there was complete resolution. The player returned to play on the fifth day with supportive taping of the MCL and no recurrence of infection to date.

## Discussion

Injury to a superficial bursa may result from a single direct impact, multiple minor impacts, or prolonged constant pressure. Trauma triggers an acute inflammatory response resulting in the overproduction of bursal fluid and subsequent bursal swelling.[1] In some cases, injury may result in intrabursal bleeding.[5] These processes damage the bursal epithelium and in turn increase susceptibility to microorganism seeding.[2,5]

In most cases, SB is presumed to occur through direct transcutaneous seeding of normal bacterial flora through local skin lesions. Infection may also occur through secondary spread from an initial cellulitis[6] or by hematogenous spread in rare cases[3]. Staphylococcus aureus is the causative agent in 80-90% of cases, followed by Group A Streptococcus accounting for 5-20%.[1] Although direct evidence is lacking, unsanitary athletic gear has been implicated as a potential source of soft-tissue infection among hockey players.[7] Significant quantities of bacteria, including Staphylococcus aureus, have been identified in protective sports equipment of high school and university aged football players.[8] Due to the prolonged and often direct contact with the skin, protective padding may serve as a fomite, facilitating bacterial contamination following localized soft tissue trauma. However, among the patients described in the present report, the exact origin of infection is unclear.

Early recognition of SB is essential as delay of treatment prolongs recovery time[9] and unmanaged bursal infections may result in skin necrosis, infection of surrounding tissues, and septicaemia[6]. However, differentiat-

ing SB and NSB on clinical examination alone is challenging due to the significant overlap in physical findings.[10] Tenderness, warmth, and peribursal cellulitis show high negative predictive values (0.9-1.0)[2,10], indicating that the absence of any of these features strongly suggests the bursitis is non-septic. The absence of an observable local skin lesion also suggests the bursitis is likely non-septic, though the negative predictive value is somewhat lower (0.79-0.88).[2,10] In the present report, none of the patients with SB showed evidence of local skin trauma. Clinicians should therefore maintain a high index of suspicion even when a portal for bacterial migration is not readily observable. In contrast, fever shows a positive predictive value of 1.0[2], suggesting that any bursitis accompanied by a fever should be considered septic. However, the absence of fever does not necessarily rule out SB, as fever demonstrates a negative predictive value of 0.30.[2] This is consistent with the afebrile presentations of Patient B and C. Although these data come from small sample sizes (n=30[2] and n=46[10]) they nonetheless suggest that clinical features may be useful in differentiating SB and NSB when applied appropriately in relation to their associated predictive values. However, as observed with Patient A, signs of infection may not be present upon initial presentation stressing the importance of educating the patient, following up, and monitoring for progression.

Septic arthritis is an important differential diagnosis to consider in athletes presenting with an acutely swollen joint as the clinical presentation is similar to that of SB.[11] A key differentiating factor suggesting an intra-articular inflammatory process such as septic arthritis is limitation in active and passive ranges of motion due to pain. Furthermore, the joint is often held in the position of maximal intra-articular space.[11] For example, a septic elbow will be held at 70 degrees of flexion[12] and a septic knee will be extended fully[11]. Unfortunately, these specific positions were not noted with our patients during the physical examination. Patients with suspected septic arthritis should be immediately referred for diagnostic arthrocentesis as delay in appropriate antibiotic therapy within the first 24 to 48 hours of onset can result in subchondral bone loss and permanent joint dysfunction.[11]

Definitive diagnosis of SB is made through bursal aspiration yielding bacteria, elevated leukocytes, and diminished fluid glucose. Identification of the specific causative agent is achieved with culture analysis. Blood samples showing elevated infection parameters (e.g. CRP and leukocytes) are also associated with SB and if considerably elevated, indicate the need for hospitalization and parenteral antibiotic therapy.[1]

Imaging studies including plain film radiography, ultrasound, and MRI have limited utility in the diagnosis of SB. However, radiography may be utilized to rule out fracture, bone lesions, spurs, and osteomyelitis. Ultrasound may also be useful in identifying possible underlying causes such as rheumatoid nodules and gouty tophi.[1]

The therapeutic approach for mild to moderate SB consists of a seven to 14 day course of oral antibiotics, NSAIDs, and the PRICE principle (protect, rest, ice, compress, and elevate).[9] The time required to achieve bursal sterility is correlated with the duration of symptoms prior to diagnosis (r=0.68)[9], stressing the importance of early antibiotic intervention. When treatment is initiated within seven days of onset, full recovery is typically achieved within two to six days with an average of four days. Beyond seven days, time to full recovery may take up to fifteen days.[9] This is consistent with the recovery time observed in Patient B and Patient C. In both cases, treatment was initiated within two days of onset and full recovery was observed between four and five days. In contrast, Patient A failed to respond to oral antibiotics over the first seven days, returned to the urgent care centre, and was prescribed parenteral antibiotics. As a result, the patient required an additional seven days of antibiotic treatment and had fully recovered by the fourteenth day.

Patient follow-up is generally recommended two days after initial diagnosis in order to evaluate the response to treatment and re-assess antibiotic selection based on aspirate culture results.[1] As demonstrated by Patient A, this may not always occur. It is encouraged that the referring clinician continue to be involved in monitoring the response to treatment, providing patient education, re-assurance, and addressing the secondary symptoms of pain and swelling.

## Summary

Septic bursitis is an important differential diagnosis in athletes presenting with an acute subcutaneous swelling of the elbow or knee, particularly in response to trauma. Due to the significant overlap in clinical features between SB and NSB it is often difficult to rule out infection. It is important for clinicians to be aware that SB can occur in

the absence of fever and the absence of an observable skin lesion. Suspected cases should be immediately referred for bursal aspiration and blood analysis. If SB appears unlikely, clinicians should maintain a high index of suspicion and follow-up with patients for signs of progression. Failure to initiate appropriate antibiotic therapy results in prolonged recovery time and may lead to infection of surrounding tissues. Articular ranges of motion and vitals should also be assessed in order rule out septic arthritis and systemic infection respectively.

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# Challenges surrounding return-to-play (RTP) for the sports clinician: a case highlighting the need for a thorough three-step RTP model

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*Return-to-play (RTP) is a multifactorial process of retuning an injured athlete back to competition when risk for re-injury is minimized. Traditionally, these decisions are made by medical practitioners based on experience or anecdotal evidence. RTP decisions continue to be a challenging task for the medical practitioner. In the interest of advancing sports medicine for the betterment of athletes, improving the RTP decision-making process with a new paradigm has been suggested.[1] It stands to clarify the intricacies used by clinicians when making RTP decisions by providing insight into the multiple factors that must be considered; not only by the athlete and medical practitioner, but all relevant parties (i.e., coaches, trainers, and organizations). This case describes a 19-year-old Ontario Junior Hockey League (OJHL) player who fractured his left clavicle during game play and consequently, suffered a more severe injury to the same clavicle 5½ weeks later by returning to competition against medical advice. This*

*Le retour au jeu (RTP) est un processus multifactoriel du retour d'un athlète blessé à la compétition lorsque les risques d'une nouvelle blessure ont été réduits. D'habitude, ces décisions sont prises par des médecins selon leur expérience ou des données empiriques. Les décisions relatives au RTP continuent d'être une tâche difficile pour le médecin. Dans l'intérêt de l'avancement de la médecine sportive pour le mieux-être des athlètes, l'amélioration du processus décisionnel relatif au RTP avec un nouveau paradigme a été suggérée[1]. Cela vise à clarifier les subtilités auxquelles ont recours les cliniciens dans leur prise de décision relative au RTP en offrant un aperçu des multiples facteurs qui doivent être tenus en compte non seulement par l'athlète et le médecin, mais aussi par toutes les parties concernées (c.-à-d. les entraîneurs et les organisations). Ce cas décrit un joueur du Ligue de hockey junior de l'Ontario (OJHL) de 19 ans qui a fracturé la clavicule gauche pendant le jeu et a subi une blessure plus grave à la même clavicule 5½ semaines plus tard lorsqu'il est retourné à la compétition contre l'avis médical. Ce cas*

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Patient consent was obtained for the use of clinical information and imaging with respect to this case report.

*case highlights the potential issues that present when a RTP protocol is poorly executed and addresses the need to adopt a thorough decision-based RTP model proposed by Creighton et al.[1] Further, the discussion will draw on current literature and issues surrounding RTP, and the potential legal implications associated with premature return to competition. Given the lack of consensus among sport medicine experts in regards to RTP criteria, the presented model stands to provide a pivotal framework upon which future research can be conducted, while improving the current criteria in place when returning an athlete to competition to aid medical practitioners.*

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KEY WORDS: Return to play, RTP, clavicle fracture, decision-based model, chiropractic

*met en évidence les problèmes potentiels qui se posent lorsqu'un protocole RTP est mal appliqué et répond à la nécessité d'adopter un modèle RTP décisionnel proposé par Creighton et autres[1]. En outre, on y discute des publications scientifiques actuelles et des questions entourant le RTP, ainsi que les conséquences juridiques potentielles associées à un retour prématuré à la compétition. Compte tenu de l'absence de consensus parmi les experts en médecine sportive en ce qui concerne les critères du RTP, le modèle présenté vise à offrir un cadre essentiel à partir duquel des recherches futures peuvent être menées, tout en améliorant les critères actuels dans la décision du retour de l'athlète à la compétition pour aider les médecins.*

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MOTS CLÉS : retour au jeu, RTP, fracture de la clavicule, modèle décisionnel, chiropratique

## Introduction

Return-to-play (RTP) decisions are inevitable for any medical practitioner working with athletes. It is necessary for these practitioners to understand the weight these decisions have on an athlete's health and career. As a result of the complexity of these decisions, they are often made in a team environment involving clinicians, therapists, or other members of the integrated support team (IST) to address all relevant concerns (i.e., movement mechanics, psychology, etc.).[1-4] Despite existing guidelines for return to sport following specific musculoskeletal injuries, such as anterior cruciate ligament (ACL) reconstruction, there is no current standardized definition for RTP.[1-4] As a result, this forces practitioners to make clinically informed decisions based on previous experience and practical judgment when injuries do not fall within a preexisting guideline or rigorously developed RTP protocol. The American College of Sports Medicine (ACSM) recognizes RTP as the "decision-making process of returning an injured or ill athlete to practice or competition."[5] Regardless of definition, the goals of any RTP decision are to return the athlete to competition, protect their health and welfare at all costs, and reduce the risk of reoccurrence.[5] It could then be suggested that one homogenous definition for RTP may not be appropriate, as these decisions require the full integration of a multitude of factors unique to the individual athlete, the given circumstances, and specific injury.[6] Recognition of this issue has resulted in a shift of attention away from creating a standardized definition to focusing on the development of a common language spoken by all parties involved in RTP decisions to ensure athletes, and their return to competition, are being viewed holistically to reduce the risk of recurrent injury.[1]

Recent scientific and legal investigations into the long-term sequelae associated with persistent mild traumatic brain injuries (MTBIs) and concussions witnessed in boxing, football, and hockey has resulted in increased media coverage about the safety of participation.[7,8] Indirectly, this has caused an increased awareness about the RTP process, bringing into question the effectiveness of the current standards when returning an athlete to competition following injury. The result has been a plethora of recent research investigating the RTP process for serious conditions resulting in long-term morbidity or even mortality (i.e., spinal cord injuries, cardiovascular abnormalities, and concussions).[1,9] However, little attention is given to the common musculoskeletal traumas experienced by athletes in all sports and the associated factors that may

impede an athlete's successful return to competition.[10] As a consequence, RTP decisions continue to be a contentious topic.

Decision-making is the cornerstone of all RTP recommendations.[1-2] Appropriate consideration and rationale must be utilized while all the parties involved are acknowledged. Traditionally, most decisions are made using the rational decision-making model that indicate a series of steps that decision-makers should consider if their goal is to maximize the quality of their outcome.[1,11] In other words, the decision-maker stands to calculate all the possible advantages and disadvantages of all available options, while selecting and implementing the best option.[11] Although the nature of this model is useful for personal or corporate decisions, it is less applicable when viewed from the medical context as it assumes one person (the clinician) is solely responsible for making a decision that affects someone else (the athlete).[1]

Historically, RTP decisions have been viewed as such, where medical practitioners attempt to determine when the risk of recurrence is minimal and performance is optimal, suggesting the appropriate return of athletes to competition.[10] Typically, these decisions are created through a combination of clinical assessments (strength, flexibility, imaging) and functional field-testing.[10] Though relevant, this approach assumes that the physiological state of healing is the only component involved in returning an athlete to competition, suggesting that once the injured tissue has healed, the athlete should be able to return to competition through progressive reintegration. This rationale fails to consider that RTP decisions may be largely influenced by extraneous factors other than physiology, such as mental preparedness or socioeconomic issues, which may mitigate or increase the risk of return. This highlights the dynamic and complex nature of RTP decisions that require an ever-evolving process to accommodate the multiple factors involved. Clinicians must understand that athletic participation is never risk-free, with evidence indicating a 4-fold increase in the risk of re-injury after sustaining an injury.[1,3,12,13]

Medical practitioners involved in RTP decisions must work towards developing consistency in these models and adopt an athlete-centred approach. Although a standardized definition for RTP may never be possible, a standardized framework that includes core principles in returning an athlete to play safely must exist. In an attempt to address these complex issues and develop a common language among all parties involved, Creighton and colleagues[1-2] created and validated a three-step model for RTP decision-making for sports medicine practitioners that can be used for emergent, urgent, and non-urgent decisions. The purpose of this current report is to highlight a case in which a RTP protocol was poorly executed, as failure in athlete compliance led to a recurrent left clavicle fracture involving an Ontario Junior A (OJHL) hockey player. Using the three-step RTP decision-making model proposed by Creighton *et al*.[1] as a guide, our discussion will address the flaws in the case presented and demonstrate how medical practitioners can appropriately confront some of the extraneous variables that occur during the RTP process with athletes.

## Case presentation

A 19 year-old male Ontario Junior Hockey League (OJHL) defensemen suffered a left shoulder injury while delivering a body check that forced him to leave the ice. After being removed from game play he was assessed on-site in the arena dressing room by the team therapist. After observing a marked global limitation in all left shoulder ranges of motion with bony tenderness, early hematoma development, and subtle deformity in the left clavicle, he was sent to the emergency department. Radiographs taken at the hospital revealed a non-displaced transverse fracture to the left middle-third of the clavicle (Figure 1). Due to the initial presentation of the injury, the orthopaedic surgeon at the hospital decided to manage the fracture conservatively. This included a 7-day prescription of Tylenol 3 (350mg of acetaminophen; 36mg codeine), stabilizing the shoulder girdle with a sling, and encouraging the patient to limit all ranges of motion above shoulder height, such as overhead reaching and cross-flexion. The patient was then scheduled for follow up at the fracture clinic in one week.

Upon orthopaedic follow up at one week, the fracture site remained stable and the decision to continue to manage the fracture conservatively was made. The patient was told that he would not be returning to sport until clearance from the surgeon was provided. At the time, the surgeon estimated that an early return to sport could occur in 6-8 weeks if signs of radiographic healing were present. In agreement with the literature, the anticipated return to contact sport was estimated at 8-12 weeks in or-

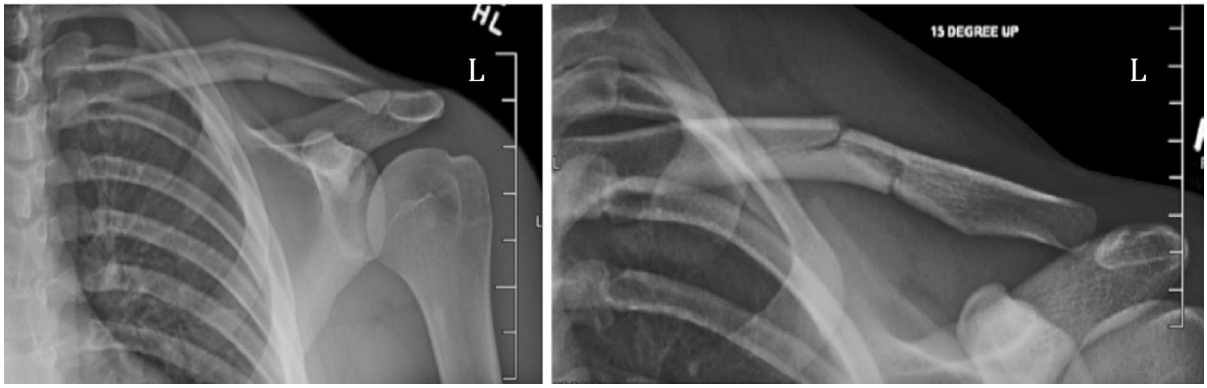


Figure 1.
*Left AP shoulder and AP clavicle spot view radiographs demonstrating a non-displaced transverse fracture through the middle-third of the clavicle.*

der to achieve tissue healing and allow adequate time to regain pre-injury levels of shoulder function[14,15] The patient was encouraged to continue wearing his sling and use regular strength acetaminophen (300mg) for comfort for the first 2-3 weeks following the injury. The surgeon also advised him to begin gentle neck and shoulder range of motion (ROM) exercises and seek physical therapy for early management. As such, the patient presented to a private practice chiropractor affiliated with the team.

On initial presentation to the chiropractor one-week post-trauma, there was minimal swelling over the fracture site. Bony tenderness and fracture tests (clavicle shear, compression, and vibration) were still provocative locally at the left clavicle. Active left shoulder ROM was painful and reduced in flexion, abduction, and cross-adduction by 15%, 20%, and 40% respectively. Passive left shoulder internal and external rotation with no added abduction was painful at end-ranges. Resisted left shoulder ROM revealed strength deficits and pain with flexion (rated 3/5), abduction (rated 4/5), and cross adduction (rated 3/5). Hypertonicity was present in several cervicothoracic spine, shoulder girdle, and periscapular muscles, most notably in the left upper trapezius, scalenes, and pectoralis muscles. To mirror the recommendations of the surgeon overseeing the case, the patient was asked to refrain from returning to ice hockey or off-ice training until medical clearance was provided. This included radiographic evidence of healing and the absence of pain and/or weakness with all provocative clinical and orthopaedic testing. The initial goals (first 2 weeks) in the plan of management included patient education, pain control, protection, and restoring ROM in the affected upper extremity joints. The patient was educated on the natural history of the injury, the rationale for the estimated return to non-contract play in 6-8 weeks, and potential complications of fracture non-union with poor adherence to the plan of management. To address pain control and reduce edema over the lesion, initial treatment involved the application of microcurrent (300 Hz, 300 $\mu$A) with ice compression over the left clavicle. Additionally, contemporary medical electroacupuncture was utilized for pain modulation and to restore neuromuscular function. Although application sites varied throughout the course of treatment, key points included bilateral segmental spinal stimulation at C2-6 and KI-27, LU-1, LU-2, LI-15 to 16, and SI-10 to 15 on the left. Active Release Techniques ® were directed to the affected periscapular, cervical, and thoracic paraspinal musculature. An overview of rehabilitation exercises utilized throughout the course of the treatment is presented in Figure 1.

At 4 weeks post-trauma, the patient was pain free in all left shoulder active and passive ROM. There was no bony tenderness or palpable movement at the left clavicle during all previously positive clinical fracture tests. There were no strength deficits present with any left shoulder ROM and they were comparable to the non-injured right shoulder. The patient was also able to perform progressive rehabilitation exercises (Stage II & III, Figure 1) involving resistance and perturbation training at all end-ranges

with no difficulty. Given these findings, the patient was allowed to return to non-contact practice with additional padding worn over the left clavicle and acromioclavicular (AC) joint at 4 ½ weeks post-trauma. Padding included a combination of leukotape as a base to provide increased proprioception to the shoulder girdle musculature and the application of a gel pad over the fracture site and AC joint to help dissipate impact loading. The patient also wore a bright red jersey to indicate to the other players that he was not to be engaged in contact during practice. During the first week back at practice, the patient experienced no issues with his shoulder during skating, stick handling, or shooting.

At the beginning of the 5th week post-trauma, the patient had a follow up appointment with the orthopaedic surgeon who was pleased with the progress. Radiographic evidence revealed signs of healing with a large callus formation. Some remnants of the original fracture line could be visualized in the trebecular portion of the mid-shaft of the clavicle. The surgeon suggested that he was cleared to continue with his training and could introduce light contact (bumping and/or pushing for puck or position without checking) in on-ice practice. He was not cleared for game play and was scheduled for one more follow up at 8 weeks with an estimated return to full body contact and game play at 8-10 weeks. Although there were no pain or strength deficits in the left shoulder, the decision to not clear the athlete for game play was based on current imaging and literature suggesting only partial healing of the fracture[14,15]

During the 5th week post-trauma, the team was entering the second round of the playoffs with a diminishing roster due to injuries. As the athlete was the captain of the team, working towards an athletic scholarship, and key member to their post-season success, pressure was placed on the team therapist from both management (owner, manager, coaches) and the patient to clear him for game play. To support their argument, the parties involved highlighted his recent success with rehabilitation, on-ice practice performance, and no issues with his shoulder with regards to pain or function. Reiterating the recommendations of the surgeon and the literature, the therapist advised continuing with the graduated return to play protocol and would not allow him to dress until radiographic evidence and clearance from the surgeon was provided. At 5 ½ weeks post-trauma, the patient was adamant about playing and threatened to dress for the game. Refusing the orders of the team therapist, chiropractor, and surgeon, the patient signed a waiver stating that he was returning to game play at his own risk against medical recommendations.

The patient returned to the second round of the playoffs at 5½ weeks post-trauma and had success in his first two games despite the high level of physical contact. During his third game, he was unexpectedly hit from behind into the boards where he suffered a second insult to the same left clavicle. Once again, after being evaluated at the arena he was sent to the hospital for assessment. Radiographs taken at the fracture clinic demonstrated a more complicated transverse fracture originating at the middle-third of the left clavicle that extended through the long-axis of the bone and through the recent callus formation (Figure 2). Under the discretion of the orthopaedic surgeon, it was decided that surgical management was warranted to stabilize the clavicle for future use in sport. As a result, the


Figure 2.
*Left AP shoulder radiograph taken 6 weeks after the initial injury demonstrating the second clavicle fracture. The image shows a more complicated middle-third clavicle fracture through the newly formed callus with displacement.*

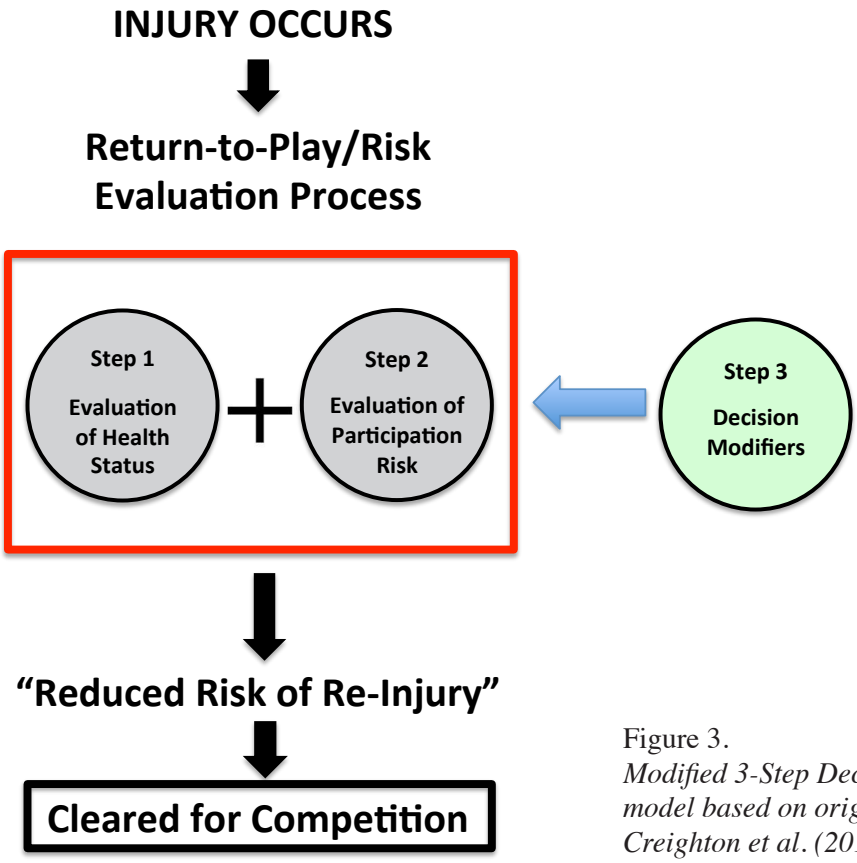


Figure 3.
*Modified 3-Step Decision-Based RTP model based on original work published by Creighton et al. (2010).*

patient suffered a season-ending injury with an estimated recovery time of three-months after surgical reduction and fixation.

## Discussion

### *Decision-Based RTP Model*[1]

The previously discussed Decision-Based RTP model is conveniently divided into 3-steps (Figure 3) with 19 factors (Table 1) that through consensus have been previously deemed as relevant in the RTP process.[1,5] The first step in the decision-based process is to evaluate the health status of the athlete. This is accomplished by assessing an athlete's recovery from a biological, psychological, and functional standpoint to determine how much healing has taken place. The information gathered is crucial for medical practitioners in determining risk of participation.[1,13,16] As previously discussed, some clinicians consider the absence of symptoms to be sufficient when returning an athlete to competition, but fail to realize that factors such as age, gender, history of previous injuries, and psychological state can significantly impact the safe return to competition.

Through integrating the health status of the athlete obtained from step 1 with the evaluation of participation risk (step 2), practitioners can weigh the advantages and disadvantages of return to competition. However, practitioners must be aware of the 5 identified risk modifiers (Table 1), such as type of sport or competition level, that can have a significant effect on increasing or decreasing participation risk.[1] It is not until these first two steps are considered that the associated risk evaluation of competition can be completed.[1]

Finally, the third step in the model actively investigates the contribution of extraneous factors, such as the timing of the season or external pressures, that may modify ones

Table 1.
*Progressive exercises used in the case RTP process following a non-displaced clavicle fracture.*

| Phase | Exercises/Stretches | Reps | Sets | Time |
|---|---|---|---|---|
| Stage I (1-2 weeks) | 1. Global shoulder passive end-range holds | 12-15 | 2-3 | 15 s |
| | 2. +/- PIR protocols | 12-15 | 2-3 | 8 s |
| | 3. Global isometric shoulder ROM | 12 | 3 | 8 s |
| | 4. Wall crawl (flexion & abduction) | 12 | 3 | |
| | 5. Scapular (wall) clocks (flexion & abduction) | 12 | 3 | |
| | 6. Wall angels with chin tuck | 12 | 3 | |
| | 7. Global shoulder ROM with tubing and/or resistance band | 10-12 | 2 | |
| Stage II (2-4 weeks) | Shoulder PNF D1 & D2 patterns with band | 12 | 3 | |
| | Side-lying external/internal rotation with band | 12 | 3 | |
| | Scaption with 10 lb dumbbell to shoulder height | 10 | 2 | |
| | Low row with resistance band | 12 | 3 | |
| | Prone dynamic scapular setting exercises (YTWL) | 12 | 2 | |
| | Wall push-up and push-up plus | 12 | 3 | |
| | Prone push-up and push-up plus | 12 | 3 | |
| | Rhythmic GHJ stabilization/perturbation drills in supine position with clinician resistance | 10 | 3 | |
| Stage III (> 4 weeks) | BOSU push-up and push up plus | 15 | 3 | |
| | Single-leg plank push-up | 15 | 3 | |
| | Exercise ball shoulder press and scaption | 15 | 3 | |
| | Exercise ball dumbbell chest press | 15 | 3 | |
| | Wall balls (medicine ball) | Max | 3 | |
| | Standing single arm push-press | 12 | 3 | |
| | Kettlebell arm bar exercise | 10-12 | 3 | |

decision.[1] The addition of these external factors can bring forth serious ethical concerns, especially when several practitioners indicate that the health and wellbeing of the athlete should be the only consideration. As previously eluded to, no participation is risk-free and consideration of these extraneous factors aids clinicians to determine the acceptable level of risk.[1,12] It is important to realize that decision modifiers are not limited to the athlete, but often involve third parties (i.e., coaches, organizations, and medical practitioners). This extraneous pressure may result in an early return to competition, resulting in potentially negative consequences that are not in the athlete's best interest. In the case presented, there were several extraneous factors that contributed to a more complicated clavicle fracture that resulted in a season-ending injury and more invasive surgical management. Additionally, some concern has been raised that not all practitioners consider the aforementioned factors as relevant as they

are indirectly related to clinical practice.[1,16] However, to address this concern the model has placed decision modification on the periphery, as decisions modifiers do not contribute to the overall risk of participation, but potentially contribute to how decisions are made. Furthermore, decision modifiers cannot be used in isolation, as they require context when making RTP decisions.

