Association chiropratique canadienne

Canadian Chiropractic Association

JCCA
Journal of the Canadian Chiropractic Association

(Formerly the Canadian Chiropractic Association Journal)

Published by the Canadian Chiropractic Association and issued quarterly

EDITORIAL AND EXECUTIVE OFFICES,
184 FRONT STREET, SUITE 200, TORONTO, CANADA M5A 4N3

General Information: The Journal of the Canadian Chiropractic Association is the official publication by the Canadian Chiropractic Association. The JCCA is published by the Canadian Chiropractic Association as a medium of communication between the Association and its members and is a forum for fair comment and discussion of all matters of general interest to the chiropractic profession and the Association. Readers are invited to comment and express their opinions on relevant subjects. Views and opinions in editorials and articles are not to be taken as official expression of the Association's policy unless so stated. Publication of contributed articles does not necessarily imply endorsement in any way of the opinions expressed therein and the Journal and its publisher does not accept any responsibility for them. Business correspondence should be addressed to: the Editor of JCCA, 184 Front Street, Suite 200, Toronto, Canada M5A 4N3.

INDEXING SERVICES

JCCA is indexed by PubMed Central, Scopus, CINAHL (Cumulative Index to Nursing and Allied Health Literature), MANTIS (formerly CHIROLARS), AMED, PASCAL, Index to Chiropractic Literature, and selectively by SPORTDiscus.

Contents

JCCA Vol 68 No 2 ISSN 00083194 (Print) and ISSN 1715-6181 (Online)

Contents

JCCA Vol 68 No 2 ISSN 00083194 (Print) and ISSN 1715-6181 (Online)

Editorial Board

ISSN 0008-3194 (p)/ISSN 1715-6181 (e)/2024/86–97/$2.00/©JCCA 2024

Commentary

Expanding concussion care in Canada: the role of chiropractors and policy implications

Carol Cancelliere, DC, MPH, PhD[1]
Scott Howitt, CK, MSc, DC, FRCCSS(C), FCCPOR[2]
Todd Halowski, DC[3]
Craig Jacobs, DC, MSc, FCCS(C)[1,2]
Michelle Da, Roza[4]
Dean Wright, DC[5]
Gaelan Connell, BHK, DC, MRSc[1]
Hainan Yu, MBBS, MSc[1]

Concussions are increasingly recognized as a public health concern. This paper evaluates Canadian concussion care guidelines, advocating for the inclusion of a broader range of healthcare professionals (HCPs) in concussion assessment, diagnosis, and management. It emphasizes the role of chiropractors, in addition to medical doctors (MDs) and nurse practitioners (NPs), highlighting their extensive training in musculoskeletal and neurological disorders. Chiropractors are

Élargir les soins pour la commotion cérébrale au Canada: le rôle des chiropraticiens et les répercussions sur les politiques

Les commotions cérébrales sont de plus en plus reconnues comme étant une préoccupation de santé publique. Le présent document évalue les lignes directrices canadiennes sur les soins pour la commotion cérébrale, en préconisant l'inclusion d'un plus large éventail de professionnels de la santé (PS) dans l'évaluation, le diagnostic et la gestion des commotions cérébrales. Il met l'accent sur le rôle des chiropraticiens, en plus des médecins (MD) et des infirmières et infirmiers praticien(ne) s (IP), en soulignant leur vaste formation aux troubles musculosquelettiques et neurologiques. Les chiropraticiens sont bien placés pour gérer les symptômes comme les maux de tête, les douleurs du cou et les étourdissements, et pour utiliser des interventions

[1] Institute for Disability and Rehabilitation Research and Faculty of Health Sciences, Ontario Tech University
[2] Canadian Memorial Chiropractic College
[3] College of Chiropractors of Alberta
[4] College of Chiropractors of British Columbia
[5] Canadian Chiropractic Protective Association

Corresponding author:
Carol Cancelliere, Institute for Disability and Rehabilitation Research and Faculty of Health Sciences, Ontario Tech University
E-mail: Carolina.cancelliere@ontariotechu.ca
Tel: 416-540-6472

The authors have no disclaimers or competing interests to report in the preparation of this manuscript. CC, GC, and HY are supported by the Canadian Chiropractic Guideline Initiative.

adept at managing symptoms like headache, neck pain, and dizziness, and employing evidence-based, comprehensive interventions including patient education, exercise therapy, manual therapy, cervicovestibular rehabilitation, and return-to-sport (RTS) protocols. The paper also addresses regional variations in chiropractors' roles, focusing on Ontario's "Rowan's Law," and argues that limiting aspects of concussion care (assessment, diagnosis, RTS clearance) to MDs and NPs may result in healthcare inefficiencies and inequities. The findings are significant for policymakers and healthcare leaders, indicating a need for updated concussion care guidelines that integrate and utilize diverse HCPs. This could lead to improved patient outcomes, healthcare efficiency, and equity in concussion management across Canada.

(JCCA. 2024;68(2):86-97)

KEY WORDS: chiropractic, concussion, diagnosis, evidence-based practice, mild traumatic brain injury, rehabilitation

complètes et fondées sur des données probantes, notamment l'éducation des patients, l'exercice thérapeutique, la thérapie manuelle, la rééducation vestibulaire et la physiothérapie de la colonne vertébrale cervicale, et les protocoles de retour à l'exercice (RE). Le document traite également des variations régionales des rôles des chiropraticiens, en mettant l'accent sur la « Loi Rowan » de l'Ontario, et soutient que la limitation des aspects des soins de commotion cérébrale (évaluation, diagnostic, autorisation RE) aux médecins et aux IP peut entraîner des inefficacités et des inégalités en matière de soins de santé. Les conclusions sont importantes pour les décideurs et les responsables de la santé, ce qui indique la nécessité de mettre à jour les lignes directrices sur les soins pour la commotion cérébrale qui intègrent et utilisent divers PS. Cela pourrait mener à une amélioration des résultats pour les patients, de l'efficacité des soins de santé et de l'équité dans la gestion des commotions cérébrales au Canada.

(JCCA. 2024; 68(2) : 86-97)

MOTS CLÉS : chiropratique, commotion cérébrale, diagnostic, pratique fondée sur des données probantes, lésions cérébrales traumatiques légères, réadaptation

Introduction

Concussion, or mild traumatic brain injury (mTBI), has emerged as a significant public health concern.[1,2] The incidence of concussion is estimated at 200–300 per 100,000 persons per year for hospitalized patients, likely doubling when including non-hospitalized patients.[1,3] In Canada, approximately 200,000 concussions occur annually, predominantly affecting children and youth.[4,5] In the United States (US), the lifetime prevalence of at least one self-reported concussion among adolescents increased from approximately 20 to 25% from 2016 to 2020.[6] A population-based survey in the US reported that approximately 36% of adult respondents had experienced at least one mTBI in their lifetime.[7] Globally, the incidence of traumatic brain injury (TBI), including concussions, varies. A study involving patients from eight low- and middle-income countries estimated the prevalence of TBI to range from less than 1% to 15%.[8] This range reflects the variability in the occurrence of TBI across different LMICs, which can be influenced by a multitude of factors including road safety, healthcare infrastructure, and the prevalence of violence in the region. The overall incidence of TBI per 100,000 people was greatest in North America (1299 cases) and Europe (1012 cases).[9]

Concussions can profoundly impact the cognitive, physical, and emotional aspects of life, leading to societal repercussions in healthcare, education, and the workplace.[10] The growing burden of concussions, driven by greater participation in sports, as well as falls and motor vehicle collisions, has led to a heightened focus on effective management strategies.[2,3] A large proportion of concussions are managed in primary-care settings outside of hospitals and emergency departments.[11] Including qualified healthcare professionals (HCPs) in concussion care, such as chiropractors and physiotherapists, in addition to medical doctors (MDs) and nurse practitioners (NPs),

may enhance the capacity of primary-care settings to manage patients more effectively and in a timely manner. This paper aims to critically examine the current state of concussion care guidelines in Canada, focusing on the roles of various HCPs in concussion assessment, diagnosis, and return to sport (RTS). It seeks to explore why the exclusive reliance on MDs and NPs for these crucial aspects of concussion care might not align with the best interest of individuals with concussions.[12-14] This is especially pertinent considering the multifaceted nature of concussion management[15-17] and the growing strain on healthcare systems[18]. Considering patient-centered care and an evidence-based approach, this paper argues for a more inclusive model that recognizes the valuable contributions of a broader range of HCPs, including chiropractors and physiotherapists,[19] in the assessment, diagnosis and RTS components of concussion care.

Evidence-Based Concussion Care

Overview of concussion care

Table 1 outlines the key stages of evidence-based concussion care, from the initial observation to management

Table 1.
Overview of Evidence-Based Concussion Care

Category	Stage	Description
Assessment	**Observation**	Practitioners look for visible signs of trauma such as swelling or bruising and assess the individual's behavior, balance, and coordination.[15-17, 20]
	Symptoms Inquiry	Immediate inquiry into symptoms like headaches, dizziness, nausea, blurred vision, sensitivity to light or noise, and any signs of confusion.[15-17, 20]
	Red Flags	Vigilance for alarming signs and symptoms such as loss of consciousness, escalating headaches, seizures, repeated vomiting, pronounced confusion, limb weakness or numbness, and slurred speech. Immediate referral for emergency medical attention if present.[15-17, 20]
	Orientation Questions	Assessment of the individual's awareness of time, place, and their own identity.[15-17, 20]
	Health History	Compilation of a comprehensive health history, including the injury's mechanism, symptoms experienced (somatic, cognitive, sleep, mood, vestibular-ocular motor), detailed review of previous concussions (e.g., dates, severity, treatment, recovery time), other physical and mental health conditions, lifestyle and other contextual factors.[15-17, 20]
	Physical Examination	Comprehensive examination encompassing neurological assessment, evaluation of cranial nerves, balance and gait analysis, autonomic system evaluation, vestibular-ocular motor screening, and thorough examination of the cervical spine, back, and other extracranial regions.[15-17, 20]
	Cognitive Assessment	Evaluation of the individual's memory, concentration, and attention, possibly involving tasks like repeating a series of numbers or words.[15-17, 20]
	Diagnostic Tools	Utilization of tools such as the SCAT-6 and SCOAT-6 (adult and child versions) to facilitate assessment and diagnosis.[17]
Management	**Personalized Approach**	Addressing the unique needs of each patient, be it children, adults, or athletes, with education about symptoms, expected recovery trajectory, and guidance on symptom management.[15-17, 20]
	Return to Learn, Work and Sport	Use an incremental stepwise approach to facilitate return to learn, work or sport. Prioritize cognitive recovery by reintegrating individuals into academic activities or work before sports. Provide accommodations to support a gradual return to school or work based on individual tolerance levels.[15, 16] Ensuring athletes are symptom-free and have received clearance from a qualified healthcare professional before returning to their sport.[15-17, 20]
Prognostic Considerations	**Adults**	Most adults recover within a few weeks, but a subset may experience prolonged symptoms. Factors such as pre-existing conditions like migraines, depression, or anxiety, may contribute to delayed recovery.[22, 23]

Category	Stage	Description
	Children and Adolescents	Often have a more extended recovery period than adults, with potential impacts on learning and social interactions. The developing brain of children and adolescents may be more vulnerable to the effects of concussions, and factors like age at the time of injury, and previous concussions can contribute to delayed recovery.[16, 17, 20, 21]
	Athletes	Unique recovery landscape due to their activities and eagerness to return to their sport. Importance of ensuring they are symptom-free before returning. Factors such as the number of previous concussions, the severity of the current concussion, and the sport's nature can influence recovery time and contribute to delayed recovery.[17, 23]

SCAT-6: Sport Concussion Assessment Tool – 6th edition; SCOAT-6: Sport Concussion Office Assessment Tool - 6th edition

strategies and prognostic considerations.[15-17, 20-23] These approaches are primarily non-pharmacological and do not predominantly rely on conventional medical treatments. Importantly, HCPs beyond MDs and NPs, such as chiropractors and physiotherapists, are competent to provide this care, highlighting the potential benefits of an inclusive approach in concussion care.[24-32]

Diagnosis and initial management

The absence of definitive biomarkers or imaging findings means HCPs interpret signs and symptoms, informed by clinical practice guidelines (CPGs) and clinical judgment.[15-17,20-23] Concussion is a clinical diagnosis, involving health history and physical and cognitive examinations. This diagnostic competence extends beyond MDs and NPs to various HCPs, including chiropractors and physiotherapists.[25, 33]

Early management of concussion includes assessing and monitoring for signs and symptoms indicative of intracranial and cervical spine injuries that require urgent medical attention.[15-17,20] Various HCPs are adept at performing these critical initial assessments, identifying potential red flags for more serious underlying conditions, and guiding appropriate referrals.[25,33] An integral part of this early management is the immediate removal from play or sport upon suspicion of a concussion. This precautionary measure is recommended in various concussion guidelines and is based on the principle of 'when in doubt, sit them out.'[13,17] The immediate removal from play helps prevent further injury, allows for a timely evaluation by qualified HCPs, and improves recovery if a concussion occurred. The decision to remove an athlete from play is not limited to MDs and NPs. Often, those who are present at the time of injury are the ones making these decisions. This responsibility extends to team providers (e.g., athletic therapists, physiotherapists and chiropractors), as well as coaches, teachers and parents.[17] The Concussion Recognition Tool can be used to facilitate this.[17]

Rehabilitation strategies and return to sport, learn and work

Concussion management involves multifaceted rehabilitation strategies, including brief initial rest followed by a gradual return to activity, and targeted therapies for specific symptoms, with common symptoms being headache, neck pain, and dizziness.[15-17,20] These symptoms and associated conditions are commonly managed by chiropractors, who are proficient in these strategies including exercise therapy (including sub-symptomatic aerobic training), manual therapies, treatment of the cervical spine, cervicovestibular rehabilitation, vestibulo-ocular rehabilitation, self-management strategies, and patient education.[25]

An important component of concussion management is RTS, which involves a structured process to ensure athletes and physically active patients can safely resume sports and fitness activities.[17] This process typically includes physical exertion testing, cognitive evaluation, and a graduated increase in activity levels under medical supervision. HCPs such as chiropractors, physiotherapists, and athletic therapists possess the necessary skills and resources to conduct comprehensive evaluations and implement graduated stepwise RTS strategies.[19] In conjunction with RTS, return to learn (RTL) and return to work (RTW) protocols are essential for cognitive recovery and are generally prioritized to ensure that individuals can perform cognitive tasks effectively and without exacerbating symptoms.[15-17] After the initial rest period, a

gradual reintroduction to cognitive tasks is initiated, with a gradual stepwise reintegration into educational or work activities. For students, this may involve accommodations such as reduced homework loads or extended test-taking times, progressing towards full academic activities. In the workplace, a similar approach is taken, starting with reduced hours or lighter tasks and gradually increasing to pre-injury job responsibilities. Throughout this process, communication with educators, employers, and healthcare providers is essential to tailor the RTL and RTW plans to the individual's progress and to adjust accommodations as needed. Chiropractors, physiotherapists, and athletic therapists can assist with RTL and RTW by providing interventions that address concurrent physical symptoms which may impact cognitive function, such as neck pain or dizziness, and by advising on activity modification to prevent symptom exacerbation. These professionals can also offer ergonomic modifications and self-management

Table 2.
Position statement by chiropractic bodies

Position statement on the assessment, diagnosis and management of concussion by the CCGI, CCA and RCCSS(C)

Chiropractors have the clinical training to assess, diagnose, and manage mild traumatic brain injury (mTBI)/concussion.

The diagnosis of mild traumatic brain injury (mTBI)/concussion is based on clinical criteria established with a health history, thorough physical examination, and exclusion of other serious injuries. Currently, there are no gold standard diagnostic tests.

According to the WHO Collaborating Center Task Force[1]:

"Mild traumatic brain injury (mTBI) is an acute brain injury resulting from mechanical energy to the head from external physical forces. Operational criteria for clinical identification include:

- one or more of the following: confusion or disorientation, loss of consciousness for 30 minutes or less, post-traumatic amnesia for less than 24 hours, and/or other transient neurological abnormalities such as focal signs, seizure, and intracranial lesion not requiring surgery; and
- Glasgow Coma Scale score of 13-15 after 30 minutes post-injury or later upon presentation for healthcare.

These manifestations of mTBI must not be due to drugs, alcohol, medications, caused by other injuries or treatment for other injuries (e.g. systemic injuries, facial injuries or intubation), caused by other problems (e.g. psychological trauma, language barrier or coexisting medical conditions) or caused by penetrating craniocerebral injury." (p. 115)

To diagnose, clinicians should rule out serious injuries to the head, neck and other bodily areas and differentiate signs or symptoms caused by other conditions (e.g., drugs, medications, other injuries) with a thorough health history and physical examination including a neurological examination. Once diagnosed, chiropractors should assess patients for associated conditions or comorbidities that may delay recovery (e.g., back pain, prior mental health issues, neck injury, learning disabilities, headache).[2]

Prompt referral for emergency medical attention may be required for persons with a suspected concussion. Chiropractors should monitor and educate patients about the associated signs and symptoms of serious pathology and refer to an appropriate diagnostic facility to investigate/confirm.

The pillars of concussion management once medical emergencies are ruled out are patient education, return to activity guidance, and symptom-targeted treatment.[3] Given the wide variation of symptoms that patients may present with after concussion, a collaborative, multidisciplinary approach to care is recommended. Keeping this in mind, chiropractors are well-positioned to manage or co-manage patients, such as those presenting with the common complaints of headache, neck and back pain, upper extremity pain, and vestibulo-ocular symptoms. Chiropractors are also able to screen for other symptoms (e.g., psychological, cognitive), which may warrant prompt referral.

References

1. Carroll LJ, Cassidy JD, Holm L, Kraus J, Coronado VG; WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. Methodological issues and research recommendations for mild traumatic brain injury: the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. J Rehabil Med 2004;36(43 Suppl): 113-125.
2. Guideline for concussion/mild traumatic brain injury & persistent symptoms, 3rd edition. Ontario Neurotrauma Foundation 2018.
3. Silverberg ND, Iaccarino MA, Panenka WJ, Iverson GL, McCulloch KL, Dams-O'Connor K, Reed N, McCrea M. Management of concussion and mild traumatic brain injury: A synthesis of practice guidelines. Arch Phys Med Rehabil 2020;101(2): 382-393.

CCGI: Canadian Chiropractic Guideline Initiative, CCA: Canadian Chiropractic Association, RCCSS(C): Royal College of Chiropractic Sport Sciences (Canada)

strategies to facilitate a successful transition back to daily cognitive tasks. The integration of cognitive and physical rehabilitation is crucial, as cognitive exertion can influence physical symptoms and recovery and vice versa. Therefore, a clinician network involving a multidisciplinary team can address the complexities of concussion management and to support the individual's return to their daily life activities, including sports, learning, and work. The latest guidelines[15-17] emphasize the importance of an individualized and graduated approach to both physical and cognitive activities post-concussion.

Position Statement by Chiropractic Bodies

The evidence-based position statement (Table 2) by the Canadian Chiropractic Guideline Initiative (CCGI), Canadian Chiropractic Association (CCA), and Royal College of Chiropractic Sports Sciences (Canada) (RCCSS(C)) highlights chiropractors' role in concussion care. It emphasizes chiropractors' comprehensive assessment and diagnostic skills, including neurological and musculoskeletal evaluations, and their ability to manage common concussion symptoms as well as during return to sport. Of note, as part of a comprehensive treatment plan, spinal manipulative therapy (SMT) is a commonly used procedure in chiropractic care, typically targeted towards addressing concurrent musculoskeletal issues, such as neck or back pain, and headaches, consistent with current CPGs.[15,34-36]

In the realms of screening versus diagnosis, chiropractors play a pivotal role. They are often the first point of contact for patients and are trained to recognize a broad spectrum of signs, symptoms, and conditions ranging from physical manifestations to psychological disorders and cognitive impairments. Within their scope of practice, chiropractors are competent in diagnosing and managing concussions, and are equipped to use appropriate patient-reported outcome measures (PROMs) to screen for signs of potential comorbidities (e.g., psychological conditions such as depression, anxiety, or post-traumatic stress disorders [PTSD]). These tools include, but are not limited to, the Patient Health Questionnaire (PHQ-9) for depression,[37] the Generalized Anxiety Disorder 7-item scale (GAD-7),[38] and the PTSD Checklist for DSM-5 (PCL-5).[39] Such instruments are validated for use in clinical settings and can help chiropractors identify patients who may require further evaluation by qualified healthcare practitioners for definitive diagnosis and appropriate treatment. This collaborative approach enhances the quality of care and supports efficient patient management.

Current State of Concussion Care Guidelines in Canada

Recent guidelines in Canada, such as those proposed by Parachute Canada,[12] and reinforced by Rowan's Law,[13] and the Government of Canada[40] have predominantly focused on MDs and NPs for the assessment and diagnosis of concussions. The Ontario Ministry of Health's Living Concussion Guidelines also offer comprehensive protocols for both adult[15] and pediatric[16] concussion management, similarly advocating primarily for the involvement of MDs and NPs in these phases.

Delving into the Ontario context, under Rowan's Law,[13] only MDs and NPs are explicitly designated as the HCPs responsible for assessing athletes and providing confirmation of medical clearance for their return to unrestricted participation in amateur competitive sport. The regulations apply to everyone under the age of 26, with an exception for universities and colleges where it applies to individuals of all ages. In the meantime, Rowan's Law mandates the removal of an athlete from sport if a concussion is suspected, which can be done by any HCP or person (e.g., coach, teacher, parent).

This decision, aimed at standardizing care, has not been substantiated with evidence or rationale explaining why other qualified HCPs are not equally considered for the roles of concussion assessment, diagnosis and RTS clearance.[41] While the guidelines acknowledge the role of other HCPs in the broader management and rehabilitation of people with concussion, the emphasis on MDs and NPs for the initial critical stages of assessment and diagnosis, as well as RTS clearance raises questions about the optimal utilization of healthcare resources and the potential for more timely and appropriate care, which may result in better patient outcomes and a reduced burden on the healthcare system.[42,43]

In rural and remote areas of Canada, where access to MDs or NPs is limited or non-existent, the guidelines permit another licensed HCPs, such as a nurse or chiropractor, to perform the role of concussion assessment and diagnosis, in communication with a NP or MD.[14] This provision highlights a disparity in the application of the guidelines based on geographic location. It suggests that

in underserved areas, other HCPs are deemed competent to assess and diagnose concussions due to necessity, yet the same level of trust and responsibility is not extended to these professionals in well-served areas. This inconsistency raises critical questions about the perceived competence of HCPs based on geographic location and the potential underutilization of skilled HCPs, who are trained and capable of contributing significantly to concussion care in different settings.

Reconsidering the Restriction: Broadening Concussion Care Beyond MDs and NPs

Training and competence in concussion care

This section compares the training of MDs, NPs, chiropractors, and physiotherapists, highlighting the specialized knowledge of HCPs such as chiropractors in concussion care and advocating for their inclusion in concussion assessment, diagnosis, and RTS.

MDs receive extensive training across various medical fields, including neurological evaluation. However, the focus on concussion management can vary based on specialization and interest areas.[44] Similarly, NPs integrate both nursing and medical models in their education, covering diagnosis and management of health conditions, including neurological evaluations.[45] The depth of their focus on concussion management can also vary. Research has highlighted the variability in the knowledge and confidence of MDs and NPs in managing concussions, including gaps in their ability to diagnose, manage patients with concussion, and make RTS decisions.[46-50]

In contrast, chiropractors and physiotherapists in Canada are provided with robust foundational training in concussion care.[24-32] Chiropractic programs, such as those at the Canadian Memorial Chiropractic College (CMCC),[27] Northeast College of Health Sciences,[28] and Northwestern Health Sciences University,[30] offer extensive training in diagnosing and treating musculoskeletal and neurological disorders, including traumatic injuries relevant to concussion management. This training includes comprehensive courses in anatomy, neurology, musculoskeletal disorders, neurological assessment (central, peripheral, cranial nerves), and diagnostic imaging.[27,51-53] The curriculum integrates basic sciences, pathology, diagnosis, orthopedics, public health, and clinical decision-making, with a strong emphasis on differential diagnosis skills. Chiropractic programs often delve deeper into areas such as neurological assessment and traumatic injuries than traditional medical school curricula,[44] aligning these competencies with those of MDs and neurologists.

Further, chiropractic licensing examinations confirm these competencies on entry to practice. These competencies and the profession's dissemination of CPGs highlight the profession's commitment to evidence-based care including concussion management.[25,41,51]

At the University of Toronto Medical School, a curriculum scan reveals that courses addressing Emergency Medicine, Complexity and Chronicity, Traumatic Brain Injury, Concussion, and Intracranial Mass Lesions are designed to integrate concussion education within the broader medical training framework.[44] Medical students participate in approximately 10 hours of targeted concussion-related instruction, encompassing didactic lectures, seminars, case-based learning, and directed independent learning.

Similarly, at the CMCC, chiropractic students receive approximately 7 hours of lecture and an additional 8 hours of cased-based discussion/experiential learning focusing on concussion. The curriculum extensively covers concussion-related topics across several modules, including Clinical Practice, Neurodiagnosis, Systems Pathology, Emergency Care, Child Care, Clinical Psychology, and Rehabilitation.[29] These courses address the pathophysiology of brain injuries, trauma mechanisms, and assessment techniques such as the Sport Concussion Assessment Tool – 6th edition (SCAT 6) and the Glasgow Coma Scale. Additionally, they cover rehabilitation strategies aimed at returning individuals to function, work, school and sport. This curriculum ensures that chiropractic students receive comprehensive theoretical and practical exposure to concussion care, comparable to medical programs but with a unique focus on manual and rehabilitative therapies.

It is important to acknowledge the inherent challenges in precisely quantifying the extent of concussion education within all curricula. Education opportunities related to concussion care are embedded throughout various courses and clinical experiences. This includes settings such as small group discussions, clinical rotations, and laboratory sessions, where both spontaneous and structured learning moments about concussion care can significantly enhance the educational experience. This dynamic and integrated approach to teaching allows for a deep, practical understanding of concussion management across different healthcare disciplines.

Furthermore, ongoing competencies in concussion management are integral to the continuous education of various HCPs, including MDs, NPs, chiropractors, physiotherapists, athletic therapists, and occupational therapists.[55] The widespread availability of these programs indicates a commitment to equipping HCPs with the latest knowledge and skills in concussion management.

Access to care and healthcare system efficiencies

Timely and appropriate care is a key predictor of recovery in concussion management, encompassing assessment, diagnosis, and RTS protocols.[56,57] The current restriction of these aspects of concussion care to MDs and NPs may inadvertently delay care, impacting the effectiveness of recovery and decision-making processes in these areas. Expanding access to other qualified HCPs can improve patient outcomes. Chiropractors are adept at initiating early rehabilitation, an important factor in effective concussion recovery. Their expertise in exercise therapy, manual therapies, cervicovestibular rehabilitation, and patient education positions them to contribute significantly not only to the assessment and diagnosis of concussion but also to the RTS process. This is especially pertinent given the guidelines that advocate for the initiation of rehabilitation within a specific timeframe post-concussion. Primary care physicians often face challenges in meeting these guidelines due to long wait times and lack of specialized facilities, such as treadmills. In contrast, HCPs such as chiropractors, physiotherapists and athletic therapists can provide timely and effective rehabilitation services, often with immediate access to the required resources.

The inclusion of these professionals in concussion care is essential in addressing the systemic shortages of MDs and NPs,[18] which can result in delays in assessment, diagnosis, and management, potentially worsening patient outcomes and prolonging recovery times. The current guidelines, which limit the diagnosis of concussions and the confirmation of medical clearance for athletes' return to unrestricted amateur competitive sport to just MDs and NPs,[12,13,15,38] do not align with evidence-based healthcare principles. Such restrictions can lead to inefficiencies and inequities. Furthermore, this focus on concussions means MDs and NPs will have less time to address other health concerns. By recognizing the competence of chiropractors and other practitioners in assessing, diagnosing, managing concussions, and facilitating RTS protocols, the healthcare system can alleviate some of this strain. Allowing these professionals to fully work within their scope facilitates quicker patient recognition, intervention, and safe reintegration into athletic activities. This approach not only enhances patient outcomes but also contributes to more efficient and equitable healthcare delivery.

Medical interventions not often required

Most concussion cases do not require advanced diagnostic imaging, and chiropractors are trained to identify red flags that necessitate emergency referrals.[15,16,20] There is no direct treatment for the physiology of concussion, but early symptom management and education are important.[15, 17] While medications may be used in the treatment of concussions, they are not typically used alone as a first-line treatment.[15, 17] Instead, they are part of a comprehensive treatment plan that includes other non-pharmacological interventions, such as relative rest, education, and various therapies tailored to the patient's symptoms. This approach is in line with the evidence-based treatment of concussions and ensures that all aspects of the patient's health are considered to facilitate recovery. Chiropractors contribute to this approach with their focus on individualized symptom management and rehabilitation, which is in line with current evidence-based treatment of concussions.

Return to sport clearance

Evidence suggests physical exertion testing along with physical and cognitive evaluation.[17] HCPs other than MDs and NPs (e.g., chiropractors, physiotherapists, athletic therapists) are more likely to have the resources, time, and competencies to do this. The inclusion of physical exertion testing in RTS protocols is increasingly recognized as best practice.[17] These other HCPs, with their expertise and access to necessary equipment, are well-positioned to conduct such evaluations. Their role in this process ensures that athletes undergo a comprehensive assessment that integrates both physical and cognitive evaluations.