### *Summary of Evidence and Model Validation*

After Creighton *et al*.[1] developed the 3-step Decision-Based RTP model from the knowledge and experience of expert clinicians, it required validation and transformation. The model needed to transform from a theoretical construct to a clinically relevant tool in a developing body of sports science literature.

Matheson *et al*.[3] performed a systematic review to determine how much evidence exists within each step of the proposed model. A detailed search revealed 148 relevant articles, with only 13 articles specifically focusing on the RTP process.[3] The results revealed a large body of low-level evidence, suggesting the urgency of developing a standardized RTP definition or process upon which clinical research can be conducted. Shultz *et al*.[16] attempted to describe the variability in the RTP decisions of experienced team medical practitioners and their clinical opinion of the 19 factors used in the 3-step RTP decision-making model using a survey questionnaire. The findings further affirmed the need for a precise definition in RTP decisions as their research demonstrated increasing variability in RTP decisions among clinicians when presented with more ambiguous definitions. In this context, a more precise definition resulted in improved consistency among clinicians when making RTP decisions. This suggests the importance of developing the 3-step RTP decision-making model upon which future research and educational resources can be established to improve these complex decisions among sports clinicians.

A recent investigation by Shrier *et al*.[2] attempted to validate the 3-step RTP decision model using a crossover design survey completed by 343 self-identified clinical members of the ACSM. The group of clinicians consisted of physicians, chiropractors, physical therapists and others (podiatrists, nurse practitioners, athletic therapists, kinesiologists, occupational therapists, physician's assistants, and registered nurses) involved in RTP decisions. It was concluded that clinicians do in fact increase activity restriction with increasing injury severity, while altering RTP decisions based on both the sports risk and decision modifiers previously discussed.[2] Additionally, the following study demonstrated that perceived increasing severity of the case presented resulted in greater activity restrictions, suggesting that RTP decisions are highly context dependent.[2]

Table 2.
*Relevant considerations at each step of the Decision-Based RTP model.*

| | Relevant Considerations |
|---|---|
| Step 1: Evaluation of Health Status | • Patient demographics (e.g. age, sex) |
| | • Symptoms (e.g. pain, clicking) |
| | • Personal medical history (e.g. recurrent injury) |
| | • Physical exam findings (e.g. swelling, discoloration) |
| | • Diagnostic imaging and lab test (e.g. MRI, blood) |
| | • Functional tests (e.g. hop test, movement screens) |
| | • Psychological state (e.g. depressed, anxious) |
| | • Potential seriousness (e.g. concussion vs. tennis elbow) |
| Step 2: Evaluation of Participation Risk | • Type of sport (e.g. contact vs. non-contact) |
| | • Position played |
| | • Limb dominance |
| | • Competitive level (e.g. recreational vs. professional) |
| | • Ability to protect (e.g. padding, taping) |
| Step 3: Decision Modification | • Timing & Season (e.g. preseason vs. playoffs) |
| | • Pressure from athlete (e.g. willingness to compete) |
| | • External pressure (e.g. coach, organization) |
| | • Masking of injury (e.g. effective analgesics) |
| | • Conflict of interest (e.g. financial) |
| | • Fear of litigation (e.g. if restricted or permitted) |

### *Application of the Decision-Based RTP Model*

In an attempt translate this theoretical model into clinical context, the case details will be outlined to highlight the contributory factors in the premature return of the patient that resulted in a more serious, recurrent injury. As previously discussed, the initial injury resulted in a stable, non-displaced left mid-clavicle fracture. Clavicle fractures are reported to represent 2.6% of all fractures with 69-81% occurring at the mid-shaft.[17] Fractures of the clavicle typically occur as a result of a direct blow to the shoulder, resulting in anterior-inferior sagging of the glenohumeral joint. As witnessed in the case, they result in an inability to lift the arm due to pain, bruising, swelling, and/or tenderness over the collarbone. They may present with a grinding sensation associated with motion and a visible deformity.[18] Traditionally, mid-shaft clavicle fractures are treated non-surgically requiring approximately 3 months of healing (8-12 weeks) before returning to competition.[14,19] However, in this case the athlete ignored sound medical advice and returned to competition after only 5½ weeks.

This case appropriately demonstrates the complexity associated with RTP decisions affecting both the clinician and the athlete. When reflecting on the case, the appropriate risk evaluation process took place (Steps 1 & 2 of the model) with the correct suggestion that the athlete should not return to competition at the 5th week post-trauma. Based on the literature, it was also correctly identified that these injuries require a range of 8-12 weeks before reintroduction to competition. This timeframe allows for both physiological and radiographic healing to take place, while the athlete can achieve pre-injury levels of function (i.e., strength, ROM, endurance) in the affected extremity. However, against sound medical advice from the team therapist, chiropractor and orthopaedic surgeon, significant decision modifiers (Step 3 of the model) resulted in the premature return to competition that consequently lead to re-injury requiring surgical fixation. A more in-depth evaluation of the RTP decision from the athlete's perspective revealed that extraneous factors including season timing (playoffs), a diminishing roster from injuries, risk of losing an athletic scholarship, and external pressure from team management significantly contributed to the premature return to play. In the final decision by the athlete to refuse medical advice about RTP, the appropriate measures were taken by the team medical staff to decrease associated liability should a second injury occur. These measures included the appropriate documentation (i.e., RTP waiver), and an assessment of the athlete's condition in which information was provided surrounding the risks of returning to competition.

### *Return-To-Play: Whose Decision Is It?*

As illustrated in this case, RTP decisions are complex and multifactorial. In addition to the implications for the injured athlete, the coaches, organizations, and even the medical personnel can be impacted. Often these decisions are made in team environments comprised of individuals with varying experience and knowledge surrounding athletic injuries.[20] Ultimately, the goal would be to achieve a unanimous decision concerning RTP of a given athlete for optimal congruency and management. However, this is not often the case resulting in mixed messaging and confusion among involved parties. Shrier *et al*.[13] conducted a survey questionnaire of Canadian sports medicine physicians, physiotherapists, athletic therapists, chiropractors, massage therapists, athletes, coaches and representatives from 3 organizations to determine which profession is best perceived to evaluate an athlete's RTP. It was concluded that medical doctors, physiotherapists, and athletic therapists were considered best able to assess factors related to risk of injury and associated complications.[13] Alternatively, it was noted that athletes, coaches and sport associations were considered to have the best capacity to assess factors related to competition (i.e., desire, psychological, and financial impact and loss of competitive standing).[13]

Currently, there is no conclusive evidence as to who is best informed to make RTP decisions. This is especially true when a particular pathology presents (such as a fracture) and the appropriate care and RTP process is reserved for the decision of a medical specialist. Through the continued and diligent involvement with National Sports Organizations (NSOs), a consistency will emerge, resulting in better interdisciplinary management of athletes and involvement with RTP decisions. However, it has been suggested that resolution of interprofessional differences in RTP decisions can be accomplished through advancing and conducting research, which is likely to result in improved education and awareness in regards to the RTP process.[13]

### Legal Implications of Return-to-Play Decisions

In a situation where a legal proceeding was to result from an improper RTP decision, the question of negligence would be at the forefront of the discussion. Negligence is defined as "a failure to exercise the care that a reasonably prudent person would exercise in like circumstances".[21] In the case of negligence the plaintiff must prove the following[21]:

1. The defendant owed a duty toward the plaintiff
2. The defendant failed to act in a reasonable way, or breached their duty
3. The defendant's breach was the actual cause of another's injuries
4. The plaintiff suffered actual injuries, for which he or she may claim damages

A negligence lawsuit can be a difficult situation for all parties involved, as the injured parties are seeking remuneration for damages, while the defendants are forced into a situation where their medical merit is being questioned. Team doctors are faced with difficult decisions everyday and are responsible for[22,23]:

1. Properly assessing the athlete's condition
2. Providing appropriate medical treatment
3. Providing clearance to participate, and
4. Informing the athlete of the risks of athletic participation given the particular medical condition

When considering medical clearance for participation, it is viewed as discretionary decision as long as it adheres to the common and most current medical practice. [22,23] In this respect, there is no liability for negligence when a clinician makes a judgment call that is within the accepted standard of medical care.[22,23] In the case presented, the athlete went against all indicated medical advice from both the acting surgeon and team therapists and returned to competition where he re-fractured his left clavicle resulting in surgical intervention. At the time of return, all involved medical staff received signed documentation indicating his participation against medical advice, voiding practitioners of medical negligence. Had this been a case involving concussion or brain injury an athlete could be deemed unable to make rational decisions about their RTP status, thus preventing from operating against medical advice as the medical practitioners are now acting within the acceptable medical standards. However, if an athlete is returned to competition prematurely as in the case presented, a clinician may be held responsible resulting in a successful negligence lawsuit. Therefore, it is paramount that team doctors be involved in RTP decisions, where pros and cons of return are discussed and clear for all parties as to avoid unwanted litigation.[24-26]

### Summary

Return-to-play (RTP) recommendations continue to be contentious issues among the sports medicine community. A detailed understanding of the RTP decision-making process is crucial for all team doctors, as these decisions are inevitably a part of a medical practitioner's duty.[1,5] Though limited evidence exists in regards to who is best positioned to make RTP decisions, medical practitioners currently bear much of this load and expertise required to adequately inform athletes of risks associated with return to competition. However, the multifactorial and context-specific nature of RTP decisions suggest that it becomes a shared decision involving all relevant parties in an ideal scenario in an athlete-centred approach.[1,3,5] Currently, chiropractors currently sit at crossroads where future involvement in RTP decisions will be based on a strong understanding of all relevant factors and a willingness to work in an Integrated Support Team (IST) that positions the athlete's needs at the forefront of all decisions. Future direction should continue to focus on developing the 3-step Decision-Based RTP Model by Creighton and colleagues[1] as it provides a pivotal framework upon which research can be conducted and future RTP recommendations can be developed.

*Authors' note:* Following the acceptance of this paper, the 2016 consensus statement on return to play from First World Congress in Sports Physical Therapy (Bern)[27] was published. This statement highlighted several key issues brought up in this paper such as the lack of standardized approaches, definitions and outcomes with RTP while stressing the need to utilize biopsychosocial models. As such, both authors highly recommend reading this consensus statement as it hopes to guide the future in RTP decision-making.

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# The utility of the King-Devick test as a sideline assessment tool for sport-related concussions: a narrative review

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Objective: *The objective of this paper is to review existing literature surrounding the utility of the King-Devick test which is a commonly used sideline assessment tool for sport-related concussions.*

Methods: *A review of the literature was performed using MEDLINE, CINHAL, and SportDiscus databases. The search was performed from the beginning of the record through November 16th, 2015.*

Results: *This search strategy yielded 27 articles from aforementioned databases. Further searching in The Cochrane Library with King-Devick AND Concuss* search terms yielded one additional article, summing a total of 28 articles. After removal of duplicates and implementation of the inclusion/exclusion criteria, 8 articles for extensively reviewed.*

Objectif : *L'objectif de cet article est de passer en revue la documentation scientifique existante concernant l'utilité du test King-Devick qui est un outil auxiliaire couramment utilisé pour évaluer les commotions cérébrales liées au sport.*

Méthodologie : *Une analyse des documents scientifiques a été réalisée en recherchant dans les bases de données MEDLINE, CINAHL et SportDiscus. La recherche a été effectuée du début des registres jusqu'au 16 novembre 2015.*

Résultats : *Cette stratégie de recherche a donné 27 articles des bases de données précitées. Une recherche plus poussée dans la bibliothèque Cochrane avec les termes de recherche King-Devick ET Concuss* a révélé un autre article, pour un total de 28 articles. Après l'élimination des doublons et la mise en œuvre des critères d'inclusion et d'exclusion, 8 articles ont fait l'objet d'un examen approfondi.*

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Conclusion: *This narrative review suggests that the King-Devick test is an efficient sideline assessment tool for sport-related concussions. However, we recommend that the King-Devick should be used as a sideline screening tool, not a concussion diagnosis tool at this time. A proper baseline time including multiple tests may be recommended to negate the learning affect and to have a reliable baseline in which to measure from for future reference. A three second difference appears appropriate to identify the possibility of concussion and to remove an athlete from play. At this time, the athlete should be monitored and further evaluated as symptoms are sometimes delayed. We suggest that further research may be useful to better determine the efficacy of the K-D test in detecting concussions across a broader range of athletes and sports. We also suggest further research may investigate the K-D test a potential return-to-play tool for clinicians and medical personnel.*

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KEY WORDS: chiropractic, concussion, King-Devick test, assessment, sideline, screening

Conclusion : *Cet examen narratif suggère que le test King-Devick est un outil d'évaluation auxiliaire efficace pour les commotions cérébrales liées au sport. Cependant, nous recommandons qu'à l'heure actuelle King-Devick soit utilisé comme un outil auxiliaire de dépistage, et non comme un outil de diagnostic de commotion cérébrale. Une période de référence appropriée comprenant des tests multiples peut être recommandée pour annuler l'effet d'apprentissage et avoir une référence fiable à partir de laquelle il soit possible de mesurer pour des références futures. Une différence de trois secondes semble appropriée pour reconnaître la possibilité d'une commotion cérébrale et pour retirer un athlète du jeu. À ce moment-là, l'athlète doit être surveillé et évalué de plus près, car les symptômes apparaissent parfois tardivement. Selon nous, d'autres recherches pourraient être utiles pour mieux déterminer l'efficacité du test K-D dans la détection des commotions cérébrales chez une plus grande variété d'athlètes dans diverses autres disciplines sportives. En outre, il nous semble que d'autres recherches pourraient étudier le test K-D comme un outil potentiel pour évaluer le retour au jeu par les cliniciens et le personnel médical.*

(JCCA. 2016;60(4):322-329)

MOTS CLÉS : chiropratique, commotion cérébrale, test King-Devick, évaluation, auxiliaire, dépistage

## Introduction

A concussion is a brain injury caused by an impulsive force transmitted to the head resulting in a complex pathological process manifesting in the rapid onset of short-lived impairment of neurological function.[1,2] Traumatic force to the head during a sports-related concussion results in shear and pressure forces to the brain as a direct result of rapid acceleratory displacement of the brain relative to the skull.[3] Shear-induced tissue damage may produce diffuse axonal stretching resulting in changes of neurological function.[3]

Current estimates state that 465 people daily suffer a brain injury in Canada, with a concussion sustained in 1 in 5 injuries in sport.[4] Reports show that individuals who have suffered one concussion have three times greater chance of having a second concussion; making them more susceptible to a rare but serious condition known as second impact syndrome, increasing their risk of long term consequences such as neurodegenerative disease.[5] In Canada from 2001 to 2005, an estimated 502 000 emergency department (ED) visits for concussion occurred in children from the ages of 8 to 19 years.[6] These estimates are alarming when combined with the notion that there are knowledge transfer gaps and different management strategies being utilized by emergency physicians.[7]

Sustaining a concussion can have a multitude of clinical symptoms for the individual involved. Headache, irritability, balance and memory dysfunction, impaired eye

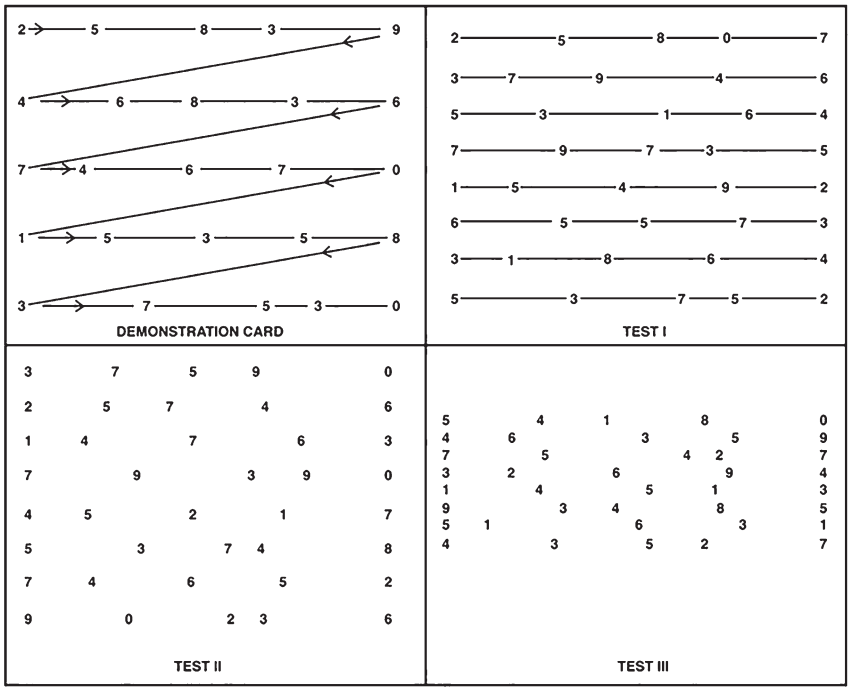


Figure 1.
*Sample King-Devick test card.*[18]

movement function, confusion, amnesia, nausea, slurred speech, fatigue, sensitivity to light, and sleep disturbances are within the spectrum of resultant signs and symptoms.[1-3, 8-10] Enhancing the ways in which we screen for concussions is pivotal, specifically in susceptible populations such as athletes where objective findings can be subtle and vastly underreported.[11] Closer screening is also important since detecting early signs of a concussion can improve outcomes.[12-14] This suggests that there is a clear need for a rapid screening test to efficiently assess high risk individuals such as athletes who may have sustained a concussion. Currently it is common practice for amateur sporting teams to utilize volunteer health care practitioners and student therapists to assist in their sideline medical coverage. Providing a modicum of reassurance are the recent studies by Bogglid and Kazemi which demonstrate that while there are gaps in knowledge, that medical students / residents and chiropractic interns / residents possess diagnostic and management skills to deal with concussions.[15,16] While a proportion of these therapists may have advanced first responder credentials, it is our contention that additional assessment tools with respect to concussion would be most useful particularly at the field of play.

The King-Devick (K-D) test is a test of the visual system and is based on measurement of the speed of rapid number naming.[17] The K-D test, takes two minutes to complete, is practical for sideline use and is quicker than the other standard tests of cognition such as Immediate Post-Concussion and Cognitive Testing (ImPACT)[18], the sport concussion assessment tool (SCAT 3) and the Military Acute Concussion Evaluation (MACE)[19]. The K-D test measures rapid number naming on three test cards; the score for the test is the sum of the three times, in seconds, needed to read the cards.[17-23] The test requires rapid eye movements, language function, and attention. These functions may be deficient and reflect suboptimal brain function in concussed athletes, individuals with Parkinson's, multiple sclerosis, extreme sleep deprivation, and hypoxia.[24,25] The objective of this paper is to present a review of the existing literature with respect to the efficacy of the King-Devick test as a sideline assessment tool for sport-related concussions.

## Methods

A search of the literature was performed using MEDLINE, CINHAL, and SportDiscus databases. The electronic search strategy employed was designed as follows: (rapid visual screening tool* OR k-d test* OR king-devick*) AND (test-retest* OR sideline screen* OR accura* OR reliab* OR valid* OR predict* OR reproducibility OR specificity OR sensitiv* OR [MH "Predictive Value of Tests"] OR [MH "Reproducibility of Results"] OR [MH "Sensitivity and Specificity"]) AND (brain injur* OR [MH "Brain Injuries"] OR [MH "Brain Concussion"] OR concuss*). Search strategies for all databases were filtered for English Language. The search was performed from the beginning of the record through November 16th, 2015. This search strategy yielded 27 articles from aforementioned databases. Further searching in The Cochrane Library with King-Devick AND Concuss* search terms yielded another article, summing a total of 28 articles. After removal of 8 exact duplicates, 20 articles were admitted for evaluation.

For the purpose of this narrative review, our inclusion/exclusion criteria required the following: 1) The King-Devick be used in side-line assessment of concussion of athletes; 2) The athletes were adults (≥ 13 years of age) as defined by the SCAT 3; 3) The King-Devick used in a clinical trial and not referenced in a review or commentary. Implementation of these criteria resulted in 8 articles for the purpose of our review.

## Results

In 2011 the *Journal of the Neurological Sciences* published the paper that provided initial evidence to support the use of the King-Devick test as a rapid sideline visual screening tool for concussions.[17] This ongoing longitudinal study involved 219 collegiate athletes from a varsity men's football team and both women's and men's soccer and basketball teams.[17] Each athlete completed a pre-season baseline King-Devick test, while the women's basketball team also underwent a pre-season Military Acute Concussion Evaluation (MACE) to assess for correlation between the King-Devick test and MACE scores. Athletes who sustained concussions in games or practices during the playing season were given an immediate sideline King-Devick test. The results showed that for the 10 athletes who sustained a concussion, as diagnosed by MACE scores and general practitioner, King-Devick scores were significantly more diagnostic (median 46.9 s post-concussion vs. 37.0 s baseline, $P < 0.009$, Wilcoxon signed-rank test).[17]

Galetta *et al*.[18] published an additional study in 2011 that evaluated the King-Devick test as a potential rapid sideline screening tool for concussion in boxers and mixed martial arts fighters. Thirty-nine fighters were tested twice at ringside immediately before and once after each round in a 3-round sparring session. Fighters who sustained head trauma during the fight were also given the MACE test immediately following the sparring session. Post-fight King-Devick scores were significantly worse for those with significant head trauma during the match (59.1±7.4 s post-fight vs 41.0±6.7 s baseline, $p < 0.0001$, Wilcoxon rank sum test). Those who lost consciousness showed an even greater worsening in pre-fight to post-fight King-Devick scores (65.5±2.9 s post-fight vs 52.7±2.9 s baseline, $p < 0.0001$, Wilcoxon rank sum test). Worsening of King-Devick scores by 5 seconds was a distinguishing characteristic noted only among participants with head trauma.[18]

Subsequently, the 2012 pilot study by King *et al*.[20] demonstrated the efficacy of the King-Devick test as a screening tool to identify neurological changes in players with both witnessed and un-witnessed head traumas. A cohort of 2 amateur rugby league teams (total of 50 players) was followed over an 8-week season and completed two trials of the King-Devick test a week before participation in any match. Players who reported any signs of a concussion, or who were suspected to have incurred a concussion as a result of match participation were removed from the match and assessed immediately with the K-D test and the SCAT2 within 30 min of the injury occurring. All players who participated in a match completed a post-game King-Devick Test regardless of concussion suspicion. A total of five athletes were diagnosed with concussion over the season.[20] Three of the five were identified by the King-Devick test after confirmed head trauma and later confirmed by the SCAT2 and physician.[20] When tested post-incident the K-D test times were longer than baseline (5.0 s–7.1 s, $p < 0.025$, Wilcoxon signed-rank test). Two of the athletes, with no witnessed head trauma were identified during post-game King-Devick testing and later confirmed by the SCAT-2 and physician.[20] These two recorded longer times on the post-match King-Devick test (8.9 s–9.1 s, $p < 0.219$, Wilcoxon signed-rank test), which

was not significant. When tested on the PCSS of the SCAT3, they recorded statistically significant difference's (14–15; $p < 0.0003$) from their baseline.

Recently two additional studies in the *Journal of the Neurological Sciences* showed that the King-Devick test was helpful in identifying cognitive impairments in both confirmed and un-witnessed head traumas.[26,27] The first study took a cohort of nineteen players of a junior level rugby team through two pre-competition baseline trials of the King-Devick Test.[26] During the competition season; any player that was removed from play or complained of concussion-like signs or symptoms was assessed on the sidelines using the King-Devick test. The players also completed a post-game King-Devick test. Any player that had a pre-to-post match King-Devick test difference greater than three seconds were referred for physician evaluation. A total of seven concussions were formally identified in six players that recorded post-match King-Devick test scores greater than three seconds from their baseline with a mean change of 7.4 s (±7.0 s, $p < 0.018$, Wilcoxon signed-rank test).[26] One player recorded 2 post-match times greater than three seconds from baseline and was identified to have incurred concussions on both occasions by his health practitioner.[26]

A second study published in 2015 by King *et al*.[27] followed 104 male, senior-level rugby union and rugby league players over three years. All 104 players completed two King-Devick trials, 10 minutes apart at the beginning of their competition season. All witnessed concussions were assessed with the King-Devick test and SCAT3 and were referred for further medical evaluation. All concussions (witnessed or un-witnessed) were only recorded if they were formally diagnosed by a healthcare practitioner. During the study, 52 concussive events were identified (8 witnessed and 44 un-witnessed).[27] Post-match King-Devick test scores were longer than the baseline score (4.6 s ±6.40; $p < 0.001$, Wilcoxon signed-rank test) for all concussive injuries identified. All 52 concussive events were detected by a three second decrease in King-Devick time and later confirmed by physician.[27] All reductions in King-Devick scores correlated with lower SCAT3 scores.[27] For every 1 point reduction in each of the post-injury SAC components of the SCAT3, there was a corresponding increase of King-Devick test times post-match for changes in orientation (2.9 [95% CI: 2.7 to 3.2]; $R^2 = 0.85$; $p < 0.001$), immediate memory (1.8 s [1.7 to 2.0]; $R^2 = 0.94$; $p < 0.001$) concentration (2.8 s [2.6 to 3.0]; $R^2 = 0.87$; $p < 0.001$), delayed recall (2.0 s [1.8 to 2.2]; $R^2 = 0.93$; $p < 0.001$) and SAC total score (1.7 s [1.6 to 1.8]; $R^2 = 0.95$; $p < 0.001$).[27]

Interestingly, Leong *et al*.[22] published an article that reported the King-Devick test (as a sideline screening tool) can be successfully administered by non-medically trained parents. Baseline King-Devick test times for 34 boxers were established before the competition by layperson testers, with no previous experience with the King-Devick test. After the sparring matches, boxers who sustained overt head trauma or who were suspected to have sustained head trauma, as assessed by a non-masked ringside physician, were given the MACE test immediately after the fight. All fighters completed King-Devick testing with a layperson following their match or following required MACE testing. Of the 34 boxers, one sustained a concussion confirmed by the ringside physician. This fighter was also accurately identified by the layperson tester due to the worsening in King-Devick test scores from the prefight baseline (48.3 s post-fight vs 45.1 s baseline).[22]

Leong *et al*.[28] further validated the King-Devick test as an accurate, reliable and rapid sideline tool to help objectively identify athletes with concussion and assist with removing from play decisions in 2015. The 127 collegiate athletes (football and men's and women's basketball) participating in the study underwent pre-season baseline testing with the King-Devick test. During the season, the King-Devick test and SCAT2 were both utilized in the sideline assessment of athletes suspected of head trauma. Post-season testing was also performed to compare non-concussed athletes' test performance. Results showed that concussed athletes consistently displayed sideline King-Devick test scores that were significantly worse than baseline test scores (36.5 ± 5.6 s sideline vs. 31.3 ± 4.5 s baseline, $p < 0.005$, Wilcoxon signed-rank test).[28]

Furthermore the recent work by Seidman *et al*.[29] demonstrated that the King-Devick test is an accurate and easily administered sideline screening tool for concussion in adolescent football players. A cohort of 343 high school athletes was given baseline King-Devick testing prior to competition. The test was re-administered to the concussed athlete for comparison to baseline immediately after a concussion diagnosis by a medical professional. Of the 343 athletes, nine were diagnosed with concussions

and all concussed players that were examined had scores for the King-Devick test were significantly worse then pre-season baseline scores (median 66.2 s sideline vs. 47.2 s baseline, $p < 0.001$, Wilcoxon signed-rank test).[29] A two tailed p-value of 0.05 or less was considered to indicate statistical significance.

## Discussion

This review identified several citations in the literature useful in exploring the efficacy of the K-D test as a sideline screening tool in the evaluation of sports-related concussions. With the increasing interest and evolving knowledge pertaining to the subject of sport-related concussions over the last decade, information pertaining to screening tools and return-to-play guidelines has risen to the forefront of discussion within the athletic community. In accordance, a substantial increase in research on screening tools such as the King-Devick test have been proposed, evaluated and published.

The King *et al*.[20] research which utilized the K-D test as a sideline screen for concussions in rugby league players showed that the K-D was able to assist medical personnel in identifying cognitive impairments in players without any clinically observable symptoms. The K-D test was able to correctly identify concussions in players with both confirmed and unconfirmed head traumas that were later verified by the SCAT 2 or SCAT 3 and a medical doctor.[20,26,27] Similar results were also found in cohorts of amateur boxers, mixed martial arts (MMA) fighters, and high school and collegiate football players. All studies included in the results section consistently showed that in comparison to pre-season or pre-fight baseline, athletes suspected of having a concussion showed a significant increase in their K-D test time. The studies we examined consistently noted increases in K-D test scores ranged from 3 seconds to 7 seconds compared to baseline when athletes sustained a suspected concussion.[19,20,22,26-30] Future studies may investigate any possible correlation between the amount of time increased from baseline to perform the task and the severity of concussion injury.

The results of various studies reviewed also showed that a worsening of K-D scores correlated well with worsening MACE scores and worsening SCAT 2 or 3 scores in concussed athletes.[19, 22] These correlative associations suggest that using the K-D in conjunction with other concussion screening tools may enhance a health care practitioner's ability to more confidently identify sub-clinical cognitive manifestations of a sports-related concussion.

In general the studies reviewed also showed that the K-D test has high baseline test-retest reliability, making it an excellent tool for sideline medical personnel to use.[27,28] Interestingly, results of Leong *et al's*.[22] study showed boxers that sustained a concussion and were diagnosed by a ring-side physician could accurately be identified by a layperson trained to administer and interpret the K-D test, with no prior knowledge of the incident. Given that a layperson demonstrated the ability to adequately administer a K-D test to the athletic population, student therapists and health care students working as sideline personnel could feel confident in their ability to similarly administer the test appropriately.

Another interesting finding from our review of the literature was that there was no worsening in K-D scores associated with fatigue. In fact, in some documented cases, intense exercise improved time scores in athletes.[17,28] Post-season K-D testing in the rugby league studies also showed that players demonstrated improvement in their time scores.[20,26,27] This improvement is consistent with the supposed learning effects found in the other studies reviewed in this paper.[19, 20, 22, 28, 29]

Furthermore, with respect to predictive factors in sustaining a concussion, Seidman *et al.'s*[29] study with high school football players used univariate analysis to confirm the common notion that a history of a previous concussion is the most predictive for the incidence of future concussions.

With the increase in sports-related concussion in all levels of sport, it is important to identify the need for a quick and reliable sideline screening tool to help team personnel accurately detect a concussion. The results of our review further support the K-D test as an effective, reliable and rapid sideline screening tool with an ability to help identify a concussive event in a variety of sports.

### *Limitations*

The overall number of publications is limited with research on the K-D test and its effectiveness as a sideline screening tool for sports-related concussions still in its infancy. We are also cognizant that our search methods may have unintentionally missed other published research studies pertaining to some aspect of the K-D test.

## Conclusion

Taking into account the available studies as defined by our search criteria, this review supports the use of the King-Devick test as an efficient sideline assessment tool for sport-related concussions. Successful identification of concussions and appropriate subsequent management will lead to a reduced risk of a secondary concussion and long-term neurological complications.[5] Therefore it is our contention that all health care professionals dealing with an athletic population stay abreast of the evolving science and familiarize themselves with additional tools such as the King-Devick test.

We recommend further research to investigate the efficacy of the K-D test in detecting concussions across a broader range of individuals and age groups. In addition, a variety of contact sports still need to be assessed and critically evaluated using screening tools such as the K-D test. We also suggest that further research investigate the K-D test as a potential return-to-play marker for concussion clinicians and medical personnel.

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# Injuries in elite Taekwondo Poomsae athletes

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*Poomsae is the only non-contact and no opponent form of Taekwondo. The purpose of this descriptive study was to determine the type and rate of injuries in elite Canadian Poomsae athletes. Strain and joint dysfunction were the most common types of injuries in Poomsae. Lower limb and back were the most common area of injury in females and males respectively. Females with a lower rank in experience level (DAN≤ 3) were more likely to suffer from chronic overuse injuries compared to their male counterparts, who reported more acute injuries. Athletes ≤40 years of age were more prone to acute injuries compared to athletes over 40. As result of reflection on this study a Poomsae Injury Report Form was developed.*

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KEY WORDS: Taekwondo, Poomsae, injury, acute, overuse

*Poomsae est la seule forme de Taekwondo contre un adversaire imaginaire. Le but de cette étude descriptive était de déterminer le genre et la fréquence de blessures chez les athlètes canadiens de Poomsae de haut niveau. Le claquage et le dysfonctionnement articulaire étaient les genres de blessures les plus courants dans le Poomsae. Les blessures des membres inférieurs et du dos étaient les plus fréquentes respectivement chez les athlètes féminins et masculins. Les athlètes féminins ayant un niveau d'expérience (DAN ≤ 3) inférieur étaient plus susceptibles de souffrir de blessures chroniques dues à un surentraînement que leurs homologues masculins qui, eux, ont signalé des blessures plus graves. Les athlètes âgés de moins de 40 ans étaient plus prédisposés à des blessures graves que les athlètes de plus de 40 ans. Les résultats de cette étude ont permis de préparer un formulaire de rapport sur les blessures dans le Poomsae.*

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MOTS CLÉS : Taekwondo, Poomsae, blessure, grave, surentraînement

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## Introduction

Since the establishment of Taekwondo (TKD) as a full medal sport in the 2000 Summer Olympic games, there has been an increase in the level of participation with over 80 million athletes worldwide.[1] To successfully compete in the Olympics and tournaments, the focus of training is sparring (Olympic style) TKD. However, in recent years many experienced athletes have started to participate in the training of the mind by focusing on the "unity of the pose" or Poomsae. Poomsae is the only non-contact form of training in TKD.

In 2000, Poomsae was established and warranted as an accepted form of competitive sport by the World Taekwondo Federation since it involves skill, technique and physical exertion. It is practiced for many purposes including self-defence training, preparation for full contact sparring and training toward promotions testing.[2] Poomsae consists of 13 defined patterns of movement, which are repeated over and over in practice.[3] Average training is six days a week and a maximum of four hours and 40 minutes of training per day.[4] As a result of this intense training, there is a probability of injury in these athletes. Most literature on Taekwondo injuries focuses on sparring (Olympic style).[1,5-7] The literature regarding the prevalence of chronic overuse injuries (COI) in Poomsae athletes worldwide is sparse. Chronic overuse injuries are injuries that result from repetitive overloading of a tissue (bone, muscles, tendons, etc.) which causes micro damage to the tissue without providing ample time to heal.[2,8] Chronic overuse injuries may cause early fatigue, soreness, prolonged pain, psychological exhaustion, reduced physical function, loss of playing time, and dropping out of sport.[2,8] A study of South Korean Poomsae athletes revealed a prevalence rate of COI of 71% while a similar study conducted in Alberta, Canada reported a 73% rate.[2,9] In these athletes, the lower body was more prone to overuse injuries than the upper body, the knee joint and hamstrings were most prevalent, and a strain type injury the most common.[2]

Any type of injury can prevent an athlete from reaching the podium. In a retrospective case-series, Kazemi[10] examined 75 sparring TKD athletes over a 10-year period to determine if there was a relationship between past injuries, present injuries, injuries during competition and success (defined as the acquisition of medals during competition). Kazemi reported that when an additional injury occurred during competition, the sparring TKD athlete was 88% ($p = 0.039$) less likely to win a medal.[10] It was further suggested that prevention, correct diagnosis, and immediate therapeutic intervention are important in elite TKD athletes.[10] Thus, it might also be beneficial for coaches and health care practitioners to understand the types of injuries that Poomsae athletes may encounter during training and competition to minimize any downtime and ensure success. Therefore, the purpose of this study was to investigate the type and characteristics of injuries (including location, severity, age of the athlete, and mechanism of injury during training or in competition), which occurred among Canadian elite Poomsae athletes.

## Methods

This study was a longitudinal retrospective study of Poomsae injuries sustained by the Canadian National Taekwondo team over a three-year period at the World Poomase Competition. Every member of the national team completed a general medical fitness form including their names, age, and any past or current injuries prior to participation in the competitions. These provided the general information for all athletes to the team doctor (a chiropractor). Each injured athlete who subsequently presented to the team doctor filled out the personal information section (including name, age, sex, address, phone number, weight, height and TKD rank) on an Injury Report Form (IRF).[10] The team doctor completed the rest of the patient history (past history, location, radiation, character and intensity, mechanism of injury, ability to continue the match), physical examination, diagnosis and severity rating, recommendations, treatment rendered, follow-up and discharge instruction sections of the IRF. No validity and reliability information for the IRF is available. Data were then extracted from the injury forms and analyzed. The team doctor, who was also the primary investigator (PI), was the only individual with access to the IRFs. To ensure confidentiality, each athlete's IRF was numbered and any identifying information was removed for the purpose of this study.

The outcome measures utilized in this study include number of athletes, number of reported injuries, number of athlete exposures, age of athlete, injury rates, TKD experience level (black belt degree, also known as DAN), location of body part injured, injury type, injury mechan-

Table 1.
*Injured athletes' characteristics.*

| Variables | Female, (n=13) mean (±SD) | Male, (n=6) mean (±SD) | Total, (n=19) mean (±SD) |
|---|---|---|---|
| All Injured Participants (n=19) | | | |
| Age (Year) | 40.1 (±14.0) | 27 (±10.4) | 34.7 (±13.4) |
| TKD level (Dan) | 3.3 (±1.5) | 4.2 (±2.1) | 3.6 (±1.7) |
| Participants with COI (n=11) | | | |
| Age (Year) | 45.3 (±13.5) | 30.3 (±11.7) | 39.8 (±14.5) |
| TKD level (Dan) | 3.4 (±1.5) | 4.8 (±2.5) | 3.9 (±1.9) |
| Participants with Acute injuries (n=8) | | | |
| Age (Year) | 34 (±13.1) | 20.5 (±0.7) | 30.6 (±12.7) |
| TKD level (Dan) | 3.2 (±1.7) | 3 (±0.0) | 3.1 (±1.5) |
| SD= Standard Deviation; TKD level (DAN) = black belt degree; COI = Chronic Overuse Injury, | | | |

ism, injury severity, and the point in time when the injury occurred (training or in competition).

The software program "STATA" version 10 was used to analyze the data. Descriptive statistics were used to describe the sample population in terms of anthropomorphic factors such as population number, number of males and females, age range and mean age average, as well as experience level expressed as a belt level. Means were used to describe the outcome measures listed above. No inferential statistics were performed due to small sample size. The Research Ethic Board of the Canadian Memorial Chiropractic College approved this study.

### *Definitions*

Sprains were defined based on a grading system. Grade 1 sprain constituted a slight stretching and some damage to the fibers (fibrils) of the ligament; Grade 2 sprain included partial tearing of the ligament; and Grade 3 sprain was a complete tear of the ligament.[11]

Joint dysfunction as defined by the World Health Organization[12] is: "a lesion or dysfunction in a joint or motion segment in which alignment, movement integrity and/or physiological function are altered, although contact between joint surfaces remains intact. It is essentially a functional entity, which may influence biomechanical and neural integrity".

Chain dysfunctions are defined as asymmetries of joint position or movement that are detected by functional tests.[13]

## Results

### *Study Participant Demographics*

There were a total of 34 athletes (16 females) who competed over a three-year period at the World Poomsae Competition included in this set of data. Overall, the mean age of the athletes was 34.7 years (SD = 13.4), ranging from 14 to 59 years. A total of 19 athletes (injury rate of 59%) reported injuries during the 3-year period. However, when injured athletes were stratified into COI and acute injuries subgroupings, a difference in characteristics was noted (Table 1).

### *Prevalence rate of injuries: COI vs. acute injuries*

Of the 34 athletes who participated in this study, 19 had sustained injuries. Of those, 11 athletes reported symptoms associated with COI and eight athletes reported symptoms that were acute in nature. The total prevalence rate of injury was 56%, with females experiencing more injuries than males.

The total prevalence rate of COI and acute injuries was 32% (n =11) and 24% (n=8) respectively. A high-

Table 2.
*Prevalence of COI and acute injury by gender, age and experience among all athletes.*

| Contents | Female n (%) | Male n (%) | Total n (%) |
|---|---|---|---|
| Total participants (athletes) | 16 | 18 | 34 |
| Total participants (athletes) injured | 13 | 6 | 19 |
| Total prevalence rate of athletes injured (%) | 81.25% | 33.33% | 55.88% |
| CI | 62.13-100.37 | 11.55-55.11 | 39.19-72.57 |
| Prevalence rate of athletes injured ≤ 40 years old | 6 (46.2%) | 5 (83.3%) | 11 (57.9%) |
| Prevalence rate of athletes injured > 40 years old | 7 (53.8%) | 1 (16.7%) | 8 (42.1%) |
| Prevalence rate of athletes injured TKD ≤ 3 | 5 (38.5%) | 3 (50.0%) | 8 (42.1%) |
| Prevalence rate of athletes injured TKD > 3 | 8 (61.5%) | 3 (50.0%) | 11 (57.9%) |
| Total COI (athletes) | 7 | 4 | 11 |
| Total prevalence rate of COI (%) | 43.75% | 22.22% | 32.35% |
| CI | 19.44-68.06 | 3.01-41.43 | 16.63-48.07 |
| Prevalence rate of COI ≤ 40 years old | 2 (28.6%) | 3 (75.0%) | 5 (45.5%) |
| Prevalence rate of COI > 40 years old | 5 (71.4%) | 1 (25.0%) | 6 (54.5%) |
| Prevalence rate of COI DAN ≤ 3 | 3 (42.9%) | 1 (25.0%) | 4 (36.4%) |
| Prevalence rate of COI DAN > 3 | 4 (57.1%) | 3 (75.0%) | 7 (63.6%) |
| Total acute injuries (athletes) | 6 | 2 | 8 |
| Total prevalence rate of acute injuries (%) | 37.5% | 7.14% | 23.53% |
| CI | 13.78-61.22 | -4.76-19.04 | 9.27-37.79 |
| Prevalence rate of acute injuries ≤ 40 years old | 4 (66.7%) | 2 (100.0%) | 6 (0.75%) |
| Prevalence rate of acute injuries > 40 years old | 2 (33.3%) | 0 (0.0%) | 2 (0.25%) |
| Prevalence rate of acute injuries DAN ≤ 3 | 2 (33.3%) | 2 (100.0%) | 4 (50.0%) |
| Prevalence rate of acute injuries DAN > 3 | 4 (66.7%) | 0 (0.0%) | 4 (50.0%) |
| CI: Confidence interval at 95%, COI: Chronic overuse injury. | | | |

er prevalence rate of COI and acute injuries is also observed in females compared to their male counterparts (44% (n=7) vs. 22% (n=4) and 38% (n=6) vs. 7% (n=2), respectively).

To consider age and injury types and rates, athletes were divided into two subgroups: age (under 40 or over 40) and experience levels (DAN under 3 or DAN over 3). Injured athletes who were under 40 years of age and who had more black belt experience (DAN over 3) had a slightly higher injury rate (57.9%, n=11) than athletes who were over 40 and who had less experience (DAN under 3) (42.1%, n=8). Athletes 40 and under were more prone to acute injuries compared to athletes over 40 (75%,(n=6) vs. 25% (n=2)) (See Table 2).

A total of 29 COIs were observed in 11 athletes; only 1 athlete was diagnosed with a single COI, 2 athletes with 2 COIs, 6 athletes with 3 COIs and 2 athletes with over 3 COIs. Female athletes presented a higher frequency of multiple COIs than male athletes. Within the group of athletes with COIs, those with 3 COIs were more prevalent

Table 3.
*Injured body regions by gender in all injured athletes (n = 19), COI (n = 9), acute (n = 8) and both (n = 2).*

| Body region | Female n (%) | Male n (%) | Total n (%) |
|---|---|---|---|
| **All injured athletes** | | | |
| Upper body part | 6 (32%) | 1 (5%) | 7 (37%) |
| Lower body part | 4 (21%) | 3 (16%) | 7 (37%) |
| Upper and Lower body part | 3 (16%) | 2 (11%) | 5 (26%) |
| Total | 13 (68%) | 6 (32%) | 19 (100%) |
| **Total COI athletes** | | | |
| Upper body part | 3 (33%) | 1 (11%) | 4 (44%) |
| Lower body part | 2 (22%) | 2 (22%) | 4 (44%) |
| Upper and Lower body part | 0 (0%) | 1 (11%) | 1 (11%) |
| Total | 5 (56%) | 4 (44%) | 9 (100%) |
| **Total acute athletes** | | | |
| Upper body part | 3 (38%) | 0 (0%) | 3 (38%) |
| Lower body part | 2 (25%) | 1 (13%) | 3 (38%) |
| Upper and Lower body part | 1 (13%) | 1 (13%) | 2 (25%) |
| Total | 6 (75%) | 2 (25%) | 8 (100%) |
| **Total of acute & COI** | | | |
| Upper body part | 0 (0%) | 0 (0%) | 0 (0%) |
| Lower body part | 0 (0%) | 0 (0%) | 0 (0%) |
| Upper and Lower body part | 2 (100%) | 0 (0%) | 2 (100%) |
| Total | 2 (1) | 0 (0) | 2 (1) |

COI: Chronic overuse injury.

(n = 6; female = 3, male = 3) than those with 1, 2 or more than 3 COIs.

### *Prevalence of COI vs. Acute injuries by body region (Table 3)*

The prevalence of COI and acute injuries by body part was considered in three categories; upper body parts defined as cervical, thoracic, upper limbs and anything above the umbilicus; lower body parts defined as low back, pelvis, lower limbs or anything that is below the umbilicus and; both upper body part and lower body part. The analysis revealed that when examining all injured athletes there were an equal number of injuries in the upper body (37%, n=7) and the lower body (37%, n=7). Similarly, COI athletes and acute injured athletes also reported equal injuries in the upper (44% (n=4) and 38% (n=3), respectively) and lower body (44% (n=4) and 38% (n=3), respectively) (upper = 38% (n=3), lower = 38% (n=3)).

There was no difference between females and males (Table 4) when comparing the rate of COI. The rate of acute injury in female vs. male athletes divided into age and level of experience subgroups (≤ 40 or > 40 years old and TKD (≤ 3 or > 3). However, males with a TKD ≤ 3 were most likely to have an acute injury. Interestingly, only females (n=2) reported both acute and chronic injuries in both upper and lower body parts.

Chronic overuse injuries were categorized by 5 specific body parts (neck, back, upper limb, pelvis and lower limb) and compared (Table 5). The lower limb was the most injured area with females (58%, 19 injuries) being affected twice as often as their male counterparts (29%, 5 injuries). Back injuries were considered the second highest injured region, with males (59%, 10 injuries) being affected almost 3 times more than females (21%, 7 injuries).

Table 4.
*Injured body regions in female and male athletes.*

| Body region | ≤ 40 years old n (%) | >40 years old n (%) | TKD ≤ 3 n (%) | TKD > 3 n (%) |
|---|---|---|---|---|
| **FEMALE** | | | | |
| **Total of all injured female athletes** | | | | |
| Upper body part | 3 (23%) | 3 (23%) | 3 (23%) | 3 (23%) |
| Lower body part | 1 (7%) | 3 (23%) | 1 (7%) | 3 (23%) |
| Upper and Lower body part | 2 (15%) | 1 (7%) | 1 (7%) | 2 (15%) |
| Total | 6 (46%) | 7 (54%) | 5 (38%) | 8 (62%) |
| **Injured body Regions of COI in females (n=7)** | | | | |
| Upper body part | 2 (29%) | 2 (29%) | 2 (29%) | 2 (29%) |
| Lower body part | 0 (0%) | 3 (43%) | 1 (2%) | 2 (29%) |
| Upper and Lower body part | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) |
| Total | 2 (29%) | 5 (71%) | 3 (43%) | 4 (57%) |
| **Injured body Regions of acute injuries (n = 6)** | | | | |
| Upper body part | 2 (33%) | 0 (0%) | 0 (0%) | 2 (33%) |
| Lower body part | 1 (17%) | 1 (17%) | 2 (33%) | 0 (0%) |
| Upper and Lower body part | 1 (17%) | 1 (17%) | 1 (17%) | 1 (17%) |
| Total | 4 (67%) | 2 (33%) | 1 (17%) | 1 (17%) |
| **MALE** | | | | |
| **Total of all injured male athletes** | | | | |
| Upper body part | 1 (17%) | 0 (0%) | 0 (0%) | 1 (17%) |
| Lower body part | 2 (33%) | 1 (17%) | 2 (33%) | 1 (17%) |
| Upper and Lower body part | 2 (33%) | 0 (0)% | 1 (0.17) | 1 (17%) |
| Total | 5 (83%) | 1 (17%) | 3 (5%) | 3 (5%) |
| **Injured body Regions of COI (n=4)** | | | | |
| Upper body part | 1 (25%) | 0 (0%) | 0 (0%) | 1 (25%) |
| Lower body part | 1 (25%) | 1 (25%) | 1 (25%) | 1 (25%) |
| Upper and Lower body part | 1 (25%) | 0 (0%) | 0 (0%) | 1 (25%) |
| Total | 3 (75%) | 1 (25%) | 1 (25%) | 3 (75%) |
| **Injured body Regions of acute injuries (n=2)** | | | | |
| Upper body part | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) |
| Lower body part | 1 (5%) | 0 (0%) | 1 (5%) | 0 (0%) |
| Upper and Lower body part | 1 (5%) | 0 (0%) | 1 (5%) | 0 (0%) |
| Total | 2 (100%) | 0 (0%) | 2 (100%) | 0 (0%) |
| COI: Chronic overuse injuries | | | | |

Table 5.
*Chronic overuse injuries by anatomical body regions a total of 50 injuries.*

| Body parts | Female n (%) | Male n (%) | Total injuries n (%) |
|---|---|---|---|
| Neck (cervical) | 5 (15%) | 1 (6%) | 6 (12%) |
| Back (cervicothoracic, thoracic & lumbar) | 7 (21%) | 10 (59%) | 17 (34%) |
| Upper limb (shoulder, arm, etc.) | 0 (0%) | 0 (0%) | 0 (0%) |
| Pelvis (SI & hip) | 2 (6%) | 1 (6%) | 3 (6%) |
| Lower limb (leg, thigh, knee, calf, toe) | 19 (58%) | 5 (29%) | 26 (52%) |
| n= number of injuries. | | | |

Table 6.
*Types of reported injury (n=50) comparing gender, age and TKD experience level.*

| Injury Type | Female n (%) | Male n (%) | Age ≤ 40 n (%) | Age > 40 n (%) | TKD ≤ 3 n (%) | TKD > 3 n (%) | Total |
|---|---|---|---|---|---|---|---|
| Sprain (Grade I & II) | 1 (2%) | 0 (0%) | 0 (0%) | 1 (2%) | 0 (0%) | 1 (2%) | 1 |
| Strain | 10 (30%) | 9 (30%) | 11 (22%) | 8 (14%) | 12 (24%) | 7 (14%) | 19 |
| Joint dysfunction | 10 (20%) | 7 (14%) | 11 (22%) | 6 (12%) | 6 (12%) | 11 (22%) | 17 |
| Myofasciopathy | 3 (4%) | 0 (0%) | 3 (6%) | 0 (0%) | 0 (0%) | 3 (6%) | 3 |
| Chain Dysfunction | 2 (4%) | 0 (0%) | 2 (4%) | 0 (0%) | 0 (0%) | 2 (4%) | 2 |
| OA | 1 (2%) | 0 (0%) | 1 (2%) | 0 (0%) | 1 (2%) | 0 (0%) | 1 |
| SICK scapula | 1 (2%) | 0 (0%) | 1 (2%) | 0 (0%) | 0 (0%) | 1 (2%) | 1 |
| Tissue irritation/ dysfunction | 1(2%) | 1 (2%) | 2 (4%) | 0 (0%) | 1 (2%) | 1 (2%) | 2 |
| Osgood-Schlatter | 0 (0%) | 2 (4%) | 2 (4%) | 0 (0%) | 2 (4%) | 0 (0%) | 2 |
| ACL deficiency | 2 (2%) | 0 (0%) | 0 (0%) | 2 (4%) | 2 (4%) | 0 (0%) | 2 |
| Total | 31 (60%) | 19 (40%) | 33 (66%) | 17 (34%) | 24 (48%) | 26 (52%) | 50 |
| TKD = Taekwondo | | | | | | | |

### *Past history of injuries*

Eleven out of 34 athletes experienced more than one injury in the past 3 years with a total of 50 injuries in this population. The most common types of injury were strain (42%, 19 injuries) and joint dysfunction (34%, 17 injuries). Sprains were rarely observed.

Overall, the injury rate was higher for females (60%, 31 injuries) and those who were 40 year-old or younger (66%, 33 injuries). There was no notable difference when comparing the levels of experience or between strains and joint dysfunction.