Emerging Role of Chiropractors in Concussion Care

Concussion management often necessitates a multidisciplinary approach, with chiropractors playing an important role. Most concussion cases do not require advanced diagnostic imaging and chiropractors are competent at identifying urgent signs and symptoms that demand immediate attention. Chiropractors' involvement should adhere to patient-centered needs and evidence-based practices, ensuring their contributions are both effective and timely.

Chiropractors are proficient in managing common symptoms such as neck pain, headaches, and dizziness, which aligns with the non-pharmacological emphasis of current concussion treatment guidelines. It is essential, however, to clearly define the scope of chiropractic care within the broader concussion management spectrum. This ensures their practices complement other treatments and remain current with the latest educational advancements.

The potential benefits of incorporating chiropractors into concussion care teams are significant, provided there is ongoing and consistent training in concussion pathophysiology and management. While chiropractic programs provide a solid foundation in neurology and musculoskeletal care, standardizing this training across educational institutions is crucial for ensuring chiropractors are effectively integrated into multidisciplinary teams.

Moreover, effective communication among these teams is paramount. Chiropractors must collaborate with other healthcare professionals to support the patient in making informed care decisions that reflect a comprehensive understanding of their health history and the latest research.

The recent discourse increasingly recognizes chiropractors' role, especially in managing post-concussion symptoms and sports-related concussion (SRC) within these teams.[17, 19] As primary contact healthcare professionals, their early interactions with patients with concussion position them to initiate appropriate care quickly and refer when necessary.

Chiropractors are encouraged to engage in forums such as the Concussion in Sport Group (CISG) and the International Consensus Conferences on Concussion.[19] Such participation is important for staying informed about the latest concussion management research and guidelines.

Additionally, chiropractors should be integral to multidisciplinary SRC teams, not only providing care but also collaborating closely with other HCPs. This involves sharing insights, participating in case discussions, and contributing to the development of individualized care plans for athletes.

These developments underscore the significant value chiropractors add to concussion care. The clinician network advocated by recent guidelines and research supports a multidisciplinary strategy.[17, 19] However, this integration must be approached with a commitment to continuous education and collaborative practice to ensure safe and effective care.

Conclusion

As healthcare continues to evolve, leveraging the expertise of diverse HCPs becomes paramount. Concussion assessment, diagnosis, and RTS are inherently clinical processes, and the growing prevalence and multifaceted impact of these injuries necessitate a comprehensive, evidence-based approach. This paper highlights the significant role that HCPs such as chiropractors, with their extensive training, can play in these areas. By considering the evidence and adapting to the evolving healthcare landscape, integrating the expertise of HCPs beyond MDs and NPs in concussion care in Canada becomes a logical step forward.

This paper has important implications for policymakers, healthcare administrators, and other stakeholders in the healthcare sector. It calls for a reevaluation of current concussion care guidelines and policies to include a broader range of qualified HCPs. By doing so, it advocates for a healthcare system that is more responsive to the needs of people with concussions, ensuring timely and effective care. The inclusion of chiropractors and other HCPs in concussion management can lead to improved patient care and outcomes, reduced healthcare inefficiencies, and a more equitable distribution of healthcare resources. This paper serves as a call to action for policymakers and healthcare leaders to consider these findings in the formulation and implementation of concussion care policies and practices.

References

1. Maas AIR, Menon DK, Adelson PD, *et al*. Traumatic brain injury: integrated approaches to improve prevention, clinical care, and research. Lancet Neurol. 2017;16(12): 987-1048. doi:10.1016/S1474-4422(17)30371-X

2. Lefevre-Dognin C, Cogne M, Perdrieau V, Granger A, Heslot C, Azouvi P. Definition and epidemiology of mild traumatic brain injury. Neurochirurgie. 2021;67(3): 218-221. doi:10.1016/j.neuchi.2020.02.002
3. Cassidy JD, Carroll LJ, Peloso PM, *et al*. Incidence, risk factors and prevention of mild traumatic brain injury: results of the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. J Rehabil Med. 2004;(43 Suppl): 28-60. doi:10.1080/16501960410023732
4. Rausa VC, Shapiro J, Seal ML, *et al*. Neuroimaging in paediatric mild traumatic brain injury: a systematic review. Neurosci Biobehav Rev. 2020;118: 643-653. doi:10.1016/j.neubiorev.2020.08.017
5. Public Health Agency of Canada. Release Notice - Injury in Review, 2020 Edition: Spotlight on Traumatic Brain Injuries Across the Life Course. Health Promot Chronic Dis Prev Can. 2020;40(9): 294. doi:10.24095/hpcdp.40.9.05
6. Veliz P, McCabe SE, Eckner JT, Schulenberg JE. Trends in the prevalence of concussion reported by US adolescents, 2016-2020. JAMA. 2021;325(17): 1789-1791. doi:10.1001/jama.2021.1538
7. Whiteneck GG, Cuthbert JP, Corrigan JD, Bogner JA. Prevalence of self-reported lifetime history of traumatic brain injury and associated disability: a statewide population-based survey. J Head Trauma Rehabil. 2016;31(1): E55-62. doi:10.1097/HTR.0000000000000140
8. Vadan I, Ilut S. Estimating the global incidence of TBI. Academy for Multidisciplinary Neurotraumatology. Accessed December 2, 2023, 2023. https://brain-amn.org/global-incidence-of-tbi/
9. Dewan MC, Rattani A, Gupta S, *et al*. Estimating the global incidence of traumatic brain injury. J Neurosurg. 2018;130(4): 1080-1097. doi:10.3171/2017.10.JNS17352
10. Theadom A, Parag V, Dowell T, *et al*. Persistent problems 1 year after mild traumatic brain injury: a longitudinal population study in New Zealand. Br J Gen Pract. 2016;66(642): e16-23. doi:10.3399/bjgp16X683161
11. Arbogast KB, Curry AE, Metzger KB, *et al*. Improving primary care provider practices in youth concussion management. Clin Pediatr (Phila). 2017;56(9): 854-865. doi:10.1177/0009922817709555
12. Parachute. Canadian Guideline on Concussion in Sport Parachute; 2017. Accessed July 17, 2023. https://parachute.ca/en/professional-resource/concussion-collection/canadian-guideline-on-concussion-in-sport/
13. Government of Ontario. Rowan's Law: Concussion safety. https://www.ontario.ca/page/rowans-law-concussion-safety
14. House of Commons. Tackling the problem head-on: Sports-related concussions in Canada. 2019. Accessed December 2, 2023. https://www.ourcommons.ca/Content/Committee/421/HESA/Reports/RP10528875/hesarp24/hesarp24-e.pdf
15. Marshall S, Lithopoulos A, Curran D, Fischer L, Velikonja D, Bayley M. Living Concussion Guidelines: Guideline for Concussion & Prolonged Symptoms for Adults 18 years of Age or Older. https://concussionsontario.org/
16. Reed N, Zemek R, Dawson J, Ledoux AA, *et al*. Living Guideline for Pediatric Concussion Care. https://doi.org/10.17605/OSF.IO/3VWN9
17. Patricios JS, Schneider KJ, Dvorak J, *et al*. Consensus statement on concussion in sport: the 6th International Conference on Concussion in Sport-Amsterdam, October 2022. Br J Sports Med. 2023;57(11): 695-711. doi:10.1136/bjsports-2023-106898
18. Duong D, Vogel L. National survey highlights worsening primary care access. CMAJ. 2023;195(16): E592-E593. doi:10.1503/cmaj.1096049
19. Shannon N, Patricios J. Sports-related concussion: assessing the comprehension, collaboration, and contribution of chiropractors. Chiropr Man Therap. 2022;30(1): 60. doi:10.1186/s12998-022-00471-z
20. Lumba-Brown A, Yeates KO, Sarmiento K, *et al*. Centers for Disease Control and Prevention guideline on the diagnosis and management of mild traumatic brain injury among children. JAMA Pediatr. 2018;172(11): e182853. doi:10.1001/jamapediatrics.2018.2853
21. Hung R, Carroll LJ, Cancelliere C, *et al*. Systematic review of the clinical course, natural history, and prognosis for pediatric mild traumatic brain injury: results of the International Collaboration on Mild Traumatic Brain Injury Prognosis. Arch Phys Med Rehabil. 2014;95(3 Suppl): S174-191. doi:10.1016/j.apmr.2013.08.301
22. Cassidy JD, Cancelliere C, Carroll LJ, *et al*. Systematic review of self-reported prognosis in adults after mild traumatic brain injury: results of the International Collaboration on Mild Traumatic Brain Injury Prognosis. Arch Phys Med Rehabil. 2014;95(3 Suppl): S132-151. doi:10.1016/j.apmr.2013.08.299
23. Cancelliere C, Hincapie CA, Keightley M, *et al*. Systematic review of prognosis and return to play after sport concussion: results of the International Collaboration on Mild Traumatic Brain Injury Prognosis. Arch Phys Med Rehabil. Mar 2014;95(3 Suppl): S210-229. doi:10.1016/j.apmr.2013.06.035
24. The Federation of Canadian Chiropractic. Program standards for the Doctor of Chiropractic degree program - Canada. Accessed December 5, 2023. https://chirofed.ca/wp-content/uploads/2021/03/program-standards-DCP-Canada-Nov-9-final-1.pdf
25. Federation of Canadian Chiropractic. Entry-to-practice competency profile for chiropractors in Canada. 2018. Accessed August 16, 2023. https://chirofed.ca/wp-content/uploads/2021/03/entry-to-practice-competency-profile-DCP-Canada-Nov-9.pdf

26. Canadian Memorial Chiropractic College. Doctor of Chiropractic Program Graduate Competencies. 2021. Accessed December 1, 2023. https://www.cmcc.ca/dA/ff765e8f5b/doctor-of-chiropractic-program-graduate-competencies.pdf?language_id=1
27. Canadian Memorial Chiropractic College. Doctor of Chiropractic Program. Accessed December 1, 2023. https://www.cmcc.ca/academic-programs/doctor-of-chiropractic-program
28. Northeast College of Health Sciences. Doctor of Chiropractic. Accessed December 1, 2023. https://www.northeastcollege.edu/programs/doctor-of-chiropractic
29. Canadian Memorial Chiropractic College. Curriculum. Accessed December 5, 2023. https://www.cmcc.ca/academic-programs/curriculum-by-year
30. Northwestern Health Sciences University. Chiropractic School and Doctor of Chiropractic Degree. Accessed December 1, 2023. https://www.nwhealth.edu/academics/chiropractic/
31. Canadian Memorial Chiropractic College. Application for expedited renewal of ministerial consent: Doctor of Chiropractic (DC) degree. Accessed December 5, 2023. https://www.peqab.ca/Private/CMCC/CMCC%20Program%20Abstract%20and%20Course%20Schedule%20FOR%20WEB.pdf
32. Temerty Faculty of Medicine. Physical Therapy University of Toronto Curriculum. Accessed December 5, 2023. https://www.physicaltherapy.utoronto.ca/curriculum-0
33. Physiotherapy Canada. Core Standards of Practice for Physiotherapists in Canada - Updated November 2020. Accessed December 4, 2023. https://scpt.in1touch.org/uploaded/web/Core%20Standards%20of%20Practice%20-%20Updated%20Nov%202020.pdf
34. Cote P, Yu H, Shearer HM, *et al*. Non-pharmacological management of persistent headaches associated with neck pain: a clinical practice guideline from the Ontario protocol for traffic injury management (OPTIMa) collaboration. Eur J Pain. 2019;23(6): 1051-1070. doi:10.1002/ejp.1374
35. Cote P, Wong JJ, Sutton D, *et al*. Management of neck pain and associated disorders: a clinical practice guideline from the Ontario Protocol for Traffic Injury Management (OPTIMa) Collaboration. Eur Spine J. 2016;25(7): 2000-2022. doi:10.1007/s00586-016-4467-7
36. Wong JJ, Cote P, Sutton DA, *et al*. Clinical practice guidelines for the noninvasive management of low back pain: a systematic review by the Ontario Protocol for Traffic Injury Management (OPTIMa) Collaboration. Eur J Pain. 2017;21(2): 201-216. doi:10.1002/ejp.931
37. Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. J Gen Intern Med. Sep 2001;16(9):606-13. doi:10.1046/j.1525-1497.2001.016009606.x
38. Spitzer RL, Kroenke K, Williams JB, Lowe B. A brief measure for assessing generalized anxiety disorder: the GAD-7. Arch Intern Med. May 22 2006;166(10):1092-7. doi:10.1001/archinte.166.10.1092
39. Blevins CA, Weathers FW, Davis MT, Witte TK, Domino JL. The Posttraumatic Stress Disorder Checklist for DSM-5 (PCL-5): Development and Initial Psychometric Evaluation. J Trauma Stress. Dec 2015;28(6):489-98. doi:10.1002/jts.22059
40. Government of Canada. Concussion: Symptoms and treatment. Accessed December 1, 2023. https://www.canada.ca/en/public-health/services/diseases/concussion-sign-symptoms.html#_Training_health_care
41. Ellis MJ, Bauman S, Cowle S, Fuselli P, Tator CH. Primary care management of concussion in Canada. Paediatr Child Health. 2019;24(3): 137-142. doi:10.1093/pch/pxy171
42. Impact. Role of athletic trainers for concussion care. Accessed December 1, 2023. https://impacttest.com/why-athletic-trainer-concussion-infographic/
43. American Physical Therapy Association. Physical therapy guide to concussion. Accessed December 1, 2023. https://www.choosept.com/guide/physical-therapy-guide-concussion
44. Temerty Faculty of Medicine. MD program University of Toronto. Accessed December 5, 2023. https://md.utoronto.ca/curriculum
45. Lawrence Bloomberg Facuulty of Nursing University of Toronto. Nurse Practitioners: Roles and Issues. Accessed December 5, 2023. https://bloomberg.nursing.utoronto.ca/class/nurse-practitioners-roles-and-issues/
46. Galbraith H, Quesnele J, Kenrick-Rochon S, Grenier S, Baldisera T. What are the knowledge, attitudes and beliefs regarding concussion of primary care physicians and family resident physicians in rural communities? J Concussion. 2020;0: 1-7.
47. Lebrun C, Mrazik M, Prasad A, Taylor T, Jevremovic T. Sport concussion knowledge base and current practice- a survey of physician sections from the Ontario Medical Association. Br J Sports Med. 2014;48(7): 623.
48. Itriyeva K, Feinstein R, Carmine L. Pediatric providers' attitudes and practices regarding concussion diagnosis and management. Int J Adolesc Med Health. 2017;31(6). doi:10.1515/ijamh-2017-0070
49. Mann A, Tator CH, Carson JD. Concussion diagnosis and management: knowledge and attitudes of family medicine residents. Can Fam Physician. 2017;63(6): 460-466.
50. Ly A, Zemek R, Wright B, *et al*. "What is the actual goal of the pathway?": examining emergency department physician and nurse perspectives on the implementation of a pediatric concussion pathway using the theoretical domains framework. BMC Health Serv Res. 2021;21(1): 119. doi:10.1186/s12913-021-06110-2

51. Kazemi M, Bogumil ME, Vora K. Concussion knowledge among sport chiropractic fellows from the Royal College of Chiropractic Sports Sciences (Canada). J Can Chiropr Assoc. 2017;61(3): 239-252.
52. Kazemi M, Deoraj KR, Hiemstra M, Santiago LK. Concussion knowledge among North American chiropractors. J Can Chiropr Assoc. 2021;65(3): 275-291.
53. Kazemi M, Pichini A, Scappaticci S, Savic M. Concussion assessment and management knowledge among chiropractic fourth year interns and residents. J Can Chiropr Assoc. 2016;60(4): 273-285.
54. Canadian Chiropractic Guideline Initiative. December 2, 2023. Accessed December 2, 2023. https://www.ccgi-research.com/condition-specific-guidance
55. Ontario Ministry of Tourism CaS. Rowan's Law: information for health care providers. Accessed December 2, 2023. https://www.ontario.ca/page/rowans-law-information-health-care-providers
56. Kontos AP, Jorgensen-Wagers K, Trbovich AM, *et al*. Association of time since injury to the first clinic visit with recovery following concussion. JAMA Neurol. 2020;77(4): 435-440. doi:10.1001/jamaneurol.2019.4552
57. Lalji R, Hincapie CA, Macpherson A, Howitt S, Marshall C, Tamim H. Association between first attempt Buffalo Concussion Treadmill Test and days to recovery in 855 children with sport-related concussion: a historical cohort study and prognostic factors analysis. Clin J Sport Med. 2023;33(5): 505-511. doi:10.1097/JSM.0000000000001134

ISSN 0008-3194 (p)/ISSN 1715-6181 (e)/2024/98–112/$2.00/©JCCA 2024

Exploration of chiropractic students' motivation toward the incorporation of new evidence on chiropractic maintenance care: a mixed methods study

Kent J. Stuber, DC, MSc, PhD[1,2]
Andreas Eklund, MSc(Chiro), PhD[3]
Katherine A. Pohlman, DC, MS, PhD[1]
Zakary Monier, MS, RD[1]
Ryan Muller, DC, MS[4,5]
Adam Browning, DC[1]
Christopher A. Malaya, DC, PhD[1]
Vanessa Morales, DC, MS[1]
Per J. Palmgren, DC, PhD[6]

Objectives: *This sequential explanatory mixed-method study aimed to explore chiropractic students' attitudes toward incorporating maintenance care (MC) focused evidence.*

Methods: *Attitudes towards using an evidence-based clinical protocol for maintenance care (MC), the MAINTAIN instrument, were assessed via surveys, monologue responses, dialogues, and qualitative feedback. Participants from a single chiropractic*

L'exploration de la motivation des étudiants en chiropratique en vue de l'incorporation de nouvelles preuves sur les soins de chiropratique d'entretien: une étude sur les méthodes mixtes

Objectifs: *Cette étude explicative séquentielle de méthode mixte visait à explorer les attitudes des élèves en chiropratique à l'égard de l'intégration des soins d'entretien (SE).*

Méthodes: *Les attitudes à l'égard de l'utilisation d'un protocole clinique fondé sur des données probantes pour les soins d'entretien (SE), l'instrument d'ENTRETIEN, ont été évaluées au moyen d'enquêtes, de réponses monologues, de dialogues et de commentaires qualitatifs. Les participants d'un seul établissement d'enseignement chiropratique ont rempli des questionnaires évaluant leur point de vue sur la centralité du patient, la douleur chronique et l'incorporation de données probantes.*

[1] Parker University, Dallas, TX
[2] Canadian Memorial Chiropractic College, Toronto, ON
[3] Institute of Environmental Medicine, Unit of Intervention and Implementation Research for Worker Health, Karolinska Institutet, Stockholm, Sweden
[4] Pain Research, Informatics, Multi-morbidities, and Education Center, VA Connecticut Healthcare System, West Haven, Connecticut, USA.
[5] Department of Biomedical Informatics and Data Science, Yale School of Medicine, New Haven, Connecticut, USA.
[6] Department of Learning, Informatics, Management and Ethics, Karolinska Institutet, Stockholm, Sweden

Corresponding author: Kent Stuber, Parker University, 2540 Walnut Hill Lane, Dallas, TX 75229
E-mail: kentstuber@parker.edu

The authors have no disclaimers, competing interests, or sources of support or funding to report in the preparation of this manuscript.

educational institution completed questionnaires evaluating their perspectives on patient-centeredness, chronic pain, and evidence incorporation. Descriptive statistics summarized quantitative data, while content analysis was used for qualitative data.

Results: *74.4% (n=419) of students participated, mostly male (57.5%), with an average GPA of 3.15 (out of a maximum of 4.0). Qualitative analysis identified the need to clarify MC terminology and factors motivating students to adopt new evidence, such as quality and alignment with healthcare beliefs.*

Conclusions: *This study's findings emphasize the importance of refining healthcare training strategies, including defining terminology and addressing motivators for evidence incorporation, as evidence for MC for low back pain evolves.*

(JCCA. 2024;68(2):98-112)

KEY WORDS: chiropractic, evidence-based practice, maintenance care, mixed methods, students

Les statistiques descriptives ont résumé les données quantitatives, tandis que l'analyse du contenu a servi à recueillir des données qualitatives.

Résultats: *74,4 % (n=419) des étudiants ont participé à l'étude, principalement des hommes (57,5 %), avec une moyenne de 3,15 (sur un maximum de 4,0). L'analyse qualitative a permis de déterminer la nécessité de clarifier la terminologie des SE et des facteurs qui incitent les élèves à adopter de nouvelles données probantes, comme la qualité et l'harmonisation avec les croyances en matière de soins de santé.*

Conclusions: *Les conclusions de cette étude soulignent l'importance de peaufiner les stratégies de formation en soins de santé, notamment en définissant la terminologie et en répondant aux motivations pour l'incorporation de données probantes, à mesure que les preuves concernant les SE pour les lombalgies évoluent.*

(JCCA. 2024; 68(2) : 98-112)

MOTS CLÉS : chiropratique, pratique fondée sur des données probantes, soins d'entretien, méthodes mixtes, étudiants

Introduction

Management of low back pain (LBP) represents an important clinical challenge. LBP is highly prevalent globally and results in more years lived with disability than any other condition.[1] While some cases of LBP have a favorable natural history, up to two-thirds of people experiencing LBP will have a recurrent episode within 12 months of recovery.[2] Given the prevalence and burden of LBP globally and that much of the LBP burden is a result of recurrences, the research community has communicated a call for a focus on secondary and tertiary prevention.[3]

Chiropractic Maintenance Care (MC) includes assessing and treating patients at regular pre-planned intervals when maximum treatment benefit has been reached from an initial care plan, regardless of symptoms, to prevent future episodes and progression of conditions.[4-6] Although MC has yet to be adequately substantiated by empirical inquiries, traditionally, it has been employed as a long-term management strategy for a wide range of musculoskeletal disorders such as LBP. Considering this scarcity of knowledge, recent inquiry into the effectiveness of MC has demonstrated a net positive effect of MC compared to symptom-based treatment only, noted as a decrease in total number of days with bothersome pain over 52 weeks, albeit with more treatment visits involved on average.[7] Eklund *et al*.[7] investigated the effectiveness of maintenance care for patients with recurrent and persistent low back pain in a pragmatic randomized clinical trial (RCT). In their trial, patients were scheduled for preplanned visits of one-to-three month intervals based on the chiropractor's clinical assessment to either maintain functional status in persistent cases (tertiary prevention) or reduce the recurrence of pain in recurrent cases (secondary prevention). A secondary analysis of this investigation revealed that psychological profiles, as defined by the West Haven-Yale Multidimensional Pain Inventory (WHYMP), adaptive copers, interpersonally distressed, and dysfunctional (see Box 1 for definitions), moderated the effect of maintenance care.8 It was reported that maintenance care increased pain and the number of visits for adaptive copers, suggesting that maintenance care is inappropriate for this subgroup.[8] Interpersonally dis-

Box 1.

West Haven-Yale Multidimensional Pain Inventory (WHYMP) psychological profiles as employed by Eklund et al.[8]

- Adaptive Copers – "low pain severity, low interference with everyday life, low life distress, a high activity level and a high perception of life control"[8];
- Dysfunctional – "high pain severity, marked interference with everyday life, high affective distress, low perception of life control and low activity levels"[8].
- Interpersonally Distressed – "perceive negative responses by spouses or significant others to their pain behavior and complaints, for example not being supportive/helpful, and expressing irritation, frustration, and anger"[8];

tressed patients experienced no additional effect from MC but received slightly more visits.[8] Patients classified as dysfunctional experienced an average of 30.0 (95% CI: 36.6, 23.4) fewer days with activity-limiting pain over a 12-month period, longer pain-free periods, and less acute flareups compared to the control group at an equal number of visits.[8]

The MAINTAIN instrument is a brief clinical assessment tool that trichotomizes patients into "low probability," "moderate probability," and "high probability" of benefiting from maintenance care for LBP. The MAINTAIN instrument has exhibited very good to excellent diagnostic accuracy for selecting patients classified as dysfunctional by the WHYMP in a clinical setting.[9] It allows for identifying high-risk patients early in a plan of care and subsequent stratification of these patients into appropriate interventions. In addition, enhanced prognostic ability allows providers to improve efficiency by treating those who will receive benefits, not those who will not, and potentially reducing individual and community financial burden for chronic non-specific LBP through improved productivity and attendance at work.

Implementing the MAINTAIN instrument into clinical practice may improve patient outcomes and reduce societal costs. However, evidence shows that knowledge gleaned from research findings needs to be better integrated into clinical practice.[10-12] While chiropractors report positive attitudes and interest in evidence-based practice (EBP), there is evidence that many do not use research evidence to guide their clinical decision-making processes[13], similar to other healthcare professions[14].

As findings from research are often not used by clinicians in practice, one strategy is incorporating new evidence into students' clinical rotations. Teaching the principles of EBP is essential in clinician training programs, especially during clinical rotations.[15,16] Swain *et al*.[17] demonstrated that half of chiropractic students value contemporary scientific evidence more than traditional chiropractic principles. Presently, we know little about chiropractic students' attitudes and beliefs towards maintenance care. Exploring students' perceptions regarding the concept of maintenance care and attitudes towards incorporating new evidence on maintenance care may be beneficial in helping researchers and policymakers understand how to facilitate the best implementation of the MAINTAIN instrument, and research in general, into clinical practice.

Therefore, the aim of this study was to explore chiropractic students' attitudes towards incorporating evidence on chiropractic maintenance care. Specifically, the research questions posed were:

1. Is there a relationship between student attitudes toward patient-centeredness, functional expectations of LBP, and their evidence-based practice perspectives?
2. How do students perceive the concept of chiropractic maintenance care?
3. What prompts students to incorporate new evidence on chiropractic maintenance care?

Methods

Study design

This study used a two-phased sequential explanatory mixed methods design that began with collecting and analyzing quantitative data, followed by a qualitative data collection and analysis phase (please see Figure 1 for a study diagram). Subsequently, the data from both phases were integrated to enhance our understanding of the findings. A sequential explanatory mixed methods design with a quantitative priority was selected as it allowed the qualitative data to help provide a deeper understanding and a contextualization of the findings generated from the quantitative data.[18]

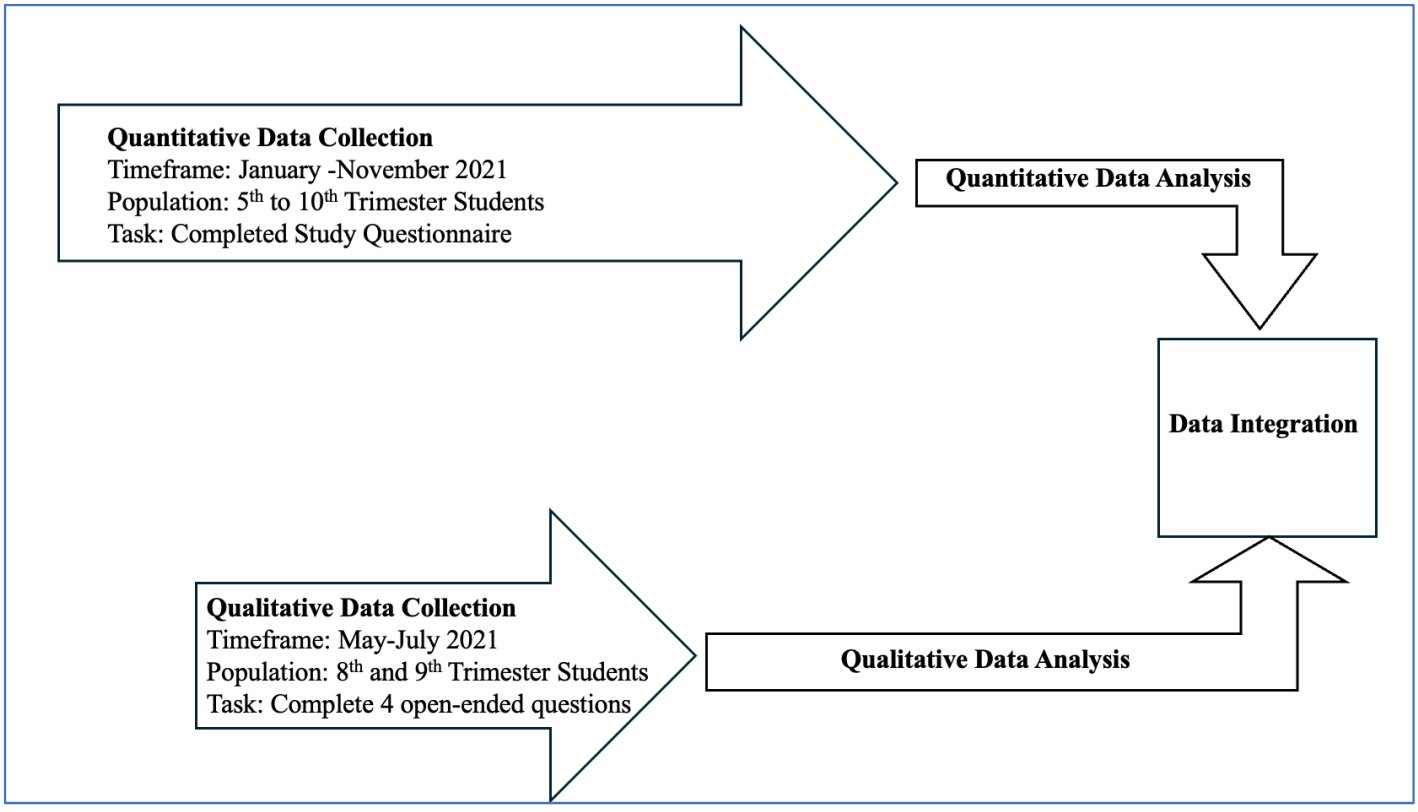

Figure 1.
Study flow diagram

Parker University's Institutional Review Board approved this study's quantitative and qualitative dimensions respectively (Assurance Numbers A-00219 and A-00220). Before data collection, participants were asked to read and sign a consent form for their participation in the study. The consent form also permitted the data to be further utilized for invitations to participate in the qualitative phase of the study. The study was conducted within an interpretative paradigm, assuming that knowledge is situated, relative, and socially constructed. The study's findings are viewed as being shaped during the interaction between the researchers and participants and do not reflect an objective truth.[19] This mixed methods study adhered to the Good Reporting of A Mixed Methods Study (GRAMMS) guidelines (see Appendix 1).[20]

Empirical context

The setting of the study was a 3.3-year graduate Doctor of Chiropractic program (DCP) at Parker University (Dallas, TX, USA). The DCP consists of 10 trimesters, each approximately four months long.