## Discussion

### *Type of injuries*

Strains (38%) and joint dysfunctions (34%) were the most prevalent injuries among those athletes who sustained injuries in our study (Table 6). Koh and Kwak[4]

also found that strains were the most common form of injury in Poomsae athletes. However, instead of a joint dysfunction, they found dislocation to be the third most common form of injury. In contrast to Poomsae, sparring seems to display a different trend with regards to the type of injury experienced by the athletes. Kazemi *et al*.[14] analyzed Taekwondo injuries retrospectively over nine years and found a total of 2164 acute injuries were reported; about half (50.2 %) were contusions whereas 12.7 % were sprains. Contusions were reported to be the most prevalent type of injury in contact (33.3% of all reported injuries) and semi-contact (71.4% of all reported injuries) Wushu athletes.[15] A literature review compiled by Pieter *et al*.[1] on injuries in Taekwondo also found that contusions (42.7% in men and 64.7% in women) were the most common type of injuries. A meta-analysis completed by Lystad *et al*.[7] analyzed the most frequent type of injury arising from sparring TKD. The most common type of injury was contusion (36 per 1000 athlete-exposures) and the least common was dislocation (0.6 per athlete-exposures).[7]

Comparing different martial art styles, Zetaruk *et al*.[16] found a significant difference in the occurrences of contusions between karate and sparring TKD, with only 17% of Shotokan karate students sustaining bruises compared with 43% of sparring TKD students. Furthermore, they found that those who trained in tai chi had low injury rates[16], similar to Poomsae athletes of the current study. In addition, Tai chi practitioners do not sustain multiple injuries compared to other styles of martial arts such as Taekwondo, aikido, Kung Fu and Shotokan karate.[16]

### *Injury rate for COI and acute injuries*

In our study, the total prevalence rate of injured athletes (combined COI and acute) was 56% and the prevalence rate of COI alone was 32% and acute 24% (Table 2). Our data contradicts the findings in the study by Koh[2] and Song and Shin[9], which reported a high prevalence rate of COIs in Poomsae athletes (73% and 71%, respectively). Injury rates and risk of sustaining multiple injuries in athletes who practice Tai Chi are extremely low compared to the other styles of martial arts presented in a study by Zetaruk *et al*.[16] The only similarity that exists between Tai Chi and Poomsae injuries is that the most prevalent injury was muscle strain.

### *Gender and type of injury*

Kazemi and Pieter[17] compared genders in sparring TKD athletes and found that contusion was the most common type of injury in which females experienced more injuries than males (81% vs. 33%).

Female athletes we studied were more likely to suffer from chronic overuse injuries; they showed a 22% higher injury rate than males. This finding was similar to that found in the study by Koh.[2] In our study, female athletes reported a higher frequency of multiple COIs than male athletes (25% vs. 11%), whereas Koh[2] reported that female athletes had a lower frequency of multiple COI than male athletes (25% vs. 75%). The non-contact form of Wushu is very similar to Poomsae. Although documentation of injuries in Wushu competitions is not readily available, Blijid *et al*.[15] reported that female semi-contact Wushu athletes had a higher incidence of injury compared to their male counterparts. This finding is similar to that found in Poomsae athletes, but in the forms (non-contact Wushu) competition, no injuries were reported.

The most common type of injury among men was sprain followed by joint dysfunction during national sparring Taekwondo championships.[17] Our study did not find any gender difference with regards to strain injuries.

### *Age and Taekwondo Experience Level (DAN)*

The mean age of Poomsae athletes with COIs observed in this study was slightly higher (Table 1) than the mean age of competitors with COI from a recent study by Koh (40 years vs. 35 years, respectively).[2] Koh and Kwak[4] showed a trend (statistically insignificant) of high injury rate in older Poomsae athletes. Our study revealed no difference in chronic overuse injuries in younger and older athletes (five of 11 athletes with COI were ≤ 40 and six were > 40) (Table 2). Athletes 40 and under were more prone to acute injuries compared to athletes over 40. Koh[2] found that athletes over the age of 30 had a slightly higher frequency of acute injury than those under 30. This difference maybe due to the difference in classification of older athletes in our study (40 years of age) versus that in Koh[2] (30 years of age).

The athletes involved in our study were elite athletes participating at a World level, which is the highest level of competition in Poomsae. In the existing literature[2,4,9] on Poomsae injuries, the level of competition was at a club or provincial level; therefore, the differences seen be-

tween results may be attributed to experience level (elite vs. non-elite athletes).

### *Body regions affected due to COI*

We found the lower limbs to be the most affected by chronic overuse injuries which was similar to other studies.[4,5,7,11,13] Back injuries were the second most occurring type of injury, which were more prevalent among males than females. Although most studies did not present results that were similar, many did not seek to make a comparison. Kazemi *et al*.[10] found that injuries to the spine (neck, upper back, low back and coccyx) were the third most often injured body region in males in a nine year longitudinal study of sparring TKD athletes.

When comparing different regions of the body in chronic overuse injuries and acute injuries, the upper and lower body regions were the dominant injured body parts. We did not find any relationship between gender and age and type of injury in poomsae athletes in contrast to Kazemi *et al*.[10] reporting a trend for increased injuries in athletes over 35 years of age in sparring TKD. We found the lower extremity to have the most commonly acutely injured region (38%) which compares favourably with Zetaruk *et al*.[16] (38.9%). Zetaruk *et al*.[16] also reported the lower extremity (35.9%) to be the most affected body part in Kung Fu.

Koh and Kwak[4] noted that female athletes had a higher prevalence of COIs compared to their counterparts, however, our data did not show any significant differences between female and male recorded COIs. This may be due to our small sample size.

We found very few injuries that actually occurred immediately during training. Very few Poomsae training injuries occurred during the training activity, but rather developed over time in response to long hours of training leading eventually to chronic overuse injuries. One study showed chronic overuse injuries in 71% of Poomsae athletes in South Korea.[4] An additional study conducted by Koh[2], showed that 73% of Poomsae athletes from Alberta, Canada reported chronic overuse injuries symptoms. Koh[2] also noted that female athletes and those who practiced more than 3 times a week had a higher prevalence of chronic overuse injuries compared to their counterparts. In Poomsae, the lower body was more prone to overuse injuries than the upper body; the dominant areas of injuries were the knee joint and hamstrings, where strain was the most common type of injury.

### Limitations

There are a number of limitations to this study. One limitation was the small sample size and therefore, the result needs to be used with caution and the conclusions may be limited to this pool and may not necessarily be considered generalizable to other populations. We cannot discount that a single clinician examined and diagnosed the injuries and it is possible that another clinician may have had different findings or diagnoses. Future studies in Poomsae injury should include various nations and investigate the injury rates during competitions with larger sample size.

The Injury Report Form (IRF)[10], which was used for recording the injuries in this study was originally designed for recording injuries in sparring athletes. Upon conducting this study and realizing the limitations and shortcomings of the Injury Report Form used, the principle author created a Poomsae specific Injury Report Form. (See Appendix)

Severity of injury has been considered to be one of the main factors that affect an athlete's participation and performance. Unfortunately, there is a paucity of recording and defining severe injuries in Taekwondo studies. To the authors' knowledge only three studies have defined severity of injuries in Taekwondo.[17-19] Sherrill[20] graded injury severity on a scale of 0–10 based on time lost from full participation. Injuries of grade three or less (time lost: < 1 day) accounted for 74%, while the remaining 26% were grade four injuries (time lost: 2–7 days). No injuries were reported to result in more than one week of time lost from full participation. Koh and De Freitas[18] classified injury severity as mild (no time lost or restriction to participation), moderate (some disruption, less than full participation) or severe (discontinued participation and/or referral to a hospital). The injury rates per 1000 Athlete Exposures (AEs) of mild, moderate, and severe injuries were reported to be 56.0, 26.5, and 25.5, respectively. Lystad *et al*.[19] recommended categorizing severity of injury: ''The number of days that have elapsed from the date of injury to the date of the player's return to full participation in training and match play''. They grouped the injuries as slight (0–1 days), minimal (2–3 days), mild (4–7 days), moderate (8–28 days), severe (> 28 days), ''career-ending'', and ''non-fatal catastrophic injuries''.[19]

| | |
|---|---|
| 6 | Unsurvivable |
| 5 | Critical impaired LOC, altered GCS in cervical spine |
| 4 | Requires immediate transfer: opened/unstable fracture/dislocations |
| 3 | Requires assessment 24hrs: minor fractures/ dislocations |
| 2 | Requires non-urgent follow up: sprains/strains |
| 1 | Minor treatment completed at scene: mild contusion, scratches |

Figure 1. *Severity Score*.[20]
*Legend: LOC=Loss of Consciousness; GCS=Glasgow Coma Scale.*

In our opinion this classification is appropriate when one is able to follow the athlete following the injury. However, when the athlete has only been provided care only once during an event, this classification would not be applicable. In our opinion The Abbreviated Injury Scale (AIS, Figure 1) would be more practical for rating severity of injury at presentation to the health care provider.[20]

This scale was used in Injury Report Form to account for the acute and on field injuries.[10] Grade 6 was not included in Kazemi[10] Injury Form Report. However, Oler *et al*.[22] reported one case of a fatal kick to the head that resulted in an occipital skull fracture, bilateral subdural haematomas, contusion of the frontal and temporal lobes, and haemorrhage and herniation of the brainstem. As such, Grade 6 injury is included in the revised Poomsae Injury Report (Appendix) to account for the worst-case scenario.

Furthermore an email address for the athlete and the treating practitioner was added since most communications are through email at this time. Signature of the health practitioner was added under their personal info section since the signature at bottom of the page had been confusing. Competition division was added. RANK was refined by revising it to BELT RANK/COLOUR/DAN for clarification. And finally a simple consent statement on the bottom of the page with athlete and or parent/guardian signature was added. The part on IRF which related to ability/inability of the sparring athlete to complete the match at which round was removed since it did not relate to Poomsae athletes. The new Poomsae IRF is not validated and future studies should investigate validity and reliability of this tool.

## Conclusion

The most prevalent injuries in Poomsae were strain and joint dysfunctions. The lower limb was the most common site of chronic and acute injuries. Furthermore, females were more likely to sustain injuries to their lower limbs than males. Males with a black belt DAN ≤ 3 were most likely to have an acute injury. Females with a lower rank in experience level (DAN) were more likely to suffer from chronic overuse injuries compared to their male counterparts. Athletes 40 years old and younger were more prone to acute injuries compared to athletes over 40. Further investigation of Poomsae injuries in various nationals with larger sample size is recommended. A new injury form for reporting Poomsae injuries was developed, which requires further validity and reliability testing.

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## Appendix
### *Poomsae Injury Report Form.*

**Date:** **Time:**

| | | | |
|---|---|---|---|
| EVENT: | | PLACE: | |
| NAME: | BIRTHDATE: | AGE: | SEX: M F |
| ADDRESS: | | CITY: | |
| PROVINCE: | POSTAL CODE: | PHONE: | |
| HEALTH CARD NO: | | WEIGHT: | HEIGHT: |
| COMPETITION DIVISION: | | | |
| NAME OF TAEKWONDO SCHOOL: | | BELT RANK/Colour/Dan: | |
| **TO BE COMPLETED BY MEDICAL PERSONNEL** | | | |
| NAME: | OCCUPATION: | | |
| CLINIC LOCATION: | PHONE: | | |
| EMAIL: | SIGNATURE: | | |

**Past History:**
**Location:**
**Radiation:**
**Character & Intensity:**
**Mechanism of Injury:**

**Front snap Kick**
**Side Kick**
**Round house Kick**
**Crescent kick**
**Punch**
**Block**
**Tripped**
**Collision**
**Other**

**During training**
**During competition**
**Completed Match** **Yes** **No**

**ALLERGIES:**

**Examination Findings:**

**Severity Score:**
**6 Unsurvivable**
**5 Critical** impaired LOC, altered GCS in cervical spine
**4 Requires immediate transfer:** opened/unstable fracture/dislocations
**3 Requires assessment 24hrs:** minor fractures/dislocations
**2 Requires non-urgent follow up:** sprains/strains
**1 Minor treatment completed at scene**

**Diagnosis:** **ACUTE** **CHRONIC** **OVERUSE**

**Recommendations:** **FIT TO COMPETE** **NOT FIT TO COMPETE**

**Treatment Rendered:**

**Follow-up:**

**Discharge Instructions:**

**I have been informed of the risks involved and consent to the treatment and recommendations stated above.**

**Athlete Signature:** **Date:**

**Parent/guardian name:** **Signature:**

**Date:**

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# Opinions of sports clinical practice chiropractors, with sports specialty training and those without, about chiropractic research priorities in sports health care: a centering resonance analysis

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Introduction: *A Canadian sports chiropractic research agenda has yet to be defined. The Delphi method can be utilized to achieve this purpose; however, the sample of experts who participate can influence the results. To better inform sample selection for future research agenda development, we set out to determine if differences in opinions about research priorities exist between chiropractors who have their sports specialty designation and those who do not.*

Methods: *Fifteen sports clinical practice chiropractors who have their sports fellowship designation and fifteen without, were interviewed with a*

Introduction : *Un programme canadien de recherche en chiropratique sportive n'a pas encore été établi. La méthode Delphi peut être utilisée pour atteindre cet objectif; cependant, l'échantillon d'experts qui participent peut influencer les résultats. Afin de mieux informer la sélection d'échantillons pour le développement futur du programme de recherche, nous avons entrepris de déterminer si des différences d'opinions sur les priorités de recherche existent entre les chiropraticiens qui sont spécialisés dans les disciplines sportives et ceux qui ne le sont pas.*

Méthodologie : *Quinze chiropraticiens spécialisés en sport ayant une désignation de spécialiste dans le domaine et quinze autres sans cette désignation ont répondu à un ensemble de questions normalisées sur les priorités de la recherche en chiropractie sportive. Les réponses données durant les entretiens ont fait l'objet*

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*set of standardized questions about sports chiropractic research priorities. A centering resonance analysis and cluster analysis were conducted on the interview responses.*

Results: *The two practitioner groups differed in their opinions about the type of research that they would like to see conducted, the research that would impact their clinical practice the most, and where they believed research was lacking. However, both groups were similar in their opinions about research collaborations.*

Conclusion: *Sports clinical practice chiropractors, with their sports specialty designation and those without, differed in their opinions about sports chiropractic research priorities; however, they had similar opinions about research collaborations. These results suggest that it may be important to sample from both practitioner groups in future studies aimed at developing research agendas for chiropractic research in sport.*

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KEY WORDS: chiropractic, sports, sports chiropractic, text analysis, discourse analysis, centering resonance analysis, research priorities

*d'une analyse par recoupement et d'une analyse qui représente les termes dans un réseau qui met en évidence leur fréquence, leur importance et leur influence (centering resonance analysis).*

Résultats : *Les deux groupes de praticiens ont exprimé des opinions divergentes quant au type de recherche qu'ils souhaitaient voir menée, à la recherche qui aurait le plus d'impact sur leur pratique clinique et aux domaines qui devaient faire l'objet de recherche. Cependant, les deux groupes avaient des réponses similaires sur les collaborations en recherche.*

Conclusion : *Les chiropraticiens spécialisés en sport ayant une désignation de spécialiste dans le domaine et ceux sans cette désignation ont des points de vue différents sur les priorités de la recherche en chiropractie sportive; cependant, ils avaient des opinions similaires sur les collaborations en recherche. Ces résultats suggèrent qu'il peut être important d'inclure des représentants des deux groupes dans les futures études visant à développer des programmes de recherche pour la recherche en chiropratique sportive.*

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MOTS CLÉS : chiropratique, sports, chiropratique sportive, analyse de texte, analyse de discours, centering resonance analysis, priorités de recherche

## Introduction

In individuals aged twelve and older, 35% of reported injuries are attained through sport. Of these injuries, strains and sprains are very common, attributing to 48% of injuries in individuals aged 12-19, 58.3% in those aged 20-60, and 36.6% for those over the age of 65.[1] Chiropractors are experts in musculoskeletal health who are primary contact providers for these injuries. As evidence-based practitioners, research should continually inform a best practices approach to the evaluation and management of sports injuries.

Research agendas identify knowledge gaps, prioritize future research, and ensure that the research being conducted is clinically relevant. The first research agenda for health services related to chiropractic in North America was published in 1997[2], and was subsequently updated in 2006[3]. Similarly, in 2000 the Consortium for Canadian Chiropractic Research Centres (CCCRC) published the results of a two-day workshop purposed to define an agenda for chiropractic research in Canada.[4] More recently, a conference was held in 2009 to update and refine the previous research agenda conducted by the CCCRC.[5] The need for a chiropractic research strategy has also been internationally recognized as demonstrated by a summit hosted in Australia in 2010[6], and more recently Europe was successful in publishing their first research agenda using a Delphi procedure[7]. This international drive to formalize research plans emphasizes the importance for research to be strategically planned in order to increase the likelihood of successful implementation.

Sports chiropractic is a specialty within the chiropractic profession that may require a specialty-specific

research agenda that addresses the unique requirements for this area of study. An internet search of prominent sports chiropractic association websites in June 2016 that included the Royal College of Chiropractic Sports Sciences (Canada) (RCCSS(C)), International Federation of Sports Chiropractic, American Chiropractic Board of Sports Physicians, and American Chiropractic Association Sports Council did not identify any formal research agendas specific to sports chiropractic that have been published to date.[8–11]

The importance of advancing chiropractic research in sport in Canada cannot be understated. Recent analysis conducted on 2,040 respondents of the 2011 cross-sectional survey of the Canadian Chiropractic Resources Databank identified "sports injuries" and "rehabilitation" as a main area of practice that was associated with a higher number of physician referrals to chiropractors.[12] Despite calls to draft a Canadian research agenda for chiropractic research in sport, a coordinated attempt to conduct this task has not been formally planned.[13,14]

Previous researchers have utilized the Delphi survey method to obtain expert consensus to define research agendas.[7,15,16] However, the results of a Delphi study can be greatly influenced by the sample of experts included as subjects. Selecting the appropriate subjects is an important first step in the Delphi process.[17,18] It has been recommended that subjects should be individuals who are highly trained and competent within the specialized area of knowledge related to the target issue, and they should also consist of individuals who are primary stakeholders related to the research effort.[17] Prior to conducting a Delphi study, it may be necessary to first conduct exploratory work to understand the potential population who will be sampled from, and gain an understanding of any key issues arising from the topic area being studied.

In Canada, the sports chiropractic specialty is overseen by the RCCSS(C), and chiropractors who have obtained their fellowship through the RCCSS(C) are regarded as experts in the field. Intuitively, sports chiropractic fellows are a group of representative content area experts to sample from for a Delphi study. However, since many chiropractors who manage sports injuries and practice in sports health care settings do not have formal sports specialty training, it may be important to consider the opinions of these practitioners when developing research agendas as they represent a sizable stakeholder group in the field of sports chiropractic. Exploratory work investigating any possible differences or similarities between these groups of practitioners and their opinions about research priorities would be beneficial prior to planning a study to define a research agenda for sports chiropractic.

Presently, little is known about sports chiropractic practice and the opinions about chiropractic research priorities in sport in Canada. In 2010, Miners *et al*.[19] conducted a cross-sectional survey of fellows from the RCCSS(C) (formally known as the College of Chiropractic Sports Sciences (Canada)) to investigate their self-reported treatment practices and intended therapeutic outcomes when treating athletes. The majority of the respondents believed that their treatments could cause a direct improvement on an athlete's performance and the most commonly utilized therapeutic intervention performed in their treatment of athletes was spinal joint manipulation/mobilization. While this survey studied the practice characteristics and opinions of chiropractic sports fellows in Canada, little is known about chiropractors practicing in sports-based settings that have not completed a sports fellowship. It is plausible that the practice characteristics and beliefs of this group may differ from sports fellows.

Considering the lack of research investigating these two practitioner types (sports fellows and non-sports fellows) in Canada, and the importance of exploring the potential subject pool for a future Delphi study to define a sports chiropractic research agenda, our primary aim of this study was to determine if there is a difference in opinion between sports-based clinical practice chiropractors who have their sports specialty training and those without, regarding sports chiropractic research priorities. If differences in opinions are found to exist, then it may be important to sample from both practitioner groups when conducting a future Delphi study. A secondary aim of the study was to explore the discourse that arose from both groups when asked about their opinions about sports chiropractic research priorities.

Exploring practitioner opinions can sometimes be difficult due to the various methodologies available to the researcher. Survey methods can inform researchers about practitioner's opinions if there is sufficient a priori knowledge to draft valid survey questions, and the statistical analysis of group responses can be objectively compared. However, survey methods have limitations in the types of responses that can be collected, and they provide limited

opportunity for subjects to fully express their opinions. Qualitative interview studies using a grounded theory approach can certainly be utilized to explore practitioner opinions. Some limitations with this method include potential researcher bias while conducting open-ended interviews, making coding decisions, and making judgement of the magnitude of importance of identified emerging themes.[20–22] Also, group comparisons using this approach tend to still be qualitative.

Quantitative analysis and data mining of text data obtained from transcribed structured interviews may be a potential method that can provide insight to researchers about practitioner opinions, and determine if differences or similarities exist between the interview responses obtained from different practitioner groups. It should be noted that these methods are not meant to be substitutes for thematic analysis techniques. Quantitative text analysis provides a different approach to analyzing discourse that provides researchers with a tool that permits the use of various statistical tools to assess and quantify text data.[23] Centering resonance analysis (CRA) is a quantitative text analysis method that uses linguistics and centering theory to model text obtained from archival sources or discourse obtained from transcribed conversations as word networks.[24] CRA was developed in the field of communication studies, and it has been utilized to perform media content analysis, conversation analysis, and the study of organizational communication.[24–28] Recently, CRA has been applied to the chiropractic field to investigate the differences in wellness management strategies between broad and narrow scope chiropractors.[29] A benefit of utilizing CRA is that the text responses obtained from interviews can be analyzed individually or pooled and analyzed as group responses to inform researchers about the overall focus of the discourse that occurred within a group. Statistical techniques, such as a cluster analysis, can be used to determine if the text responses obtained from each respondent group can be objectively clustered based on the degree of similarity between texts. The application of CRA in exploring research opinions is novel. Consequently, a secondary intent of our study is to provide a use case of CRA within this setting to further our understanding of this method.

In order to better understand the research needs within the field of chiropractic in sport, an exploratory cross-sectional interview study was conducted to investigate the difference in opinions about sports chiropractic research priorities between sports clinical practice chiropractors who have their sports specialty designation and those who do not. We hypothesize that the opinions between these two practitioner groups will differ. Since there is limited research about the opinions of sports chiropractic research priorities, this study will serve as the first exploratory step in a larger undertaking to plan a future Delphi study to set a research agenda for chiropractic research in sport in Canada.

## Methods

Fifteen licensed sports clinical practice chiropractors with their sports specialty designation and fifteen without were recruited into one of two groups – the sports specialty designation group (SS) or non-sports specialty designation group (NS). To be included in the study, subjects must: be a licensed Doctor of Chiropractic (DC), self-reportedly manage a minimum of ten sports-related cases per week in clinical practice, self-reportedly practice evidence-informed chiropractic, and have a minimum of five years of clinical practice experience. To be included in the SS group, subjects must also be a registered fellow of the RCCSS(C). Considering the aim of the present study was to obtain opinions regarding research, it was determined to be important to recruit practitioners who are regular users of research to inform their clinical practice. Therefore, one of our inclusion criteria included asking subjects to self-identify as a practitioner that practices evidence-informed chiropractic, which we defined as a practitioner who regularly uses research evidence to inform their clinical chiropractic practice.

Participants were recruited from a geographical region defined by a radius of 100 km using the Canadian Memorial Chiropractic College (CMCC) as the center point. Convenience and snowball sampling methods, such as sampling by the use of personal acquaintances, telephone directories, and reviewing public professional association registries were utilized. Considering the present study is exploratory, and to the authors' knowledge, there presently is no known method for determining a sample size for CRA, a research methodologist experienced in CRA recommended a sample size of 15 subjects per study group. In qualitative research, the collection of an adequate sample has been justified by determining the point at which data saturation has occurred.[30,31] As CRA is a novel appli-

cation to investigating opinions regarding research priorities, the authors present a method for determining data saturation taking account the structure of the CRA word networks. This is described below in the methods section following the description of CRA. Participant rights and safety were reviewed and approved by the CMCC Research Ethics Board.

Once informed consent was obtained, participants were given a sheet of paper containing four standardized interview questions pertaining to their opinions about sports chiropractic research priorities (Table 1). Question one was constructed to allow respondents to openly comment about the type of research they would like to see occur if there were no real or perceived barriers to research. The intent of question two was to elicit practitioner opinions about the type of research that they thought would directly impact their clinical practice. Question three was intended to compel practitioners to conduct their own needs assessment of what research needs to be conducted to advance the field, and the final question queried respondent's opinions about the types of research collaborations they deemed important. Participants were given ample time to review the questions prior to the commencement of the study. All interviews were conducted in person and the participant's responses were recorded using a digital voice recorder. To ensure that full responses were obtained from the participants, at the completion of responding to each question, the interviewer repeated the question to the subject, and informed them that they had the opportunity to add to their answer. Once the participant felt that their response was exhausted, the interviewer then proceeded to the next question.

All audio files from the interviews were transcribed into a text file for subsequent analysis. An a priori decision was made to remove any extraneous speech from the text file that occurred during audio recording that was judged by the research team, as determined by a majority vote of three out of four, to be irrelevant to answering the interview question. Examples of such irrelevant speech included "Can you repeat the question?", "That's a great question.", and words such as "um" and "uh". Individual text files of respondent interviews were separated by interview question, and then compiled into larger text files to represent aggregated group responses to each interview question. This yielded four text files per group representing the four interview questions, each containing n=15 interview responses. For the SS group, the data files were SS Question 1 (SSQ1), SSQ2, SSQ3, and SSQ4. For the NS group, the data files were NSQ1, NSQ2, NSQ3 and NSQ4. A CRA of these text files was conducted with Crawdad Analysis Software (version 1.2) (Crawdad Technologies LLC, Chandler, Arizona).

Table 1.
*Standardized interview questions.*

| Questions | |
|---|---|
| 1. | If there were no limitations, what type of research would you want to be conducted related to chiropractic and sports health care? |
| 2. | What research relative to sports health care and chiropractic would impact your clinical practice the most? |
| 3. | Where do you believe most of the research is lacking for sports chiropractic? |
| 4. | What type of collaborations would you like to see occur in sports chiropractic research? |

CRA is a network text analysis method that uses linguistic theory to create word networks of a body of text by constructing a network of the noun-phrases to represent main concepts, their influence and their interrelationships within this word network.[24,25] This method is based on centering theory, which posits that speakers and writers construct and locate noun phrases within a stream of discourse in such a way as to create coherence.[32] In CRA, sentences are first parsed into noun phrases, and a network is constructed with nouns represented as nodes of the network. Once constructed, the *influence* of a word is measured by calculating the betweenness centrality of each word within the CRA network.[33] Betweenness centrality is a network measure that calculates how often a given node in a network falls along the shortest path between two other nodes in a network,[33,34] and provides a measure of how much a node within a network can control the amount of "flow" (which could be information, knowledge, meaning, etc.) through a network.[24,34] In regards to CRA text networks, where centering words are the nodes of the network, betweenness centrality represents the extent to which a particular centering word channels the flow of meaning through a network of centering words.[24] Word *influence* is a measure of the structural importance of the word within the discursive network. Words that are high in *influence* create coherence in text connecting

words within the network to mediate meaning.[24] Influence values are normalized between 0 and 1. While the average influence of words changes slightly due to text size, in general, influence values above 0.01 are considered significant, and values above 0.05 are considered very significant.[27]

CRA also provides a measure of word *resonance*, which is a measure of the structural similarity of two or more word networks. The more two texts frequently use the same words in influential positions, the more word *resonance* they have.[24] A cluster analysis can be conducted on the *resonance* of two or more word networks to determine whether a body of text can be clustered into distinct groups based on the degree of similarity within the text. Crawdad Analysis Software uses Wards hierarchal clustering method to group objects of interest with minimal information loss, where loss is described as the minimization of the sum of squares error.[35] Analysis algorithms for the generation of CRA word networks, the calculation of word *influence* and word *resonance*, and the reporting of face and representational validity for this text analysis method are described in detail in Corman *et al*.[24]

To answer our primary research question, which was to determine if there exists a difference in opinion regarding research priorities between the two study groups, CRA networks were generated for each of the 8 input text files (with each file representing each group's responses to each interview question), and a cluster analysis was conducted to determine if these text files could be clustered into distinct groups based on the degree of similarity within the text.

To investigate the effect of sample size on this approach, the cluster analysis was repeated using a sequentially ascending sample size of group responses to each question starting with text files that included 1 subject response, and progressively proceeded to text files that included 15 subject responses. Therefore, the cluster analysis was repeated 15 times, with each successive run adding data from another subject to the group responses to each interview question. The sequence for serially adding subjects to the analysis was randomized for each study group using a random list generator provided by the website random.org/lists.[36] Data saturation for this method of analysis was defined as the point where the cluster analysis results are found to be stable across sample size, where further addition of subjects does not change the cluster pattern.

To explore the discourse that arose from the interview responses from both groups, CRA networks and network visualizations were created for each of the 8 input text files that represented the group responses to each interview question. CRA network visualizations were qualitatively analyzed, and an influence analysis was conducted on each CRA network to identify influential nouns and noun pairs within the discourse. A decision was made to report the top 20 ranked influential nouns and noun pairs identified. To investigate the effect of sample size on the use of CRA to explore the discourse obtained from the interview responses, it must be recognized that CRA models text as word networks. In order to determine a point where data saturation of a CRA word network has likely to have occurred, one must determine the point at which the further addition of interview responses contributed from sequential subjects does not substantially alter the network structure. Word *influence* is calculated based on the betweenness centrality of a word within a word network, and it represents how often a given node in a network falls along the shortest path between two other nodes in a network.[24,34] As a result, word *influence* will change as the network size increases. Also, this metric does not provide a measure of the network structure. Word *resonance* represents a better measure to evaluate the effect of sample size on CRA as it provides a measure of the structural similarity between word networks.[24] A method was devised to compare the CRA word networks across sample sizes based on word *resonance*. Separate text files of interview responses with a sequentially ascending sample size were created for each interview question for each study group. A cluster analysis based on word resonance was conducted on the CRA networks generated from these text files. The same random sequence created for serially adding subjects to the previous analysis was used for this purpose. The result of this cluster analysis can determine how similar or dissimilar the structure of the CRA word networks are as sample size is increased. If the clustering pattern for each question clusters according to sample size, and demonstrates large clusters that include files with sequential sample sizes that saturate up to the maximum sample size of 15 subjects, then this may provide some evidence that further addition of subject data may not affect the overall CRA network structure

for each group's response to the interview question being analyzed. If the cluster analysis returns a pattern that does not follow a rationale grouping based on sample size, then one may conclude that the CRA network structure for each group's response to each individual question has not been saturated.

## Results

### *Participant Demographics (see Table 2)*

Twenty-one sports clinical practice chiropractors with their sports specialty designation and 30 without their specialty designation were recruited to participate in this study. A total of 15 participants in each group were enrolled, and all 30 participants completed the study. The participation rate was 71.4% and 50% for the SS and NS groups, respectively. The mean age and years of practice

Table 2.
*Demographics of participants.*

| Demographics | Sports Specialty Designation Chiropractors | Non-Sports Specialty Designation Chiropractors |
|---|---|---|
| Participants recruited | 21 | 30 |
| Participants interviewed | 15 (14:1, male:female) | 15 (12:3, male:female) |
| Participation rate | 71.4% | 50% |
| Age (mean +/– SD) | 41.4 +/– 5.5 | 41.8 +/– 9.4 |
| Years of practice (mean +/– SD) | 15.9 +/– 8.3 | 12.8 +/– 7.4 |
| Number of participants with formal research experience (masters, PhD or chiropractic residency program) | 15 (100%) | 2 (13%) |

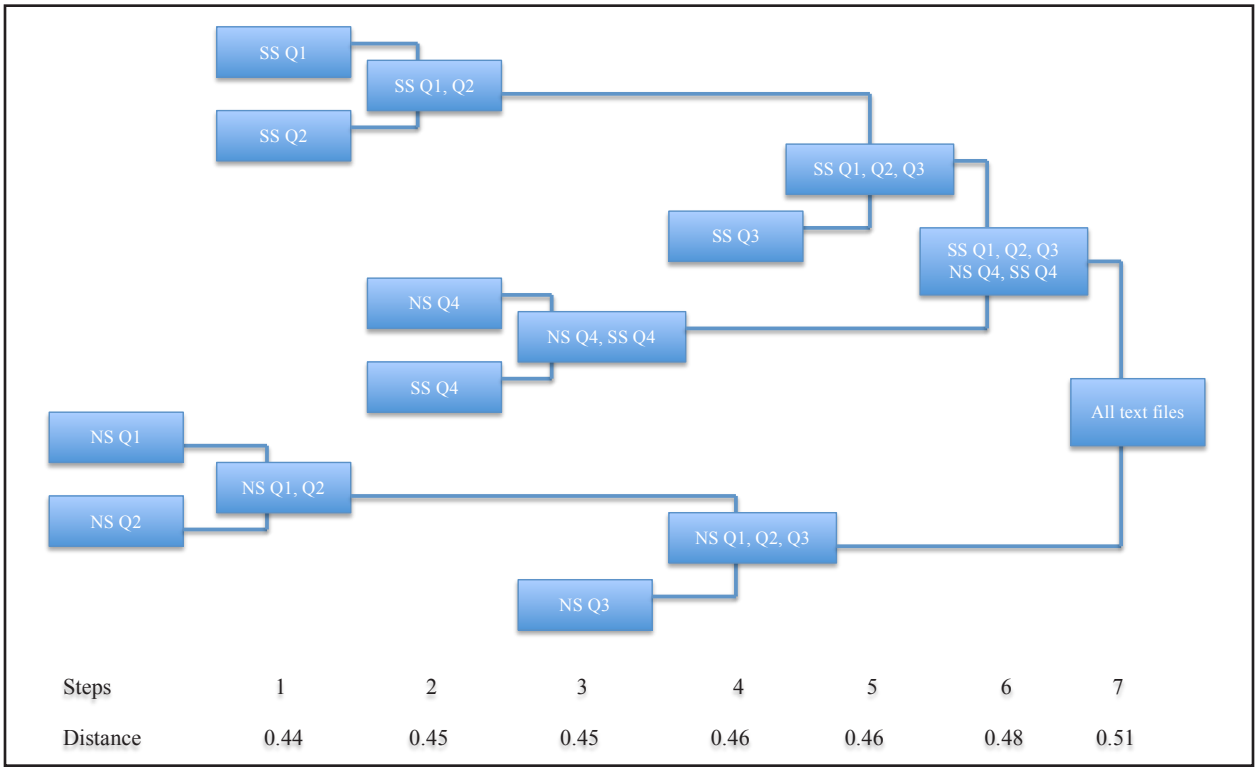


Figure 1.
*Hierarchical clustering dendrogram.*
A cluster analysis was conducted on the eight CRA word networks generated from the eight input text files representing the aggregated group responses to each interview question. A distinct clustering pattern is observed. Note that questions one, two and three clustered by study group and question four clustered by question. When interpreting a dendrogram, the strength of similarity between objects is strongest on the left and decreases at each step to the right.

Table 3.
*Effect of sample size on the cluster analysis of group responses to interview questions.*

| Cluster Analysis | Sample Size Per Group (n) | Group Clusters For Each Cluster Analysis | | |
|---|---|---|---|---|
| 1 | 1 | NSQ1, NSQ4, NSQ3, NSQ2 | SSQ1, SSQ2, SSQ3, SQ4 | |
| 2 | 2 | NSQ2, SSQ3, SSQ4 | NSQ1, NSQ4, NSQ3 | SSQ1, SSQ2 |
| 3 | 3 | SSQ3, SSQ4, NSQ2 | NSQ1, NSQ4, NSQ3 | SSQ1, SSQ2 |
| 4 | 4 | SSQ1, SSQ2, SSQ3, SSQ4 | NSQ1, NSQ4, NSQ3, NSQ2 | |
| 5 | 5 | SSQ3, NSQ2, SSQ4 | NSQ1, NSQ4, NSQ3 | SSQ1, SSQ2 |
| 6 | 6 | NSQ1, NSQ4, NSQ3, SSQ4 | NSQ2, SSQ3 | SSQ1, SSQ2 |
| 7 | 7 | NSQ1, NSQ2, NSQ3 | NSQ4, SSQ4 | SSQ1, SSQ2, SSQ3 |
| 8 | 8 | NSQ4, SSQ4, NSQ3 | NSQ1, NSQ2 | SSQ1, SSQ2, SSQ3 |
| 9 | 9 | NSQ1, NSQ2, NSQ3 | NSQ4, SSQ4 | SSQ1, SSQ2, SSQ3 |
| 10 | 10 | NSQ1, NSQ2, NSQ3 | NSQ4, SSQ4 | SSQ1, SSQ2, SSQ3 |
| 11 | 11 | NSQ1, NSQ2, NSQ3 | NSQ4, SSQ4 | SSQ1, SSQ2, SSQ3 |
| 12 | 12 | NSQ1, NSQ2, NSQ3 | NSQ4, SSQ4 | SSQ1, SSQ2, SSQ3 |
| 13 | 13 | NSQ1, NSQ2, NSQ3 | NSQ4, SSQ4 | SSQ1, SSQ2, SSQ3 |
| 14 | 14 | NSQ1, NSQ2, NSQ3 | NSQ4, SSQ4 | SSQ1, SSQ2, SSQ3 |
| 15 | 15 | NSQ1, NSQ2, NSQ3 | NSQ4, SSQ4 | SSQ1, SSQ2, SSQ3 |

Note: the overall clustering pattern remained stable after a sample size of 9 subjects per group, indicated by the darker shading.

between both groups were similar. However, the number of participants with formal research experience differed between the groups with 100% of the SS group and 13% of the NS group reporting formal research experience, which was defined as previous participation in a masters, PhD or chiropractic residency training program.

### *Cluster Analysis*

The cluster analysis (Figure 1) revealed that the CRA networks generated from the input text files clustered by study group for questions one, two and three, indicating that the SS and NS groups differed in their responses to these questions. Questions one and two, that asked respondents about the type of research they wanted to be conducted in the field and the type of research they thought would impact their clinical practice the most, clustered by study group at steps one and two. This revealed that questions one and two elicited similar responses within each study group. Question three, that asked respondents where they believed most of the research is lacking in the field, clustered by study group at steps four and five of the analysis, revealing that question three elicited different responses compared to questions one and two from participants within their own group, but the responses still differed between groups. Interestingly, the word networks for question four clustered by question and not by study group at step three of the analysis, revealing that both groups responded similarly to question four, which asked respondents about the types of collaborations they would like to see occur in sports chiropractic research. The results from the 15 repeated cluster analyses with a sequentially ascending sample size revealed that the main clustering pattern was stable from the inclusion of data from 9 subjects onward (Table 3). This provides some evidence that this method of analysis reached data saturation at 9 subjects per study group, and the further addition of subjects will not likely change the overall clustering pattern.

### *CRA Network Visualizations and Influence Analysis*

CRA network visualizations (Figures 2 to 9) and word influence analyses (Tables 5 to 8) were conducted for each text file that contained the group responses to each

Table 4.
*Cluster analyses of text files with different sample sizes for each interview question.*

| Cluster Analysis | Question Per Group | Cluster Grouping of Text Files With Different Sample Sizes | | | |
|---|---|---|---|---|---|
| 1 | NSQ1 | 1,2,3 | 4,5,6,7,8,9,10 | 11,12,13,14,15 | |
| 2 | NSQ2 | 1,2,3 | 4,5,6 | 7,8,9,10 | 11,12,13,14,15 |
| 3 | NSQ3 | 1,2,3 | 4,5,6,7,8 | 9,10,11,12,13,14,15 | |
| 4 | NSQ4 | 1,2,3 | 4,5,6 | 7,8,9 | 10,11,12,13,14,15 |
| 5 | SSQ1 | 1,2,3,4,5,6 | 7,8,9,10,11 | 12,13,14,15 | |
| 6 | SSQ2 | 1,2,3,4,5,6 | 7,8,9,10,11 | 12,13,14,15 | |
| 7 | SSQ3 | 1,2,3,4,5,6 | 7,8,9,10,11 | 12,13,14,15 | |
| 8 | SSQ4 | 1,2,3,4,5,6 | 7,8,9,10,11 | 12,13,14,15 | |

Each number represents a text file that contains the corresponding amount of subject responses to the interview question.

interview question. In order to interpret the findings of a CRA, it is important to first assess the visualization of the CRA word network, and then utilize the results of the influence analysis to identify the key areas of focus that occurred within the discourse. Since CRA networks typically contain hundreds of word connections, the CRA visualization that is constructed by Crawdad Analysis Software provides a visualization of a sub-network based on the most influential words in the document. Typically, nodes in the network with influence values above 0.015 are shown, which generates CRA network maps that include approximately 20 to 30 nodes per visualization. To interpret CRA network diagrams, the primary influential nouns are found in red, the secondary influential nouns are in yellow, and tertiary influential nouns are not assigned a colour. The lines in the map depict links between the words, with darker lines depicting stronger ties in the network. The most influential words tend to be located near the top of the diagram, and the lower portion of the graph contains less influential words.[37] The interpretation of the CRA network visualizations and influence analyses are presented below in relation to their corresponding interview question with selected excerpts from the discourse that highlight the CRA results.

The results of the analysis to investigate the effect of sample size on the structure of the CRA networks generated for the group responses to each interview question is found in Table 4. For both groups, across all questions, the files clustered by sample size. The cluster analysis illustrates the evolution of the similarity between CRA word network structure as sample size increases. For the SS group, the CRA word networks that included data from 12 subjects onward were grouped similarity based on word resonance. For the NS group, the CRA word networks that included data from as low as 9 subjects onward, and as high as 11 subjects onward were grouped similarly. This systematic grouping of CRA word networks over sample size provides evidence that the CRA word networks are not changing substantially in structure from sample sizes as low as 9 subjects onward and as high as 12 subjects onward, depending on the group or individual question. This provides some evidence that the inclusion of 15 subjects per study group for the present study led to stable CRA word network structures.

### *Question 1: If there were no limitations, what type of research would you want to be conducted related to chiropractic and sports health care?*

The CRA network visualization for the NS group (Figure 2) for this question revealed that the primary influential words in the network diagram were *injury*, *chiropractic*, *research*, *care* and *athlete*. The secondary influential words within the network were *sports*, *chiropractor*, *good*, *treatment*, *knee*, *study* and *performance*. Notable word network connections within the CRA visualization that involved the primary and secondary

influential words included *chiropractic-injury-care*, *injury-sports-care*, *injury-sports-therapy*, *injury-general*, *chiropractic-treatment*, *research-chiropractor-athlete*, *research-good-treatment*, *research-great*, *injury-athlete-performance*, and *chiropractic-treatment-performance*. The top 5 word-pairings of the influence analysis (Table 5) were *chiropractic-care*, *research-good*, *injury-care*, *chiropractic-sports* and *injury-sports*. Other interesting influential word pairings included the pairings *injury-general*, *care-performance*, *athlete-performance* and *care-sports*.

Interpreting both the CRA network visualization and influence analysis collectively, the central focus of the discourse generated from the NS group in response to this question included discussions about the research of chiropractic care of sports injuries related to athletes. The NS group also had discussions about chiropractic care as it relates to athletic performance within the discourse; however, it seemed to be a secondary focus within the word network.

Below are selected excerpts from the discourse generated from the NS group:

> "I would think that we would want to look at something in terms of treatment, looking at the effects of chiropractic care, and if that includes soft tissue therapy and rehab, that we would be able to have a multimodal approach to sports injuries, whether its musculoskeletal or post-op, or however the injuries occurred."

> "Research on the efficacy comparing outcomes to physiotherapy, medication, etc. Also awareness as to whether or not people are aware that chiropractors treat sports injuries and treat them well and effectively. There is a lack of awareness with respect to patients that come in with spinal care that aren't aware that we can also deal with a sprained ankle or twisted knee."

> "I also think it would be exciting to increase quality evidence of performance care. So how seeing chiropractic, aside from anecdotally, can help athletes function through the season, if we can actually see improvements that are maintained in performance, and if we can see preventative care relating to performance care, so by decreasing injuries throughout a season for example, if we can then improve the performance of a team or an individual athlete."

The CRA network visualization for the SS group (Figure 3) revealed that the primary influential words in the network were *sports*, *performance*, *research*, *chiropractic* and *chiropractor*. These words were the most connected nodes within the word network. The main word pairings for the word *sports* were *sports-chiropractic*, *sports-chiropractor*, *sports-performance*, *sports-research*, and *sports-athlete*. The main word pairings with the word *research* were *sports-research* and *research-chiropractic*. The secondary influential words within the network were *care*, *athlete*, *manipulation*, *various*, *trial*, *area*, and *treatment*. As can be seen by the CRA network visualization, many influential network connections were observed with the word *performance*, such as *performance-effect*, *performance-chiropractic-care-athlete*, *performance-chiropractic-manipulation*, and *performance-chiropractic-treatment*. The influence analysis (Table 5) revealed that the word *performance* was the third most influential word identified, and it was paired 6 times within the top 20 influential word pairs with the pairings being *sports-performance*, *performance-chiropractic*, *performance-manipulation*, *performance-care*, *performance-effect*, and *performance-chiropractor*. The position and connectivity of the word *performance* in the CRA network revealed that discussions about performance were a central focus of the SS group's discourse in response to this question. Referring again to the CRA network visualization, there were strong links between the words *sports-chiropractic-care-athlete* within the network. This provides evidence that the discourse arising from the SS group involved discussions about sports chiropractic care of athletes as related to research. The word *manipulation* was a secondary influential word and it has many strong ties within the CRA word network, as can be visualized on the lower left quadrant of the CRA network visualization for the SS group (Figure 3). *Manipulation* was paired with the words *performance-manipulation*, *manipulation-extremity*, *manipulation-tissue*, *manipulation-soft*, *manipulation-spinal*, and *manipulation-effect*. Clearly, the SS group responses involved discussions regarding manipulation. Also of interest, the

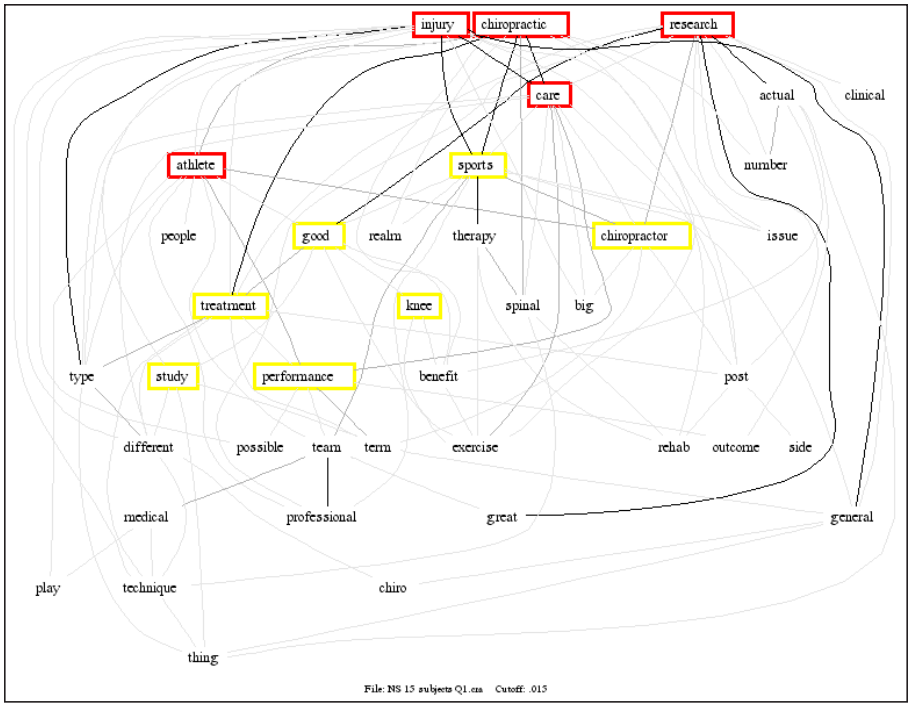


Figure 2.
*CRA visualization for question 1, NS group*

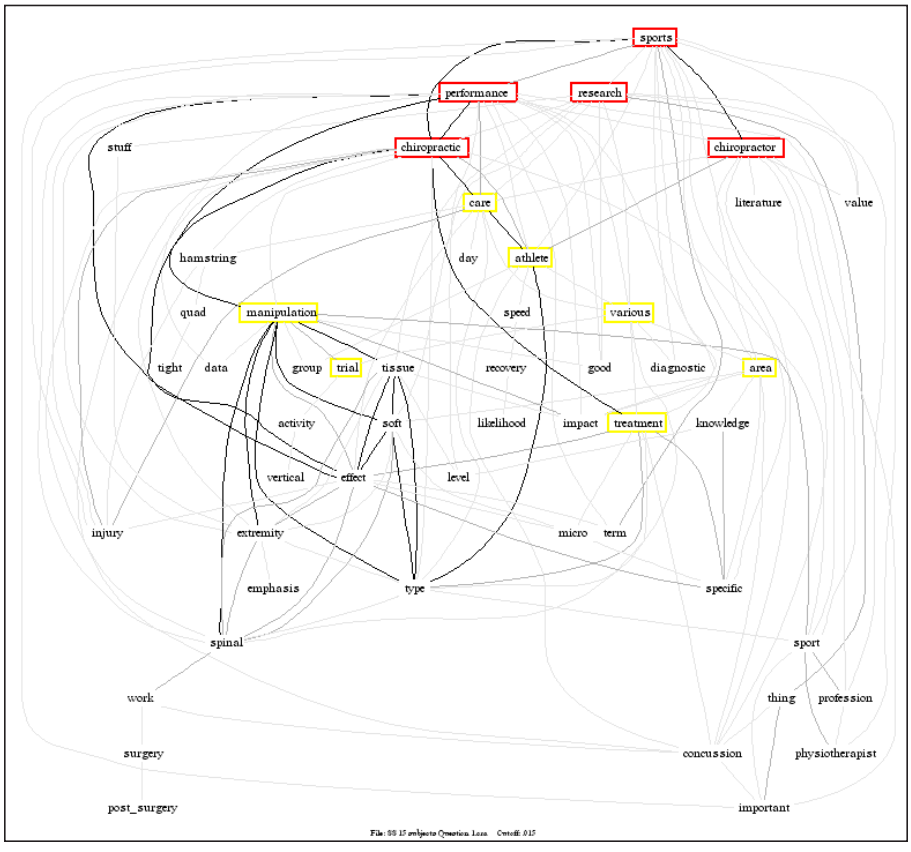


Figure 3.
*CRA Visualization for question 1, SS group.*

Table 5:
*Influence Analysis for Question 1*
Question 1: If there were no limitations what type of research would you want to be conducted related to chiropractic and sports health care?

| NS Group | | | | SS Group | | | |
|---|---|---|---|---|---|---|---|
| **Words** | **Influence** | **Pairs** | **Influence** | **Words** | **Influence** | **Pairs** | **Influence** |
| research | 0.260 | chiropractic \| care | 0.222 | sports | 0.166 | sports \| chiropractic | 0.120 |
| chiropractic | 0.159 | research \| good | 0.078 | research | 0.151 | sports \| chiropractor | 0.106 |
| injury | 0.158 | injury \| care | 0.066 | performance | 0.148 | tissue \| soft | 0.052 |
| care | 0.140 | chiropractic \| sports | 0.049 | chiropractor | 0.106 | sports \| performance | 0.049 |
| athlete | 0.115 | injury \| sports | 0.049 | chiropractic | 0.103 | performance \| chiropractic | 0.046 |
| sports | 0.078 | chiropractic \| athlete | 0.037 | care | 0.095 | performance \| manipulation | 0.036 |
| good | 0.075 | research \| care | 0.036 | athlete | 0.081 | chiropractic \| care | 0.029 |
| treatment | 0.066 | research \| chiropractor | 0.033 | manipulation | 0.080 | performance \| care | 0.028 |
| chiropractor | 0.063 | chiropractic \| treatment | 0.032 | various | 0.059 | sports \| research | 0.025 |
| study | 0.054 | research \| actual | 0.027 | treatment | 0.054 | care \| athlete | 0.023 |
| knee | 0.052 | injury \| type | 0.022 | area | 0.053 | manipulation \| extremity | 0.020 |
| performance | 0.051 | injury \| general | 0.019 | trial | 0.050 | performance \| effect | 0.019 |
| post | 0.049 | research \| great | 0.018 | tissue | 0.047 | manipulation \| tissue | 0.019 |
| type | 0.047 | injury \| athlete | 0.018 | soft | 0.044 | chiropractor \| athlete | 0.017 |
| term | 0.042 | research \| treatment | 0.017 | effect | 0.042 | chiropractic \| athlete | 0.017 |
| general | 0.040 | athlete \| chiropractor | 0.015 | stuff | 0.042 | chiropractic \| treatment | 0.017 |
| actual | 0.035 | care \| performance | 0.014 | extremity | 0.041 | manipulation \| soft | 0.017 |
| team | 0.033 | research \| post | 0.013 | type | 0.038 | research \| chiropractic | 0.016 |
| people | 0.028 | athlete \| performance | 0.012 | good | 0.037 | performance \| chiropractor | 0.016 |
| number | 0.028 | care \| sports | 0.011 | activity | 0.035 | sports \| athlete | 0.014 |

word *effect* had many strong links within the lower left quadrant of the network visualization, and was also an influential word identified from the influence analysis. The word pairings and network connections involving this word included *performance-effect*, *soft-tissue-effect*, *chiropractic-treatment-effect*, and *manipulation-effect*. Some notable tertiary words of the CRA network visualization included *surgery*, *post-surgery*, *concussion*, *hamstring*, and *recovery*.

Taking into account both the CRA network visualization and influence analysis, the SS group's discourse was centered around discussions about research regarding sports chiropractic in the care of athletes, the study of performance as it relates to chiropractic and chiropractic manipulation, and the effects of manipulation and soft tissue therapy. The discussions regarding performance and manipulation were main areas of focus within the discourse. There were also some discussions regarding surgery, post-surgery, concussion, and recovery.

Below are selected excerpts from the SS group's discourse for this question:

> "There are a couple of areas that would be of some benefit. One big one is how chiropractic care benefits performance in an athlete. So being able to show that certain parts of what we do if it's SMT or joint manipulation, soft tissue therapy and how they can transition from treatment from office to performance related marker on the field or in the sport that they do."

> "So we need more research to demonstrate that whether it's some sort of spinal manipulation or extremity manipulation or a soft tissue type approach or even a rehabilitation approach that is effective in actually managing or treating a condition. And then, as an extension on to that, if it is ac-

tually helpful in performance care or performance enhancement."

"Well, certainly I would like to see more research being done on sports performance and that related to either possibly manipulative maneuvers, so manipulation and sport performance, certainly maybe even more data on manipulation, possibly extremity manipulation on range of motion, again more studies regarding soft tissue therapies and their effects on soft tissue responses to soft tissue therapy. We certainly need work being done in concussion treatments as well, possibly cervicogenic headaches or neck pain related to concussion are also important."

"The same thing would go with some of the peripheral joint stuff we do, the extremity manipulation we do as sport chiropractors specifically in the feet, wrist and hand with various types of athletes seeing what the actual mechanism that is occurring as to why it feels better when we do that and relating that back to performance."

"Our biggest limitation in terms of the sports practice is the effect we can have on soft tissue. So research in and around changes say with imaging for example on tendinopathy, tendinosis, small tears, micro tears with either soft tissue by hand or with soft tissue assisted devices and/or more in depth research on tendon repair or ligament repair under load with soft tissue or exercise."

"I would like to see more research into things that are within our scope of practice but including things such as post-surgical work, although we don't do surgery, we manage post-surgical cases."