Sample

A non-probability convenience sample of chiropractic students in their fifth to tenth trimester was invited to participate in the quantitative phase of the study using in-person presentations with an invitation to the online survey. Students in those trimesters were considered most suitable as they would at that point have learned about different forms of care, including maintenance care, in their education at the University. Follow-up e-mails were sent to all qualified students at two-day intervals for a maximum of five attempts to maximize student responses. In the qualitative phase, between May and July 2021, a purposeful sample of students in their eighth and ninth trimesters were invited to contribute. Students in these trimesters were selected as they are the first and second terms of the clinical rotation/internship. These students have provided

patient care and would potentially be able to provide more insight into the topics explored in the qualitative phase.

Quantitative data collection

The study questionnaire consisted of demographic questions such as gender, prior education, and self-reported grade point average (GPA), along with the scale of evidence perspectives (SoEP) developed by McGregor *et al*.[21] (2014), the Patient-Practitioner Orientation Scale (PPOS)[22] to assess attitudes toward patient-centeredness, and the Health Care Providers' Pain and Impairment Relationship Scale (HC-PAIRS)[23] to assess attitudes towards chronic pain patients. We hypothesized that higher PPOS scores, thus, more patient-centered attitudes, would correlate with lower HC-PAIRS scores and more evidence-based perspectives. The questionnaire was accessible via QR code distributed by invitations extended to students through e-mail and live presentations between January and November 2021 using the Research Electronic Data Capture (REDCap) data management software.[24,25]

McGregor *et al*.[21] developed and validated the SoEP to elicit divergent perspectives held by chiropractors and categorized chiropractors into six possible subgroups (see Box 2) based on their perceptions of the conditions they treat. The SoEP measures the single question: "Which ONE of the following best describes the predominant view you have of the conditions you treat/you will treat?"

Box 2.

Chiropractic subgroups as defined in the Scale of Evidence Perspectives (SoEP) by McGregor et al.[21]

- (1 - most evidence-based perspective) Biomechanical- "I treat/will treat musculoskeletal or neuromusculoskeletal problems and may include specific disorders such as low back and neck-related pain";
- (2) General Problem/Biomechanical- "I treat/will treat a combination of general problems and biomechanical group complaints";
- (3) Biomechanical/Organic Visceral– "I treat/will treat a combination of biomechanical group and organic/visceral complaints";
- (4) General Problems- "I treat/will treat the broadest spectrum of health concerns, and may include lifestyle and wellness issues";
- (5) Somatic Dysfunction- "I treat/will treat vertebral subluxation as a somatic joint dysfunction and/or related to functional or musculoskeletal problems";
- (6 - least evidence-based perspective) Vertebral Subluxation- "I treat/will treat vertebral subluxation as an encumbrance to the expression of health – vertebral subluxation is seen as an entity in and of itself, which is corrected to benefit patient well-being."

The Patient-Practitioner Orientation Scale (PPOS) is an 18-item, self-administered, closed-ended inventory relating to various topics directly pertinent to attitudes toward patient-centeredness and the doctor-patient relationship.[22] Each item is scored by respondents using a six-point Likert response ranging from "strongly agree" = 1 to "strongly disagree" = 6. The values from all the items are averaged to determine the Overall PPOS score.[22] Higher Overall PPOS scores indicate more patient-centered attitudes, while lower scores indicate more doctor-centered attitudes. Krupat *et al*.[22] previously described respondents holding patient-centered attitudes when PPOS scores were greater than 5.0, medium when scores were between 4.57 and 5.0, and doctor-centered when scores for 4.57 or lower. The validity of the PPOS has been supported by Shaw *et al*.[26], who showed that healthcare practitioners whose encounters with patients devoted more attention to lifestyle issues and rapport building and less to biomedical matters had more patient-centered views on the PPOS when compared with other practitioners whose encounters with patients did not demonstrate those characteristics.

The HC-PAIRS is a 15-item measurement tool developed to assess healthcare providers' attitudes, beliefs, and understanding regarding functional expectations for patients with chronic low back pain (CLBP).[23] The HC-PAIRS uses a seven-point rating response (1=completely disagree; 7=completely agree) with higher scores indicating a greater belief that CLBP justifies disability and

the limiting of activities.[27] The internal consistency of the HC-PAIRS has routinely been measured at acceptable levels with Cronbach's alpha ranging between 0.69-0.92 and demonstrating acceptable test-retest reliability, construct validity, and criterion validity.[23,28-32]

Qualitative data collection

We developed a survey that consisted of four open-ended, reflective questions. The authors developed reflective questions based on the research questions. Specifically, student comprehension of maintenance care and other types of care was explored by asking how they would select patients for active care, maintenance care, and wellness care. There were no prompts or definitions of those different types of care were provided. Additionally, there was a question that explored what motivates students to incorporate new evidence into patient care plans as follows:

1. How would you select a patient for active care?
2. How would you select a patient for maintenance care?
3. How would you select a patient for wellness care?
4. What would motivate you to incorporate new evidence on how you select a patient for a care plan?

The open-ended questions were sent to participants via a text message or e-mail with a link to a REDCap data collection form. The reflective question responses were linked to the student's initial quantitative questionnaire results.[24,25] We did not provide participants with definitions of active, maintenance, or wellness care. Thus, their understanding would be based on information gleaned from previous coursework, that learned during their clinical rotations, and external sources of information such as the scientific literature or personal experiences with those forms of care.

Analysis

Descriptive statistics were reported for the demographic data, SoEP, PPOS, and HC-PAIRS. A Spearman's correlation was conducted to assess the strength of the relationships between the three scales because of the non-parametric findings. Survey scores were treated as ordinal variables. Non-parametric difference comparisons were conducted using the Mann-Whitney U test to assess if the differences between groups on the SoEP were significant. A Bonferroni-adjustment was included in the calculation to account for the increased possibility of type -I error due to multiple tests.

Qualitative data were analyzed using an inductive approach to conventional qualitative content analysis guided primarily by the method outlined by Graneheim and Lundman.[33,34] Responses to the open-ended questions were initially entered into tables for review in Microsoft Excel. The responses were individually reviewed line by line several times by multiple team members (KS, ZM, KAP). Two team members (KS, ZM) individually generated codes *de novo* for the responses. KS is a health professional with experience in mixed methods research, qualitative data analysis, and coding, while ZM is a health professional with a graduate degree. The team members met on numerous occasions to establish a coding tree and determine a coding agreement. A third team member (KAP) was available to resolve differences if needed, while a fourth team member (PP), an experienced qualitative researcher, provided oversight, advice, and guidance to the analysis. We identified frequently used codes and significant sentences. Central concepts were inductively grouped into emerging themes through manifest content analysis33 using an iterative process of going back and forth among the responses, significant sentences, and themes. Throughout the analytical process, constant comparisons between the categories and the original data transcripts were made to ensure a good fit between the data and the findings. Consequently, as described by Patton[35], there was attentive devotion toward internal homogeneity and external heterogeneity. To further consolidate the analysis, frequent debriefing sessions among all investigators ensued throughout the process.

Data integration

To integrate quantitative and qualitative data and determine coherence between instrument scores related to student understanding of maintenance care and barriers and facilitators towards incorporating new evidence, the qualitative data coding results were contrasted against the Evidence Perspective Scale, PPOS, and HC-PAIRS scores. Upon finalizing the qualitative data analysis, one team member (KS) searched for patterns of code distribution among participants with higher and lower PPOS and HC-PAIRS scores, respectively, as well as among those distributed to the different chiropractic subgroups described by McGregor *et al*.[21] Where such coding patterns

were identified, representative quotes were extracted into a joint display. Other team members (ZM, KP, AE, PP) reviewed these findings with additional discussion to resolve differences when necessary.

Results

Quantitative questionnaire

The quantitative questionnaire was completed by 74.4% of all students in their fifth to tenth trimester (n=419/563). The response rate by trimester ranged from 53.1% to 90.3%. Table 1 displays the response rates and descriptive data for participants' characteristics and questionnaire findings by trimester. The majority of students previously received a Bachelor's degree (84.5%, trimester range: 82.4%-88.5%), were male (57.5%, trimester range: 50.4%-70.6%), and had a mean self-reported grade point average (GPA) of 3.15/4.0 (SD: 0.369, trimester range: 3.06-3.26).

Table 1.

Descriptive data for student participant demographics and quantitative and qualitative questionnaires.

	Trimester 5 (n=117)	**Trimester 6 (n=65)**	**Trimester 7 (n=65)**	**Trimester 8 (n=69)**	**Trimester 9 (n=52)**	**Trimester 10 (n=51)**	**TOTAL (n=419)**
Quantitative response rate (%)	88.6%	90.3%	76.5%	53.1%	68.4%	75.0%	74.4%
Qualitative response rate (%)	-	-	-	53.1%	76.5%	-	-
Gender-female, n (%)	58 (49.6%)	27 (41.5%)	30 (46.2%)	31 (44.9%)	17 (32.7%)	15 (29.4%)	178 (42.5%)
Bachelor's degree received, n (%)	97 (82.9%)	56 (86.2%)	55 (84.6%)	58 (84.1%)	46 (88.5%)	42 (82.4%)	354 (84.5%)
GPA, mean (SD)	3.26 (0.32)	3.11 (0.37)	3.06 (0.33)	3.16 (0.39)	3.06 (0.41)	3.12 (0.40)	3.15 (0.37)
Evidence Perspective Scale (SoEP), n (%)							
1 - Biomechanical	26 (22.2%)	27 (41.5%)	19 (29.2%)	27 (39.1%)	17 (32.7%)	24 (47.1%)	140 (33.4%)
2 - General Problem/ Biomechanical*	6 (5.1%)	3 (4.6%)	2 (3.1%)	3 (4.4%)	1 (1.9%)	3 (5.9%)	18 (4.3%)
3 - Biomechanical/ Organic Visceral*	2 (1.7%)	1 (1.5%)	1 (1.5%)	1 (1.5%)	1 (1.9%)	0	6 (1.4%)
4 - General Problems	37 (31.6%)	17 (26.2%)	19 (29.2%)	13 (18.8%)	16 (30.8%)	8 (15.7%)	110 (26.3%)
5 - Somatic Dysfunction	11 (9.4%)	10 (15.4%)	9 (13.9%)	8 (11.6%)	7 (13.5%)	4 (7.8%)	49 (11.7%)
6 - Vertebral Subluxation	35 (29.9%)	7 (10.8%)	15 (23.1%	17 (24.6%)	10 (19.2%)	12 (23.5%)	96 (22.9%)
Patient-Practitioner Orientation Scale – PPOS (1-6; high score desired), mean (SD)							
Overall PPOS	3.99 (0.549)	3.97 (0.621)	4.03 (0.557)	3.88 (0.496)	3.88 (0.650)	3.74 (0.586)	3.93 (0.578)
Health Care Providers' Pain and Impairment Relationship Scale - HC-PAIRS (1-7; low score desired), mean (SD)							
Overall HC-PAIRS	4.36 (0.785)	4.21 (0.680)	4.30 (0.698)	4.11 (0.633)	3.94 (0.687)	3.98 (0.666)	4.19 (0.718)
HC-PAIRS Factor 1 (Functional Expectations)	4.22 (0.928)	4.05 (0.822)	4.03 (0.886)	3.92 (0.729)	3.82 (0.799)	3.80 (0.796)	4.01 (0.850)
HC-PAIRS Factor 2 (Social Expectations)	3.86 (0.878)	3.76 (0.779)	3.77 (0.864)	3.65 (0.788)	3.23 (0.922)	3.69 (0.803)	3.71 (0.852)

	Trimester 5 (n=117)	Trimester 6 (n=65)	Trimester 7 (n=65)	Trimester 8 (n=69)	Trimester 9 (n=52)	Trimester 10 (n=51)	TOTAL (n=419)
HC-PAIRS Factor 3 (Need for Cure)	4.29 (1.191)	4.19 (1.163)	4.38 (1.070)	4.08 (1.059)	3.62 (1.237)	3.71 (1.143)	4.09 (1.171)
HC-PAIRS Factor 4 (Projected Cognition)	5.47 (1.007)	5.37 (0.954)	5.63 (0.796)	5.26 (1.043)	5.33 (1.119)	5.24 (0.965)	5.40 (0.989)

*- Combined subgroups for analysis because of small individual cell sizes.
Legend: HC-PAIRS- Health Care Providers' Pain and Impairment Relationship Scale; PPOS- Patient-Practitioner Orientation Scale

As shown in Table 2, differences between the PPOS and HC-PAIRS survey by the SoEP were small and only statistically significant for HC-PAIRS (p=0.03), albeit likely not clinically meaningful. No statistically significant correlations between any of the questionnaires were found (p>0.113), as shown in Table 3.

Table 2.
PPOS and HC-PAIRS scores (n, median, Interquartile Range) based on SoEP.

	1 – Biomechanical	2 and 3 – General Problem/ Biomechanical/ Organic Visceral	4 – General Problems	5 – Somatic Dysfunction	6 – Vertebral Subluxation
Overall PPOS (1-6; high score desired)	n=126 3.89 (3.56-4.28)	n=20 4.03 (3.56-4.50)	n=104 4.00 (3.75-4.39)	n=40 3.89 (3.58-4.22)	n=79 4.11 (3.67-4.33)
Overall HC-PAIRS (1-7; low score desired)**	n=119 4.00 (3.60-4.47)	n=23 4.13 (3.87-4.93)	n=96 4.40 (3.90-4.77)	n=40 4.17 (3.87-4.73)	n=92 4.13 (3.67-4.60)

** - Statistically significant difference
Legend: HC-PAIRS- Health Care Providers' Pain and Impairment Relationship Scale; PPOS- Patient-Practitioner Orientation Scale

Table 3.
Correlation between quantitative questionnaires (rho, n, p-value).

	PPOS	HC-PAIRS	SoEP
PPOS	1.00 n=369 -		
HC-PAIRS	-0.02 n=334 0.732	1.00 n=370 -	
SoEP	0.08 n=369 0.159	0.08 n=370 0.121	1.00 n=419 -

Qualitative questionnaire findings

The qualitative questionnaire was completed by students in their eighth and ninth trimesters; 134 of the 215 eligible students responded (62.3%), with 69 students in their first clinical term (53.1%) and 65 in their second term (76.5%). Most of these respondents were males (n=71, 53.0%) with an average self-reported GPA of 3.1/4.0.

Student understanding of chiropractic maintenance care (MC)

We identified two themes during the content analysis of student responses to the open-ended reflective questions regarding their understanding of how to select patients for MC and how they relate to higher and lower PPOS and HC-PAIRS scores, respectively (see Figure 2 for a joint display depicting representative quotes). There was no pattern of responses identified among different SoEP categories and how they select patients for MC, partially because some of the EBP categories were under-represented among students.

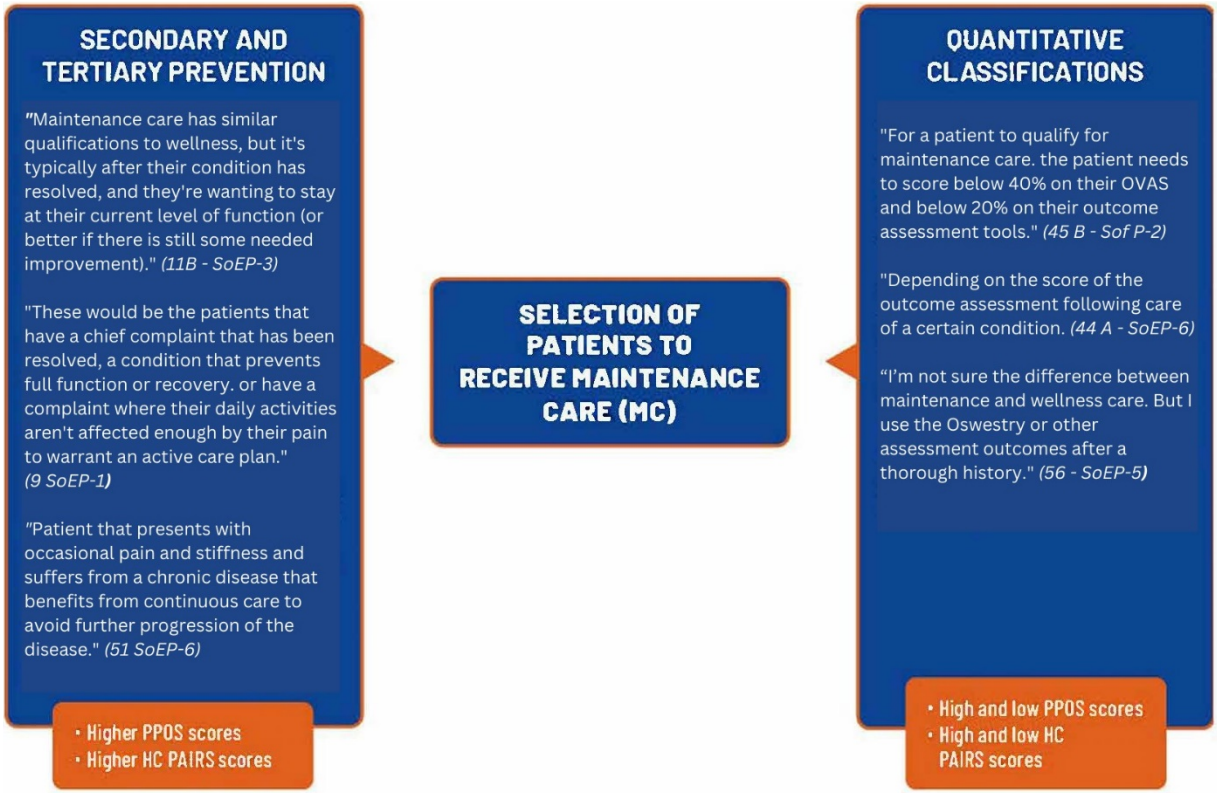

Figure 2.

Joint display depicting themes identified from student responses to open-ended reflective questions regarding how they select patients to receive Maintenance Care (MC) and their relationships with PPOS and HC-PAIRS scores.

The first theme identified was "Secondary and tertiary prevention." This theme related to students describing maintenance care as best suited to patients with no or minimal symptoms or trying to prevent the progression or recurrence of a condition. Respondents indicated that some patients would benefit from maintenance care to continue improvement of their function and overall health, prevent symptom recurrence, and other patients may express a preference for or elect to receive maintenance care. Responses coded under this theme were frequently provided by students with more patient-centered attitudes (higher PPOS scores) and students with lower functional expectations (higher HC-PAIRS scores).

The second theme identified was "Quantitative classifications," and it was related to students determining that MC was appropriate in response to patient scores on quantitative outcome measures performed during patient assessments. Responses to how students would select patients for 'active', 'maintenance', or 'wellness' care were frequently based on patient scores from paper-based outcome measures completed during patient intake, such as the Visual Analog Pain Scale (QVAS or Quadruple Visual

Analog Scale) and the Oswestry Disability Questionnaire. Responses coded under this theme were frequently provided by students with scores at both extremes of PPOS and HC-PAIRS scores. In selecting patients for 'active' care, respondents also articulated one or several other clinical elements, such as a patient's subjective presentation, ability to complete their activities of daily living, presence of any functional limitations, or examination findings.

> *"Depending on how much their complaint affects their activities of daily living and what is scored on the QVAS." - (36T8)*

For 'maintenance' care, respondents stated they selected patients who improved past 'active' care.

> *"These would be the patients that have a chief complaint that has been resolved, a condition that prevents full function or recovery, or have a complaint where their daily activities aren't affected enough by their pain to warrant an active care plan. Outcome assessments would play an equally important role in determining maintenance care, as in active care." - (9QO)*

'Wellness' care patients were commonly selected using the same criteria as 'maintenance' care. Respondents pointed to "Wellness Care" for patients with no or minimal symptoms. Some students mentioned it was challenging to articulate the difference between maintenance and wellness care.

> *"I consider maintenance and wellness very similar and would use "wellness" as a term to describe patients with no complaints and good function overall wanting to prevent issues in the future." - (38T8)*

Motivation for incorporating new evidence

We identified four themes during the content analysis of student responses to the open-ended reflective question regarding what motivates them to incorporate new evidence when they select a care plan for a patient and how they relate to higher and lower PPOS and HC-PAIRS scores, respectively (see Figure 3 for a joint display depicting representative quotes). Again, no pattern of responses was identified among different SoEP categories or motivators for incorporating new evidence when selecting patients for a care plan.

The first theme was "Modern, high-quality evidence," which related to students' motivation to incorporate new evidence into practice when selecting patients for care plans if that evidence was contemporary and notably if it demonstrated internal validity and supporting studies were well-conducted and readily available to them. Responses coded under this theme were frequently provided by students with more patient-centered attitudes (higher PPOS scores) and those with both extremes of HC-PAIRS scores.

The second theme was "Improved outcomes," which related to students' motivation to incorporate new evidence when selecting patients for care plans if it increased the likelihood of improved patient outcomes. Responses coded under this theme were frequently provided by students with more patient-centered attitudes (higher PPOS scores) and those with lower functional expectations (higher HC-PAIRS scores).

The third theme was "Categorizing patients and quantifying findings," which related to students' motivation to incorporate new evidence if it allowed them to determine how patients responded to care and aligned with other outcome measures and could aid with making care decisions. Responses coded under this theme were frequently provided by students with more doctor-centered attitudes (lower PPOS scores).

The fourth theme was "Healthcare beliefs," which related to students' motivation to incorporate new evidence if it aligned with their healthcare views, specifically their approach to providing chiropractic care. Responses coded under this theme were frequently provided by students with higher functional expectations (lower HC-PAIRS scores).

Discussion

This study explored chiropractic students' attitudes towards incorporating evidence on chiropractic maintenance care. Advancements in scientific research can offer new knowledge and patient care techniques that can help clinicians offer the best possible care. Nevertheless, new findings are not always adopted by practicing clinicians

Figure 3.

Joint display depicting themes identified from student responses to open-ended reflective questions regarding what motivates them to incorporate new evidence for selecting patients for care plans and their relationships with PPOS and HC-PAIRS scores.

and attempts to bridge this gap present an ongoing challenge for many clinical professions. Teaching practicing clinicians how to incorporate new evidence could start while they are still students.

In our quantitative exploration of student attitudes, we did not identify any association between final-year chiropractic students' attitudes toward patient-centredness, functional expectations for patients with chronic LBP, and evidence-based practice perspectives. Additionally, this study's qualitative data revealed that while the concept of chiropractic MC could hold multiple definitions for chiropractic students, they would be motivated to incorporate chiropractic MC evidence that was new and high-quality, could be used to improve patient outcomes, helps them categorize patients and quantify their response to care, and aligns with their healthcare beliefs.

Overall, the students had more doctor-centered attitudes towards care based on the PPOS scores, had lower functional expectations of patients with chronic pain based on the HC-PAIRS scores, and espoused a wide range of evidence-based practice perspectives. In a systematic review of patient-centered attitudes in healthcare students, Bejarano and colleagues[36] reported participants to be more doctor-centric, potentially because healthcare

students continually learn new information and may have limited time to focus on other aspects of patient care. This can be further supported by an educational empirical investigation that explored chiropractic students' knowledge, attitudes, and beliefs before and after one of three educational interventions focused on new academic information and one on patient-centeredness; the study found that studying the new academic information led to a decrease in patient-centeredness using the same PPOS instrument.[37]

As interdisciplinary healthcare is no longer an innovation but a way of life, understanding healthcare and public health terminology will ensure optimal interdisciplinary communication.[38,39] Our study found chiropractic students interpret and apply MC in two ways: based on prevention strategies or patient-centered outcomes. The students who portrayed MC as a prevention strategy described care plans based on the public health concepts of secondary (preventing reoccurrence of a previous condition that a patient recovered from) or tertiary (management of an ongoing chronic condition or disease) prevention strategies; however, the public health terms of secondary or tertiary prevention were not explicitly mentioned, indicating some potential for miscommunication with terminology. These findings are in line with previous research among experienced clinicians. In a systematic review it was reported that patients who had experienced previous episodes of low back pain and had improved with treatment were more likely to be recommended MC as a clinical strategy by their chiropractor.[40]

The MAINTAIN instrument was developed based on a clinical trial that collected data with WHYMP and patient-reported outcomes for pain and disability.[9] From these outcomes, the MAINTAIN classification group found a clinically significant correlation with patient-reported pain and disability.[8] In our study, some students described deciding on an MC treatment plan using quantitative patient-reported outcome measures to determine what care plan was best for their patients. However, they described that differentiating between patients who were eligible for different prevention strategies based on these outcomes was difficult. As such, training on psychological profiles found within a screening tool like the MAINTAIN instrument could assist with the better use of patient-reported outcome measures that optimize goal-setting and improve patient outcomes.[41,42]

Over the past 30 or more years there has been increasing integration of research person-centred healthcare.[43] In congruence, this study found several different identified motivators for incorporating new evidence when selecting care plans for patients. Among students with more patient-centered attitudes and lower functional expectations of chronic pain patients, one desire was to improve patient-reported outcomes. Conversely, students who had higher functional expectations of chronic pain patients were frequently described as being more motivated to incorporate new evidence if it aligned with their healthcare beliefs. Students with more doctor-centered attitudes often mentioned a desire to categorize patients and use outcome measures to gauge their progress. Finally, students with more patient-centered attitudes, as well as those with either higher or lower functional expectation of chronic pain patients, considered the quality of new evidence an important consideration before implementation of a new procedure.

Limitations

While this mixed method analysis gave a unique perspective into chiropractic students' motivation to incorporate new evidence, implications from this study should be viewed considering its limitations. Foremost, this was a cohort of students from a single educational institution. Completion of the initial quantitative questionnaire items, specifically any or all the SoEP, PPOS, and HC-PAIRS may have led to student reflection that could have influenced their responses to the subsequent qualitative questions. Additionally, while the quantitative survey had prior property measures conducted, the qualitative questions were not pilot tested. Within qualitative studies, pilot testing has been argued to provide more confidence in the interview schedules and methods used for data collection[44], which may be relevant to these study findings as some responses did not reflect comprehension of the questions. Our study also examined the qualitative data from a manifest rather than a latent angle. Therefore, it is possible that if other forms of analysis (e.g., Phenomenography or Grounded theory) would have been used or if data were looked at using other lenses (e.g., post-positivism), other concepts and/or latent notions could have surfaced. Nonetheless, the research team held recurrent discussions regarding preconceived assumptions while collecting, analyzing, and interpreting the qualitative data.

Future work

Several key findings from this study could assist healthcare educational institutions in considering strategies to motivate the use of these concepts by their students. Our study findings indicate that additional work is needed to determine the need for and content of tailored implementation strategies that will encourage students to incorporate new evidence into their future clinical interactions with patients. Our findings did not suggest one explicit implementation strategy, it is possible that multimodal implementation strategies may be more suitable. Implementation research in healthcare training settings is less advanced than in healthcare provision sectors.[45] Lessons learned in the healthcare provision sector could assist with implementation strategies in educational settings, such as tailored plans that are iteratively adapted as educational interventions are implemented. An example of a tailored program for educational settings is the School Implementation Strategies, Translating ERIC Resources (SISTER) project.[46] SISTER had educational experts adapt the Expert Recommendations for Implementing Change (ERIC) project to assist with implementation research specifically in school settings.

Conclusions

This study did not identify significant associations between chiropractic students' attitudes toward patient-centeredness, functional expectations of LBP, or their evidence-based practice perspectives. The concept of maintenance care was found to be unclear to participants and in need of an operational definition used throughout training programs. The exploration of chiropractic students' attitudes identified a desire to incorporate new evidence on chiropractic maintenance care if the evidence was high quality, aligned with their healthcare beliefs, or could affect patient management or outcomes. Emerging evidence for MC, including that on the development and use of the MAINTAIN tool, could prove useful in this regard as it meets several of these needs.