The cluster analysis revealed that the responses to question one clustered separately between the NS and SS groups. The main differences between the two groups can be seen from the differences outlined in their CRA word networks and influence analyses. The NS group's word network had a primary focus on discussions about research regarding injury care, and they had a secondary focus on discussions related to sports and performance. In contrast, the SS group's CRA word network had a primary focus on the discussion of sports chiropractic and performance, and the effect of manipulation within their word network. Interestingly, the word injury was not identified as an influential word in the SS group's influence analysis. These differences most likely led to the two groups clustering separately for this question.

### *Question 2: What research relative to sports health care and chiropractic would impact your clinical practice the most?*

The CRA network visualization for the NS group (Figure 4) identified the words *research*, *sports*, *thing* and *practice* as primary words in the network. The influence analysis (Table 6) revealed that the word *research* was highly influential within this CRA network, and the influential word pairings with this word included *research-thing*, *research-type*, *research-sports*, *research-care*, *research-chiropractic*, *research-injury*, *research-clinical*, *research-chiropractor*, *research-pattern*, *research-approach*, *research-area*, *research-different*, *research-manipulation* and *research-mobility*. The influential word *thing* was a surprising finding. It was paired with *research-thing* and *thing-practice*. Referring back through the transcribed interviews, the word *thing* was frequently used in speech by the respondents as a pronoun, such as "…things like that would be a huge gain for us from a profession standpoint". The pairings with the word *sports* included *research-sports*, *sports-chiropractic* and *sports-injury*. It was not surprising that the word *practice* was an influential word with network connections, such as *practice-clinical-impact,* since many respondents often answered the question by repeating part of the question back in their response making reference to "…research that would impact my clinical practice". Referring back to the visualization of the CRA word network, secondary influential words included *chiropractic*, *chiropractor*, *injury*, *care* and *type*. Notable connections in the CRA network visualization included *sports-injury-care*, *chiropractic-care-injury-sports*, *sports-professional*, *chiropractic-care-performance*, and *research-effectiveness*. While only identified as tertiary words in this network, there were many network connections between the words *care* and *performance*. Some interesting tertiary words in the CRA network included *adjustment*, *manipulation*, *modality*, *post-surgical*, *soft tissue* and *concussion*.

From both the CRA network visualization and influence analysis, when asked about what type of research would impact their clinical practice, the discourse from the NS group primarily focused on discussions about chiropractic care and sports injury care as it relates to clinical practice. Discussions about chiropractic and injury care related to performance, and research about effectiveness were secondary and tertiary focuses within the discourse. There was some discussion about professional sports and athletes. Some respondents seemed to have discussions about manipulation, mobility, modalities, post-surgical care, soft tissue and concussion.

Below are select passages from the discourse of the NS group:

> "If there was more specific research relative to chiropractic and sports injuries for spine and extremities it could have an impact on clinical practice. Different outcomes or different approaches to care could change clinical practice."

> "Improved diagnostic algorithm for sports injuries would be beneficial as well as more specific treatment protocols."

> "I want to know with specific injuries – I'm looking at tendinosis, I'm looking at mobility issues, I'm looking at post-surgical fracture healing – How do I get the athlete back to performing as quickly as possible and efficiently as possible using chiropractic care."

> "I'd like to see where the evidence shows our full scope of practice of showing joint manipulation and how it could change a throwing pattern, how it can change in SI and hip patterns in a hurdler. Things that I would do when I go out and actually treat in practice. I would want to see that be put into quantitative evaluation because you can see it anecdotally, but there is nothing out there that says it. The only research I would like to see would be looking at the actual practically of it. I would like to see how MSK and joint manipulations can work in a fundamental sports environment."

The CRA network visualization for the SS group is found in Figure 5 and the influence analysis is found in Table 6. The primary influential words identified in this visualization were *research*, *injury*, *athlete*, *treatment* and *patient*. Notable network connections and word pairings utilizing these words were *research-prevention*, *injury-prevention*, *injury-treatment*, *injury-care*, and *athlete-patient-outcome*. Secondary influential words were *orthopedic*, *specific*, *tissue*, *outcome*, *care*, *thing*, *important*, *chiropractic*, *sports*, *clinical* and *practice*. Network connections from the CRA visualization involving these secondary words were *research-specific-outcome*, *treatment-tissue-therapy-soft*, *orthopedic-assessment,* and the links of the word *effectiveness* with the words *treatment* and *research*. Similar to the NS group, the words *clinical* and *practice* were secondary influential words with the connection *clinical-practice-impact,* and reflected the tendency of the respondents to repeat back parts of the question when responding. In terms of the word *orthopedic*, upon reviewing the interview transcripts, respondents referred to the use of the word *orthopedic* in relation to orthopedic surgeons and orthopedic assessment. Amongst the tertiary words identified from the CRA visualization, notable words were *assessment*, *functional*, *conditioning*, *effect* and *effectiveness*.

In response to the question about the type of research that would impact clinical practice, the SS group's discourse tended to focus primarily on research about injury treatment and injury prevention for athletes. The secondary focus from the SS group's discourse involved discussions regarding soft tissue therapy, orthopedics, and specific outcomes. Some respondents discussed assessment, effect and effectiveness.

Selected excerpts from the SS group's discourse for this question are found below:

> "I think that the research that would be most relative to my clinical practice would be more research that demonstrates the effectiveness of the treatment that we have to offer. I've done a number of presentations to CASEM and to different events where say there is orthopedic surgeons in attendance and their suggestion to me is to just be able to provide them research evidence that our intervention is effective for a given sports diagnoses, and that would be what they need to see to increase their referrals."

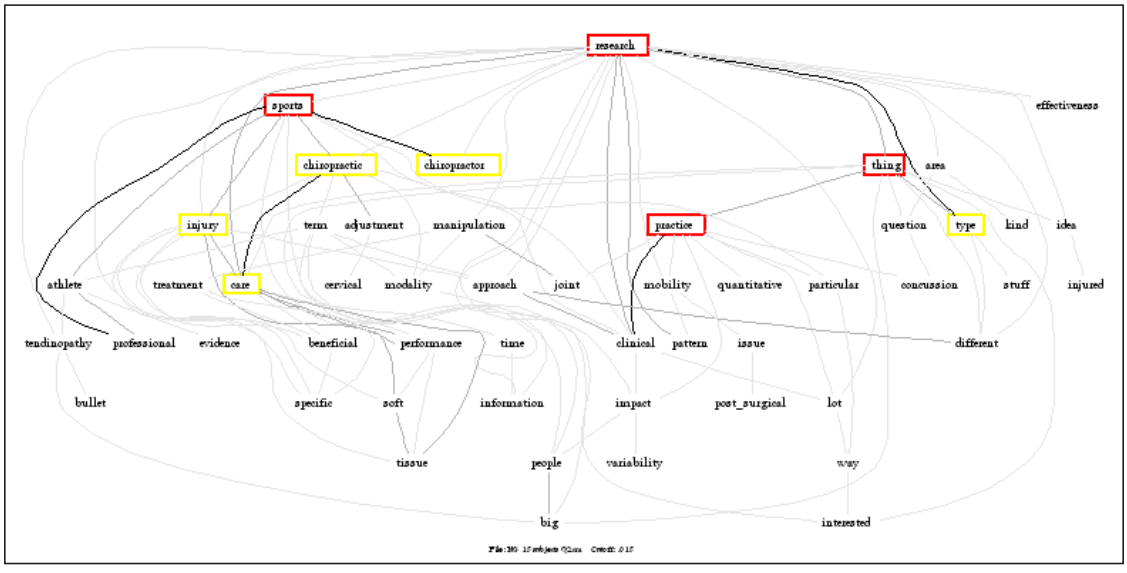


Figure 4.
*CRA visualization for question 2, NS group.*

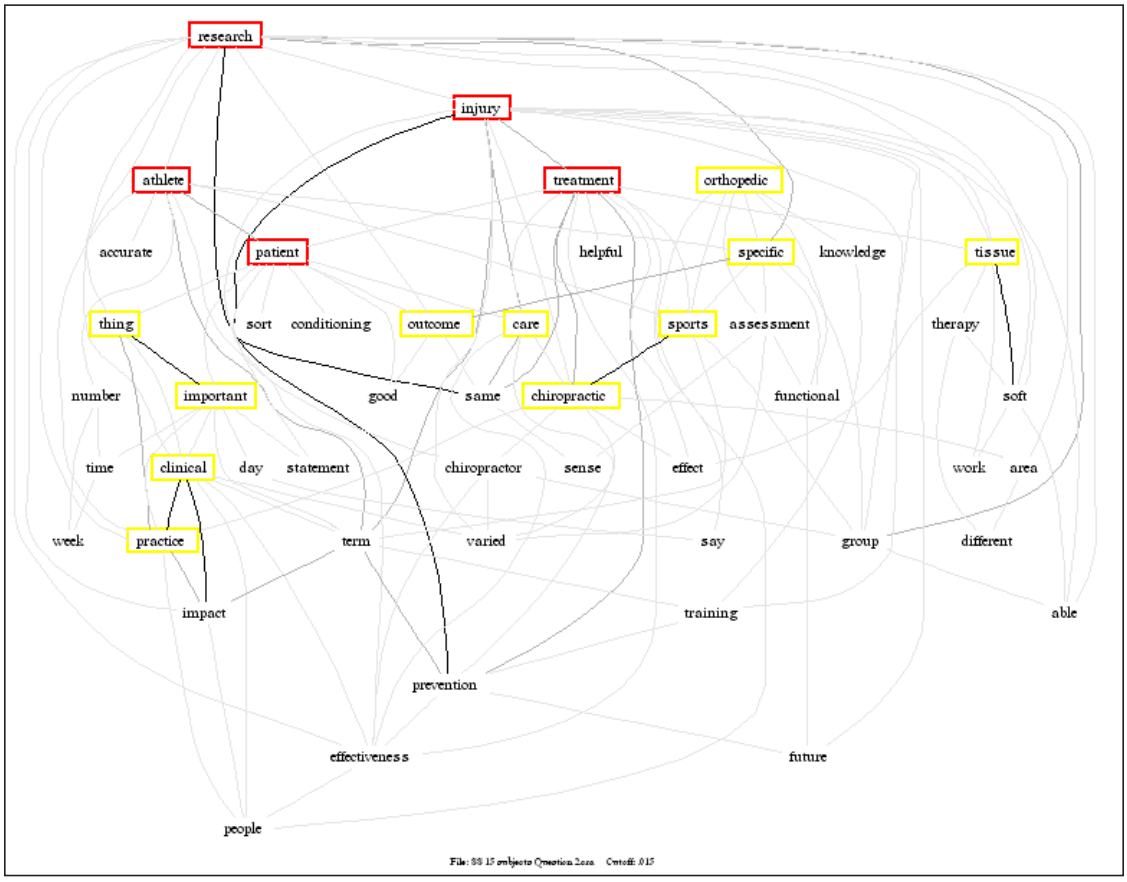


Figure 5.
*CRA visualization for question 2, SS group.*

Table 6:
*Influence Analysis for Question 2*
Question 2. What research relative to sports health care and chiropractic would impact your clinical practice the most?

| NS Group | | | | SS Group | | | |
|---|---|---|---|---|---|---|---|
| **Words** | **Influence** | **Word Pairs** | **Influence** | **Words** | **Influence** | **Word Pairs** | **Influence** |
| research | 0.411 | research \| thing | 0.118 | research | 0.210 | injury \| treatment | 0.043 |
| thing | 0.143 | research \| type | 0.094 | injury | 0.157 | research \| specific | 0.035 |
| sports | 0.125 | research \| sports | 0.051 | treatment | 0.136 | research \| injury | 0.033 |
| practice | 0.104 | research \| care | 0.049 | athlete | 0.127 | injury \| prevention | 0.030 |
| chiropractic | 0.080 | research \| chiropractic | 0.033 | patient | 0.103 | research \| athlete | 0.027 |
| injury | 0.076 | research \| injury | 0.031 | care | 0.087 | injury \| care | 0.027 |
| chiropractor | 0.068 | research \| clinical | 0.031 | orthopedic | 0.087 | athlete \| patient | 0.026 |
| care | 0.059 | thing \| practice | 0.030 | specific | 0.083 | clinical \| practice | 0.022 |
| type | 0.057 | research \| chiropractor | 0.028 | sports | 0.069 | research \| same | 0.018 |
| term | 0.049 | sports \| chiropractor | 0.026 | tissue | 0.062 | treatment \| chiropractic | 0.016 |
| approach | 0.047 | research \| pattern | 0.022 | chiropractic | 0.060 | Injury \| term | 0.014 |
| area | 0.045 | sports \| chiropractic | 0.020 | thing | 0.056 | treatment \| patient | 0.014 |
| different | 0.044 | practice \| clinical | 0.020 | important | 0.055 | research \| tissue | 0.013 |
| manipulation | 0.044 | research \| approach | 0.019 | clinical | 0.054 | research \| thing | 0.012 |
| athlete | 0.043 | sports \| injury | 0.019 | outcome | 0.053 | treatment \| care | 0.012 |
| modality | 0.042 | research \| area | 0.018 | practice | 0.051 | athlete \| term | 0.012 |
| mobility | 0.041 | research \| different | 0.018 | term | 0.045 | sports \| chiropractic | 0.012 |
| evidence | 0.039 | research \| manipulation | 0.018 | knowledge | 0.044 | research \| clinical | 0.011 |
| tendinopathy | 0.039 | research \| mobility | 0.017 | chiropractor | 0.042 | research \| outcome | 0.011 |

"I probably have to say, probably performance, like pre-performance care and injury prevention and effectiveness. So if we can show our effectiveness, then people will seek us out to do treatments. And I guess further research on effective treatments can inform us on what to do in treating patients. That would probably impact my practice the most."

"On the efficacy of chiropractic care in regards to athletic injuries would be the most important. Also, the effects of chiropractic care on performance, specifically, on speed and agility, reaction and prevention of injuries."

"Because I work primarily with shoulders, I think specific research looking at insuring the validities, specificities, sensitivities, positive/negative predictive value of specific functional and orthopedic assessments tools, whether that's things like visually assessing a scapula-humeral rhythm, objective orthopedic tests with labral tears, things like that are important. So being sure that I am being diagnostically accurate when I am treating an athlete. Looking at how is my treatment effecting performance, prevention of injury, treatment of injuries, and prevention of future injuries after they have been injured. So diagnosis, treatment, and prevention."

"Research based on specific interventions to provide specific outcomes. I think at the end of the day that's the most important thing to the patient, and so any sort of high quality trials, so prospective studies, opposed to retrospective or case series, or anything along those lines, but to establish specific defined interventions for specific health outcomes to try and make patients better. I think that's by and large the most important thing to clinical practice specifically."

The cluster analysis revealed that the two groups clustered separately for this question. The CRA word network

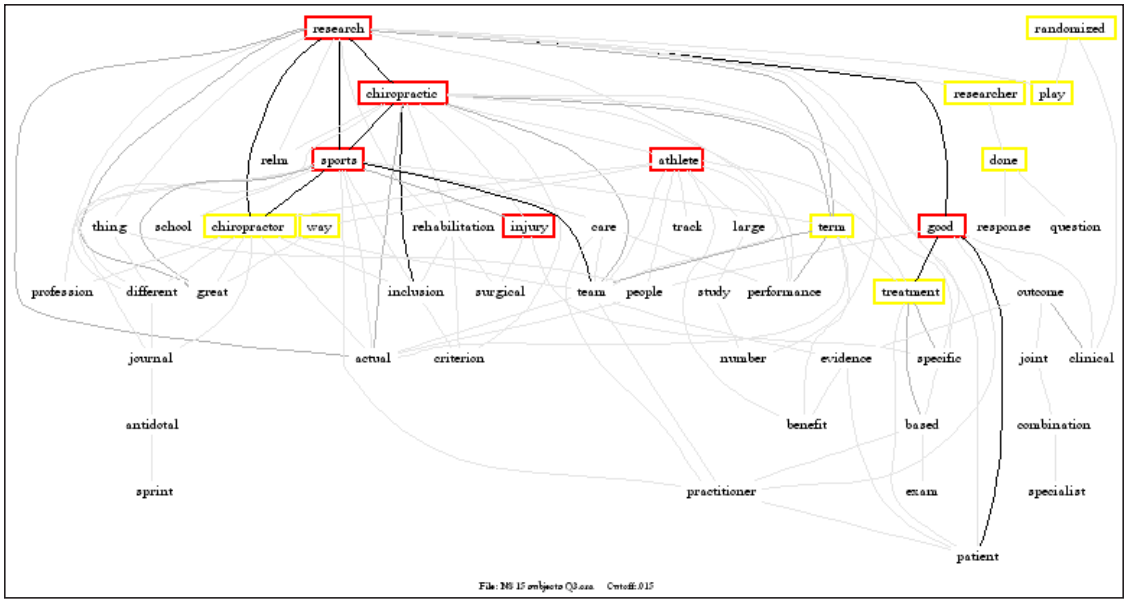


Figure 6.
*CRA visualization for question 3, NS group.*

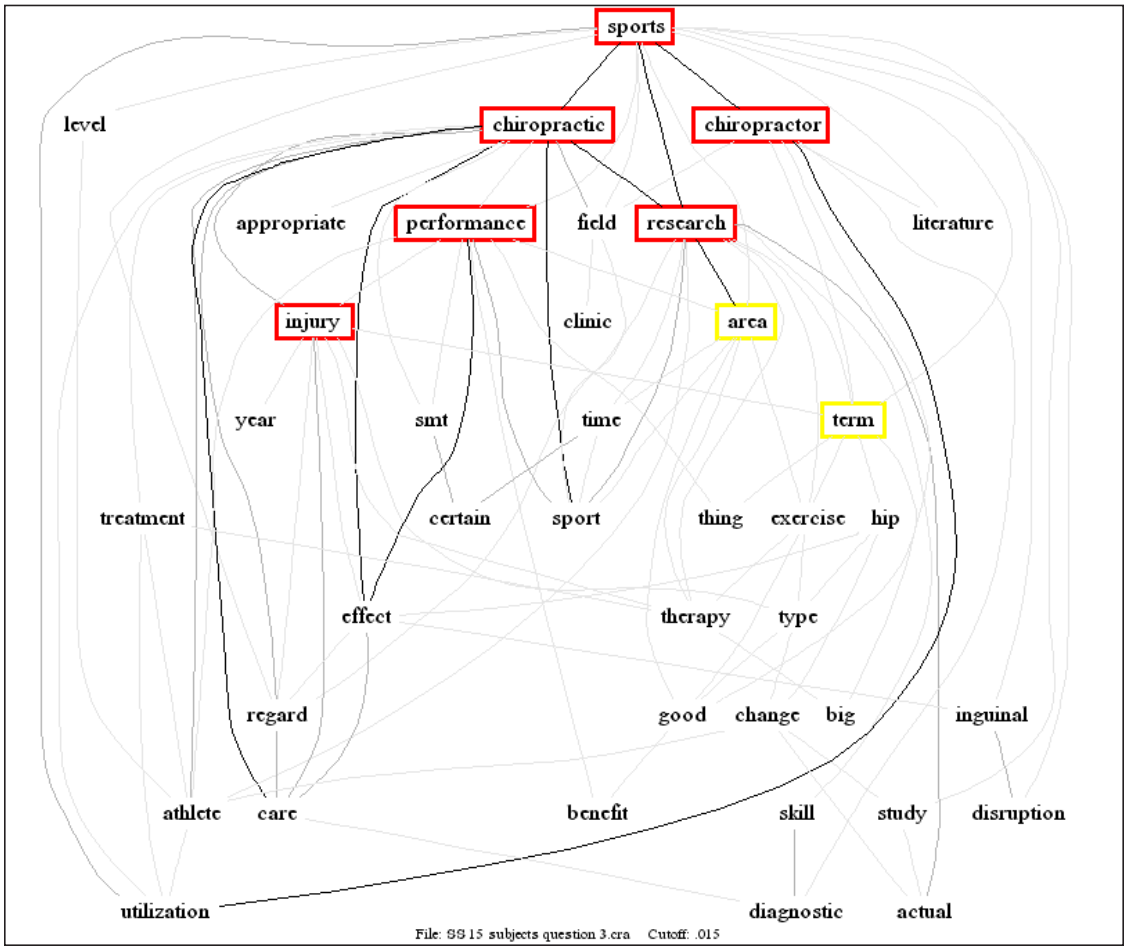


Figure 7.
*CRA visualization for question 3, SS group.*

Table 7:
*Influence Analysis for Question 3*
Question 3: Where do you believe most of the research is lacking for sports chiropractic?

| NS Group | | | | SS Group | | | |
|---|---|---|---|---|---|---|---|
| **Words** | **Influence** | **Word Pairs** | **Influence** | **Words** | **Influence** | **Word Pairs** | **Influence** |
| research | 0.310 | research \| sports | 0.337 | sports | 0.289 | sports \| chiropractic | 1.138 |
| chiropractic | 0.210 | chiropractic \| sports | 0.327 | chiropractic | 0.208 | sports \| chiropractor | 0.387 |
| athlete | 0.174 | research \| chiropractic | 0.196 | research | 0.203 | sports \| research | 0.234 |
| sports | 0.155 | research \| good | 0.098 | performance | 0.115 | chiropractic \| research | 0.211 |
| good | 0.106 | research \| chiropractor | 0.095 | injury | 0.108 | research \| area | 0.083 |
| injury | 0.103 | sports \| chiropractor | 0.057 | chiropractor | 0.103 | chiropractic \| injury | 0.045 |
| term | 0.074 | research \| term | 0.046 | term | 0.092 | sports \| performance | 0.033 |
| way | 0.063 | chiropractic \| athlete | 0.037 | area | 0.058 | chiropractic \| effect | 0.032 |
| researcher | 0.063 | sports \| injury | 0.032 | thing | 0.045 | sports \| term | 0.026 |
| chiropractor | 0.061 | chiropractic \| term | 0.031 | hip | 0.044 | chiropractic \| performance | 0.024 |
| randomized | 0.055 | sports \| team | 0.031 | exercise | 0.043 | chiropractic \| sport | 0.023 |
| play | 0.052 | chiropractic \| injury | 0.022 | level | 0.041 | research \| term | 0.019 |
| treatment | 0.051 | chiropractic \| team | 0.021 | effect | 0.038 | sports \| area | 0.017 |
| done | 0.050 | research \| researcher | 0.019 | time | 0.037 | performance \| effect | 0.017 |
| care | 0.050 | research \| play | 0.016 | literature | 0.037 | chiropractic \| care | 0.014 |
| team | 0.050 | good \| treatment | 0.016 | regard | 0.032 | chiropractic \| regard | 0.013 |
| specific | 0.049 | research \| team | 0.015 | type | 0.030 | sports \| level | 0.012 |
| rehabilitation | 0.047 | research \| specific | 0.015 | field | 0.030 | chiropractic \| field | 0.012 |
| based | 0.046 | research \| great | 0.015 | skill | 0.028 | performance \| injury | 0.012 |

for the NS group focused on research about sports injury care and chiropractic care related to clinical practice. There was a secondary focus of the NS group's discourse related to injury care and performance. The SS group's discourse had a focus on injury treatment, but also had a focus related to research regarding injury prevention, where the NS group's CRA did not reveal any influential discussions about injury prevention. There was also a secondary focus to the SS group's responses on discussions about soft tissue therapy, orthopedics and specific outcomes. These differences in word network structure between groups most likely led to the two groups being classified separately by the cluster analysis.

### *Question 3: Where do you believe most of the research is lacking for sports chiropractic?*

The CRA network visualization (Figure 6) and influence analysis (Table 7) for the NS group revealed that the primary influential words were *research*, *chiropractic*, *sports*, *athlete*, *injury* and *good*. Influential network connections involving the primary influential words included *research-sports-chiropractic*, *research-sports-injury*, *research-chiropractic-inclusion*, *research-chiropractic-athlete*, *research-good-treatment*, *research-sports-team*, and *research-chiropractic-rehabilitation*. The network connections between the primary influential words *research-chiropractic-sports* had strong ties within the network, and this is evidenced by the influence analysis (Table 7) where the top three pairings were *research-sports*, *chiropractic-sports* and *research-chiropractic*. The secondary influential words in the CRA diagram were *chiropractor*, *way*, *term*, *treatment*, *randomized*, *researcher*, *play* and *done*. Network connections that included these words were *research-good-treatment*, and *treatment-specific,* and *randomized-play-research*. Upon reviewing the transcriptions from the NS group, there was some discussion regarding randomized clinical trials involving return to play. The secondary influential word

*term* was surprising, and upon reviewing the discourse, subjects would use of the word *term* in statements such as "…in terms of performance". Tertiary words that were identified were *rehabilitation*, *surgical*, *performance*, *clinical*, and *outcome*. Notable network connections that included these tertiary words were *research-rehabilitation-surgical*, *sports-care-performance*, and *randomized-clinical-outcome*.

Summarizing the interpretation of the CRA visualization and influence analysis, in response to this question, the discourse from the NS group centered on discussions regarding research about sports chiropractic in the treatment of injury for the athlete. There was some discussion about randomized clinical trial research looking at outcomes about return to play. Some respondents discussed performance care, rehabilitation related to surgery, and research related to chiropractic and teams.

Selected excerpts from the discourse of the NS group for this question included:

> "Specifically to chiropractic management of sports injuries. There's probably not a lot of specific research in that area. There is research on how to treat an ankle sprain, how to treat and rehabilitate an ACL injury, post surgical rehabilitation, all that research is there, but there is not enough research indicating that chiropractors are capable of doing this or applying the appropriate care that is necessary. Without that research out there it doesn't trickle down to the medical practitioners, to the patients, to the general population. The research is there and ongoing but the link that chiropractors are applying it is missing."

> "…so if we know that the natural history of an injury is 4-6 weeks, is the inclusion of sports chiropractic adding some kind of benefit in terms of decreasing the time lost. The actual chiropractic manipulation, does the inclusion of chiropractic manipulation enhance the recovery of a sporting injury?"

> "Difficult to narrow down to one thing, there is lots of research going on in chiropractic but not sports chiropractic. The effect of chiropractic care on preparing athletes pregame, for example. Is there any benefit to treating athletes before a game, after a game or treating athletes at all. Looking at chiropractic as a performance enhancing adjunct to an athlete."

> "So I think over the whole, again, return to play, is a big area, but seeing high quality research in return to play, so randomized trials, even cohort studies would be helpful there. And then, similar with performance based care, so moving out of just sort of I publish what I've done with one athlete, we need to be working on a much larger scale, so that then leads to a lack of funding and a lack of training in terms of how to publish and produce this research."

> "Pre and post surgical. Even if you look at lumbar discectomy or laminectomy there isn't much in the sports chiropractor world. There is some for general chiropractic, but not for sports chiropractic. Sports chiropractic would focus more on soft tissue work and functional rehabilitation. Which is where we don't have much for."

> "In terms of athletic performance, in terms of integration of chiropractic with sports teams. Most chiropractors that work with athletes and teams, there is a lot, but there is a very few that are fully integrated into teams, so if there was research into how chiropractors could be implemented into a team and their role in the team as one of the primary care practitioners on that sports team, if the evidence was there, I think that would help our cause and help us with our chunk of the pie in terms of treatment for athletes specifically. In terms of chiropractic's role in the integration with the sports medical team and with actual teams directly."

Assessing the CRA visualization (Figure 7) and influence analysis (Table 7) for the SS group, the primary influential words identified were *sports*, *chiropractic*, *chiropractor*, *performance*, *research* and *injury*. *Performance* was found to be a highly influential word in this network, and was the fourth highest influential word in the influence analysis. Influential word pairings for this word were

*sports-performance, chiropractic-performance, performance-effect and performance-injury*. The network connections with the word *performance* included *performance-SMT*, *performance-effect-care*, *sport-performance*, and *performance-benefit*. A strong link within the network existed between the words *effect* and *chiropractic*, with the word *effect* being identified as a top 20 influential word. Another strong connection in the network visualization was between *sports-chiropractor-utilization*.

Summarizing the interpretation of the CRA, the SS group had a word network that was most focused on discussions regarding sports chiropractic research and the effect of chiropractic care on performance. There was also some discussion about sports chiropractic research on injury and utilization of sports chiropractors.

Notable excerpts from the discourse of the SS group included:

> "And really, I think really a little bit more in the treatment of the biomechanics of a patient for injury prevention. So, if you can look at their mechanics separate from what they have came in for. But treatment of mechanics, is that helpful for performance or for prevention?"

> "The effect of manipulation on performance, the effect of chiropractic in general on performance and the effect on speed and reaction."

> "Most concerned with research to say that our skill set can influence, predict, or somehow manage performance or biomechanics and then prevent further injuries."

> "Definitely, manipulation on performance. I think performance is one thing that we don't know either."

> "…obviously there is limited research on pretty much everything we do for athletes including manipulation, soft tissue therapy, so looking at just how does treatment effect natural history, performance and all those same factors I talked about before. I think it is really tough to research this topic."

> "Most lacking in area of performance, because a previous study by Dr. Miners, he surveyed the sports fellows, and we all said we are aiding in performance, but there are no objective measures that we can use to say that if we do X, then the outcome will be Y."

> "If the ultimate goal is to increase utilization of sports chiropractors and inclusion of sports chiropractors, then I think tracking the utilization of athletes of chiropractic treatment, whether it is at a game where it would be easy to do because all the data is there, they keep track of where you are and what sport they are in and how many times they saw a certain practitioner. This could lead to inclusion of more sports organizations and from there you could do other research. Bigger picture to have inclusion would be the most impactful and there is not much of this done."

The cluster analysis revealed that the two groups clustered separately for this question that asked respondents where they felt research was lacking in sports chiropractic research. The NS group's word network revealed a primary focus in the discourse regarding research about sports chiropractic and injury for athletes. There was also a secondary focus regarding randomized clinical trial research investigating return to play. In contrast to the NS group, the SS group's CRA word network revealed a primary and highly centralized focus on discussions about research investigating sports chiropractic and its effect on performance. There was also a focus on discussions about utilization of sports chiropractors. Interestingly, the SS group's word network did not reveal any influential discussions regarding return to play.

### *Question 4: What type of collaborations would you like to see occur in sports chiropractic research?*

The primary influential words identified in the CRA network visualization (Figure 8) and the influence analysis (Table 8) for the NS group were *sports*, *collaboration*, *chiropractor*, *good*, *thing* and *people*. The secondary influential words were *research*, *physiotherapist*, *chiropractic*, *patient*, *able* and *area*. Analyzing the network visualization, the strong links between the primary and secondary influential words *sports-chiropractor-collaboration-physiotherapist* was central to the word network.

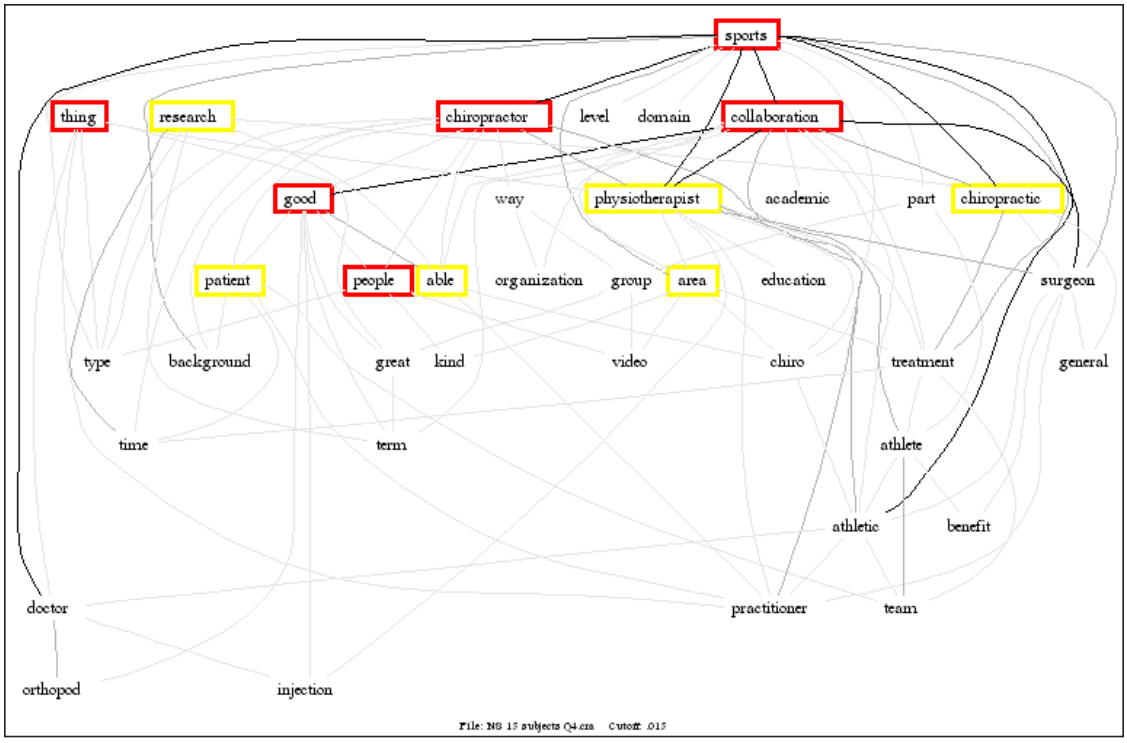


Figure 8.
*CRA visualization for question 4, NS group.*

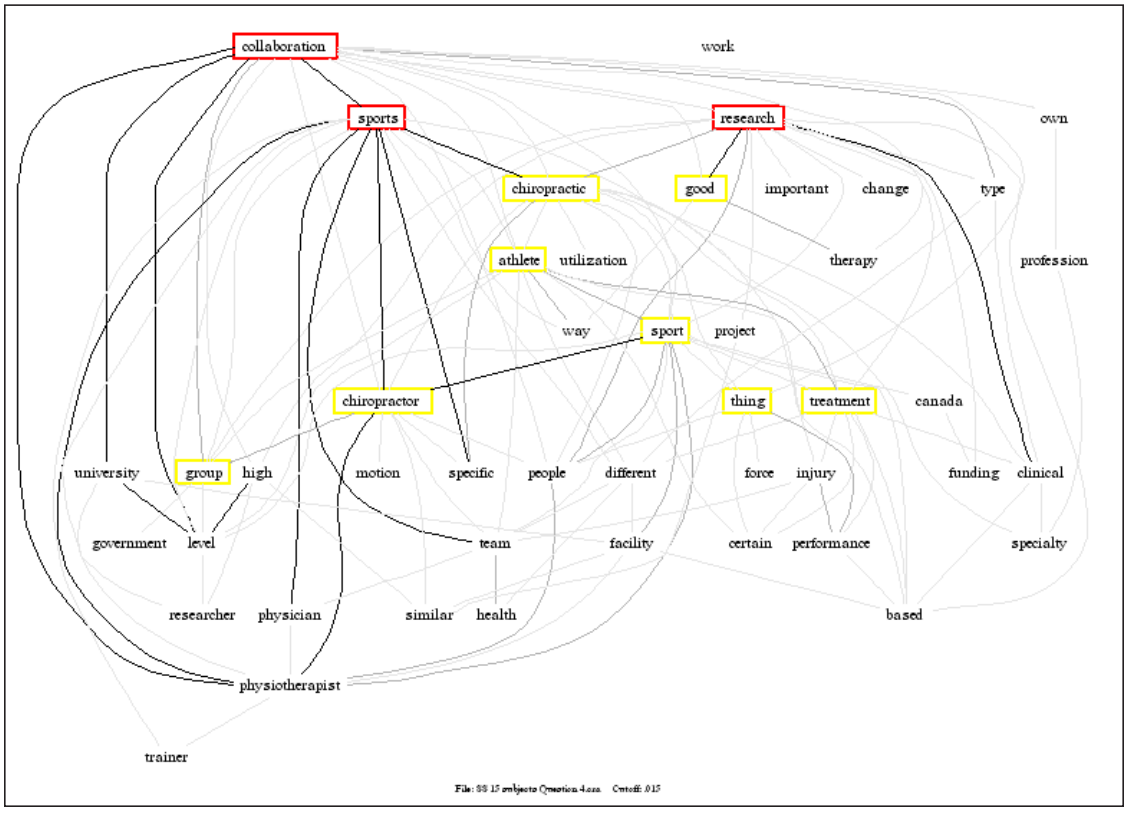


Figure 9.
*CRA visualization for question 4, SS group.*

Table 8:
*Influence Analysis for Question 4*
Question 4: What type of collaborations would you like to see occur in sports chiropractic research?

| NS Group | | | | SS Group | | | |
|---|---|---|---|---|---|---|---|
| **Words** | **Influence** | **Word Pairs** | **Influence** | **Words** | **Influence** | **Word Pairs** | **Influence** |
| sports | 0.260 | sports \| chiropractor | 0.231 | collaboration | 0.209 | collaboration \| sports | 0.104 |
| collaboration | 0.166 | sports \| collaboration | 0.216 | research | 0.197 | sports \| chiropractic | 0.098 |
| chiropractor | 0.127 | sports \| chiropractic | 0.099 | sports | 0.166 | sports \| chiropractor | 0.098 |
| good | 0.110 | sports \| physiotherapist | 0.075 | chiropractic | 0.098 | collaboration \| research | 0.041 |
| thing | 0.106 | collaboration \| good | 0.055 | athlete | 0.079 | research \| chiropractic | 0.039 |
| people | 0.101 | collaboration \| physiotherapist | 0.048 | sport | 0.075 | research \| good | 0.032 |
| physiotherapist | 0.096 | sports \| area | 0.031 | chiropractor | 0.066 | sports \| physician | 0.029 |
| research | 0.083 | collaboration \| surgeon | 0.029 | treatment | 0.059 | sport \| chiropractor | 0.025 |
| chiropractic | 0.064 | sports \| treatment | 0.025 | thing | 0.057 | collaboration \| university | 0.024 |
| able | 0.062 | sports \| athletic | 0.025 | good | 0.053 | collaboration \| group | 0.021 |
| area | 0.060 | chiropractor \| physiotherapist | 0.025 | group | 0.050 | collaboration \| chiropractic | 0.020 |
| patient | 0.051 | sports \| surgeon | 0.023 | injury | 0.046 | collaboration \| type | 0.018 |
| treatment | 0.048 | sports \| doctor | 0.022 | type | 0.042 | collaboration \| athlete | 0.017 |
| surgeon | 0.044 | collaboration \| chiropractic | 0.021 | people | 0.040 | collaboration \| level | 0.017 |
| level | 0.042 | sports \| background | 0.016 | university | 0.038 | sports \| team | 0.017 |
| type | 0.041 | chiropractor \| good | 0.014 | different | 0.035 | collaboration \| sport | 0.016 |
| kind | 0.039 | good \| able | 0.014 | team | 0.035 | research \| people | 0.016 |
| chiro | 0.037 | chiropractor \| people | 0.013 | physician | 0.034 | research \| sport | 0.015 |
| part | 0.034 | sports \| level | 0.011 | therapy | 0.031 | sports \| physiotherapist | 0.015 |

In fact, the word *physiotherapist* was a secondary influential word and the influence analysis identified the word pairs *sports-physiotherapist*, *collaboration-physiotherapist*, and *chiropractor-physiotherapist* within the top 20 influential pairs. Other strong ties within the network visualization were *sports-surgeon*, and *sports-doctor-orthopod*. The influence analysis identified *surgeon* as a top 20 influential word and the word pairs *collaboration-surgeon* and *sports-doctor* were identified as a top 20 influential word. The primary influential word *collaboration* also had a strong tie to the tertiary word *athletic*. When cross-examining the word *athletic* with the NS group's discourse, the NS group regularly referred to collaborations with athletic trainers. The word *good* was central to the network, and it was paired with words such as *collaboration*. When analyzing tertiary words identified in the network visualization, the words *organization* and *academic* had connections to the word *collaboration*.

Summarizing the findings of the CRA for the NS group, in response to the question regarding research collaborations in sports chiropractic, the NS group's discourse centered around discussions about collaborations with physiotherapists, sports doctors, sports surgeons, and athletic trainers. There were also discussions about collaborations with organizations and academics. The group also thought that these collaborations were likely good things for sports chiropractic.

Notable excerpts from the discourse of the NS group included:

> "More collaboration with not only physiotherapists, but also with orthopedic surgeons perhaps, and trying to see if some of the techniques that we use or are taught, [they] see their benefits, and particularly with surgeons."

> "Pretty much all of them, MD with chiro, PhD in a certain area of sports injury and chiro, definitely adding in multiple disciplines, so having athletic therapists, physiotherapists, kinesiologists, and chiros work together to develop a plan to increase the effectiveness of the sports treatment."

"More collaboration with orthopedic surgeons and sports medical doctors. Chiropractors still have a ways to go with getting into those groups."

"Sport doctors and orthopods would be a good collaboration."

"Collaborations with orthopedic surgeons, medical practitioners, athletic therapists, and physiotherapists. General awareness across those populations that chiropractors are an integral part of treating sports injuries."

"I think this is a push in general with chiropractic research, is that integrated model, with working alongside physiotherapists, sports medicine doctors, strength and conditioning coaches. I think it needs to be there, it's there to a point, but you typically see the chiropractor on the side, they aren't officially with the team. You know, the more we can collaborate with other providers, the better feel they get for what we can do and what our scope can be, and what benefits we can add to an athlete and to an athletic team."

"I would probably think and love it to take place from a range of grass roots all the way to pros, with the formal collaborations with those respective governing organizations. Let's say for example, if it's hockey it could be done with a major hockey organization, let's say if it's inside of minor hockey, you can build the roads to kind of do something at a GTHL level, right across a major-minor organization, right through all the way up."

"On the academic side, seeing more sports chiropractors that are integrated into the university setting, whether its teaching courses in athletic care, or into the actual athletic sports care models that are in universities as well. Adding a bit to the academic collaboration as well too, in terms of research and being recognized as part of kinesiology programs or physical education programs."

"I think that the collaboration needs to be done at major recognized universities. It's hard to publish and do things without that backdrop, but absolutely there are the people that are in place now that have the academic swag and the resume that is bullet proof. But really in the spine and at an occupational level. Not in the sports realm. So there is no one that is really sport based."

The CRA visualization (Figure 9) and influence analysis (Table 8) of the SS group's responses revealed that the primary influential words were *collaboration*, *sports* and *research*. Upon visualizing the CRA diagram, strong ties within the word network exist between the words *collaboration-sports-physician*, *collaboration-sports-team*, *collaboration-university-researcher*, *collaboration-physiotherapist*, and *collaboration-level-high*. The influence analysis of the top 20 influential word pairs identified the word pairs *sports-physician*, *collaboration-university*, *collaboration-athlete*, and *sports-physiotherapist*. Other interesting network connections involving secondary and tertiary words included *sport-canada-funding* and *research-funding*. The word *trainer* was identified as a tertiary word in the CRA network diagram, and when scanning the transcriptions from the interview responses, its use was often related to the term athletic trainer. In summary, the discourse analyzed from the SS group's responses revealed that it focused on discussions about collaborations with sports physicians, teams, university researchers, physiotherapists and athletic trainers. There were also some discussions about research funding related to sport in Canada and discussions about the government.

Selected excerpts from the interview responses from the SS group included:

"Universities, I think we need full time researchers. We need to partner with full time academic researchers to get some grants and run some research, so we definitely need that. I think we also need to collaborate with sports physicians, anyone in that care team. I think collaborative research is probably the best way to go."

"I'd like to see more collaboration at the university level, with sports chiropractors."

"PhD, chiropractors, physiotherapist, medical doc-

tors, and a facility such as a University to oversee everything.

"More collaboration with physiotherapists, because those are the people we are sharing the same ground with."

"I think more collaboration with larger sport-based facilities, similar to what they have done in baseball down in St. Andrews in the states where they have a huge orthopedic facility where they have orthopedic surgeons, sports medical doctors, physiotherapists, PhD's all assessing all of the factors such as performance, treatment, prevention and diagnosis."

"An additional thing would be looking to get Sport Canada funding for research. They are the funding agency for anything sports in Canada, and it's usually disseminated within various pre-arranged funding mechanisms, such as say an NSO, or an association, that's perhaps the Ontario Soccer Association or the Canadian Soccer Association. But I don't see a whole lot of collaboration between sport chiropractors working with funding from groups like that. Funding is available for research projects."

In response to this question regarding research collaborations, both study groups clustered similarly, providing evidence that the word networks of interview responses for both groups were similar. The CRA visualizations and influence analyses revealed that the discourse from both groups centered on research collaborations with physiotherapists, sports physicians, university and/or academic researchers, athletes, and teams. The similarity of the word network structures of both groups provided some evidence that both groups had similar discourse when asked about research collaborations in sports chiropractic.

## Discussion

A main finding in this study was that the cluster analysis revealed the NS and SS groups differed in their responses to questions one, two and three; but had similar responses to question four. Question one asked respondents about the type of research they would like to see conducted in sports chiropractic. In response to this question, the NS group had a primary focus on discussions about research related to chiropractic care of sports injuries, and had a secondary focus on chiropractic care as it relates to sports performance. The SS group's responses were primarily centered on discussions about the effect of sports chiropractic, manipulation, and soft tissue on performance. In response to question two that queried the type of research participants thought would impact their clinical practice the most, the NS group primarily discussed research about chiropractic care and sports injury care as it related to clinical practice. In contrast, the SS group was more focused on discussions about injury treatment and injury prevention for athletes. When responding to question three that asked respondents where they believed research was lacking with respect to chiropractic research in sports health care, the NS group's discussion centered on sports chiropractic in the treatment of athletic injuries, while the SS group was predominantly focused on the effect of sports chiropractic care on performance. However, when analyzing the group responses for question four that asked participants about what type of research collaborations they would like to see occur in sports chiropractic research, both groups were similar in their discourse identifying collaborations with physiotherapists, sports physicians, universities, academic researchers, athletes and teams to be important collaborations.

The ability of CRA to analyze interview responses by creating word networks of transcribed interview data provided insight into the differences in the discourse generated from both groups when asked about their opinions regarding research priorities. While the NS and SS groups clustered separately for questions one to three, there were some similarities between both groups in their discourse. The SS group had a primary focus on the effect of sports chiropractic on performance for both questions one and three. While primarily centered on discussions about chiropractic care of sports injuries, the NS group did have some discourse regarding the topic of chiropractic care and performance; however, their discussions on this topic had a secondary or tertiary focus within their word networks. Since CRA models discourse based on the network relationships of words within noun phrases, the secondary and tertiary focus on performance within the NS group meant that the frequency of occurrence of the word *performance* and its co-occurrence with other influential

words was much less prominent than in the SS group's discussions. As a result of these differences between practitioner groups, a future study seeking to obtain consensus from experts to define a research agenda for sports chiropractic should recruit experts from both practitioner groups to ensure that the opinions from both stakeholder groups are adequately represented.

A potential confounder that may contribute to the contrast of opinions between study groups could be the baseline difference between study groups in the number of individuals with formal research experience (100% for the SS group versus 13% for the NS group), as defined as previous participation in a Master's, PhD or chiropractic residency program. It is not surprising that 100% of the SS group had previous formal research experience, as completion of a chiropractic sports sciences residency is a requirement to obtain a chiropractic sports specialty designation in Canada. A disparity in research experience can potentially lead to differences in the ability to judge the practicality and methodology of research, which can potentially contribute to the difference in opinions between groups regarding research priorities. It is also possible that the differences in opinions between these two groups could be related to the possible contrasting practice styles and clienteles that may exist between the two practitioner types. In efforts to minimize the effect of these confounders, we attempted to recruit participants into the study who had similar sport-focused clinical practices by only including practitioners who self-reportedly manage a minimum of ten sports-related cases per week in clinical practice. Despite our intent to recruit practitioners with similar sport-focused clinical practices, it is still possible that there exist differences in practice styles and/or clientele between study groups. The language attained by the SS group, by virtue of their sports specialty training, could also contribute to the differences in discourse between the two study groups. While this is certainly a possibility, the CRA networks from the SS group did not reveal any specific language that the authors judged to be interpreted as being noticeably distinct from the vocabularies of non-sport specialty designation chiropractors. Future research investigating the practice styles, clientele and language used between both practitioner types could provide more insight into the impact of these confounders to the present study's results.

To date, there is limited research on the opinions of sports clinical practice chiropractors. Miners *et al*.[19] surveyed fellows from the College of Chiropractic Sports Sciences (Canada) to investigate their opinions on intervention practices and intended therapeutic outcomes when treating athletes. The authors found that 73% of respondents stated that they treat asymptomatic athletes with the specific goal of enhancing sport performance. Moreover, a "chiropractic treatment", as defined by the respondents, would most commonly include some combination of spinal or extremity manipulation/mobilization, specific soft tissue therapy, and exercise/rehabilitation/sports specific training prescription. The most anticipated outcomes following the treatment of athletes reported in this survey study was the goal of affecting athletic performance. The results of our present study, that identified the effect of chiropractic treatment on performance as a primary focus of the SS group's discourse, is consistent with the previous work from Miners *et al*.[19] Investigating the effect of therapeutic interventions on sport performance can often be challenging due to the potential small effect sizes and ceiling effects that can be encountered when studying a highly skilled population. Future work in this area should investigate methodological approaches to study the effect of chiropractic treatment on sport performance.

The present study is unique in that it is the first to utilize CRA to investigate practitioner opinions regarding research priorities. CRA allowed us to analyze the interview responses as a group of pooled responses, and permitted a quantitative comparison of the discourse generated from both groups based on the similarity and structure of their word networks. By modelling discourse as word networks, CRA provided an objective overview of the most influential discourse that occurred within each group. The visualization of the CRA networks and influence analyses assisted in objectively assigning a measure of importance to identify key areas of discussion identified within the discourse.

While CRA has its advantages, it is not without its limitations. CRA constructs word networks using noun phrases, which is defined as a noun plus zero or more additional nouns and/or adjectives. This methodology identifies the subject or object of a sentence, and the subsequent network constructed of these words represent the text's main content. As a result, CRA intentionally excludes verb phrases, which are the "action" compon-

ents linking different noun phrases.[24] Given the aim of the present study was to identify practitioner "opinions", which is a noun, our use of CRA is justified. Despite this rationale, it is still possible that the verb phrases within the interview responses may impart some useful information. By modelling text as a network of noun phrases, CRA provides an objective overview of the key areas of focus that occurs within the text. However, it should be noted that it does not provide a detailed account of all areas of focus within a text. This is especially true if certain areas of a text are determined to be minor contributors in creating coherence within the text by the computational linguistics methods deployed by CRA. Also, while it objectively identifies influential words and their connections, the end user is still required to make some form of subjective interpretation of the CRA network visualization and linkages of the words identified. Furthermore, certain artifacts of speech, such as the use of pronouns to refer to subjects and objects of sentences, may affect how discourse is indexed in CRA. This was evidenced by the surprising finding of the words "thing" and "term" being identified as influential words in our analysis. Moreover, discourse often can contain secondary or hidden meanings, such as the use of metaphors. Quantitative text analysis systems may not be sensitive enough to identify all of the subtleties within language that convey meaning, and in such cases, a human may be required to interpret these hidden meanings. Given these limitations, it should be reinforced that CRA should not be viewed as a substitute for a thematic analysis.

Another method that could be used to investigate practitioner opinions is grounded theory. While there have been criticisms that researcher bias is still present in this qualitative methodology, grounded theory does have its advantages. It can provide an in depth analysis of all aspects of the discourse collected; a researcher can identify all themes that are judged to have occurred within the discourse – no matter how small or insignificant they may be; and since humans are interpreting the responses, secondary or hidden meanings of the discourse may be better interpreted. Future investigations could apply a grounded theory approach to exploring practitioner opinions about research directives for the field of sports chiropractic. In fact, little is known about the differences between quantitative text analysis and grounded theory approaches. Future research could analyze the same dataset using both methods, and systematically compare the output from both approaches. Another limitation of the present study includes the use of convenience and snowball sampling from a defined geographical region. Consequently, our results may not be generalizable to other practitioner populations from different locations. Future work can consider expanding this study to larger and more diverse populations using random sampling.

Reflecting on our experience applying CRA to our present study, we found the cluster analysis conducted on the CRA word networks useful in answering our primary research question that sought to determine if differences existed in the discourse between sports clinical practice chiropractors with their sports fellowship and those without when asked about their opinions about research priorities. Considering CRA's methods do not identify all areas of focus within a text, our use of CRA to explore the discourse was likely not as detailed as if we had conducted a thematic analysis. However, CRA provided an objective method for identifying important areas of focus within the discourse analyzed. In our opinion, the decision to utilize CRA to analyze data should reside in the researcher's judgement of whether the method can adequately answer the precise research question under investigation while balancing the method's limitations. As a result of our experience, we believe that this method may be useful if used in conjunction with a thematic analysis in the opinion gathering phase of a future Delphi study aimed at defining a research agenda for sports chiropractic in Canada.

## Conclusion

CRA revealed that sports clinical practice chiropractors with their sports specialty designation and those without, differed in their opinions about chiropractic research priorities in sports health care pertaining to the type of research that they would like to see conducted, the research that would impact their clinical practice the most, and where they believed research was lacking. Interestingly, both groups of practitioners were similar in their opinions about the type of research collaborations they would like to see occur. These results suggest that it may be important to recruit experts from both of these sport practitioner groups in future Delphi studies aimed at developing research agendas for chiropractic research in sport.