References

1. Murray CJ, Lopez AD. Measuring the global burden of disease. New Engl J Med. 2013;369(5): 448-457.
2. Da Silva T, Mills K, Brown BT, *et al*. Risk of recurrence of low back pain: a systematic review. J Orthopaed Sports Phys Ther. 2017;47(5): 305-313.
3. Foster NE, Anema JR, Cherkin D, *et al*.; Lancet Low Back Pain Series Working Group. Prevention and treatment of low back pain: evidence, challenges, and promising directions. Lancet. 2018;391(10137): 2368-2383. doi: 10.1016/S0140-6736(18)30489-6.
4. Breen AC. Chiropractors and the treatment of back pain. Rheumatol Rehabil. 1977;16(1): 46–53.
5. Mitchell M. Maintenance care. Some considerations. ACA J Chiropr. 1980;17: 53–55.
6. Rupert RL. A survey of practice patterns and the health promotion and prevention attitudes of US chiropractors. Maintenance care: part I. J Manip Physiol Ther. 2000;23(1): 1–9.
7. Eklund A, Jensen I, Lohela-Karlsson M, *et al*. The Nordic Maintenance Care program: effectiveness of chiropractic maintenance care versus symptom-guided treatment for recurrent and persistent low back pain—a pragmatic randomized controlled trial. PLoS ONE. 2018;13:1–20.
8. Eklund A, Hagberg J, Jensen I, *et al*. The Nordic maintenance care program: maintenance care reduces the number of days with pain in acute episodes and increases the length of pain free periods for dysfunctional patients with recurrent and persistent low back pain-a secondary analysis of a pragmatic randomized controlled trial. Chiropr Man Ther. 2020;28: 19.
9. Eklund A, Palmgren PJ, Jakobsson U, Axén I. Development and evaluation of the MAINTAIN instrument, selecting patients suitable for secondary or tertiary preventive manual care: the Nordic maintenance care program. Chiropr Man Ther. 2022;30(1): 15.
10. Grimshaw JM, Eccles MP, Lavis JN, Hill SJ, Squires JE. Knowledge translation of research findings. Implement Sci. 2012;7(1):1-7.
11. Grol R. Successes and failures in the implementation of evidence-based guidelines for clinical practice. Med Care. 2001: II46-54.
12. McGlynn EA, Asch SM, Adams J, Keesey J, Hicks J, DeCristofaro A, Kerr EA. The quality of health care delivered to adults in the United States. New Engl J Med. 2003;348(26): 2635-2645.
13. Bussières AE, Terhorst L, Leach M, Stuber K, Evans R, Schneider MJ. Self-reported attitudes, skills and use of evidence-based practice among Canadian doctors of chiropractic: a national survey. J Can Chiropr Assoc. 2015;59(4): 332-348.
14. Portela Dos Santos O, Melly P, Hilfiker R, *et al*. Effectiveness of educational interventions to increase skills in evidence-based practice among nurses: the EDITcare Systematic Review. Healthcare (Basel). 2022; 10(11): 2204. https://doi.org/10.3390/healthcare10112204
15. Radack KL, Valanis B. Teaching critical appraisal and application of medical literature to clinical problem-solving. Acad Med. 1986;61(4): 329-331.
16. Ferwana M, Al Alwan I, Moamary MA, Magzoub ME,

Tamim HM. Integration of evidence based medicine into the clinical years of a medical curriculum. J Fam Commun Med. 2012;19(2): 136.
17. Swain MS, Gliedt JA, de Luca K, Newell D, Holmes M. Chiropractic students' cognitive dissonance to statements about professional identity, role, setting and future: international perspectives from a secondary analysis of pooled data. Chiropr Man Ther. 2021;29(1).
18. Ivankova NV, Creswell JW, Stick SL. Using mixed-methods sequential explanatory design: from theory to practice. Field Methods. 2006; 18(1): 3–20. https://doi.org/10.1177/1525822X05282260
19. Watzlawick P, Bavelas JB, Jackson DD. Pragmatics of human communication: a study of interactional patterns, pathologies and paradoxes: WW Norton & Company; 2011.
20. O'Cathain A, Murphy E, Nicholl J. The quality of mixed methods studies in health services research. J Health Serv Res Policy. 2008;13(2): 92-98. doi: 10.1258/jhsrp.2007.007074.
21. McGregor M, Puhl AA, Reinhart C, Injeyan HS, Soave D. Differentiating intraprofessional attitudes toward paradigms in health care delivery among chiropractic factions: results from a randomly sampled survey. BMC Complement Altern Med. 2014;14:51. doi: 10.1186/1472-6882-14-51.
22. Krupat E, Rosenkran SL, Yeager CM, Barnar K, Putnam SM, Inui TS. The practice orientations of physicians and patients: the effect of doctor-patient congruence on satisfaction. Pat Educ Counsel. 2000; 39: 49-59.
23. Rainville J, Bagnall D, Phalen L. Health care providers' attitudes and beliefs about functional impairments and chronic back pain. Clin J Pain. 1995;11(4): 287-295. doi: 10.1097/00002508-199512000-00006.
24. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)--a metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform. 2009;42(2): 377-381. doi: 10.1016/j.jbi.2008.08.010. Epub 2008 Sep 30.
25. Harris PA, Taylor R, Minor BL, et al; REDCap Consortium. The REDCap consortium: building an international community of software platform partners. J Biomed Inform. 2019;95: 103208. doi: 10.1016/j.jbi.2019.103208.
26. Shaw WS, Woiszwillo MJ, Krupat E. Further validation of the Patient-Practitioner Orientation Scale (PPOS) from recorded visits for back pain. Patient Educ Couns. 2012;89(2): 288-291. doi: 10.1016/j.pec.2012.07.017.
27. Bishop A, Thomas E, Foster NE. Health care practitioners' attitudes and beliefs about low back pain: a systematic search and critical review of available measurement tools. Pain. 2007;132(1-2):91-101. doi: 10.1016/j.pain.2007.01.028.
28. Houben RM, Vlaeyen JW, Peters M, Ostelo RW, Wolters PM, Stomp-van den Berg SG. Health care providers' attitudes and beliefs towards common low back pain: factor structure and psychometric properties of the HC-PAIRS. Clin J Pain. 2004;20(1): 37-44. doi: 10.1097/00002508-200401000-00008.
29. Chen G, Tan BK, Jia HL, O'Sullivan P, Burnett A. Questionnaires to examine back pain beliefs held by health care professionals: a psychometric evaluation of Simplified Chinese versions. Spine. 2011;36(18): 1505-1511. doi: 10.1097/BRS.0b013e3181f49eec.
30. Domenech J, Sánchez-Zuriaga D, Segura-Ortí E, Espejo-Tort B, Lisón JF. Impact of biomedical and biopsychosocial training sessions on the attitudes, beliefs, and recommendations of health care providers about low back pain: a randomised clinical trial. Pain. 2011;152(11): 2557-2563. doi: 10.1016/j.pain.2011.07.023. 7.
31. Moran RW, Rushworth WM, Mason J. Investigation of four self-report instruments (FABT, TSK-HC, Back-PAQ, HC-PAIRS) to measure healthcare practitioners' attitudes and beliefs toward low back pain: reliability, convergent validity and survey of New Zealand osteopaths and manipulative physiotherapists. Musculoskelet Sci Pract. 2017;32: 44-50. doi: 10.1016/j.msksp.2017.08.008.
32. Roitenberg N. Translation and psychometric evaluation of the Hebrew version of the Health Care Providers' Pain and Impairment Relationship Scale. Physiother Res Int. 2019;24(1): e1759. doi: 10.1002/pri.1759.
33. Graneheim UH, Lundman B. Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness. Nurse Educ Today. 2004;24(2): 105-112. doi: 10.1016/j.nedt.2003.10.001.
34. Hsieh HF, Shannon SE. Three approaches to qualitative content analysis. Qual Health Res. 2005;15(9): 1277-1288. doi: 10.1177/1049732305276687.
35. Patton M. Qualitative Research and Evaluation Methods.3rd ed. Thousand Oaks, CA: Sage Publications; 2002.
36. Bejarano G, Csiernik B, Young JJ, Stuber K, Zadro JR. Healthcare students' attitudes towards patient centred care: a systematic review with meta-analysis. BMC Med Educ. 2022;22(1): 324. doi: 10.1186/s12909-022-03371-1.
37. Miller K, Boylan P, Mullen C, Randolph, Kettner N, Pohlman KA. Evaluation of chiropractic students' knowledge and attitudes following pain interventions: a randomized educational trial. J Chiropr Educ (under review).
38. Reeves S, Pelone F, Harrison R, Goldman J, Zwarenstein M. Interprofessional collaboration to improve professional practice and healthcare outcomes. Cochrane Database Syst Rev. 2017;6(6):CD000072.
39. O'Leary KJ, Buck R, Fligiel HM, *et al*. Structured interdisciplinary rounds in a medical teaching unit:

improving patient safety. Arch Int Med. 2011; 171(7): 678–684. https://doi.org/10.1001/archinternmed.2011.128
40. Axén I, Hestbaek L, Leboeuf-Yde C. Chiropractic maintenance care - what's new? A systematic review of the literature. Chiropr Man Therap. 2019; 27: 63.
41. Rao JK, Anderson LA, Inui TS, *et al*. Communication interventions make a difference in conversations between physicians and patients: a systematic review of the evidence. Med Care. 2007;45(4):340-349.
42. Hyland CJ, Mou D, Virji AZ, *et al*. How to make PROMs work: qualitative insights from leaders at United States hospitals with successful PROMs programs. Qual Life Res. 2023;32(8): 2259-2269. doi:10.1007/s11136-023-03388-z
43. Sacristán JA. Clinical research and medical care: towards effective and complete integration. BMC Med Res Methodol. 2015;15: 4. doi: 10.1186/1471-2288-15-4.
44. Malmqvist, J., Hellberg, K., Möllås, G., Rose, R., Shevlin, M. Conducting the pilot study: a neglected part of the research process? Methodological findings supporting the importance of piloting in qualitative research studies. International J Qual Method. 2019; 18. https://doi.org/10.1177/1609406919878341
45. Sanetti LMH, Charbonneau S, Knight A, Cochrane WS, Kulcyk MCM, Kraus KE. Treatment fidelity reporting in intervention outcome studies in the school psychology literature from 2009 to 2016. Psychol School. 2020;57: 901–922. doi: 10.1002/pits.22364.
46. Cook CR, Lyon AR, Locke J, Waltz T, Powell BJ. Adapting a compilation of implementation strategies to advance school-based implementation research and practice. Prev Sci. 2019;20(6): 914-935. doi: 10.1007/s11121-019-01017-1.

Appendix 1.
Good Reporting of A Mixed Methods Study (GRAMMS)20

GRAMMS item	**Location in Paper**
(1) Describe the justification for using a mixed methods approach to the research question	Methods section
(2) Describe the design in terms of the purpose, priority and sequence of methods	Methods section
(3) Describe each method in terms of sampling, data collection and analysis	Methods section
(4) Describe where integration has occurred, how it has occurred and who has participated in it	Methods section, Integration subsection
(5) Describe any limitation of one method associated with the presence of the other method	Discussion section, Limitations subsection
(6) Describe any insights gained from mixing or integrating methods	Discussion section

ISSN 0008-3194 (p)/ISSN 1715-6181 (e)/2024/113–121/$2.00/©JCCA 2024

Exploring strategies to improve clinical decision making in a chiropractic office: a case series

Joshua Plener, DC, MSc, FCCS(C)[1,2]
Demetry Assimakopoulos, DC[3]
Chadwick Chung, DC, FCCS(C)[1]
François Hains, DC, MSc, FCCS(C)[4]
Silvano Mior, DC, PhD, FCCS(C)[5-7]

Background: *Clinicians make clinical decisions using the dual process theory. The dual process theory comprises two approaches, System 1, based on heuristics, and System 2, involving an analytical and effortful thought process. However, there are inherent limitations to the dual process theory, such as relying on inaccurate memory or misinterpreting cues leading to inappropriate clinical management. As a result, clinicians may utilize mental shortcuts, termed heuristics, and be susceptible to clinical errors and biases that may lead to flawed decision making and diagnosis.*

Methods: *This case series describes four clinical cases whereby the clinicians use distinct strategies to assess and manage complex clinical presentations.*

Explorer des stratégies pour améliorer la prise de décision clinique dans un bureau chiropratique: une série de cas

Contexte: *Les cliniciens prennent des décisions cliniques en utilisant la théorie du double processus. La théorie du double processus comprend deux approches, le premier système qui est basé sur l'heuristique, et le deuxième système qui implique un processus de réflexion analytique et exigeant. Cependant, il existe des limites inhérentes à la théorie du double processus, telles que le fait de s'appuyer sur une mémoire inexacte ou une mauvaise interprétation des indices conduisant à une gestion clinique inappropriée. Par conséquent, les médecins peuvent utiliser des raccourcis mentaux, appelés heuristiques, et être susceptibles de tenir compte d'erreurs et de biais cliniques qui peuvent conduire à une mauvaise décision et à un mauvais diagnostic.*

Méthodes: *Cette série de cas décrit quatre cas cliniques où les cliniciens utilisent des stratégies distinctes pour évaluer et gérer des présentations cliniques complexes.*

[1] Department of Clinical Education, Canadian Memorial Chiropractic College, Toronto, ON
[2] Department of Medicine, Mount Sinai Hospital, Toronto, ON
[3] Private practice, Vaughan, ON
[4] Department of Chiropractic, Université du Québec à Trois-Rivières, Trois-Rivières, PQ
[5] Department of Research and Innovation, Canadian Memorial Chiropractic College, Toronto, ON
[6] Institute of Health Policy, Management and Evaluation, University of Toronto, Toronto, ON
[7] Institute for Disability and Rehabilitation Research, Oshawa, ON

Corresponding author: Joshua Plener, Canadian Memorial Chiropractic College, 6100 Leslie Street, Toronto, ON, M2H 3J1
Email: jplener@cmcc.ca
Tel: 416-482-2340

The authors have no disclaimers, competing interests, or sources of support or funding to report in the preparation of this manuscript. The involved patients provided consent for case publication.

Discussion: *Through the use of self-reflection and acknowledging diagnostic uncertainty, the clinicians were able to reduce common cognitive biases and provide effective and timely patient care. We discuss strategies that clinicians can implement in their daily practice to improve clinical decision-making processes and deliver quality care.*

(JCCA. 2024;68(2):113-121)

KEY WORDS: diagnosis, chiropractic, heuristics, clinical decision making, metacognition, bias

Discussion: *Grâce à l'autoréflexion et à la reconnaissance de l'incertitude diagnostique, les cliniciens ont pu réduire les biais cognitifs courants et fournir des soins efficaces et opportuns aux patients. Nous discutons des stratégies que les cliniciens peuvent mettre en œuvre dans leur pratique quotidienne pour améliorer les processus de prise de décision clinique et fournir des soins de qualité.*

(JCCA. 2024; 68(2) : 113-121)

MOTS CLÉS : diagnostic, chiropratique, heuristique, prise de décision clinique, métacognition, biais

Introduction

In making clinical decisions, clinicians typically gather patient information, generate hypotheses about their diagnosis, test their hypotheses, and then reflect on their clinical encounter.[1,2] Broadly, clinicians diagnose patients using the dual process theory that is comprised of two systems, System 1 and System 2. A System 1 approach is characterized by clinicians using a more automatic response that relies on heuristics and develops with greater clinical experience and repetition.[1,3] Due to time constraints in practice, clinicians often prefer a System 1 approach. In contrast, System 2 takes on a more analytical approach, where the clinician uses slower and more effortful thought processes; one often used by those with limited clinical experience or knowledge of a condition.[1,3,4]

However, the dual process theory has inherent limitations. System 1 is built on heuristics, and relies on a clinician's memory to recognize cues and patterns during the clinical encounter.[2] Unfortunately, improper decision making can occur when the clinician relies on inaccurate memory or misinterprets cues.[2] In contrast, System 2 is a more methodical approach using decision pathways or algorithms (e.g., decision trees) in the course of the encounter, that is assumed to improve diagnostic reasoning. Still, clinicians may generate hypotheses based on faulty decision trees, resulting in inaccurate clinical decisions being made.[2,4] Therefore, despite the clinician's best effort to provide high quality clinical care, the utilization of inaccurate knowledge and data gathered using either system could lead to inappropriate clinical management.[2]

Specifically, when utilizing a System 1 approach, the risk of working on 'autopilot' and relying on mental shortcuts, termed heuristics, may occur. Heuristics are often linked to clinician errors and biases.[1] Three basic types of errors include skill-based errors, knowledge-based errors, and rule-based errors.[1] Skill-based errors occur when clinicians follow an habitual course of action, knowledge-based errors occur when clinicians lack necessary information, whereas rule-based errors occur when a clinician misapplies a clinical rule.[1] Despite differences, these errors are interconnected and can result from cognitive biases. An example of a cognitive bias is 'order effect', which occurs when the clinician pays more attention to information presented at the beginning and end of a patient's story but the middle portion is lost.1,3 Other biases include the 'availability heuristic' that judges a patient's presentation based on the likelihood of the condition coming to the clinician's mind, 'anchoring bias' that results from the clinician fixating on certain features too early in the patient interaction resulting in difficulty changing the course of their clinical reasoning, and finally, 'confirmation bias', when one is looking for evidence to support their clinical thoughts, thereby potentially failing to identify co-pathology.[1,3] Unless these unconscious cognitive biases are brought to the forefront, clinicians may continue to utilize flawed decision making processes, resulting in inappropriate patient care.[5]

Furthermore, as a result of errors and biases, a delay in diagnosis or misdiagnosis/diagnostic error may occur. Caputo *et al*. identified characteristics in primary health

care contact providers that could lead to a delay in diagnosis of neurological conditions.[6] They identified that a delay in diagnosis may occur with clinicians who are less experienced with the pathology of conditions they see infrequently.[6] Thus, because a clinician may be unaware of particular condition(s), they may not consider them in their differential diagnoses. For example, chiropractors are considered experts in musculoskeletal health, and if clinical encounters are only viewed through this lens, they run the risk of falling into the trap of "*what you see is all there is*", becoming potentially vulnerable to faulty decision making and inappropriate clinical care.[7] To help mitigate against this, it is important to implement distinct strategies such as self-reflection during and after the clinical encounter in an effort to reduce the susceptibility to various heuristics and cognitive biases. Therefore, the objective of this case series is to outline a number of cases where chiropractors implemented distinct strategies in order to reduce common cognitive biases and improve patient management as a result.

Ethics

Ethics approval was received from the Research Ethics Board at the Canadian Memorial Chiropractic College (#2202X01). Patient consent was obtained as available.

Case presentations

Case 1

The first case involves a 55-year-old female who fell while walking down a ramp, fracturing her left ankle in May 2018. She presented to an urgent care centre the following day due to severe ankle pain, swelling and inability to weight bear. An x-ray was taken which demonstrated an undisplaced fracture through the fifth metatarsal base, with extension to the adjacent intra-articular space. Prior to the incident, the patient was relatively healthy and exercised five days per week for 30 minutes each day. She was not taking any medications. Her past medical history was unremarkable other than being diagnosed with osteopenia earlier that year.

Following her assessment at urgent care, she was placed in a walking boot and was re-evaluated two weeks later. Upon re-evaluation, a new x-ray demonstrated widening of the fracture site and she was subsequently placed in a hard cast for four weeks. At her four-week follow-up the patient still complained of sharp pain, but repeat x-rays demonstrated a less visible fracture line at the base of the fifth metatarsal, suggestive of interval healing. She was subsequently placed in a walking boot and told to limit her weight bearing. She was re-evaluated four weeks later, but continued to experience sharp pain at the fracture site with significant swelling of her foot and limited ability to weight bear. Upon examination by the attending physician, the patient was diagnosed with Complex Regional Pain Syndrome (CRPS). The diagnosis was made based on the patient being immobilized in a walking boot and hard cast for a prolonged period, significant pain and swelling still present at the fracture site, and some red discolouration noted when observing the area.

After being diagnosed with CRPS, the patient was assessed by a chiropractor. The examination demonstrated swelling of the left foot with severe pain upon palpation at the base of the fourth and fifth metatarsal bases and calcaneal tuberosity, in addition to decreased calcaneal fat pad thickness. There was no left foot somatosensory hyperesthesia, limb sweating, abnormal hair growth, dystonia, or dystrophy. In addition, there was no dorsal left foot temperature asymmetry when measured with a surface temperature thermometer. There was mild decreased ankle range of motion and pain-related weakness during active and resisted ankle eversion. Further examination did not reveal any nerve tension signs. Following the examination, the chiropractor suspected that the patient was not suffering from CRPS. In consultation with a physiatrist, the patient was referred for a three-phase bone scan which showed mild activity in the lateral aspect of the left midfoot/forefoot suggesting healing fractures involving the fourth and fifth metatarsal heads. In addition, the patient had an MRI which showed a healing nondisplaced fracture at the base of the fifth metatarsal with associated subcutaneous edema and flexor hallucis tenosynovitis with associated muscle edema. Following the chiropractor's examination and imaging results, the patient was diagnosed with healing fractures of the fourth and fifth metatarsal bases and plantar calcaneal fat pad atrophy. Over the course of the next two months, the patient was provided with appropriate care, consisting of manual therapy to improve ankle range of motion, graded exposure and ankle/foot exercises to improve weightbearing tolerance and healing. Manual therapy included soft tissue therapy (i.e. muscle release technique) to the surrounding ankle musculature and mobilization

of the left ankle mortise and fibular head to increase ankle range of motion. The patient was provided with exercises to increase ankle range of motion, as well as improve strength of her lower limb musculature and intrinsic foot muscles. In addition, as a result of significant pain when weight bearing, the patient was provided with graded exposure exercises. The patient was instructed to fold a blanket enough times to create adequate padding in order to walk 10 steps barefoot within her tolerance for pain. Once she was able to complete this she was advised to reduce the thickness of the blanket while walking 10 steps. Over time, she was able to walk barefoot on the floor. Following her treatment, the patient returned to her pre-injury physical activity levels including walking, biking and resistance training with no re-occurrence of symptoms.

This case demonstrates the potential limitation of the dual process theory. The patient's physician diagnosed her with CRPS without careful consideration of the CRPS diagnostic criteria. As a result, the clinician experienced various biases such as 'availability heuristics', 'confirmation bias' or 'base-rate neglect'.[8] The clinician assumedly used a System 1 approach based on the clinical presentation and risk factors for the development of CRPS. For instance, limb immobilization, female, and middle-aged adults are all risk factors for the development of CRPS.[9-12] However, when the patient was assessed by the chiropractor, the chiropractor presumably used a System 2 approach, requiring a careful assessment of her signs and symptoms to arrive at the appropriate diagnosis. The chiropractor compared the patient's symptoms to the Budapest criteria (Table 1), which is the current best practice for the diagnosis of CRPS.[13] Although the patient had some features of CRPS, her main presenting signs and symptoms did not fit all four criteria required for a diagnosis of CRPS. Specifically, the patient only exhibited swelling and discoloration which is a vasomotor sign/symptom, but did not experience any sensory, sudomotor or motor signs/symptoms. Additionally, the patient did not satisfy criterion 4 of the Budapest criteria as the diagnosis made by the chiropractor better accounted for their symptoms. This case highlights the importance of conducting a complete assessment, as well as not prematurely jumping to conclusions.

Table 1.
Budapest clinical criteria for diagnosing Complex Regional Pain Syndrome.[12]

1. Continuing pain that is disproportionate to any inciting event
2. Must report at least one symptom in three of the four categories: a) **Sensory:** hyperesthesia and/or allodynia b) **Vasomotor:** temperature asymmetry and/or skin color changes and/or skin color asymmetry c) **Sudomotor/edema:** reports of edema or sweating changes and/or sweating asymmetry d) **Motor/trophic:** decreased range of motion and/or motor dysfunction (weakness, tremor, dystonia) and/or trophic changes (hair, nail, skin)
3. Must display at least one sign in two or more of the following categories: a) **Sensory:** hyperalgesia to pinprick, allodynia to light touch and/or deep somatic pressure and/or joint movement b) **Vasomotor:** evidence of temperature asymmetry and/or skin color changes and/or asymmetry c) **Sudomotor/edema:** evidence of edema and/or sweating changes and/or sweating asymmetry d) **Motor/trophic:** evidence of decreased range of motion and/or motor dysfunction (weakness, tremor, dystonia) and/or trophic changes (hair, nail, skin)
4. No other diagnosis that better explains the signs and symptoms

Case 2

The second case is a 56-year-old male who was previously seen by a chiropractor for chronic back pain, which responded well to conservative care and self-management strategies including a regular exercise routine. In the winter of 2019, he visited his chiropractor after experiencing sharp pains in his left hip and a deep ache in his right shoulder. He attributed his left hip pain due to cold weather, as well as traveling by plane for a work trip. Following the examination, the chiropractor suggested that the pains were of a musculoskeletal origin, namely that the patient was experiencing symptoms related to a strain to the left hip with underlying osteoarthritic changes, as well as a strain to the right shoulder likely related to work postures and his recent travel. The patient began receiving conservative care to his lumbar spine, left hip and shoulder inclusive of spinal manipulation to the lumbar spine, mobilizations to the left hip and shoulder, and soft tissue therapy to the surrounding musculature. The patient was provided a home-based exercise program to improve their ranges of motion and to strengthen the core and pelvic musculature. The patient reported good relief of his lower back pains, but only short-term relief of his hip pain, which was described as a persistent low-grade ache, deep into the joint. His right shoulder pain did not improve significantly following conservative therapy described above. Upon revaluation, the chiropractor reflected on the presentation and lack of improvement. The chiropractor suspected the patient's pains were related to the presence of an underlying systemic disease. As a result, the chiropractor referred the patient to the family doctor suggesting further diagnostic investigations to be performed.

The patient received diagnostic tests including radiographs, ultrasound and blood tests. Radiographs of his hips revealed early degenerative joint disease in both hips, radiographs of his lumbar spine revealed moderate multilevel degenerative changes with normal sacroiliac joints, and those of his shoulder demonstrated degenerative joint disease of his acromioclavicular joint with no soft tissue calcifications. An ultrasound of his shoulder showed mild bilateral supraspinatus tendinosis with acromioclavicular joint degenerative joint disease and no rotator cuff tears. Serology testing was negative for Antinuclear Antibody (ANA), Rheumatoid Factor (RF) was <10 U/ml and his Erythrocyte Sedimentation Rate (ESR) was elevated at 34 mm/hr. He was subsequently diagnosed with an inflammatory arthritide, was prescribed methotrexate by his rheumatologist and reported improved treatment outcomes.

This case highlights a common challenge in clinical practice, where there is diagnostic uncertainty in a patient's presentation. In this case, the chiropractor had previously treated this patient's low back pain successfully; however, when the patient developed new areas of pain that were not responding to care, the chiropractor took a step back to re-assess the patient. After reflecting on the clinical presentation and expected recovery of the working diagnoses, the chiropractor initiated a diagnostic pathway of investigations for the possibility of a systemic condition, specifically inflammatory arthritis. Although the chiropractor did not specifically identify the patient's underlying clinical condition, they methodically assessed the patient using a System 2 approach thereby determining the need for further testing. Inflammatory arthritis typically has a long diagnostic delay but the clinician's approach ensured the patient received appropriate and timely assessment and management.[14]

Case 3

The third case is a 65-year-old male who presented to their family doctor with acute low back pain rated 9/10 which he developed after painting his staircase at home. Upon examination, their family doctor diagnosed the condition as a muscle strain and prescribed Tramadol. Three weeks after the onset of pain the patient was not improving, and elected to see a chiropractor for an assessment. The patient reported that since the onset, the pain was manageable when using the medication but there was no significant improvement in the patient's pain levels overall. He described that transitioning from sitting to standing was especially difficult and medication was required to control his pain at night. In addition, the patient mentioned he was in relatively good health with no comorbidities. Lumbar spine radiographs ordered by his family doctor showed mild lower lumbar degenerative disc disease and facet arthrosis. Upon examination by the chiropractor lumbar spine range of motion was relatively normal, there were no nerve root tension signs nor neurological deficits noted. There was mild paraspinal muscle tenderness and segmental dysfunction noted at the lumbosacral junction.

Several aspects of the patient's clinical presentation suggested both mechanical and non-mechanical sources

of their pain. For instance, the mechanism of injury, paraspinal muscle tenderness and segmental dysfunction at the lumbosacral junction could explain the mechanical source of pain. However, a non-mechanical source of pain should be considered given the patient's age, 65 years old, this being their first episode of acute low back pain, severe nocturnal pain, absence of any sustained improvement over a three-week period, and the inability to completely reproduce their pain. As a result of these findings, the patient was referred to a nearby hospital emergency department for further investigation. At the emergency department, a CT scan of the lumbar spine suggested probable prostate cancer metastasis of the L5 vertebral body. The patient was transferred to oncology for immediate urgent care.

This case presented many challenges to the chiropractor who could have easily misdiagnosed the patient if they had not conducted their own examination and carefully evaluated the facts, rather than relying upon the diagnosis of another healthcare provider. For example, the chiropractor could have been susceptible to "anchoring bias" based on the mechanism of injury, a report of a normal lumbar spine x-ray and previous advice by other health care providers. A quick System 1 approach may have resulted in treating this patient conservatively for a period of time which would have resulted in delaying urgent medical care. However, after conducting a comprehensive examination, the chiropractor used clinical judgment to suspect a non-mechanical source of pain, as well as recognizing that musculoskeletal related symptoms and examination findings can co-exist with pathology, thereby ensuring this patient received appropriate care in a timely manner.

Case 4

The fourth case is a 62-year-old retired man who presented with right buttock pain and an associated pulling sensation around the right lateral ankle. The patient reported that this pain gradually began two months prior which he attributed to a period of increased physical activity consisting of playing ice hockey and tennis. There was no preceding trauma that occurred. His average pain intensity was 6/10 but would increase to 8/10 at its worst. His pain significantly limited his daily activities, and he was unable to return to sports. The Keele STarT Back screening tool suggested a moderate to severe risk for chronicity, with significant pain catastrophizing.

When the patient developed this pain, he saw his family doctor who suspected his symptoms were caused by a lumbar disc herniation and ordered a lumbar spine MRI. The MRI showed severe degenerative disc disease at the L1-2 and L2-3 levels with Modic type 1 change, and central stenosis noted at the L2-3 level with facet degenerative joint disease at multiples levels. In addition, there was a suspected entrapment of both the L2 and L3 nerve roots, bilaterally. Following the MRI results, the patient was referred to physiotherapy where he was prescribed McKenzie lumbar extension exercises, which did not provide any significant relief. In addition, he had four sessions of chiropractic care using lumbar flexion-distraction mobilization but once again did not experience significant relief.

As a consequence of feeling no significant relief, the patient consulted another chiropractor. On examination, the chiropractor reported that the patient's lumbar range of motion was limited by 25% in lumbar extension and right lateral bending, straight leg raise was 90 degrees bilaterally without any nerve root tension signs and femoral nerve stretch was negative bilaterally. In addition, sacroiliac joint testing was negative. Palpation over the greater trochanter and gluteus medius muscle was painful and reproduced the chief complaint. The patient's chief complaint was diagnosed as gluteus medius tendinosis that slowly responded to soft tissue therapy (i.e. muscle release technique) combined with a graded exercise program. In addition, the patient required considerable reassurance due to his pain catastrophizing behaviour and kinesiophobia. Specifically, the chiropractor had to consistently reassure the patient of the course of recovery and aetiology of their symptoms.

This case highlights a common scenario encountered in clinical practice whereby a patient has positive imaging findings that do not correlate with the clinical presentation.[15] The imaging findings for this patient suggested a high lumbar spinal nerve irritation contributing to the patient's symptoms; however, the clinical examination did not corroborate the suggested nerve root entrapment as causing this patient's pain nor symptoms. The second chiropractor could have been susceptible to cognitive biases, such as "availability heuristic", "confirmation bias" or "search satisfying" based on previous assessments conducted by the other providers, as well as the imaging findings.[8] However, they instead relied on the

use of a methodical assessment approach and was able to correctly diagnose this patient, providing appropriate care targeted at the correct structures.

Discussion

The case scenarios presented herein illustrate that the clinicians used distinct strategies to assess and manage complex clinical situations. Each case highlights that clinical decision making involves the application of various information sources to develop a logical and purposeful clinical plan of management.[16] In the context of evidence-based practice, these information sources can consist of clinical experience and research evidence. Research suggests that clinicians with more experience can develop management plans with greater certainty due to their ability to recognize diagnostic patterns.[16,17] However, diagnostic uncertainty is inherent in all clinical decisions irrespective of clinician experience.

Although there is no widespread accepted definition of diagnostic uncertainty, a proposed definition is the "subjective perception of an inability to provide an accurate explanation of the patient's health problem".[18] In clinical practice, strategies can be utilized to further understand, manage and cope with diagnostic uncertainty. For example, Santhosh *et al*. suggests contrasting the related knowledge about diagnostic accuracy and certainty when arriving at a diagnosis (See Table 2).[19] By comparing and contrasting what is known, clinicians can determine if their diagnosis is a "slam dunk", "cautiously optimistic", "diagnostic hubris", or a "diagnostic mystery".[19] This 2x2 table could help clinicians identify and subsequently reduce their knowledge gaps. As well, this approach can improve communication with patients by acknowledging uncertainty that is present, responding to patient's concerns, and clearly conveying next steps.[19] For instance, the chiropractor in case number 3 would have fit into the category of 'accurate and uncertain' as he had a suspicion of a non-MSK diagnosis but was uncertain as to the exact diagnosis. This line of thinking facilitated patient referral with eventual receipt of appropriate and timely medical care. Using this proposed model allows the clinician to reflect on the case and presenting features, considering their level of uncertainty. The clinician can formulate an evolving hypothesis rather than a static one, allowing for the opportunity to change their clinical management as new information comes to light.

Table 2.
Adapted from the proposed model by Santhosh et al.[19] comparing diagnostic uncertainty to diagnostic accuracy.

	Certain	Uncertain
Accurate	"Slam dunk"	"Cautiously optimistic"
Inaccurate	"Diagnostic hubris"	"Diagnostic mystery"

It is important that clinicians self-reflect on clinical encounters to identify what has gone well and what could be improved in order to analyze and alter clinical decision making processes.[20, 21] Reflection can take place at many stages such as during the patient encounter, which helps inform hypothesis generation; after a patient interaction, which helps clinicians learn and improve their clinical decision making moving forward; and on professional experience, which assists in understanding their way of thinking about clinical decision making.[21] This process of reflection is critical in order for a clinician to self-assess, learn from past experiences and further their clinical expertise. Literature suggests that similar to experienced clinicians, novice clinicians also reflect on their clinical encounters following an interaction, albeit to a lesser degree.[21] Unlike the novice clinicians, experienced clinicians engage in greater reflection and on-going self-assessment during the encounter.[21] Developing reflection skills during and after a clinical encounter is important to positively impact patient outcomes, as well as self-assessment and professional growth.[21]

In addition, the act of reflection is important in reducing heuristics and cognitive errors. Graber *et al*. identified that cognitive errors contributed to 74% of cases assessed involving diagnostic error.[22] For instance, when placed in familiar environments and seeing a similar patient presentation multiple times during a day in clinical practice, clinicians may be prone to being overconfident. This overconfidence could lead to inappropriate patient care as clinicians may prematurely come to a diagnosis, termed 'premature closure bias', or be susceptible to other biases such as 'anchoring bias' and 'confirmation bias'.[23] However, reflective practice strategies can assist in reducing susceptibility to these biases.[24] For example, using a checklist during a patient encounter (either mentally or on paper) can provide clinicians with a diagnostic "time out", allowing one to consider other possibilities and re-

duce the chance of applying these various biases.[24] This would also allow clinicians to actively reflect on each case rather than work on autopilot. Furthermore, reflection will assist clinicians in analyzing patient symptoms in their entirety while reducing the chance of overlooking important clinical details in order to determine an appropriate diagnosis and plan of management.

Reflective practice can be challenging to teach to students and novice clinicians. As a result, students and novice clinicians typically encounter greater challenges when faced with diagnostic uncertainty and are unsure how to proceed. Therefore, it is important that educators and experienced clinicians discuss its inherent nature in clinical practice.[18,25] Students and new graduates should be provided with strategies to cope with diagnostic uncertainty. For example, within a teaching environment educators can walk through cases with trainees, thinking aloud their cognitive and clinical reasoning.[21] This would provide trainees with a unique look at how an experienced clinician critically thinks about clinical decision making.[7, 23] These exercises can assist trainees by brainstorming as a group what next steps would be suitable in order to understand how to approach patients when there is no clear diagnosis. Ensuring new learners understand and consider diagnostic uncertainty as a normal part of clinical practice can help reduce negative internal feelings such as anxiety, feeling overwhelmed and self-doubt.[26]

Summary

This case series described four cases that required the treating chiropractor to apply specific strategies in order to reduce common cognitive biases and avoid inappropriate care. In applying these strategies, the chiropractor in each case was able to provide effective and timely patient care. Cognitive biases and diagnostic uncertainty are an inherent part of patient management that could be effectively addressed by using tools such as reflection and systematic diagnostic approaches. For learners, novice and experienced clinicians, accepting the significance of and implementing strategies to cope with diagnostic uncertainty is important for continuous professional development and optimizing patient outcomes. Future research should focus on assessing if the implementation of strategies discussed herein can result in improved patient care and outcomes.

References

1. Trimble M, Hamilton P. The thinking doctor: clinical decision making in contemporary medicine. Clin Med. 2016;16(4): 343-346.
2. Banning M. A review of clinical decision making: models and current research. J Clin Nurs. 2008;17(2): 187-195.
3. Bate L, Hutchinson A, Underhill J, *et al*. How clinical decisions are made. Br J Clin Pharmacol. 2012;74(4): 614-620.
4. Monteiro SM, Norman G. Diagnostic reasoning: where we've been, where we're going. Teach Learn Med. 2013;25 Suppl 1: S26-S32.
5. Doherty TS, Carroll AE. Believing in overcoming cognitive biases. AMA J Ethics. 2020;22(9): E773-E778.
6. Caputo L, Mior S, Cusimano M, *et al*. A study on the frequency of delayed diagnosis of neurological conditions by primary contact health care providers. J Chiro Educ. 1997;10(4).
7. Croskerry P. A model for clinical decision-making in medicine. Med Sci Educator. 2017;27.
8. Croskerry P. Achieving quality in clinical decision making: cognitive strategies and detection of bias. Acad Emerg Med. 2002;9(11): 1184-1204.
9. Birklein F, Dimova V. Complex regional pain syndrome-up-to-date. Pain Rep. 2017;2(6): e624.
10. Jellad A, Salah S, Ben Salah Frih Z. Complex regional pain syndrome type I: incidence and risk factors in patients with fracture of the distal radius. Arch Phys Med Rehabil. 2014;95(3): 487-492.
11. Marinus J, Moseley GL, Birklein F, *et al*. Clinical features and pathophysiology of complex regional pain syndrome. Lancet Neurol. 2011;10(7):637-648.
12. Pons T, Shipton EA, Williman J, *et al*. Potential risk factors for the onset of complex regional pain syndrome type 1: a systematic literature review. Anesthesiol Res Pract. 2015;2015: 956539.
13. Harden NR, Bruehl S, Perez R, *et al*. Validation of proposed diagnostic criteria (the "Budapest Criteria") for Complex Regional Pain Syndrome. Pain. 2010;150(2): 268-274.
14. Zhao SS, Pittam B, Harrison NL, *et al*. Diagnostic delay in axial spondyloarthritis: a systematic review and meta-analysis. Rheumatol. 2021;60(4): 1620-1628.
15. Brinjikji W, Luetmer PH, Comstock B, *et al*. Systematic literature review of imaging features of spinal degeneration in asymptomatic populations. AJNR Am J Neuroradiol. 2015;36(4): 811-816.
16. Widerström B, Elvén M, Rasmussen-Barr E, *et al*. "How does physical examination findings influence physiotherapists' decision-making when matching treatment to patients with low back pain?". Musculoskelet Sci Pract. 2021;53: 102374.
17. Choudhry NK, Fletcher RH, Soumerai SB. Systematic review: the relationship between clinical experience and

quality of health care. Ann Intern Med. 2005;142(4): 260-273.
18. Bhise V, Rajan SS, Sittig DF, *et al*. Defining and measuring diagnostic uncertainty in medicine: a systematic review. J Gen Intern Med. 2018;33(1): 103-115.
19. Santhosh L, Chou CL, Connor DM. Diagnostic uncertainty: from education to communication. Diagnosis (Berl). 2019;6(2): 121-126.
20. Croskerry P. A universal model of diagnostic reasoning. Acad Med. 2009;84(8): 1022-1028.
21. Wainwright SF, Shepard KF, Harman LB, *et al*. Novice and experienced physical therapist clinicians: a comparison of how reflection is used to inform the clinical decision-making process. Phys Ther. 2010;90(1): 75-88.
22. Graber ML, Franklin N, Gordon R. Diagnostic error in internal medicine. Arch Intern Med. 2005;165(13): 1493-1499.
23. Croskerry P. Clinical cognition and diagnostic error: applications of a dual process model of reasoning. Adv Health Sci Educ Theory Pract. 2009;14(Suppl 1): 27-35.
24. Ely JW, Graber ML, Croskerry P. Checklists to reduce diagnostic errors. Acad Med. 2011;86(3): 307-313.
25. Alam R, Cheraghi-Sohi S, Panagioti M, *et al*. Managing diagnostic uncertainty in primary care: a systematic critical review. BMC Fam Pract. 2017;18(1): 79.
26. Almond A, Zou Y, Forbes R. Navigating diagnostic uncertainty in musculoskeletal practice: the perspectives and experiences of new graduate physiotherapists. Musculoskelet Sci Pract. 2021;52: 102354.

ISSN 0008-3194 (p)/ISSN 1715-6181 (e)/2024/122–130/$2.00/©JCCA 2024

Sonographic evaluation of spondylolysis: technique description and feasibility study of diagnostic ultrasound for the detection of L5 pars interarticularis fractures

Christopher L. Smoley, DC, DACBR[1]
John Cho, DC, DACBR[2]
Whitney Graff, DC, DACBR[2]
Nicole Zipay, DC, DACBR[2]

Objective: *Technique description and verification of L5 pars interarticularis (L5PI) using diagnostic ultrasound (DUS).*

Methods: *Asymptomatic 10-year-old male subject was scanned with diagnostic ultrasound applying a linear array transducer (8-13 MHz) over L5/S1 facets; long-axis slide cephalad to capture both superior (SAP) and inferior articulating process (IAP) of L5. Contiguous hyperechoic cortex with deep acoustic shadowing between the SAP and IAP was assumed to be L5PI. To confirm in vivo technique representing L5PI, two spine models (plastic, human spine) were scanned to verify authors' assumption. Metallic paperclip was placed over L5PI then DUS image captured. Lastly, a subject with known spondylolysis was imaged and sonographic appearance of L5PI compared.*

L'évaluation échographique de la spondylolyse: une description de la technique et une étude de faisabilité de l'échographie diagnostique pour la détection des fractures de l'isthme interarticulaire de la L5

Objectifs: *La description de la technique et la vérification de l'isthme interarticulaire de la L5 (IIL5) à l'aide d'ultrasons diagnostiques (USD).*

Méthodes: *Un sujet masculin asymptomatique âgé de 10 ans a été scanné à l'aide d'une échographie diagnostique utilisant un transducteur linéaire (8-13 MHz) sur les facettes de la L5/S1; un glissement en direction céphalique sur grand axe pour capturer le processus d'articulation supérieur (PAS) et inférieur (PAI) de la L5. Le cortex hyperéchogène contigu avec ombrage acoustique profond entre le PAS et le PAI a été supposé être de l'IIL5. Afin de confirmer la technique in vivo représentant l'indice de l'IIL5, deux modèles de colonne vertébrale (plastique, colonne vertébrale humaine) ont été scannés pour vérifier l'hypothèse des auteurs. Un trombone métallique a été placé sur l'IIL5 puis une image d'USD a été prise. Enfin, un sujet présentant une spondylolyse connue a été imagé et l'aspect échographique de l'IIL5 a été comparé.*

[1] Northwestern Health Sciences University, Bloomington, MN
[2] Parker University, Dallas, TX

Corresponding author: Christopher L. Smoley, 11542 8th St. NE, Hanover, MN 55341
Tel: 320-224-4512
E-mail: csmoley@nwhealth.edu

The authors have no disclaimers, competing interests, or sources of support or funding to report in the preparation of this manuscript.

Results: *The structures localized with the metal paperclip on L5PI models were equivalent to the in vivo DUS image. Spondylolysis demonstrates an abrupt step-off defect at L5PI.*

Conclusion: *We report the first technique description and verification of the L5PI using DUS.*

(JCCA. 2024;68(2):122-130)

KEY WORDS: ultrasound, pars interarticularis, sonography, pars defect, spondylo, spondylolytic spondylolisthesis, stress reaction, stress fracture, anatomy, feasibility, exploratory, pilot study, chiropractic

Résultats: *Les structures localisées avec le trombone métallique sur les modèles de l'IIL5 étaient équivalentes à l'image d'USD in vivo. La spondylolyse montre un défaut abrupt de décrochage à l'IIL5.*

Conclusion: *Nous rapportons la première description technique et la vérification de l'IIL5 à l'aide d'USD.*

(JCCA. 2024; 68(2) : 122-130)

MOTS CLÉS : échographie, isthme interarticulaire, échographie, défaut de l'isthme, spondylo, spondylolisthésis spondylolytique, réaction de stress, fracture de stress, anatomie, faisabilité, exploratoire, étude pilote, chiropratique

Introduction

There is an ever-increasing utilization of musculoskeletal diagnostic ultrasound imaging (DUS) in healthcare; trends within the chiropractic profession are no different.[1,2] Increased application has led to the adoption and integration of the technology into some of the chiropractic institutions with 65% of these institutions reporting DUS training should be provided to students and 75% of institutions reporting that chiropractic programs should be providing accredited postgraduate DUS courses.[3] Except for perinatal imaging and interventional anatomical localization for facet injections, the majority of musculoskeletal DUS has been focused on extremity application for both clinical practice and research application. Although the primary focus of chiropractic is spinal care, there has been limited application to spinal evaluation with DUS in the chiropractic field. The most common reason for individuals seeking chiropractic care is low-back pain.[4] In adolescent athletic patients with low back pain, 47% have been found to have spondylolysis.[5] Although the general population only has an estimated 6.4% prevalence of spondylolysis according to Aoki *et al*,[6] due to the higher prevalence of spondylolysis in the adolescent athletic population, the authors of this article had interest in the ability of DUS to identify the pars interarticularis and defects via DUS, because its relatively low-cost and lack of ionizing radiation exposure.

To the authors' best knowledge, evaluation methods with DUS of the pars interarticularis have not been published nor have any publications around the DUS assessment of pathologic alterations of this structure. Non-operative spinal/paraspinal ultrasound is investigational according to the American Institute of Ultrasound in Medicine (AIUM), stating "there is insufficient evidence in the peer-reviewed medical literature establishing the value of nonoperative spinal/paraspinal ultrasound in adults for diagnostic evaluations of conditions involving the intervertebral disks, facet joints and capsules, and central nerves." Therefore, the AIUM states that, at this time, the use of ultrasound in diagnostic evaluations, screening, or monitoring of therapy for these conditions has no proven clinical utility and should be considered investigational.[7] Moreover, the single case study detecting spondylolisthesis using ultrasound focused on the malalignment of facet joints from level-to-level without observation of the pars interarticularis.[8]

Methods

Diagnostic ultrasound (GE LOGIQ e; Milwaukee, WI), using 8-13 MHz linear array transducer was used to obtain images of the pars interarticularis of the fifth lumbar vertebra (L5). For scanning the pars interarticularis at L5, an asymptomatic 10-year-old male was used as a subject for experimental identification of the pars interarticularis due to typical age of onset of spondylolysis and the subject's tissue thickness lending itself to increased image resolution for an initial anatomical comparison to the models.

Each subject and spine model were scanned in the prone position with the L5/S1 motion segment examined. Each subject or parent/guardian signed informed con-

sent and permitted the authors to use images and clinical information. The transducer was placed over the neural arch of the posterior spinal column. In the sagittal plane, the most lateral structure is the hyperechoic transverse process. Through a short-axis glide towards the midline, facet joints were visualized with the characteristic "camel hump" pattern.[9] The lumbosacral junction was located by sliding the transducer caudally, where a downward curved, hyperechoic sacrum appeared. As the sacrum was located, the transducer was then maneuvered slightly cephalad to capture both the superior and inferior articulating process of L5, matching the normal slight angulation of the neural arch as displayed within VH Dissector image (Figure 1). A slight side-to-side short axis glide of the probe was utilized until a contiguous cortex bridge producing a deep acoustic shadow between the superior and inferior articulating process of L5 was achieved (Figure 2). The contiguous hyperechoic region with deep acoustic shadowing corresponded to the cortical region between the superior and inferior articulating processes and therefore, was speculated to be the pars interarticularis of L5.

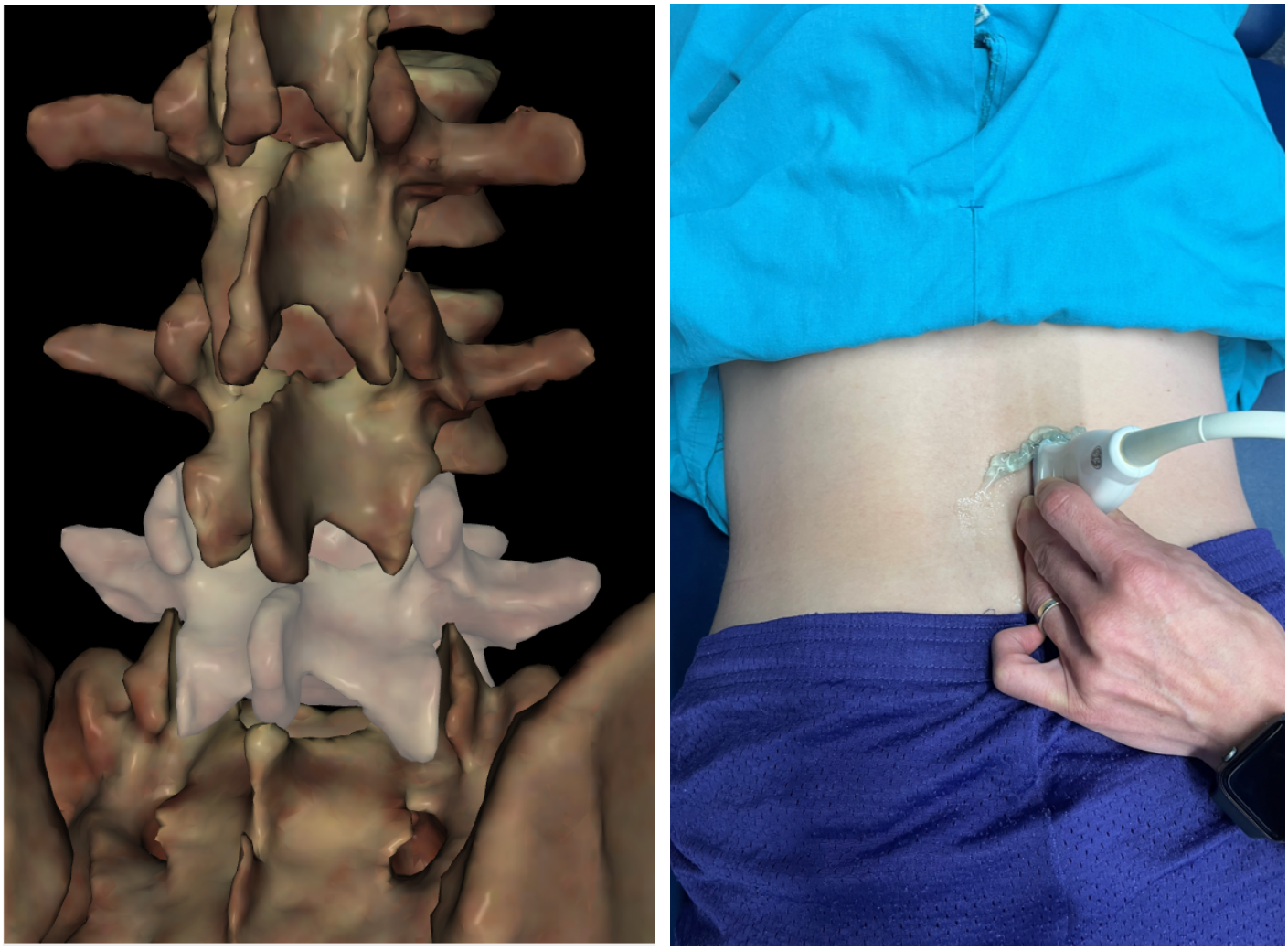

Figure 1.
Placement of the ultrasound probe. (Rectangle= Placement site for the ultrasound probe) Permission to use from Toltech (www.toltech.net)

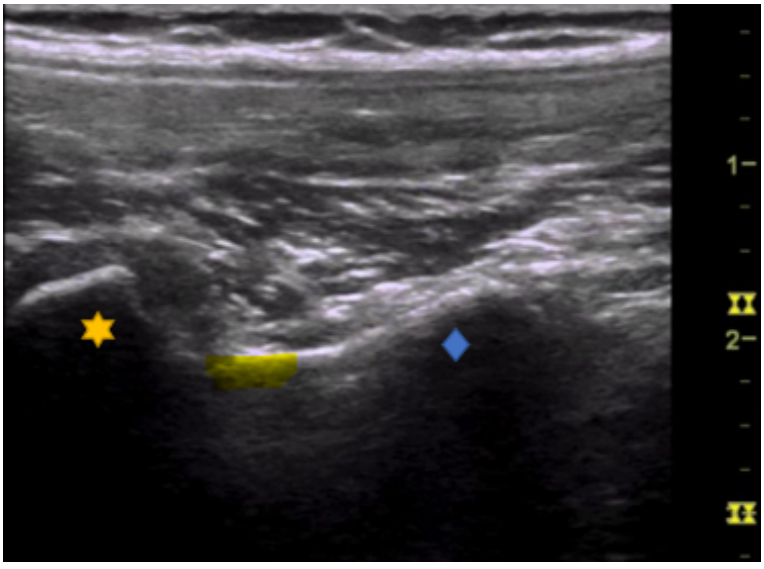

Figure 2.
Ultrasound image of L5 pars interarticularis of a 10-year-old male. (Yellow highlighted area) pars interarticularis; (Star) Superior articulating process at L5; (Diamond) Inferior articulating process at L5.

To confirm the in vivo ultrasound image accurately represented the pars interarticularis, two spine models were scanned to verify the authors' assumption. First, a plastic spinal column model was submersed in a tub filled with water to simulate tissue around a spine. A metal paperclip was placed over the L5 pars interarticularis (Figure 3a); a subsequent ultrasound image was captured (Figure 3b). Additionally, a disarticulated, human dry spine was scanned (Figure 4a) and confirmed the same appearance of the L5PI (Figure 4b) compared to in vivo image.

Figure 3(a).
Plastic spinal column was submersed in a tub filled with water. Paperclip is placed over the L5 pars interarticularis then ultrasound was captured.

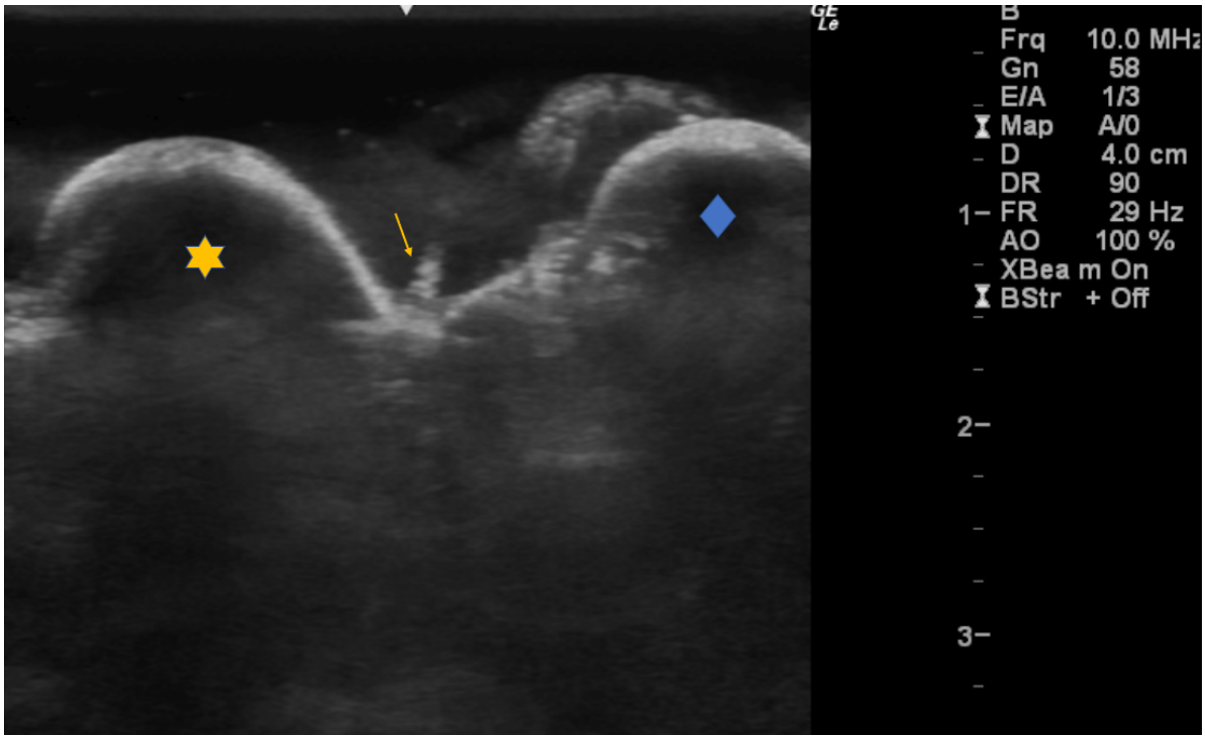

Figure 3(b).
Ultrasound image of the plastic spinal column. (Arrow) artifact from tip of the paperclip pointing to the L5 pars interarticularis; (Star) Superior articulating process at L5; (Diamond) Inferior articulating process at L5.

Figure 4(a).
Human spinal column scanning was done at L5 pars interarticularis with placement of the paperclip over the L5 pars interarticularis.