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Chiropractic History

# History of the Royal College of Chiropractic Sports Sciences (Canada): the early years

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*In 1978 the Canadian Chiropractic Association recognized the need to establish an organization that would prepare chiropractors to treat athletic injuries and promote these services to sports organizations. Dr. Adrian Grice approached three chiropractors to establish such an organization. The Canadian Chiropractic Sports Academy (CCSA) was established in 1978. This was the start of the chiropractic sports movement which has seen chiropractors playing prominent roles as team doctors to professional and amateur teams and athletes and in the delivery of care at major national and international competitions. This paper will show the work done by the original founders of the CCSA which has helped to pave the way to the*

*En 1978, l'Association chiropratique canadienne a reconnu la nécessité de créer une organisation qui préparerait les chiropraticiens à traiter les blessures sportives et proposerait ces services à des organisations sportives. Le Dr Adrian Grice a approché trois chiropraticiens pour établir une telle organisation. Le Canadian Chiropractic Sports Academy (CCSA) a été créé en 1978. Ce fut le début du mouvement sportif en chiropratique qui a vu les rôles importants joués par les chiropraticiens en tant que médecins d'équipe auprès d'équipes et d'athlètes professionnels et amateurs, et dans la prestation de soins pendant les principaux événements sportifs nationaux et internationaux. Cet article présente le travail effectué par les fondateurs initiaux du CCSA qui a contribué à ouvrir la voie au*

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*present level of acceptance of chiropractic sports injury management and performance enhancement and as the progenitor of the Royal College of Chiropractic Sports Sciences Canada.*

(JCCA. 2016;60(4):370-376)

KEY WORDS: sports chiropractic, history

*niveau actuel d'acceptation de la gestion des blessures sportives en chiropratique et l'amélioration des performances et, comme le prédécesseur du Collège royal des sciences du sport chiropratique (Canada).*

(JCCA. 2016;60(4):370-376)

MOTS CLÉS : chiropratique sportive, histoire

## Early History

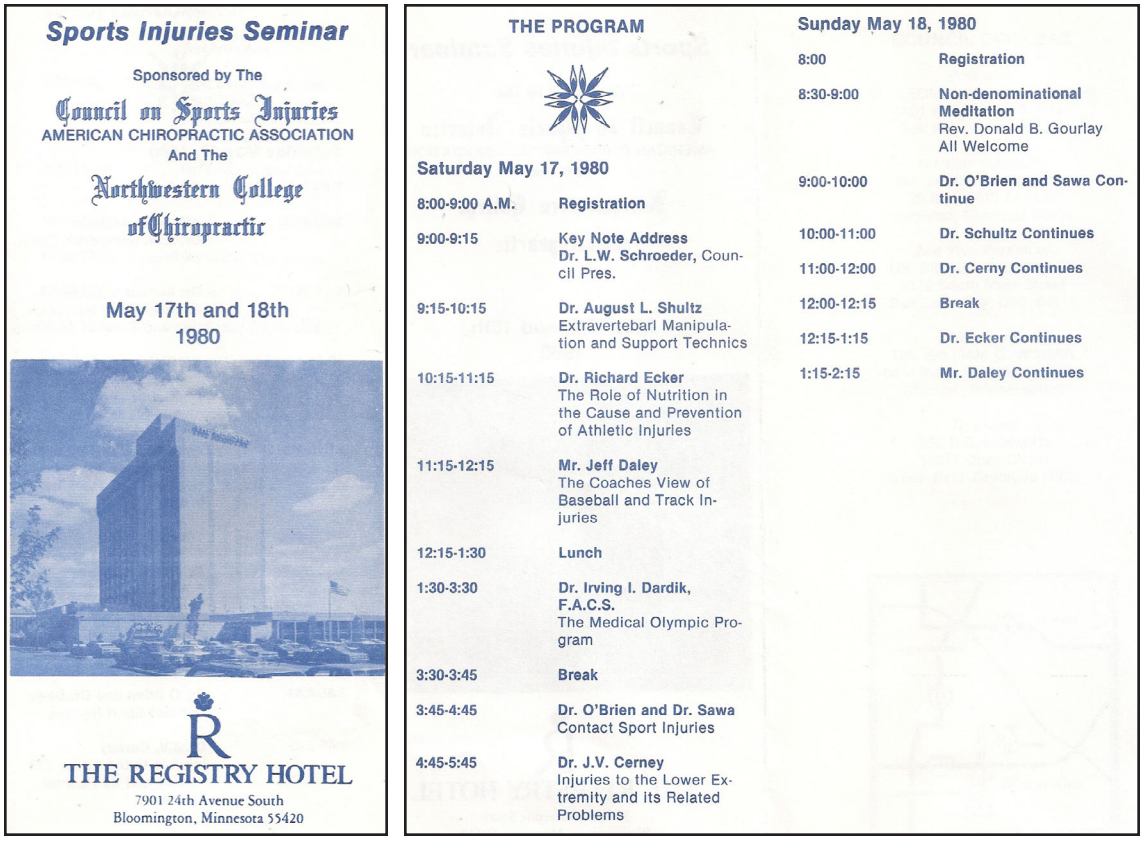
By the mid 1970s the Canadian chiropractic profession had made great advances. The Canadian Memorial Chiropractic College (CMCC) moved from downtown Toronto to a new larger facility at 1900 Bayview Ave in Toronto.[1] All the provinces, except for Newfoundland, were regulated.[2]

Although chiropractic had proven itself quite capable and successful in treating injured athletes, there was no body to oversee research and education in the area of chiropractic management of sports injuries.[3]

During this period chiropractors were not included in the healthcare teams for national and international competitors.[3] There were a few notable chiropractors who had great success with prominent athletes from the amateur to the professional ranks. Dr. Dan Komesh was the team chiropractor to the University of Ottawa GeeGees for years and also for the Ottawa Rough Riders of the Canadian Football League.[4] Dr. Terry Watkins was the team chiropractor for the Winnipeg Blue Bombers of the CFL, the chiropractor for the National Throwing Centre and also worked on a world champion sprint cyclist and several National Hockey League players.[5] Dr. John Kos was known for advocating for health through physical fitness.[6] Dr. Al Schulte made contributions not only by treating athletes but also developing muscle testing techniques and devising a modified sphygmomanometer for muscle testing. He was also an avid lecturer with many presentations across Canada and the U.S.[7] Dr. Harry Williams worked as a trainer for the Toronto Argonaut Football team and the Toronto Maple Leafs, as well as seeing many athletes in his East Toronto practice.[8]

With the emergence of amateur sports and the trend towards encouraging health through physical fitness as well as the success and publicity of the Montreal Olympic Games in 1976, the Canadian Chiropractic Association (CCA) began to realize the need for a sports organization within the Canadian chiropractic community.[3] In April of 1978, Dr Adrian Grice, with the approval and encouragement of the CCA approached Dr. Tom Sawa, Dr. Stewart O'Brien and Dr. John De Finney to encourage them to form a chiropractic sports therapy association.[9] Three CMCC students: Claude Bourassa, Keith Innes and David Lowe were also recruited by Dr. Grice to help out with literature reviews and publication of articles.[9] The first meeting was held that month at Dr. Grice's office. The new association was formed under the name of The Canadian Chiropractic Sports Therapy Association. The executive was established and Dr. Thomas Sawa became the first president, Dr. Stewart O'Brien served as vice president, and Dr. John De Finney took on the duties of secretary treasurer.[9] Many ideas were discussed with expansive plans for chiropractic and the care of athletic patients. The focus was on the prevention and treatment of sports injuries in athletes.[9]

The executive began immediately to formulate a plan to establish aims, objectives and a constitution and to map out a strategy to acquire a membership. Within a few months of operation, a discussion on the name of the Association took place. It was suggested that the name of the organization did not convey the academic input that chiropractic would add to the field of sports medicine. As a result of these discussions the name was changed to The Canadian Chiropractic Sports Academy (CCSA).[9] With the help of Henry Czarnota the constitution was approved by the CCA.[9] There were no subsidies from the chiropractic governing bodies. The CCSA functioned on the personal resources and donated time of the executive and volunteers. Members were recruited through announcements in the CCA Journal and fees were collected



**Sports Injuries Seminar**

Sponsored by The

Council on Sports Injuries
AMERICAN CHIROPRACTIC ASSOCIATION
And The
Northwestern College of Chiropractic

May 17th and 18th
1980

THE REGISTRY HOTEL
7901 24th Avenue South
Bloomington, Minnesota 55420

**THE PROGRAM**

**Saturday May 17, 1980**

| | |
|---|---|
| 8:00-9:00 A.M. | Registration |
| 9:00-9:15 | Key Note Address<br>Dr. L.W. Schroeder, Council Pres. |
| 9:15-10:15 | Dr. August L. Shultz<br>Extravertebarl Manipulation and Support Technics |
| 10:15-11:15 | Dr. Richard Ecker<br>The Role of Nutrition in the Cause and Prevention of Athletic Injuries |
| 11:15-12:15 | Mr. Jeff Daley<br>The Coaches View of Baseball and Track Injuries |
| 12:15-1:30 | Lunch |
| 1:30-3:30 | Dr. Irving I. Dardik, F.A.C.S.<br>The Medical Olympic Program |
| 3:30-3:45 | Break |
| 3:45-4:45 | Dr. O'Brien and Dr. Sawa<br>Contact Sport Injuries |
| 4:45-5:45 | Dr. J.V. Cerney<br>Injuries to the Lower Extremity and its Related Problems |

**Sunday May 18, 1980**

| | |
|---|---|
| 8:00 | Registration |
| 8:30-9:00 | Non-denominational Meditation<br>Rev. Donald B. Gourlay<br>All Welcome |
| 9:00-10:00 | Dr. O'Brien and Sawa Continue |
| 10:00-11:00 | Dr. Schultz Continues |
| 11:00-12:00 | Dr. Cerny Continues |
| 12:00-12:15 | Break |
| 12:15-1:15 | Dr. Ecker Continues |
| 1:15-2:15 | Mr. Daley Continues |

Figure 1.
*Sports Injury Seminar pamphlet Northwestern College of Chiropractic May 17th and 18th 1980.*[11]

enabling the executive to produce a series of newsletters under the editorship of Dr. John De Finney.[9] Notably, at the time, this was the first chiropractic sports organization in the world and in Canada it was one of the first, if not the first health profession with a sports injury specialty designation; these were true pioneers. Despite the humble beginnings and without much financial or manpower support much was accomplished in those early years.

A brief summary of the activities and output of the Canadian Chiropractic Sports Academy beginning in 1978 includes:

- A pamphlet on Fitness under the guidance of Henry Czarnota, CCA Executive Director was published and the term "preventacare" – see your chiropractor was coined and registered.[10]
- The CCSA was approached in 1978 by members of the ACA who wanted to establish a similar organization in the U.S.[10]
- The position paper "Sports, Fitness and Posture" was presented at the CCA convention in Quebec City in 1978 by Dr John Kos (an honorary member of the Royal College of Chiropractic Sports Sciences (C)) with contributions from Dr. Stu O'Brien and Dr. Tom Sawa.[10]
- In 1979 Dr. O'Brien and Dr. Sawa presented a program on Sports Injuries in Winnipeg as part of the CCA-CMCC Continuing Education Program. The next year it was presented in Regina.[10]
- The CCSA began relations with the ACA in 1979 by participating in research and curriculum presentations to the Pennsylvania Chiropractic Association in Pittsburgh and Philadelphia. This was spearheaded by Doctors John Pammer and Louis Sportelli. Post-graduate courses included a presentation to the Midwest Chiropractic Association on traumatic injuries

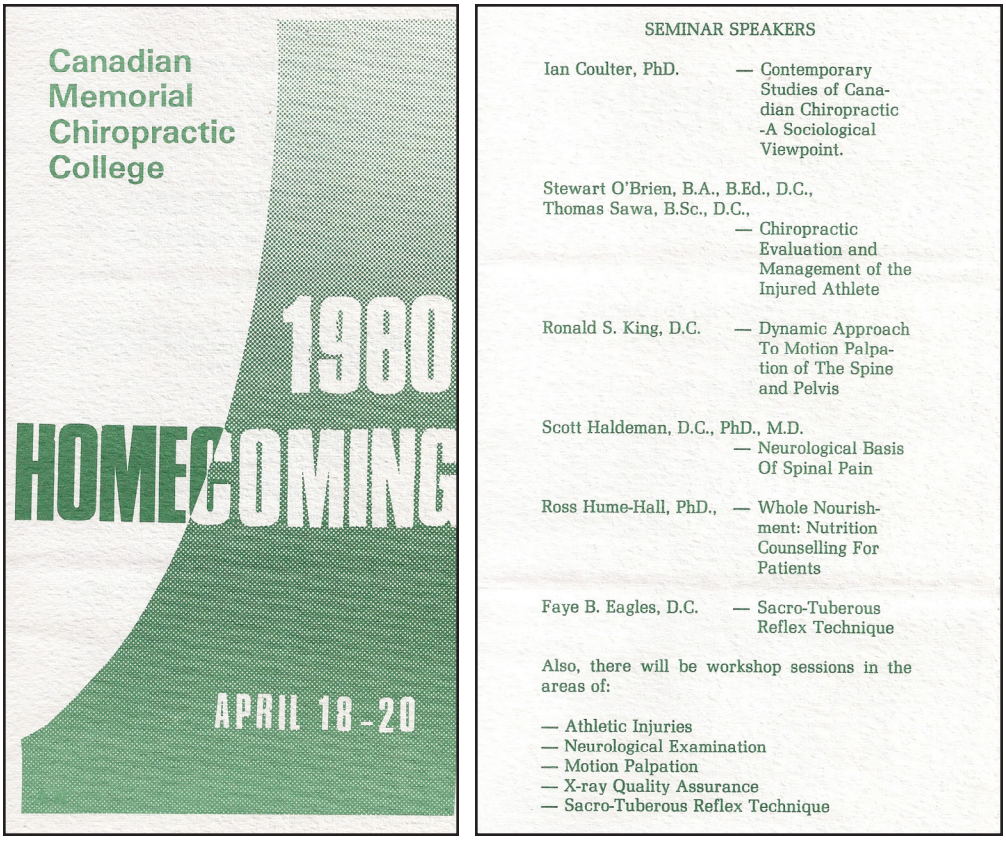
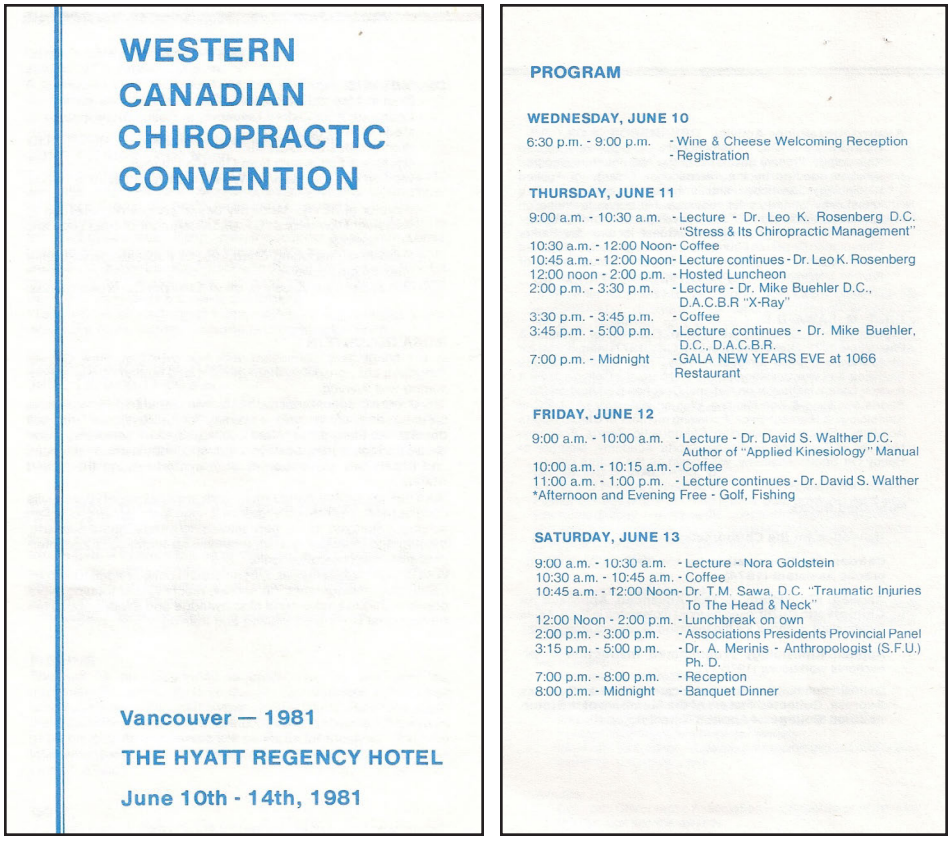



Figure 2.
*CMCC Homecoming pamphlet April 18 -20 1980.*[12]

and one co-chaired with Dr. Schultz, another pioneer in the field.[9]

- Dr. Len Schroeder, President of the ACA Council on Sports Injuries welcomed articles from CCSA members to be published in the ACA Journal.[9]
- The Canadian Olympic Wrestling Coaches Association invited the CCSA in 1979 to make a presentation to its group in Toronto. Dr. Sawa and Dr. O'Brien introduced the concept that neck bridging to build neck strength in wrestling was harmful to the facets and surrounding musculature of the cervical spine and suggested that other methods of strengthening the neck should be researched and implemented in their program.[9]
- Dr. Sawa and Dr O'Brien spoke on Contact Sport Injuries to the Sports Injuries Seminar sponsored by the Council on Sports Injuries of the American Chiropractic Association and Northwestern College of Chiropractic on 17, 18 May 1980, in Bloomington Minnesota (see Figure 1 for pamphlet).[11]
- Fellowship papers were presented at the scientific portion of the CCA convention in Banff, Alberta 1980.[9]
- In 1980 Dr. O'Brien and Dr. Sawa spoke on Chiropractic Evaluation and of the Injured Athlete at CMCC Homecoming (see Figure 2 for pamphlet).[12]
- In 1981 Dr. O'Brien and Dr. Sawa spoke in Vancouver on Traumatic Injuries to the Head and Neck to the Western Canadian Chiropractic Convention (see Figure 3 for pamphlet).[13]
- Representatives from the CCSA (Drs. De Finney, O'Brien, Sawa) were on the advisory committee of the OCA Council on Sports chaired by Dr. Tony Martin.[9]



WESTERN
CANADIAN
CHIROPRACTIC
CONVENTION

Vancouver — 1981
THE HYATT REGENCY HOTEL
June 10th - 14th, 1981

PROGRAM

WEDNESDAY, JUNE 10

6:30 p.m. - 9.00 p.m. - Wine & Cheese Welcoming Reception
- Registration

THURSDAY, JUNE 11

9:00 a.m. - 10:30 a.m. - Lecture - Dr. Leo K. Rosenberg D.C. "Stress & Its Chiropractic Management"
10:30 a.m. - 12:00 Noon - Coffee
10:45 a.m. - 12:00 Noon - Lecture continues - Dr. Leo K. Rosenberg
12:00 noon - 2:00 p.m. - Hosted Luncheon
2:00 p.m. - 3:30 p.m. - Lecture - Dr. Mike Buehler D.C., D.A.C.B.R "X-Ray"
3:30 p.m. - 3:45 p.m. - Coffee
3:45 p.m. - 5:00 p.m. - Lecture continues - Dr. Mike Buehler, D.C., D.A.C.B.R.
7:00 p.m. - Midnight - GALA NEW YEARS EVE at 1066 Restaurant

FRIDAY, JUNE 12

9:00 a.m. - 10:00 a.m. - Lecture - Dr. David S. Walther D.C. Author of "Applied Kinesiology" Manual
10:00 a.m. - 10:15 a.m. - Coffee
11:00 a.m. - 1:00 p.m. - Lecture continues - Dr. David S. Walther
*Afternoon and Evening Free - Golf, Fishing

SATURDAY, JUNE 13

9:00 a.m. - 10:30 a.m. - Lecture - Nora Goldstein
10:30 a.m. - 10:45 a.m. - Coffee
10:45 a.m. - 12:00 Noon - Dr. T.M. Sawa, D.C. "Traumatic Injuries To The Head & Neck"
12:00 Noon - 2:00 p.m. - Lunchbreak on own
2:00 p.m. - 3:00 p.m. - Associations Presidents Provincial Panel
3:15 p.m. - 5:00 p.m. - Dr. A. Merinis - Anthropologist (S.F.U.) Ph. D.
7:00 p.m. - 8:00 p.m. - Reception
8:00 p.m. - Midnight - Banquet Dinner

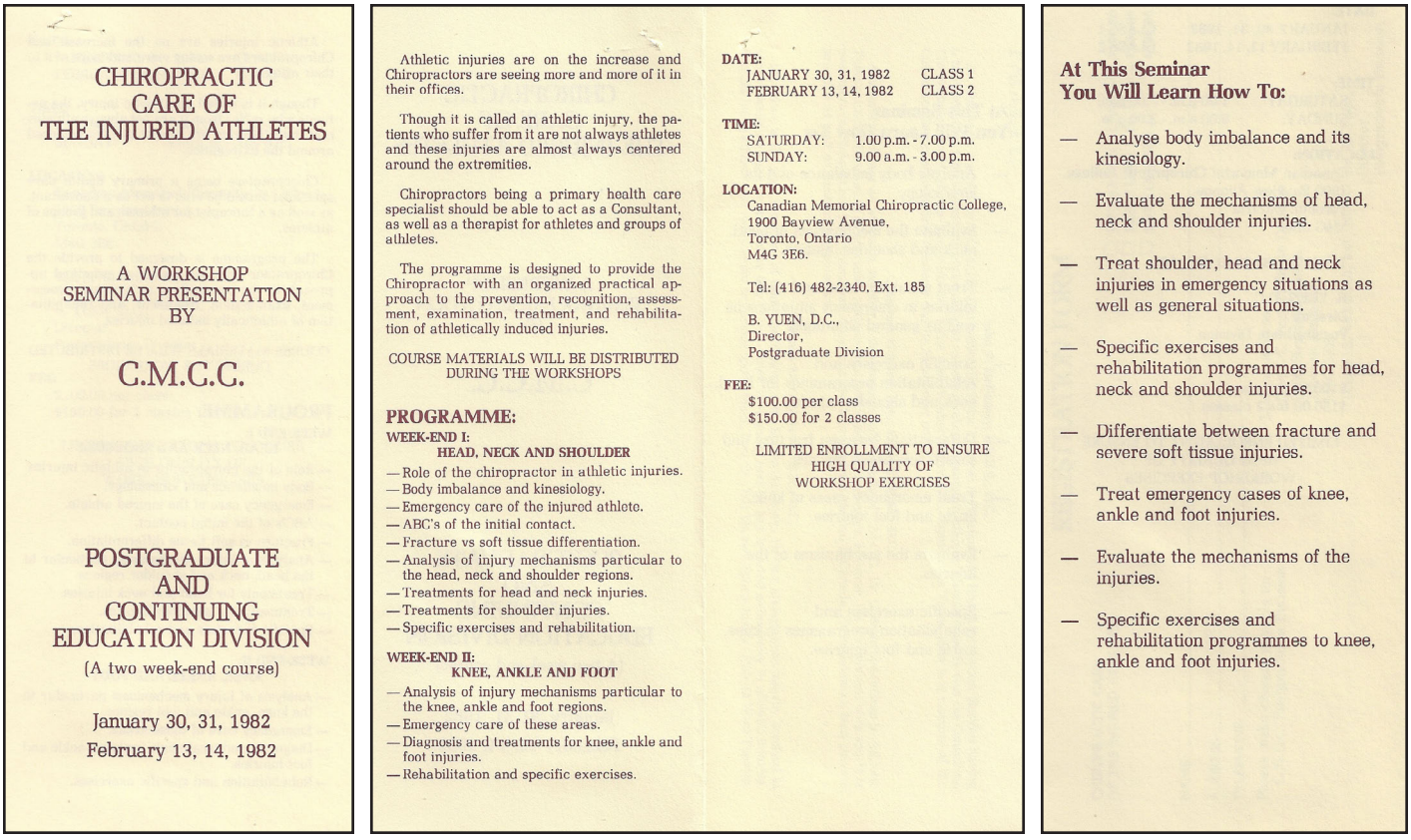
Figure 3.
*Western Canadian Chiropractic Convention pamphlet Vancouver June10th – 14th 1981.*[13]

- A meeting with Mr. Jack Lynch of the Canadian Olympic Swim Association was arranged to enlist his help and advice on forming a professional affiliation with the Sports National bodies and coaching association of Canada. This eventually happened in 1984.[9]
- Four newsletters were published between 1979 and 1981 by editor Dr. John De Finney and mailed to all of the CCSA members. These newsletters will be archived in the CMCC library.

## Transition to a New Board

Elections were held in August 1981 with the intent of bringing in new people with fresh ideas to the executive. Dr. Jamie Laws was elected as president, Dr. Larry Laughlin was elected as vice president by acclamation and Dr. Bruce Fligg was elected as secretary-treasurer by acclamation. There is very little to report about the years from 1981 to 1984.[10,14-16] In January and February of 1982, Drs. Sawa, O'Brien and De Finney were asked to present a seminar/workshop on Chiropractic Care of the Injured Athlete for CMCC's postgraduate and continuing education division (see Figure 4).[17]

In 1984, Dr. James Watkins, the Executive Director of the CCA, requested that Dr. Tom Sawa chair an open meeting in conjunction with the CCA convention in Ottawa to see if Canadian sports chiropractic should be revitalized.[10, 16] The consensus in the meeting was that a Canadian chiropractic sports body was needed to guide the profession in the ever burgeoning area of sports injury management.[16] Elections were held and Dr. Jacques Breton (now deceased), was elected President, Dr. Wayne Walker 1st Vice President, Dr. John De Finney 2nd Vice President and Dr. Gordon Lawson Secretary Treasurer. Dr. Tom Sawa, Dr. Stu O'Brien, Dr. Jamie Laws were appointed as advisors while Dr. Brian Seaman and Dr. Dominique Dufour were appointed as directors. The elec-



CHIROPRACTIC
CARE OF
THE INJURED ATHLETES

A WORKSHOP
SEMINAR PRESENTATION
BY

C.M.C.C.

POSTGRADUATE
AND
CONTINUING
EDUCATION DIVISION
(A two week-end course)

January 30, 31, 1982
February 13, 14, 1982

Athletic injuries are on the increase and Chiropractors are seeing more and more of it in their offices.

Though it is called an athletic injury, the patients who suffer from it are not always athletes and these injuries are almost always centered around the extremities.

Chiropractors being a primary health care specialist should be able to act as a Consultant, as well as a therapist for athletes and groups of athletes.

The programme is designed to provide the Chiropractor with an organized practical approach to the prevention, recognition, assessment, examination, treatment, and rehabilitation of athletically induced injuries.

COURSE MATERIALS WILL BE DISTRIBUTED DURING THE WORKSHOPS

**PROGRAMME:**

**WEEK-END I:**
**HEAD, NECK AND SHOULDER**

— Role of the chiropractor in athletic injuries.
— Body imbalance and kinesiology.
— Emergency care of the injured athlete.
— ABC's of the initial contact.
— Fracture vs soft tissue differentiation.
— Analysis of injury mechanisms particular to the head, neck and shoulder regions.
— Treatments for head and neck injuries.
— Treatments for shoulder injuries.
— Specific exercises and rehabilitation.

**WEEK-END II:**
**KNEE, ANKLE AND FOOT**

— Analysis of injury mechanisms particular to the knee, ankle and foot regions.
— Emergency care of these areas.
— Diagnosis and treatments for knee, ankle and foot injuries.
— Rehabilitation and specific exercises.

**DATE:**
JANUARY 30, 31, 1982 CLASS 1
FEBRUARY 13, 14, 1982 CLASS 2

**TIME:**
SATURDAY: 1.00 p.m. - 7.00 p.m.
SUNDAY: 9.00 a.m. - 3.00 p.m.

**LOCATION:**
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**At This Seminar**
**You Will Learn How To:**

— Analyse body imbalance and its kinesiology.
— Evaluate the mechanisms of head, neck and shoulder injuries.
— Treat shoulder, head and neck injuries in emergency situations as well as general situations.
— Specific exercises and rehabilitation programmes for head, neck and shoulder injuries.
— Differentiate between fracture and severe soft tissue injuries.
— Treat emergency cases of knee, ankle and foot injuries.
— Evaluate the mechanisms of the injuries.
— Specific exercises and rehabilitation programmes to knee, ankle and foot injuries.

Figure 4.
*Chiropractic Care of the Injured Athlete for CMCC's postgraduate and continuing education division January 30, 31 and February 13, 14 1982.*[17]

tion took place under the name of the College of Chiropractic Sports Sciences (Canada) pending approval of the name change by the CCA.[16,18]

So began a new chapter in the role chiropractors played in the management of athletic injuries in Canada. The executives that followed have taken the Sports College to levels about which the pioneers could only have only dreamed.

## Acknowledgement

This paper could not have been produced without the invaluable help and contributions from Dr. Tom Sawa who provided most of the historical references.

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15. Conversations with Dr. Bruce Fligg, circa February 2015.
16. Conversations with Dr. Gordon Lawson, circa January 2015.
17. See Figure 4.
18. Notes from CCSS(C) executive meeting Montreal, November 3, 1984.