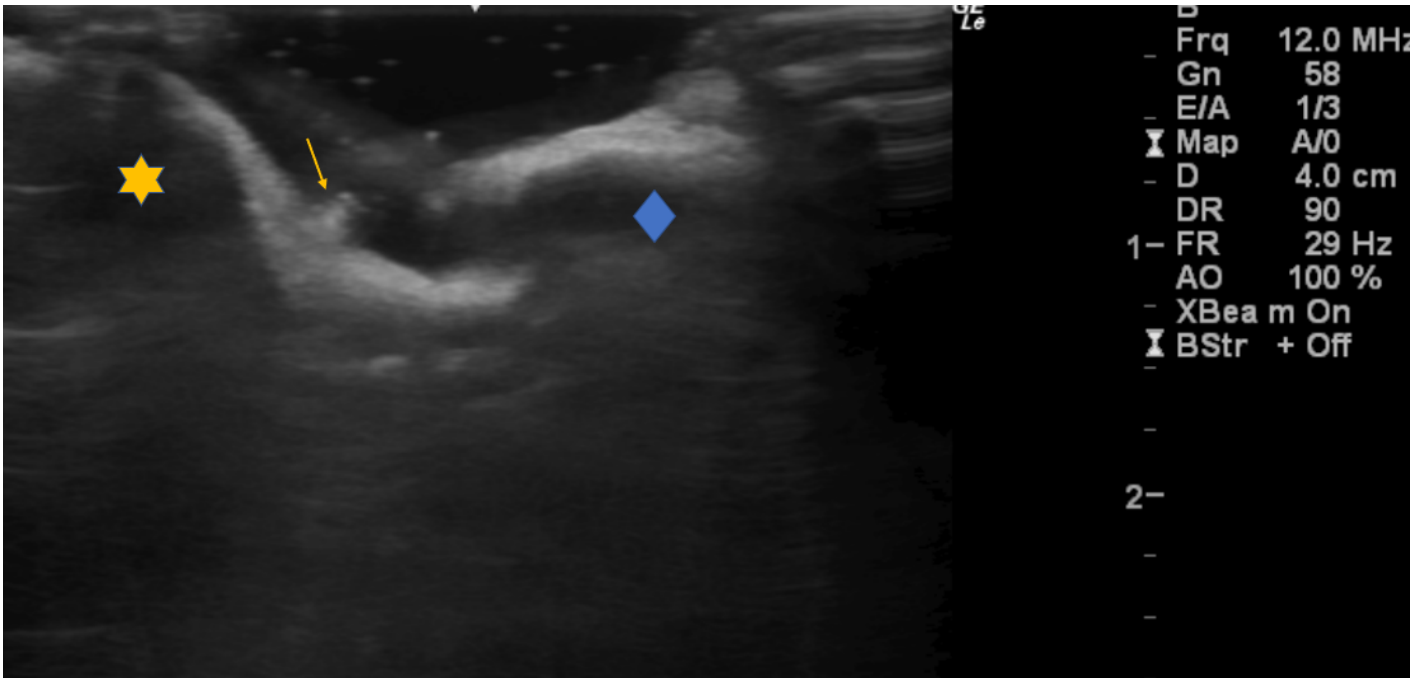

Figure 4(b).
Ultrasound image of the human spinal column. (Arrow) artifact from tip of the paperclip pointing to the L5 pars interarticularis; (Star) Superior articulating process at L5; (Diamond) Inferior articulating process at L5.

Lastly, a young adult subject (25-year-old male) with known diagnosis of L5 spondylolysis, confirmed on radiographic examination, (Figures 5a and 5b) was scanned with DUS using the previously described technique of locating the pars interarticularis.

Results

A concave smooth hyperechoic bridge with deep acoustic shadowing was identified extending between the superior and inferior articulating processes, consistent with cortical bone of the L5PI on ultrasound. The L5PI localized with the metal paperclip on two spine models were compatible with the baseline, in-vivo DUS image.

DUS of a spondylolysis demonstrated an interrupted cortex, displayed as a hypoechoic gap with an abrupt step-off defect at L5PI that contrasts the normal images of the L5PI obtained on the two models and in vivo subject, but was compatible with the radiographic appearance of a pars defect.

Discussion

This investigation yields promising evidence that the pars interarticularis can be visualized in young individuals by utilizing DUS. The cortex of the pars interarticularis was well defined in all subjects (human, plastic model, and human spine). This provides evidence that a pars interarticularis fracture resulting in spondylolytic spondylolisthesis may be visible using DUS. Further, DUS may provide valuable additional clinical data in cases with inconclusive radiographic evaluation of the lumbar spine. One potential advantage could be evaluating the stability of spondylolysis via real-time, dynamic evaluation that is not available with MRI, CT, or radiography.

Sharpe *et al*.[1] looked at the trends of DUS utilization in the United States of America (USA) over the first decade of this century. The authors reported a 316% increase in the total number of diagnostic DUS examinations paid under Medicare Part B, between 2000 (56,254 studies) and 2009 (233,964 studies).[1] The chiropractic field is also seeing a growth in the number of chiropractic programs using DUS with five out of 24 respondents stating they have DUS at their program, with an additional nine of the 24 respondents having plans to implement the technology during the 2017 study by Rogan *et al*.[3] Because of its unsurpassed spatial

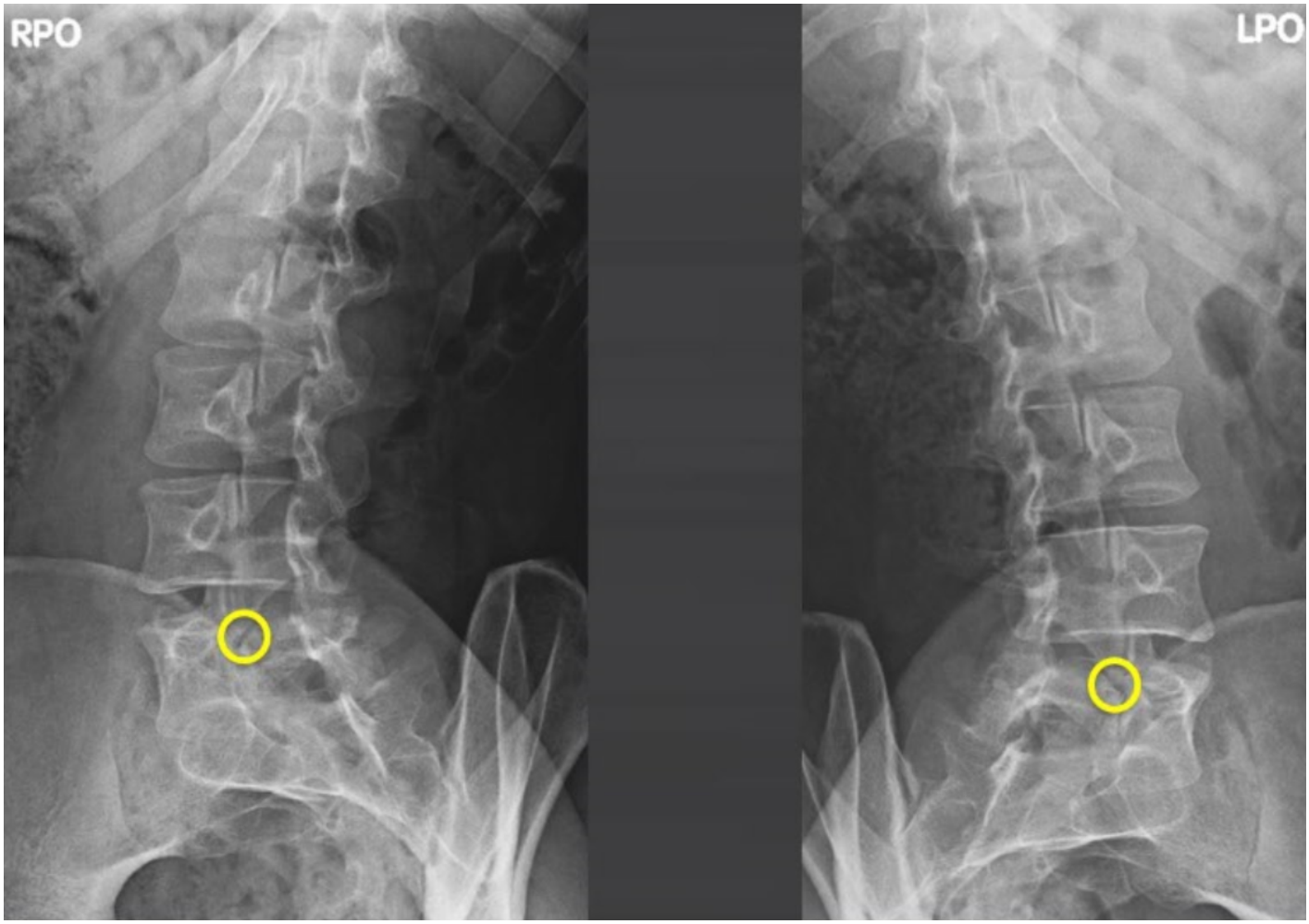

Figure 5(a).
Lumbar oblique radiographs of the same subject scanned in Figure 5b demonstrating bilateral pars defects (yellow circle) at L5.

resolution and dynamic imaging capabilities, applications for DUS have broadened significantly over the years making ultrasound an effective, cost efficient alternative to MRI in many clinical applications, and the imaging test of choice in others.[2] In addition to the benefit of decreased cost, DUS does not have an ionizing radiation dose unlike CT, nuclear imaging, and radiography; each of which are currently used to evaluate spondylolytic spondylolisthesis.

Tibial stress fractures have been reported to be visible using DUS with a defect in the cortex, adjacent edema, and Doppler imaging changes.[10] Given DUS's ability to show hyperemia via power Doppler, it is plausible that it may provide differentiation of acute from chronic pars defects and possibly early identification of stress reactions at the pars interarticularis region prior to progression to a complete pars defect/fracture. Timely diagnosis and management are critical in preventing progression[11] and increase the likelihood of a favorable prognosis including complete healing.5 DUS may be a cost-effective method for monitoring the healing process for spondylolytic spondylolisthesis in the acute setting, as DUS has been shown to provide earlier information about fracture healing and earlier prediction/identification of delayed union and nonunion.[9]

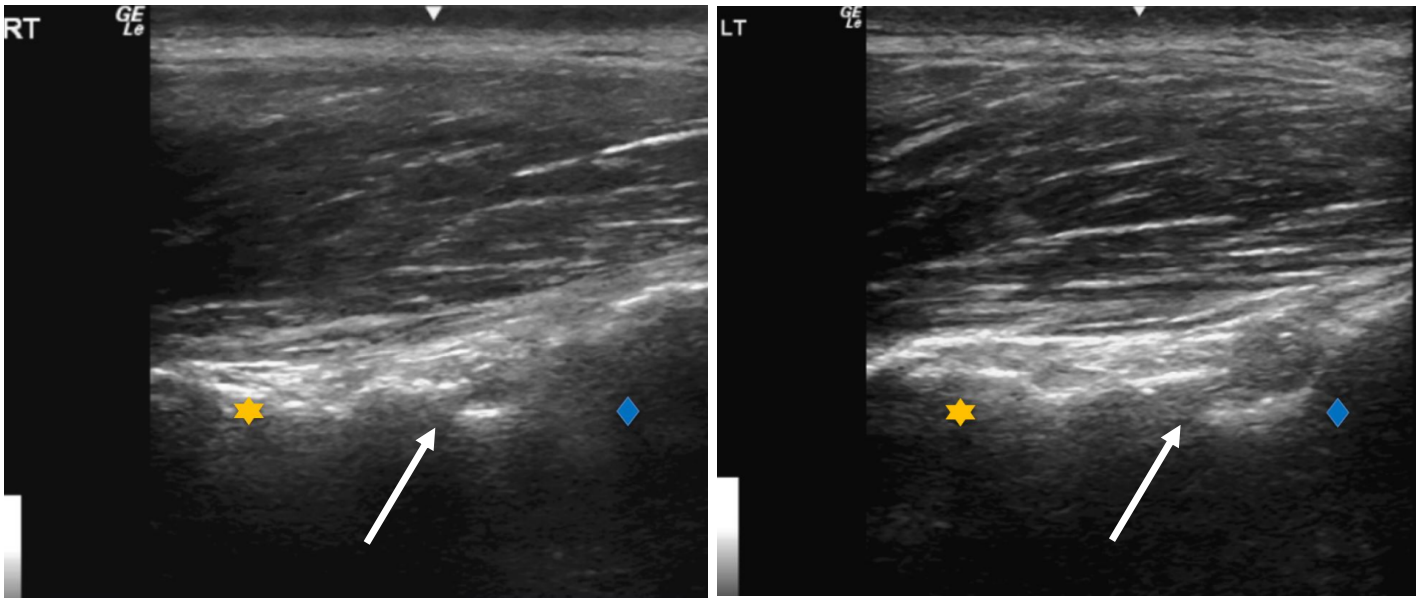

Figure 5(b).
Ultrasound images of the bilateral pars defects at L5; between the superior articulating process (star) and the inferior articulating process (diamond) at L5, a cortical step-off is noted (white arrow) at the pars interarticularis with discontinuity of the hyperechoic cortex.

This study demonstrated sonographic identification of the L5PI, verified using spine models. In a subject with a known spondylolytic spondylolisthesis, a cortical step-off was a noteworthy characteristic appearance in contrast to the smooth, concave L5PI between the articular processes in the unaffected subject and models.

Limitations

There are limitations in this study. This feasibility study only employed a single observer and as with all DUS studies, there can be considerable variability in the inter-observer and intraobserver reliability, especially with respect to the operator's experience in obtaining DUS images. The authors feel an important area of future research would be to evaluate reliability across multiple individuals performing the scan at various skill and experience levels to determine the likely applicability of DUS in the evaluation of the pars interarticularis at a spectrum of skill levels. The authors also acknowledge this study used a single adolescent subject, and therefore the reproducibility is unknown at this time. This subject selection decision was made because typically spondylolysis develops in the adolescent population and the subcutaneous soft tissue thickness of this age group is likely to produce better resolution for anatomic localization. Future studies should attempt to attain a larger sample size with varying age groups and body sizes.

Conclusion

MSK-DUS provides potential for a cost-effective method of evaluating the pars interarticularis in populations at risk for spondylolytic spondylolisthesis. With the relatively low cost compared to CT and MRI as well as the lack of ionizing radiation dose, DUS may be a valuable adjunctive tool in the evaluation and monitoring of the L5PI in subjects and patients with suspected pars pathology. Furthermore, with the well documented findings of stress fracture using ultrasound[12], it is plausible that spondylolytic spondylolisthesis, an acute stress disorder in adolescents, may be detectable via DUS prior to progression to complete fracture.

For future studies, validation on the scanning protocol and reliability study on identifying L5PI analysis is of high importance.

This study provides a foundation for future studies to include but not limited to DUS's ability to identify L5PI fractures, distinguish acute vs. chronic spondylolysis, evaluate stress reactions of pending pars fractures, monitor healing, and measure for motion/instability, given the dynamic capabilities of DUS.

References

1. Sharpe RE, Nazarian LN, Parker L, Rao VM, Levin DC. Dramatically increased musculoskeletal ultrasound utilization from 2000 to 2009, especially by podiatrists in rivate offices. J A College Radiol. 2012;9(2): 141–146.
2. Bureau NJ, Ziegler D. Economics of musculoskeletal ultrasound. Curr Radiol Rep. 2016;4: 44.
3. Henderson REA, Walker BF, Young KJ. Current and prospective use of musculoskeletal diagnostic ultrasound imaging at chiropractic teaching institutions: a worldwide survey of diagnostic imaging staff. J Chiropr Med. 2017;16(1): 54–63.
4. Beliveau PJH, Wong JJ, Sutton DA, Simon NB, Bussières AE, Mior SA, *et al*. The chiropractic profession: a scoping review of utilization rates, reasons for seeking care, patient profiles, and care provided. Chiropr Man Therap. 2017;25(1): 1–17.
5. Micheli LJ, Wood R. Back pain in young athletes. Significant differences from adults in causes and patterns. Arch Pediatr Adolesc Med. 1995;149(1):15-18.
6. Aoki, Y., Takahashi, H., Nakajima, A., *et al*. Prevalence of lumbar spondylolysis and spondylolisthesis in patients with degenerative spinal disease. Scientific Rep. 2020;10(1): 6739. https://doi.org/10.1038/s41598-020-63784-0
7. American Institute of Ultrasound in Medicine. Official Statement Nonoperative Spinal/Paraspinal Ultrasound in Adults. Apr 2014; Reaffirmed 11/02/2019. Retrieved on Jul 7, 2024 from http://www.aium.org/soundWaves/article.aspx?aId=773&iId=20140521
8. Beneck GJ, Gard AN, Fodran KA. Spondylolisthesis identified using ultrasound imaging. J Orthopaed Sport Phys Ther. 2017;47(12): 970.
9. Wong MJ, Rajarathinam M. Ultrasound-guided axial facet joint interventions for chronic spinal pain: a narrative review. Can J Pain. 7(2): 2193617.
10. Ricciardi L, Perissinotto A, Dabala M. Mechanical monitoring of fracture healing using ultrasound imaging. Clin Orthop Relat Res. 1993;(293): 71–76.
11. Yamane T, Yoshida T, Mimatsu K. Early diagnosis of lumbar spondylolysis by MRI. J Bone Joint Surg (Br). 1993;75(5): 764–768.
12. Amoako A, Abid A, Shadiack A, Monaco R. Ultrasound-Diagnosed tibia stress fracture: a case report. Clin Medi Insights: Arthr Musculoskel Dis. 2017; 10: 10.

ISSN 0008-3194 (p)/ISSN 1715-6181 (e)/2024/131–141/$2.00/©JCCA 2024

Musculoskeletal symptomatology in skeletally immature students carrying heavy backpacks: a cross-sectional study

Zehra Alvi[1]
Ali Alvi[1]
Melanie A. Mascarenhas, MA[2,3]
Mansour Alvi, PhD, MD[4]
Konstantine K. Zakzanis, PhD[1,3]

Background: *Young students with skeletal immaturity report an increasing number of musculoskeletal symptoms associated with daily use of heavy backpacks. This cross-sectional study investigated the relationship between heavy backpack use and reports of pain.*

Methods: *Data were collected from 300 students aged 11 to 18 at the University of Toronto Schools.*

Results: *Students, on average, carried 15.9% of their body weight. 54% of students reported physiological complaints, primarily back, shoulder, neck, and leg pain. Backpack weight as a % of body weight was strongly associated with pain complaints. Younger students and those with longer commutes were more likely to report heavy backpacks (50% compared to 22.6% of older students, p< .001) and pain.*

La symptomatologie musculosquelettique chez des étudiants dont le squelette est immature, et qui portent des sacs à dos lourds : une étude transversale

Contexte: *Les jeunes étudiants souffrant d'immaturité squelettique signalent un nombre croissant de troubles musculosquelettiques des symptômes associés à l'utilisation quotidienne de sacs à dos lourds. Cette étude transversale a examiné la relation entre l'utilisation de sacs à dos lourds et les signalements de douleurs.*

Méthodes: *Les données ont été recueillies auprès de 300 étudiants âgés de 11 à 18 ans dans les écoles de l'Université de Toronto.*

Résultats: *Les étudiants, en moyenne, portaient 15,9 % de leur poids corporel. 54 % des élèves ont signalé des troubles physiologiques, principalement des douleurs au dos, aux épaules, au cou et aux jambes. Le poids du sac à dos exprimé en pourcentage du poids corporel était fortement associé aux douleurs. Les étudiants plus jeunes et ceux qui ont des trajets plus longs étaient plus susceptibles de déclarer avoir des sacs à dos lourds (50 % comparativement à 22,6 % des étudiants plus âgés, p< .001), ainsi que des douleurs.*

[1] University of Toronto St. George, Department of Human Biology
[2] University of Toronto Scarborough, Department of Psychological Clinical Science
[3] University of Toronto Scarborough, Department of Psychology
[4] Scarborough Health Network, Toronto, ON

Corresponding author: Konstantine K. Zakzanis, University of Toronto, Scarborough, 1265 Military Trail, Toronto, Ontario, M1C 1A4
Tel: (416) 287 7424.
Fax: (416) 287 7642
E-mail: konstantine.zakzanis@utoronto.ca

The authors have no disclaimers, competing interests, or sources of support or funding to report in the preparation of this manuscript.

Conclusion: *Carrying heavy backpacks could result in increased musculoskeletal complaints in young students. Findings suggest that even the upper bound of currently recommended guidelines (20% of body weight) may be too high, especially for younger children.*

(JCCA. 2024;68(2):131-141)

KEY WORDS: back pain, students, pain, child health, cross-sectional studies

Conclusion: *Le port de sacs à dos lourds pourrait entraîner une augmentation des plaintes musculosquelettiques chez les jeunes élèves. Les résultats suggèrent que même la limite supérieure des recommandations actuelles (20 % du poids corporel) pourrait être trop élevée, en particulier pour les jeunes enfants.*

(JCCA. 2024; 68(2) : 131-141)

MOTS CLÉS : douleur dorsale, étudiants, douleur, santé de l'enfant, études transversales

Introduction

According to recommendations from the American Academy of Pediatrics (AAP), a child's backpack should not exceed 10 to 20 percent of their body weight, with a new study stating that any backpack exceeding 15% of the carrier's bodyweight can result in musculoskeletal complaints.[1,2] Consequent research has further suggested the limit should be lowered and not exceed 5-10% of body weight.[3-5] There remains a lack of clarity on this topic, as there is currently no universal guideline for backpack weight, varying recommendations on weight, and little evidence that it has been shared with students and parents.[6] Despite this, research has demonstrated that a heavy backpack is a notable contributor to lower-back pain in children and that carrying a heavy backpack for long periods, carrying it on one shoulder instead of two, and climbing stairs while lugging a heavy load can exacerbate the problem.[7-11] This issue warrants further investigation as the detrimental health effects can be combatted by increasing awareness of ergonomic principles, including a backpack's content and weight.[6,7,12]

The effects of carrying heavy backpacks have come under global investigation, as evidenced by research conducted across Europe.[4,13-19] Studies have observed an increase in thoracic kyphosis as students have to adjust their centre of gravity to bear the weight, particularly when the weight carried surpasses 10% of body weight.[20] Although neck pain and lower back pain are experienced by individuals of all ages, these problems become an increasing concern in adolescence, with the prevalence rates ranging from 21% to 42%.[12,21] Consequently, this can warrant increases in consultations with health professionals and medication prescription, which can burden the healthcare system while simultaneously leading to reduced physical activity in children and higher rates of pain-related school absences.[21] Thus, determining an acceptable limit for a child's backpack and ensuring it is shared with stakeholders is essential in reducing back, neck, and shoulder injuries and preventing poor posture.[6,22] The combined effects of a heavy load, position on the body, size and shape, distribution, and time spent carrying the load, further influenced by the physical characteristics and condition of the individual, are considered factors that may be associated with these problems.[8]

While efforts have been made to set a weight limit for students' backpacks, not enough is done to share and enforce such limits.[6] Early adolescence (during middle and high school years) is a critical developmental period for spinal growth.[23] During this time, the early and mid-adolescent spine increases in length and volume without substantially adding mass, thereby causing the adolescent spine to be less able to withstand stresses that are considered normal for the adult spine.[24-27] Furthermore, experiencing lower back pain as a child or adolescent is strongly associated with chronic lower back pain in adulthood.[28] Preventive measures and appropriate guidelines regarding safe backpack weights for school children are essential in the reduction of musculoskeletal complaints among children to prevent the chronicity of such issues in adulthood.

Accordingly, we first sought to determine if the average backpack weight that students (aged 11-18) were carrying exceeded the recommended guidelines outlined by the AAP. Here, we additionally wanted to determine

if carrying overweight backpacks was associated with musculoskeletal (pain) complaints among these skeletally immature students. We investigated the relationship between musculoskeletal complaints and the average weight being carried and, in turn, determined whether carrying overweight backpacks was related to compromised health. To this end, we examined the subjective perception of pain and daily backpack load to ascertain whether an association exists. We also explored factors such as the time spent carrying a backpack to school and other variables that could further affect the subjective backpack load and related musculoskeletal complaints.

Methods

Ethics approval was obtained prior to the commencement of the study through the institutional Research Ethics Board Review Committee. Informed student consent and parental consent were both obtained. Students and staff were briefed regarding the purpose of the study. The study was designed and conducted by members of an academic club at the University of Toronto Schools (UTS), a merit-based middle and high school in the Greater Toronto Area. Two members were responsible for data collection. Additionally, a faculty member supervised the study progression. All procedures were in accordance with Canada's Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans.

Participants

Participants were recruited at the UTS Institute in the city of Toronto, Ontario, over a period of six months. An email detailing the study was sent to all students, allowing them to opt in or out of the study, with no incentive offered to participants. Of 612 eligible participants, 11 students opted out of participation. Of the remaining 601 interested students, stratified random sampling was used to recruit equal numbers of males and females for a total of 50 students from each grade (grades 7 through 12). Younger students were categorized as Grades 7 – 9 (ages 11 – 14) and older students as Grades 10 – 12 (ages 15 – 18). Figure 1 illustrates the participant eligibility and selection process.

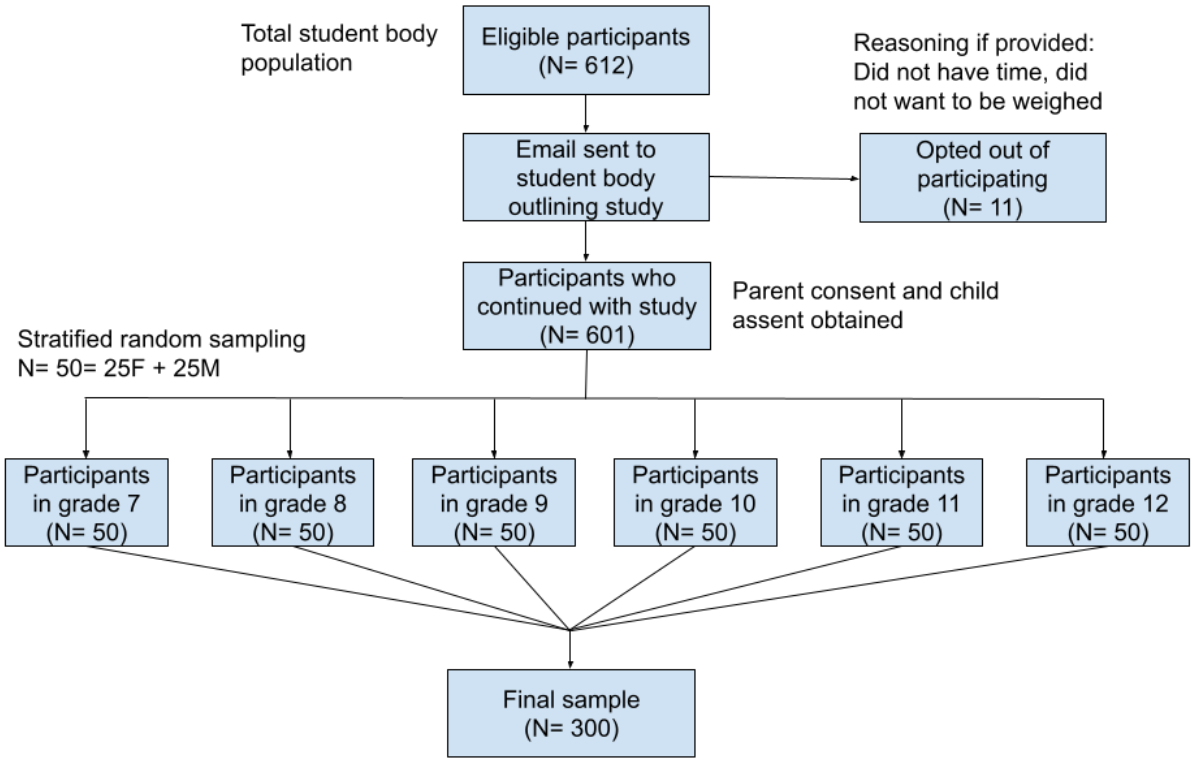

Figure 1. *Flowchart of Participant Eligibility and Selection*

Sample size justification

The sample was determined based on consideration of research objectives and representation of the target population. This investigation explored musculoskeletal concerns associated with carrying overweight backpacks among grades 7-12 students. For a comprehensive and unbiased sample, stratified random sampling was used.

A power analysis determined that the minimum required sample size for this study was 210 participants (effect size of 0.25, $\alpha = 0.05$, power $[1-\beta] = 0.95$). Previous research in this field have highlighted the absence of a standard reference effect size. This has made determining the appropriate sample size challenging due to a lack of literature. For example, one study recruited 123 students based on an estimation that pain prevalence was 30% with a confidence level of 95%.[10]

The student body comprised of 612 students, with 102 in each grade level. For equitable representation, 50 students (25 female and 25 male) were randomly selected from each grade, yielding a total sample size of 300 students, equally distributed across genders. Thus, data were collected from 50% of the student body, ensuring inclusivity of diverse student backgrounds and facilitating generalizability to the broader school context. This was done to mitigate potential bias from over or under-representation of grades or genders. The chosen sample size ensured the statistical power for detecting anticipated effects and enhanced the validity of the findings by adhering to ethical principles for addressing the research objectives.

Data collection

Data collection was conducted consecutively, beginning with the recruitment of students in Grade 7 and ending with students in Grade 12. Data collection took place on random days such that students would not be influenced by the study and alter their backpack's weight in anticipation of the data collection. All data were collected in the morning following each student's arrival, at lunch, and before departure from school. First, a consent form and a questionnaire to gather primary data were administered. The questionnaire included details about age, gender, grade, body weight, height, area of residence, commute type, duration of commute, backpack weight, subjective perception of backpack weight, items in the backpack, how it is carried, physical complaints, frequency of physical complaints, medical intervention, any medical diagnosis, and any use of medications. The study ensured that all students used a dual-strap backpack, with all participants reporting they carried the load on both shoulders. Regarding physical complaints, students were asked if they experienced any musculoskeletal complaints, such as pain in the neck, shoulder, lower back, or leg(s). Second, the weight of the backpacks was obtained using a Klau Hanging Scale with the capacity to measure between 0.2 kg and 500 kg with high precision. The validity of this instrument was tested using functional cuff weights of 0.45 kg, 1.36 kg, and 2.27 kg, revealing accurate measurements over repeated trials. Third, the weight of participants was collected using a Seca 803 digital floor scale, calibrated at the start of each day of data collection. Finally, the height of participants was measured using a Health O Meter professional wall-mounted height rod.

Analyses

The Statistical Package for the Social Sciences (SPSS, Version 28.0) was used for all data analysis.[29] Backpack weight as a % of bodyweight was measured on a continuous ratio scale. Chi-square tests were conducted to assess objective backpack weight (as a percentage of body weight) and commute time on the pain response in students. Independent samples t-tests and analyses of variance (ANOVA) were conducted to assess differences in outcomes across groups of categorical variables (reported pain complaints, subjectively perceived heaviness of bags). All assumptions were assessed and met for each analysis.

Results

Sample characteristics and outcomes are summarized in Table 1. The present study found that 75% of students carried a backpack that was more than 10% of their body weight, and 17% of students carried a backpack more than 20% of their body weight. On average, students carried 15.9% of their body weight, and approximately 54% reported physiological impacts with primarily back, shoulder, neck, and leg pain complaints. On average, younger students (Grades 7 – 9; ages 11 – 14) were carrying heavier backpacks in proportion to their body weight compared to older students (Grades 10 – 12; ages 15 – 18) (Table 1). The average backpack weight to bodyweight ratio for younger students was 17.7%, compared to 13.6% for older students. In addition, younger students

were more likely to be carrying backpacks that were more than 10% (98%, 92%, and 94% of students in grades 7, 8, and 9, respectively), or 20% (44%, 36%, and 20% of students in grades 7, 8, and 9, respectively) of their body weight. There was no great difference in the average backpack weight alone, with younger students carrying backpacks weighing 8.3 kg and older students carrying backpacks weighing 7.9 kg. However, the average body weight of younger students was 47.24 kg while, in comparison, the average body weight of older students was 58.35 kg. Here, the younger group's lower body weight had a significant impact on the backpack-to-bodyweight ratio.

Students in younger grades 7 – 9 were more likely to report their backpacks as being heavy compared to older students in grades 10 – 12 [50% compared to 22.6%, χ^2 (5, n = 300) = 75.54, p < .001]. In addition, a higher proportion of students in grades 7 – 10 reported musculoskeletal pain complaints (66%, 56%, 62%, and 72%, respectively) compared to students in grades 11 and 12 (34% and 32%, respectively), a statistically significant difference in proportions, χ^2 (5, n = 300) = 28.54, p < .001. Figure 2 and Figure 3 further illustrate these differences.

The relationship between objective backpack weight, subjective perception of backpack weight, and pain

An independent samples t-test revealed a significant difference in the relative backpack weight as a % of body weight between students who reported pain complaints (M = 17.2, SD = 4.2), and students who reported no pain (M = 14.3, SD = 3.8), t(298) = -6.1, p < .001).

To assess the relevance of AAP guidelines with regard to reports of pain, a chi-square test found that 21.1% of students were carrying less than 10% of their body weight reported physical pain complaints, compared to 50.6% of students carrying between 10-20% of their body weight and 80% of students carrying more than 20% of their body weight, a statistically significant difference in proportions, χ^2 (2, n = 300) = 22.92, p <.001 (Figure 4).

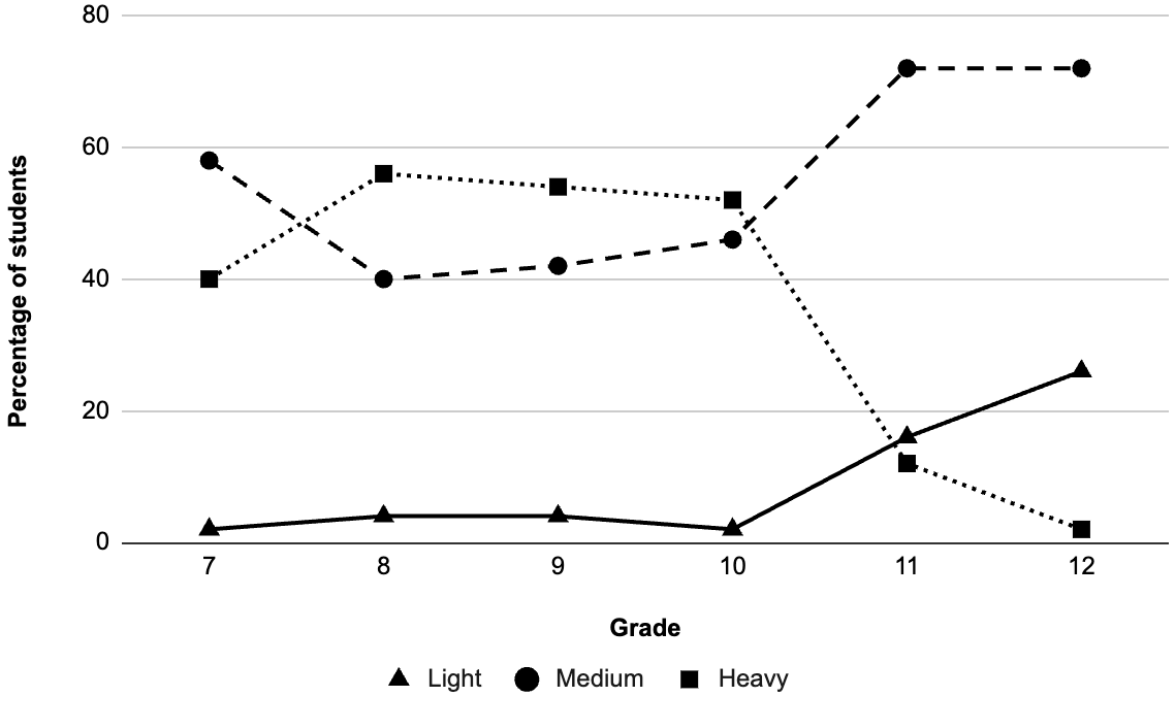

Figure 2.

Reports of subjective perceptions of backpack weight by grade (Note. A greater percentage of younger students (Grades 7-10) reported heavy backpacks compared to older students (Grades 11-12). Similarly, a greater percentage of older students reported light backpacks compared to younger students). (—▲—) reports of light backpacks; (— ● —); reports of moderately heavy backpacks; (•• ■ ••) reports of heavy backpacks.

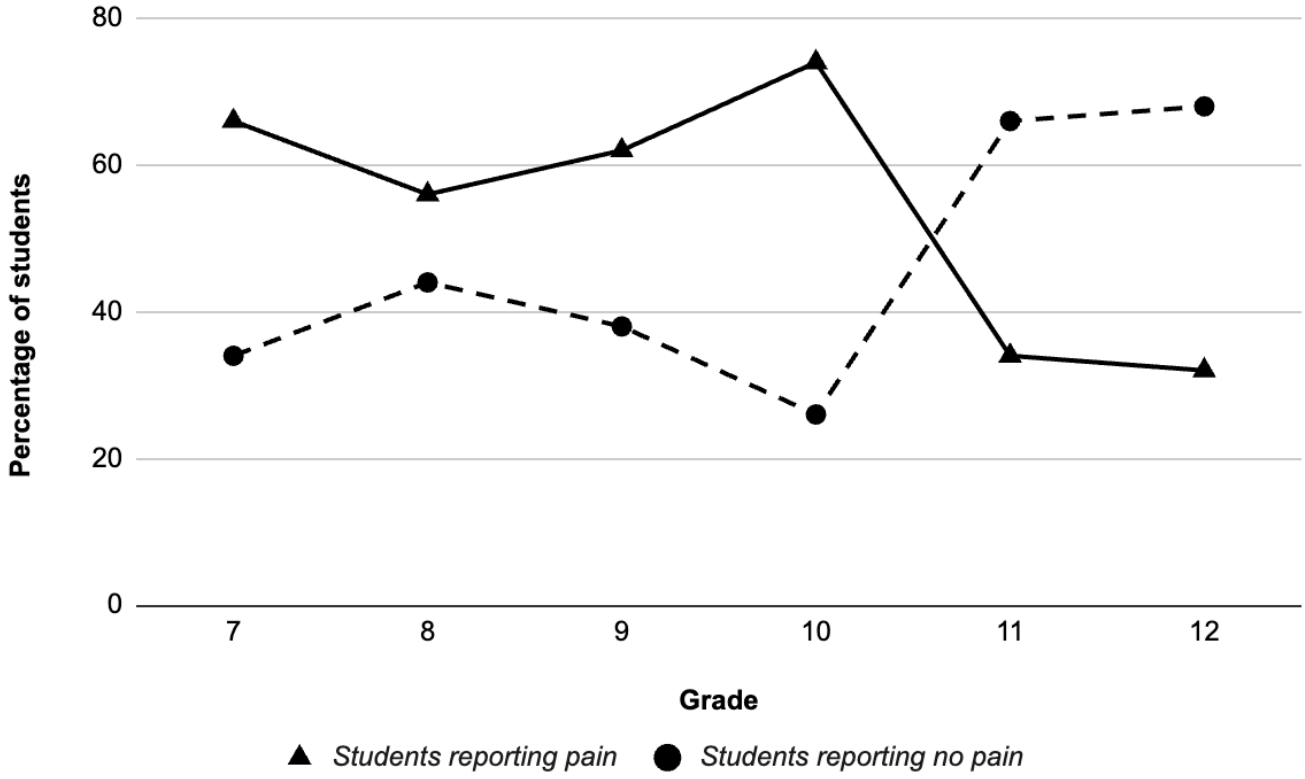

Figure 3.
Reports of pain by grade (Note. A greater percentage of younger students (Grades 7-10) reported musculoskeletal pain compared to older students (Grades 11-12)). (—▲—) reports of pain; (— ● —), reports of no pain.

To determine whether students' subjective reports of their backpack weight were related to the objective weight of their backpacks, a one-way ANOVA revealed significant differences in the backpack weight as a % of body weight between students who reported their bags as very heavy (M = 18.34, SD = 3.86), moderately heavy (M = 15.01, SD = 3.63) and light (M = 11.08, SD = 2.81), $F(2, 297) = 52.67$, $p < .001$, $\eta 2 = .26$, indicating a large effect size (Cohen, 1988). Further, a chi square test revealed significant differences in the proportion of students who reported pain complaints between those who reported their backpacks as very heavy (76.1%), moderately heavy (43.3%), and light (25.9%), χ^2 (2, n = 300) = 37.61, p <.001.

The relationship between commute time, subjective perception of backpack weight, and pain

A chi-square test found that 83% of students with a commute time of greater than two hours reported physical pain, compared to 51% of students with a commute time of between one and two hours, 57% of students with a commute time of between 30 minutes and one hour, and only 39% of students with a commute time of fewer than 30 minutes, a statistically significant difference in proportions, χ^2 (3, n = 300) = 11.44, p =.01 (Figure 5). Specifically, a commute time of over two hours resulted in significantly more reports of physical pain than shorter commute times (i.e., less than 30 minutes).

Further, students were more likely to report their bags as being very or moderately heavy (as opposed to being light) if they had a longer commute. Here, 100% of students with a commute time of greater than two hours reported heavy backpacks, compared to 96.4% of students with a commute time of between one and two hours, 88.2% of students with a commute time of between 30 minutes and one hour, and 62.5% of students with a commute time of fewer than 30 minutes, a statistically signifi-

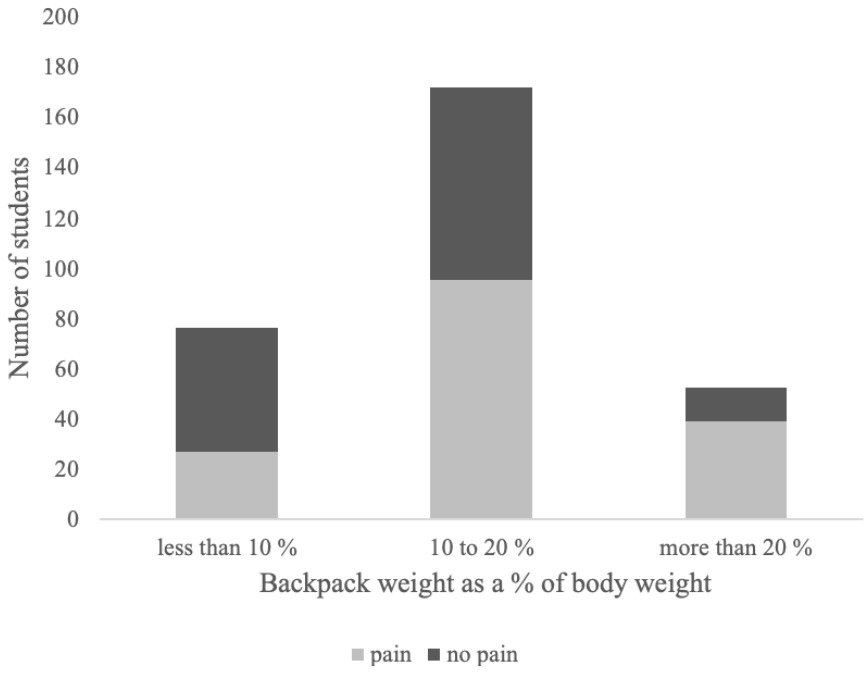

Figure 4.

The relationship between backpack weight and pain complaints (Note. On average, students carrying a heavier percentage of their body weight reported significantly more pain complaints. (▒), pain; (■), no pain).

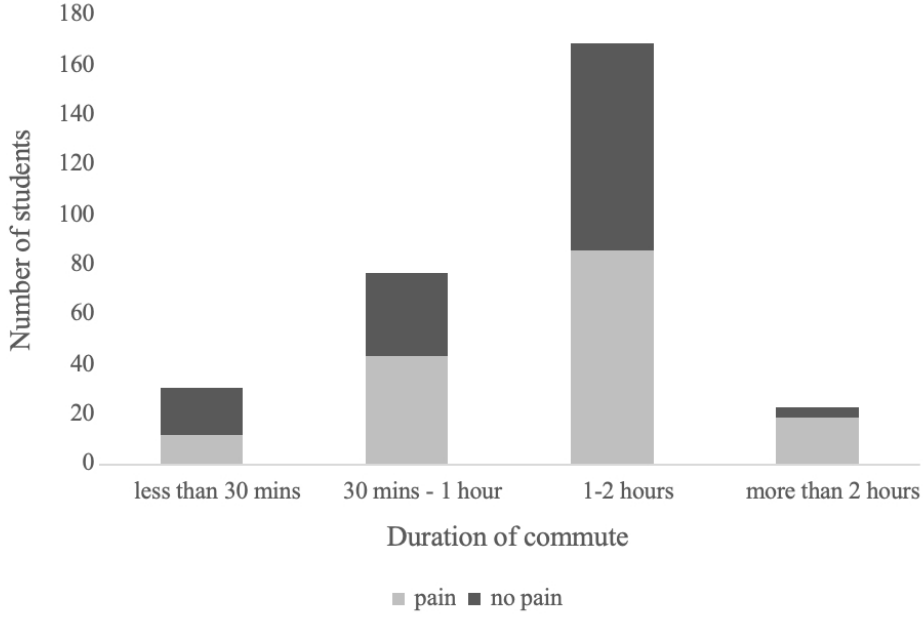

Figure 5.

The relationship between duration of commute and pain complaints (Note. Duration of commute was related to pain complaints; there were significantly more reports of pain among students with commute times of over two hours compared to those with shorter commute times). (▒), pain; (■), no pain.

cant difference in proportions, χ^2 (3, n = 300) = 42.70, p <.001. No significant differences were observed for variables such as commute type and area of residence.

The role of additional demographic variables in assessing perceptions of bag weight and pain

Further group-level analyses were conducted to assess the role of demographic characteristics in perceptions of backpack weight and reports of pain. A point biserial correlation revealed a small but significant association between height and pain complaints, where pain was more frequently reported among shorter students than taller students (rpb (298) = - .150[-.259, -.037], p = .009). There was no observed effect of sex; reports of pain did not significantly differ between male and female students (50% compared to 57.3%, χ^2 (1, n = 300) = 1.62, p = .203).

Discussion

The AAP recommends that a child's backpack be no more than 10-20% of their body weight.[1] The present study found 75% of all students carrying a backpack more than 10% of their body weight, and 17% of students carried a backpack more than 20% of their body weight. In this sample, 33.3% of younger students ages 11-14 carried backpacks at or over the maximal 20% limit recommended by the AAP. In comparison, 1.3% of older students ages 15-18 surpassed this limit. This appears to be related to the finding that backpack weight remained relatively stable across age groups even though there is a high degree of variance in body weight and height across children aged 11-18. Typically, while backpack weight across ages and grades tended to remain stagnant, lower body weights of younger students appeared to lead to more pain complaints, likely due to the ratio of backpack weight to body weight, which has previously been identified as a predictor of back pain.[7]

Backpack weight as a percentage of the child's body weight was significantly related to the presence of increased pain complaints for all students, as was their subjective perception of this weight. Further, this study and other research found that younger students were much more likely to report musculoskeletal pain as compared to older students.[30] While only 17% of students carried a backpack more than 20% of their bodyweight, the proportion of students with musculoskeletal complaints was much higher, with approximately 54% of students reporting pain primarily in the back, shoulder, neck, and legs. Accordingly, even the upper bound of presently recommended guidelines (20% of body weight) may be too high, especially for younger children.

Prior evidence has suggested that the time spent carrying the backpack, in addition to its weight, is a factor in instances of back pain.[31,32] The present study found that commute duration to school was significantly related to students' perceived backpack weight and their reports of musculoskeletal pain, especially when commute times were longer than one hour. Research has also indicated the impact on musculoskeletal health associated with the distance and time spent carrying the backpack might exceed that of weight alone, thus being a crucial contributing factor considered in this study.[32] With 64% of students reporting a commute greater than or equal to one hour, this poses a significant concern and warrants further consideration.

While previous research on this subject has found a correlation between back pain and the factors identified in this study, they have been unable to identify specific risk factors as a result of inconsistent methods of reporting, as most studies on this topic do not consider the type of back pain, spinal posture and illness factors.[24,30] These reviews call upon future studies to be more rigorous in considering the factors that lead to back pain, which this study addressed by inquiring about the regions of the back affected by back pain and regarding spinal posture and illness factors by inquiring whether participants have been previously diagnosed by medical professionals for any musculoskeletal issues.

The effects of carrying excess weight in school backpacks have been a long-discussed subject in paediatric research, yet students are required to carry loads that exacerbate this problem and cause physical pain.[33] Excessive backpack weight, especially that exceeding 20% of the individual's body weight, has recently gained attention from multiple studies as a major contributor to pain in the early stages of development.[3,34,35] Consequently, back pain in children has become a prominent public health concern.[36]

The backpack was designed to be the appropriate method to load the spine closely and symmetrically while maintaining stability.8 However, risk evaluation when carrying over the recommended maximum weight in a backpack is essential. Exceeding recommended guide-

lines of backpack weight can cause an individual's center of gravity to be displaced which can create excess tension in one's muscles in the back and neck. Such excessive tension is further associated with spinal column dysfunction and a decrease in lung volume.[10] Previous work has also demonstrated an association between backpack weight and musculoskeletal complaints.[33] There is an increased risk to younger children and adolescents considering that their musculoskeletal system is undergoing a period of growth and maturation and considering the frequency of backpack use in this group.[23]

Musculoskeletal problems associated with backpack use are becoming an escalating concern for skeletally immature students.[6] Studies have found that back pain in adolescents is a strong predictor of developing chronic back pain in adulthood.[37-41] Unaddressed back pain can get exacerbated, resulting in long-lasting complications. Prior research has also found that carrying heavy backpacks may lead to detrimental changes in trunk posture and muscle activity.[42]

Limitations

This study has some limitations which must be considered. First, while the sample is representative of the school's population, these results may not be generalizable on a city-wide or regional scale. Further research is required to produce comprehensive data on the pervasiveness of the adverse effects of overweight backpacks among skeletally immature students. Secondly, this study was reliant on self-reported musculoskeletal complaints. As such, data on pain are vulnerable to participant subjectivity and reliability. Finally, the impact of a cross-sectional dataset introduces certain limitations, as the nature of the design restricts the establishment of causal relationships, with data being collected at only one time point. As such, there are limitations in capturing longitudinal changes, potentially overlooking trends and fluctuations in the investigated variables. While this study provides valuable insight into the relationship between backpack weight and musculoskeletal pain, there are limitations in generalizing the findings. Expanded cohort studies with diverse student populations are required to further explore these findings.

Conclusion

In conclusion, the findings of this study demonstrated that the current backpack weight for many (particularly younger) students is higher than recommended guidelines and likely related to a high number of pain complaints. Most students carrying between 10-20% of their body weight reported mild to moderate pain, which is often overlooked in practical settings as it falls below the upper bound of AAP recommended guidelines (i.e., 20% of body weight). Heavy backpacks are an influential factor in the cause of early-age back pain, and previous research has suggested that reducing the load to 10% of body weight can help maintain normal posture.[3,35] The present study's findings could inform further research that aims to address the issue of heavy backpack use. Additionally, considering commute time was significantly related to pain complaints, reductions in the time spent carrying backpacks should be considered. Current recommendations include carrying adequately adjusted backpacks to better fit the child's back, backpacks with padded dual straps, carrying only necessary items, placing the heaviest items closest to the back, the provision of lockers to store heavier items (e.g., textbooks), and division of textbooks into smaller modules.[6,43] These recommendations were provided to UTS to facilitate changes that decrease backpack load for students. Considering that previous research has consistently demonstrated that back pain in adolescence contributes to chronic back pain in adulthood, early intervention in this population is imperative. Ultimately, further research is needed to elucidate the relationship between backpack weight and musculoskeletal pain in early educational settings to create a healthier learning environment for students.

References

1. Grant L. Backpack weight: how heavy is safe? AAP Gd Rounds. 2007; 18(1): 10–11.
2. Djajasasmitan D, Manoe ZJ, Wulandari, F. Relationship between backpack weight and incidence of low back pain in senior high students. Acta Med and Health Sci. 2023; 1(3): 105–111.
3. Moore MJ, White GL, Moore DL. Association of relative backpack weight with reported pain, pain sites, medical utilization, and lost school time in children and adolescents. J Sch Health. 2007; 77(5): 232–239.
4. Al-Hazzaa HM. School backpack. How much load do Saudi school boys carry on their shoulders? Saudi Med J. 2006; 27(10): 1567–1571.
5. Lindstrom-Hazel, D. The backpack problem is evident but the solution is less obvious. Work. 2009; 32(3): 329–338.

6. Dockrell S, Simms C, Blake C. Guidelines on schoolbag use: messaging to inform the stakeholders. Work. 2016; 54(2): 489–492.
7. Siambanes D, Martinez JW, Butler EW, Haider T. Influence of school backpacks on adolescent back pain. J Pediatr Orthop. 2004; 24(2): 211–217.
8. Knapik J, Harman E, Reynolds K. Load carriage using packs: a review of physiological, biomechanical and medical aspects. Appl Ergon. 1996; 27(3): 207–216.
9. Perton M. Aching backs affect children, too. Consumer Reports. https://www.consumerreports.org/cro/news/2009/07/heavy-backpacks-can-add-to-children-s-back-problems/index.htm. July 21, 2009. Accessed August 21, 2022.
10. Hernández TL, Ferré MC, Martí SG, Salvat IS. Relationship between school backpacks and musculoskeletal pain in children 8 to 10 years of age: an observational, cross-sectional and analytical study. Int J Environ Res Public Health. 2020; 17(7): 2487.
11. Dockrell S, Simms C, Blake C. Schoolbag carriage and schoolbag-related musculoskeletal discomfort among primary school children. Appl Ergon. 2015; 51: 281–290.
12. Arrifqi M, Bahrudin, M. Effect of backpack with the incidence of low back pain at 7-20 years of age. APISIO Medika. 2023; 1(1): 29-32.
13. Cardon G, Balague F. Backpacks and spinal disorders in school children. Eura Medicophys. 2004; 40(1): 15–20.
14. Negrini S, Politano E, Carabalona R, Tartarotti L, Marchetti ML. The backpack load in schoolchildren: clinical and social importance, and efficacy of a community-based educational intervention. Eura Medicophys. 2004; 40(3): 185–190.
15. Cottalorda J, Rahmani A, Diop M, Gautheron V, Ebermeyer E, Belli A. Influence of school bag carrying on gait kinetics. J Pediatr Orthop B. 2003; 12(6): 357–364.
16. Chow D, Leung K, Holmes A. The effects of load carriage and bracing on the balance of schoolgirls with adolescent idiopathic scoliosis. Eur Spine J. 2007; 16(9): 1351–1358.
17. Vitiello A, Pollard H. Backpack design: the use of ratings of perceived exertion (borg scale) – a review. Chiropr J Aust. 2002; 32(3): 91–98.
18. Ismaila SO, Oriolowo KT. Determination of safe backpack mass for students in tertiary institutions. Proceedings of the 2015 International Conference on Industrial Engineering and Operations Management; March 3–5, 2015; 2526–2529; Dubai, UAE.
19. Steele E, Bialocerkowski A, Grimmer A. The postural effects of load carriage on young people – a systematic review. BMC Musculoskelet Disord. 2003; 4: 2.
20. Drzał-Grabiec J, Truszczyńska A, Rykała J, et al. Effect of asymmetrical backpack load on spinal curvature in school children. Work. 2015; 51(2): 383–388.
21. Minghelli B. Musculoskeletal spine pain in adolescents: Epidemiology of nonspecific neck and low back pain and risk factors. J Orthop Sci. 2020; 25(5): 776–780.
22. Sturdy J, Rizeq HN, Silder A, Sessoms PH, Silverman AK. Walking slope and heavy backpack loads affect torso muscle activity and kinematics. J Electromyogr Kinesiol. 2023; 70: 10279.
23. Stücker R. The growing spine: normal and abnormal development. Orthopäde. 2016; 45(6): 534–539.
24. Beynon AM, Hebert JJ, Lebouef-Yde C, Walker BF. Potential risk factors and triggers for back pain in children and young adults. A scoping review, part II: unclear or mixed types of back pain. Chiropr Man Ther. 2019; 27(1): 61.
25. Hirsch L. Kids Health. Backpacks. Nemours Foundation. https://kidshealth.org/en/kids/backpack.html. May 2020. Accessed August 21, 2022.
26. Jones GT, Macfarlane GJ. Epidemiology of low back pain in children and adolescents. Arch Dis Child. 2005; 90(3): 312–316.
27. Reneman MF, Poels BJJ, Geertzen JHB, Dijkstra PU. Back pain and backpacks in children: biomedical or biopsychosocial model? Disabil Rehabil. 2006; 28(20): 1293–1297.
28. Brattberg, G. Do pain problems in young school children persist into early adulthood? A 13-year follow-up. Eur J Pain. 2004; 8(3): 187–199.
29. IBM Corp. (2021). IBM SPSS Statistics for Mac, Version 28.0. Armonk, NY: IBM Corp. [Computer software].
30. Beynon AM, Hebert JJ, Lebouef-Yde C, Walker BF. Potential risk factors and triggers for back pain in children and young adults. A scoping review, part I: incident and episodic back pain. Chiropr Man Ther. 2019; 27(1): 58.
31. Szpalski M, Gunzburg R, Balagué F, Nordin M, Mélot C. A 2-year prospective longitudinal study on low back pain in primary school children. Eur Spine J. 2002; 11(5): 459–464.
32. Perrone M, Orr R, Hing W, Milne N, Pope R. The impact of backpack loads on school children: a critical narrative review. Int. J. Environ. Res. Public Health. 2018; 15(11): 2529–2554.
33. Rodriguez-Oviedo P, Ruano-Ravina A, Perez-Rios M, Garcia FB, Gomez-Fernandez D, Fernandez-Alonso A, et al. School children's backpacks, back pain and back pathologies. Arch Dis Child. 2012; 97(8): 730–732.
34. Rai A, Agarawal S. Back problems due to heavy backpacks in school children. IOSR JHSS. 2013; 10(10): 1–5.
35. Rai A, Agarawal S, Bharti S. Postural effect of back packs on school children: its consequences on their body posture. IJHSR. 2013; 3(10): 109–116
36. Noll M, Candotti CT, Nichele da Rosa B, Loss JF. Back pain prevalence and associated factors in children and adolescents: an epidemiological population study. Rev Saude Publica. 2016; 50: 31.

37. Mackenzie WG, Sampath JS, Kruse RW, Sheir-Neiss GJ. Backpacks in children. Clin Orthop Relat Res. 2003; 409: 78–84.
38. Ahlqwist A, Sällfors C. Experiences of low back pain in adolescents in relation to physiotherapy intervention. Int J Qual Stud Health Well-being. 2012; 7(1).
39. Schechter NL, Berde CB, Yaster M. Pain in infants, children and adolescents: an overview.2nd ed. Baltimore: Williams & Wilkins, 2003; 3–9.
40. Kjaer P, Wedderkopp N, Korsholm L, Leboeuf-Yde C. Prevalence and tracking of back pain from childhood to adolescence. BMC Muscoskelet Disord. 2011; 12: 98.
41. Alfvén G, Olsson GL. Långvarig smärta hos barn och ungdomar kan och bör behandlas. Problemet är vanligt och medför stort lidande [Chronic pain in children and adolescents can and should be treated. The problem is common and causes great suffering]. Läkartidningen. 2008; 10: 720–722.
42. Hong Y, Cheung C. Gait and posture responses to backpack load during level walking in children. Gait Posture. 2003; 17(1): 28–33.
43. Skaggs DL, Early SD, D'Ambra P, Tolo VT, Kay RM. Back pain and backpacks in school children. J Pediatr Orthop. 2006; 26(3): 358–63.

Table 1.
Sample characteristics and outcomes

Grade	**Total**		**7**		**8**		**9**		**10**		**11**		**12**	
Age range	11-17		11-12		13-14		14-15		15-16		16-17		17	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Height (cm)	162.9	10.1	154.3	8.9	155.0	7.4	157.7	5.7	165.9	9.3	166.5	6.7	173.1	6.1
BW (kg)	52.6	8.4	43.7	6.5	47.9	6.8	50.1	5.8	55.1	6.7	58.0	4.3	60.7	5.8
Backpack weight (kg)	8.1	1.5	8.0	1.7	8.3	1.6	8.8	1.3	8.9	0.7	7.7	1.0	6.8	1.0
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Backpack as a % of BW		15.4		18.3		17.3		17.6		16.2		13.3		11.2
Students carrying > 10% BW	225	75	49	98	46	92	47	94	44	88	28	56	11	22
Students carrying > 20% BW	52	17.3	22	44	18	36	10	20	2	4	0	0	0	0
Students reporting heavy backpacks	109	36.3	20	40	28	56	27	54	27	54	6	12	1	2
Students reporting pain	161	53.67	33	66	28	56	31	62	36	72	17	34	16	32

Note. BW = body weight

ISSN 0008-3194 (p)/ISSN 1715-6181 (e)/2024/142–148/$2.00/©JCCA 2024

An unusual presentation of Herpes zoster and associated differentials

Scott Dunham, BSc, DC, MSc, MEd.[1]
Alyson Morris, BSc[2]

This case study documents the case of a 27-year-old female who presented with a complaint of left anterolateral thigh numbness, initially diagnosed as meralgia paresthetica with a differential diagnosis of lumbar radiculopathy. Over a span of two weeks, the patient endured emotional trauma and subsequently developed lesions in the area of complaint. The patient was diagnosed at a medical clinic with herpes zoster and was prescribed anti-viral medication which resulted in complete resolution.

This case highlights the importance of considering herpes zoster as a differential diagnosis for nerve-related symptoms. Features of lumbar radiculopathy, meralgia paresthetica, varicella zoster and herpes zoster are discussed, as well as the defining characteristics and treatment options. Practitioners must remain vigilant in

Une présentation inhabituelle du zona et des différentiels associés

Cette étude de cas documente le cas d'une femme de 27 ans qui a présenté une plainte d'engourdissement antérolatéral gauche de la cuisse, initialement diagnostiquée comme une méralgie paresthésique avec un diagnostic différentiel de radiculopathie lombaire. En l'espace de deux semaines, le patient a subi un traumatisme émotionnel et a par la suite développé des lésions dans la zone de la plainte. Le zona a été diagnostiqué chez le patient dans une clinique médicale et un traitement antiviral lui a été prescrit, ce qui a permis une guérison complète.

Ce cas souligne l'importance de considérer le zona comme étant un diagnostic différentiel pour les symptômes liés aux nerfs. Les caractéristiques de la radiculopathie lombaire, de la méralgie paresthésique, du zona varicelleux et du zona font l'objet de discussions, ainsi que les caractéristiques et les options de traitement qui les définissent. Les praticiens doivent rester vigilants en cas de suspicion d'infections virales

[1] Division of Undergraduate Education, Canadian Memorial Chiropractic College, Toronto, ON
[2] Canadian Memorial Chiropractic College, Toronto, ON

Corresponding author: Scott Dunham, Canadian Memorial Chiropractic College, 6100 Leslie Street, Toronto, ON, M2H 3J1
Tel: 647-805-2021
E-mail: sdunham@cmcc.ca

The authors have no disclaimers, competing interests, or sources of support or funding to report in the preparation of this manuscript.
The involved patient provided consent for case publication.

suspicion of viral infections such as herpes zoster even with lower incidence due to approved vaccines.

(JCCA. 2024;68(2):142-148)

KEY WORDS: chiropractic, differential diagnosis, herpes zoster, lumbar radiculopathy, meralgia paresthetica, patient management, varicella zoster

telles que le zona, même avec une incidence plus faible en raison de vaccins approuvés.

(JCCA. 2024; 68(2) : 142-148)

MOTS CLÉS : chiropratique, diagnostic différentiel, zona, radiculopathie lombaire, méralgie paresthésie, prise en charge des patients, varicelle-zona

Introduction

Low back pain can radiate into the lower extremities, giving rise to symptoms such as numbness, tingling and pain.[1] Differentiating nerve related diagnoses such as meralgia paresthetica, herpes zoster, and lumbar radiculopathy is important in determining what can be treated by a chiropractor and which patients should be referred for further investigation. This paper presents a case of a patient who presented to a chiropractic clinic with nerve related symptoms, later revealed to be a case of herpes zoster, after originally being diagnosed as meralgia paresthetica.

Meralgia paresthetica is a mononeuropathy of the lateral femoral cutaneous nerve, a sensory nerve that innervates the anterolateral part of the thigh.[2] Meralgia paresthetica is an elusive diagnosis to make because it can often mimic a lumbar radiculopathy presenting with decreased sensation to pinprick, pain, or burning within its distribution.[2] The entrapment site for this nerve is under the inguinal ligament just beneath the anterior iliac spine.[2]

Herpes zoster, also known as "shingles," is an acute, localized infection of the central nervous system involving the dorsal root ganglion.[3] It is caused by the varicella zoster virus which is a member of the Herpesvirus family.[4] Following a primary varicella infection, the virus remains dormant in the dorsal root ganglia, often for many years.[4] When the virus re-activates, pain within the dermatome results followed by an outbreak of vesicles.[5]

This case study highlights an instance where a nerve complaint presenting as meralgia paresthetica was later revealed to be a latent herpes zoster infection. Herpes zoster should remain as a differential for the clinician when diagnosing nerve-related complaints.

Case presentation

A 27-year-old female presented with a primary complaint of numbness of the left anterolateral thigh, and low back pain. The pain and numbness began insidiously four months prior while on a trip to Australia where she was hiking through rugged terrain, often sleeping on non-ideal surfaces and had no opportunity to have her symptoms investigated. There was no progression or resolution after returning from her trip, and the numbness still woke her up at night. The numbness was localized to the anterolateral aspect of her thigh, from her greater trochanter down to above her knee, never extending beyond the knee. The numbness occurred when lying supine or sitting for a prolonged period. Standing and walking provided some relief. She was not taking any medication for the current condition, and her family doctor recommended seeking chiropractic treatment, and strengthening her core. The pain was rated as a 2-3/10 and did not prevent her from engaging in her daily activities. Also, there was a slight burning sensation noted centrally in her L4/5 region, which originated when the numbness arose.

The patient was quite active and maintained a healthy lifestyle. Family history was unremarkable as was any personal history of back pain. The patient was concurrently being treated for a minor right knee injury at the clinic, and her health history was otherwise unremarkable.

Physical examination revealed full and pain-free lumbar ranges of motion, with large ranges of flexion and extension demonstrated. Orthopedic testing for the low back was within normal limits with Yeoman's, straight leg raise, Braggards, Bowstrings and sacroiliac joint compression not eliciting any abnormal response. Valsalva's was pain-free and did not increase the symptoms, with Kemp's revealing mild discomfort at L4/5 bilaterally. Motion palpation of the low back revealed a large range of motion throughout the lumbar spine with no restrictions or pain on joint challenge.

A lower extremity neurological exam was performed. Sensory testing for the lower limb revealed an area of de-

creased sensation located on the anterolateral aspect of the thigh, from the greater trochanter to three inches (~7.5 cm) superior to the lateral condyle of the knee. Testing was performed with soft touch and sharp and dull, with a decreased awareness within the area of diminished sensation. Strength testing for the lower limb was rated 5/5 bilaterally with reflexes for patellar and Achilles rated as 2+ bilaterally.

The patient was referred to her family doctor for radiographic examination of her low back including flexion/extension views to help rule out hypermobility as a cause for her neurological complaints. She continued treatment for an unrelated knee complaint, and the area of paresthesia on her left thigh was monitored.

Two weeks after the initial evaluation, the patient presented to her family doctor with 3-4 red scab-like lesions within the area. Her family doctor diagnosed them as "spider bites" and no medication was prescribed. Two days later, when more scab-like lesions appeared within the area she went to a walk-in clinic where a preliminary diagnosis of herpes zoster was made through visual inspection, and she was provided a prescription for anti-viral medication. No further testing was arranged by the physician, but a follow-up was encouraged to the patient if it did not resolve with the prescribed medication. The lesions disappeared within four to five days, and patient reported that she had complete resolution of her paresthesia within two weeks. Although no follow-up neurological or physical examination was performed, the patient relayed 3 months later that her resolution was maintained. It is worth noting that at the time of outbreak of her lesions, the patient reported to be under considerable emotional stress, as she was experiencing problems at work and had to relocate after a fire in her apartment.

Discussion

Varicella zoster

Varicella zoster (VZ) is a childhood disease commonly referred to as chickenpox, which presents with an itchy, blistered rash and is often associated with a fever and or respiratory symptoms.[5] VZ symptoms can present 10 to 20 days post infection and last up to two weeks.[5] Symptoms are typically mild for most children however can be severe in the immune compromised population. Prior to wide-spread availability of a vaccine, VZ infected 50% of children by age five, and 90% by age 12 in Canada.[6] Pre vaccine statistics in Canada show that there were approximately 350,000 cases each year and 1500-2000 related hospitalizations.[6] Once infected with VZ the virus remains latent in the sensory nerve ganglion and can be reactivated later in life as the herpes zoster virus. Although rarely performed because the diagnosis is usually made on inspection of the rash, cultures from a lab can confirm the diagnosis of VZ.[5]

The live attenuated VZ vaccine became licensed in Canada in 1998 and available in Ontario in 2004.[6] The vaccine in children is estimated to be 94.4% effective following a single dose and 98.3% effective following a second dose.[6] The recommended doses of the vaccine should be given at 15 months old and at 4-6 years of age.[6] The vaccines are included in the publicly funded schedule and are offered free to all children in Ontario. A child born after 2010 is required to have the chickenpox vaccine unless they have a valid exemption. Adverse reactions to the VZ vaccine are uncommon and few have been reported. The most common reactions include pain, swelling, redness at the injection site, and a low-grade fever. Although this vaccine is most effective in children it should be highly prioritized in high-risk populations.[6] The risk of contracting the herpes zoster virus is 4-fold to 12-fold lower in those who have had the VZ vaccine in comparison to those unvaccinated.[6] There are documented cases where individuals who have been vaccinated against chickenpox may still get HZ years later.[6]

Herpes zoster

Herpes zoster (HZ) virus also known as shingles, is the reactivation of the varicella zoster virus. HZ presents with symptoms commonly of the trunk such as pain and tingling in a unilateral dermatomal pattern, often with associated fluid filled blisters.[7] This typically occurs in those above 50 years of age, due to weakening of the immune system or when triggered by emotional stress.[7] Someone with HZ can transmit the virus to someone who has never had chickenpox or who is unvaccinated. The transmission of HZ occurs with contact of fluid from the rash of one person or via respiratory droplets.[7] A common complication of HZ is post herpetic neuralgia which often presents with debilitating neurogenic pain in a dermatomal pattern.[7] The incidence of postherpetic neuralgia reported in patients with HZ is 9-34%.[8] Canadian statistics show that each year there are 130,000 new cases of HZ, 17,000

Figure 1.
Example of Herpes Zoster lesions. Diepgen TL, Yihune G et al. Dermatology Online Atlas. https://dermis.net/shop/49/11410.jpg

of which progress to post herpetic neuralgia.[7] The most useful and definitive laboratory test to diagnose HZ is a Polymerase Chain Reaction Test which involves swabbing open lesions during the acute phase of the virus.[9] Acyclovir is the usual first line antiviral in treatment of herpes zoster.[9] Psychological stress has been associated with triggering latent infections such as herpes zoster. This is a modifiable risk factor and should be incorporated into the patient's plan of management.[10] Although the most common location for HZ is the trunk, other dermatomal distributions should always be considered. Differentials for HZ and postherpetic neuralgia should include discogenic irritation resulting in radiculopathy and other peripheral neuropathies.

Currently in Canada there are two different herpes zoster vaccines authorized for use: A live zoster vaccine Zostavax II and a recombinant zoster vaccine Shingrix.[7] These vaccines were developed to treat people who have previously been infected with VZ and are hosting a latent virus that could reactivate and cause HZ. Even those who have previously had the chickenpox vaccine are recommended to get the Shingrix vaccine, because it is still pos-

Figure 2.
Example of Herpes Zoster lesions. Diepgen TL, Yihune G et al. Dermatology Online Atlas. https://dermis.net/shop/49/11438.jpg

sible to get herpes zoster after being vaccinated against chickenpox.[6] This vaccine is recommended for anyone above 50 years of age and is safe, cost effective and highly recommended for preventing HZ infection and associated symptoms such as postherpetic neuralgia.[7]

Meralgia Paresthetica

Meralgia Paresthetica (MP) is a neurological condition caused by entrapment of the lateral femoral cutaneous nerve. MP presents with unilateral symptoms such as numbness, paresthesia, and pain in the anterolateral thigh, the associated sensory distribution of the nerve.[11] The most common location of lateral femoral cutaneous nerve entrapment occurs as it passes under or above the inguinal ligament.[12] Patients most affected by MP include females around 40-50 years of age and those with increased intra-abdominal pressure, including pregnant women and obese individuals.[12] The incidence of MP is approximately 3-4% per 10,000 person years.[2] MP can be classified as spontaneous, mechanical, or iatrogenic. Spontaneous MP results in those with conditions such as diabetes mellitus or hypothyroidism which predispose them to this condition.[12] Mechanical causes result from external forces compressing the nerve such as seat belts or restrictive clothing.[12] Lastly, iatrogenic MP occurs after surgical intervention such as a hip replacement surgery or an inguinal repair, where there has been direct nerve injury.[12]

Physical exam findings for a patient with suspected MP include sensory deficits within the associated dermatome, no change in symptoms between sitting and standing, potentially aggravated symptoms with extension, and symptom exacerbation with Valsalva maneuver or other testing causing an increase in intra-abdominal pressure.[13] Treatment for MP includes passive and active care, patient education and reassurance, discussion of weight loss if this is a contributing factor, ice and NSAIDS.[13] If symptoms persist beyond 1-2 months with conservative treatment, a referral should be considered.[13] The prognosis is good with conservative treatment, 85% of patients report spontaneous recovery.[13]

Lumbar radiculopathy

Lumbar radiculopathy refers to the irritation of nerves within the spinal canal or as they exit the spine, resulting in symptoms that radiate down the lower extremities within the associated dermatome or myotome. Patients

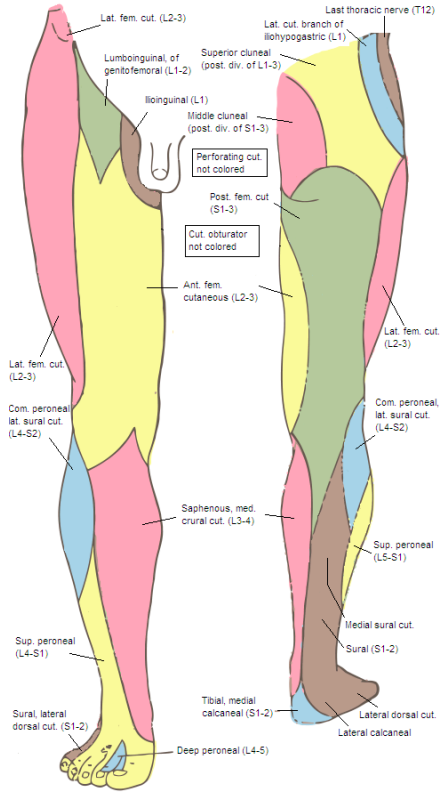

Figure 3.
Lateral Femoral Cutaneous Nerve Distribution. Henry Vandyke Carter, Public domain, via Wikimedia Commons. https://upload.wikimedia.org/wikipedia/commons/b/bf/Gray826and831.PNG

suffering from lumbar radiculopathy typically present with symptoms distinct from mechanical low back pain including sensations such as burning, stinging, weakness, and sensory alterations into the lower extremities.[14] Disc lesions and degeneration are the most common causes of lumbar radiculopathy, with other potential causes including spinal stenosis and space occupying lesions such as tumors or infection. Among patients with low back pain, radicular symptoms are present in 12-40% of cases.[15]

Physical exam findings for a patient with radiculopathy can include pain, weakness, and sensory disturbances within the affected myotome and dermatomal distribution.[15] Symptoms are often exacerbated with ranges of motion as well as with orthopaedic testing including Valsalva maneuver, slump test, and straight leg raise. Conservative

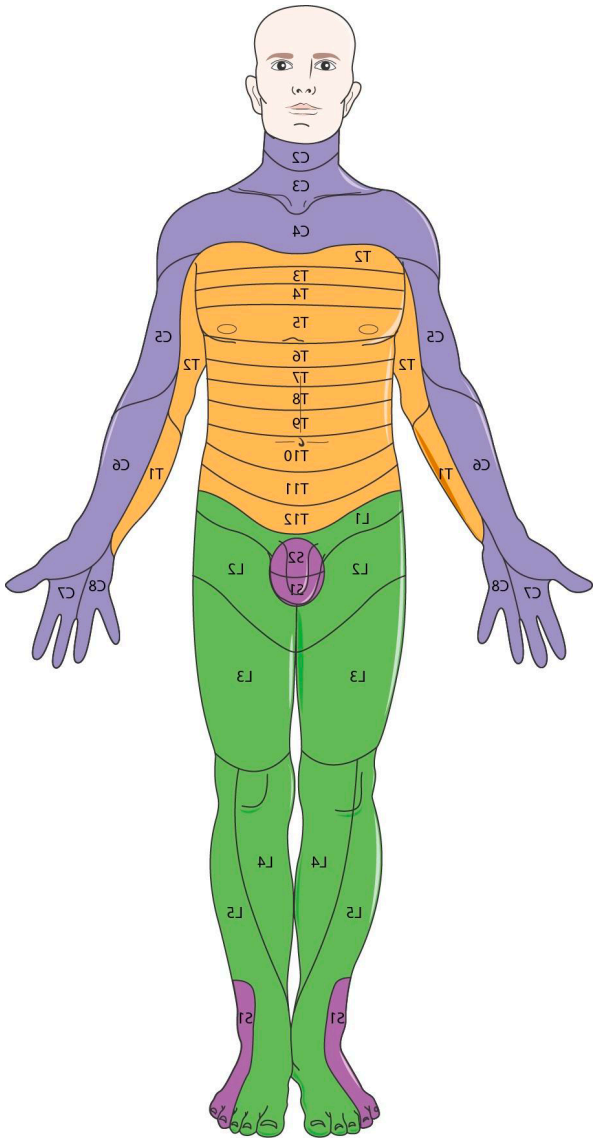

Figure 4.
Dermatome Chart Anterior View. Servier Medical Art. Dermatomes, Servier Medical Art licensed under CC by 4.0. https://smart.servier.com/smart_image/dermatomes/

management is typically the first line of treatment for radiculopathies. Pharmacological agents can be effective in reducing symptoms as well as nonpharmacological interventions such as acupuncture, spinal manipulation, and traction mobilizations.[15] If conservative management fails to alleviate the patient's symptoms, surgical intervention is considered.

Differentiation

There are documented instances where nerve related complaints are caused by herpes zoster, but rarely in the upper leg. One report documented a 43-year-old who experienced subjective paresthesia and radiating pain down her leg after a work-related injury. A decrease in light touch sensation and pinprick in the left L5 dermatome was present, along with a clear MRI. Three weeks after presentation she developed "scabbed" vesicles and was diagnosed with herpes zoster.[3] Another case is of a 31-year-old who described a "sunburn on the inside" of the leg, with fluctuating intensity over the past year. No hard orthopedic signs were present, but crusted pustules were discovered over the left iliac crest, and the diagnosis of herpes zoster was made.[3] A final case report documented a 58-year-old woman with dull left leg pain of one-year duration. Sensory testing revealed hyperesthesia over the mid anterior thigh, to both pin prick and light touch. A provisional diagnosis of L2/3-disc lesion was made, but three days later a vesicular type of rash over the region of the left mid anterior thigh was discovered. Subsequently the diagnosis of herpes zoster was made.[4]

A common theme to the articles retrieved on herpes zoster is the retrospective nature of the diagnosis. Often the patient was being treated under a different diagnosis or the patient did not present until lesions were present, with these patients often suffering for weeks or months with pain and paresthesia. This is consistent with the clinical course of our patient, and the rapid resolution of her symptoms with the appropriate diagnosis and intervention. The contributing effect of emotional stress triggering the symptoms is also a commonality that clinicians should be aware of in herpes zoster patients.[17]

This case highlights the importance of including herpes zoster in the list of differentials when addressing nerve-related complaints. For conditions such as meralgia paresthetica or lumbar radiculopathy, clinicians should retain herpes zoster as a differential diagnosis.

Clinicians must be vigilant in conducting regular visual inspections of the affected area and carefully examining the skin for any presenting lesions. It is also important to ask these patients whether they have a history chickenpox or if they have received the varicella zoster or herpes zoster vaccine. Prompt referral for medical treatment is

crucial and can help prevent long-term sequelae such as post-herpetic neuralgia.

Summary

Neurological conditions pose a diagnostic challenge to the clinician managing musculoskeletal complaints. While conditions like lumbar radiculopathy are more prevalent, it is also important to consider rare neurological syndromes such as both meralgia paresthetica and herpes zoster.

Herpes zoster is a difficult diagnosis to make and is often made retrospectively only after lesions appear. It is the author's hope that this case study will heighten awareness of herpes zoster as a viable differential for nerve-related complaints within the lower extremity.

References

1. Wong JJ, Lu M, Côté P, Watson T, Rosella LC. Effects of chiropractic use on medical healthcare utilization and costs in adults with back pain in Ontario, Canada from 2003 to 2018: a population-based cohort study. BMC Health Services Research. 2023; 23(1):793.
2. Van Slobbe AM, Bohnen AM, Bernsen RM, Koes BW, Bierma-Zeinstra SM. Incidence rates and determinants in meralgia paresthetica in general practice. J Neurol. 2004; 251: 294-297.
3. Kruse, MB. Herpes Zoster and the differential diagnosis of lower extremity radiculopathy: a case report. JNMS. 1996;(4:2): 116-119.
4. Reggars JW, French SD. Sometimes they may be zebras: herpes zoster of the L2 spinal nerve: a case report. Australasian Chiropr Osteopath.. 1996; 5(2): 45.
5. Ayoade F, Kumar S. Varicella-Zoster Virus (Chickenpox). StatPearls [Internet]. 2023 [Cited Sept 2023]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK448191/
6. Public Health Agency of Canada. [Chapter 4, Part 1]: Canadian Immunization Guide [Internet]. Ottawa (ON): Government of Canada; 2023
7. Public Health Agency of Canada. [Chapter 4, Part 3]: Canadian Immunization Guide [Internet]. Ottawa (ON): Government of Canada; 2023
8. Parikh R, Singer D, Chmielewski-Yee E, Dessart C. Effectiveness and safety of recombinant zoster vaccine: a review of real-world evidence. Human Vaccines Immunother. 2023; 19(3): 2263979.
9. U.S. Center for Disease Control and Prevention. Shingles (Herpes Zoster). [Internet]. 2023. [cited Oct 8 2023]. Available from: https://www.cdc.gov/shingles/index.html
10. Schmidt SA, Sørensen HT, Langan SM, Vestergaard M. Perceived psychological stress and risk of herpes zoster: a nationwide population-based cohort study. Br J Dermatol. 2021; 185(1): 130-138.
11. Grossman MG, Ducey SA, Nadler SS, Levy AS. Meralgia paresthetica: diagnosis and treatment. J Am Acad Orthopaed Surg. 2001; 9(5): 336-344.
12. DynaMed. Meralgia Paresthetica. EBSCO Information Services. [Internet]. 2023 [cited April 4, 2024]. Available from: https://www.dynamed.com/condition/meralgia-paresthetica
13. Coffey R, Gupta V. Meralgia Paresthetica. StatPearls [Internet]. 2023 [cited Sept 8 2023].
14. Alexander M, Massa R, Mesfin F. Disc Herniation. StatPearls [Internet]. 2023. [cited Spet 8 2023].
15. Wenger HC, Cifu AS. Treatment of low back pain. J Am Med Assoc. 2017; 318(8): 743-744.
16. Al Qaraghli MI, De Jesus O. Lumbar Disc Herniation. StatPearls [Internet]. 2023 [cited Oct 10, 2023].
17. Harpaz R, Leung JW, Brown CJ, Zhou FJ. Psychological stress as a trigger for herpes zoster: might the conventional wisdom be wrong?. Clin Infecti Dis. 2015; 60(5): 781-785.

ISSN 0008-3194 (p)/ISSN 1715-6181 (e)/2024/149–159/$2.00/©JCCA 2024

The evolution of teaching chiropractic skills: part 1 – a narrative review of lessons learned during the 120 collective years of four tutors in the technique trenches at the Canadian Memorial Chiropractic College

Brian J. Gleberzon, DC, BA, MHSC, PhD (cand)[1]
J. Kim Ross, DC, PhD[2]
F. Stuart Kinsinger, DC, MA[3]
Zoltan Szaraz, BA, DC, FIACA, FCCRS (C)[4]

"The only constant is change" – Heraclitus, Greek Philosopher

The objective of this article, Part 1 of a two part series, is to provide a narrative review of the evolution of teaching chiropractic manual skills by four tutors who taught in the technique trenches at the Canadian Memorial Chiropractic College collectively for 120 years. Based on their collective memories, this narrative review describes the evolution of: central demonstrations; inconsistency between tutors with respect to demonstrating and grading chiropractic manual skills; determining course content; policy on students providing high velocity, low amplitude thrusts on each other during class time and testing; quantitative versus qualitative grading; remediation; acknowledgment of risk and; changes to technique class due to Covid. The results of a unique survey evaluating students' perception of these changes is presented. The intent of this article is for faculty at other accredited educational programs to learn from our experiences and

L'évolution de l'enseignement des compétences en chiropratique: la première partie - un examen narratif des leçons apprises au cours des 120 années collectives de quatre tuteurs dans les tranchées techniques au Canadian Memorial Chiropractic College

La seule constante est le changement » - Héraclite, philosophe grec

L'objectif de cet article, la première partie d'une série en deux parties, est de fournir une revue narrative de l'évolution de l'enseignement des compétences manuelles en chiropratique par quatre tuteurs qui ont enseigné dans les tranchées techniques au Canadian Memorial Chiropractic College, pendant 120 ans. En se fondant sur leurs souvenirs collectifs, cet examen narratif décrit l'évolution : des démonstrations centrales; de l'incohérence entre les tuteurs en ce qui concerne la démonstration et la notation des compétences manuelles chiropratiques; de la détermination du contenu du cours; de la politique sur les étudiants qui se poussent les uns les autres avec une grande vitesse et une faible amplitude pendant le temps de la classe et des tests; de la notation quantitative par rapport à la notation qualitative; de la remédiation;

[1] Australian Chiropractic College, Adelaide, Australia
[2] Canadian Memorial Chiropractic College, Toronto, ON
[3] Faculty, Northeastern College of Health Sciences
[4] Retired from Private Practice

Corresponding author: Brian J Gleberzon, 306-3335 Yonge Street, Toronto, ON, M4N 2M1
Tel: 416 277 8612
E-mail: Brian.gleberzon@gmail.com

The authors have no disclaimers, competing interests, or sources of support or funding to report in the preparation of this manuscript.

potentially strengthen their pedagogical approach to teaching chiropractic manual skills.

(JCCA. 2024;68(2):149-159)

KEY WORDS: chiropractic manual skills, teaching, technique, evaluation

de la reconnaissance du risque et; des changements apportés à la classe technique en raison de la COVID. Les résultats d'un sondage unique évaluant la perception des élèves à l'égard de ces changements sont présentés dans cet article. L'objectif de cet article est de permettre aux professeurs d'autres programmes d'enseignement accrédités d'apprendre de nos expériences et de renforcer leur approche pédagogique de l'enseignement des compétences manuelles en chiropratique.

(JCCA. 2024; 68(2) : 149-159)

MOTS CLÉS : compétences manuelles en chiropratique, enseignement, technique, évaluation

Introduction

Although they began teaching during either the 1970s (Szaraz), 1980s (Kinsinger, Ross) or 1990s (Gleberzon) all four authors taught together at CMCC starting in 2004. Over the decades three of them (Szaraz, Ross, Gleberzon) were the chair of the technique department, and all four were course coordinators and taught in the technique trenches for over 25 years.

Methods

A narrative review of the challenges encountered and solutions implemented is chronicled by four technique instructors (tutors) during their time in the 'technique trenches' at the Canadian Memorial Chiropractic College (CMCC). This review is principally based on their recollections of events throughout the collective 120 years they were on faculty, using a qualitative research methodology. Since no human subjects were involved in this review, ethics approval was not required.

Results

Initial organization of technique classes

Prior to 1999, technique classes were held on the main floor of the campus on 1900 Bayview Ave in Toronto, Ontario, Canada. The larger of two rooms housed seven of the 12 tutors and a separate room across the hall housed the other five. When the library was moved across the street into a separate building, technique classes were relocated to one large and two smaller rooms on the third floor overlooking the adjacent cemetery and accessible only by a single staircase (not counting the fire escape that led to the parking lot).

Although it was necessary in both cases to have smaller rooms due to the large student population, the students and tutors in the smaller rooms were isolated from the main room. Despite the fact that the course coordinator described the tasks of the day to all the tutors, the separation resulted in two versions of the same daily lesson. Once the technique lab was relocated this was solved by having the demonstration in the main room sent to the smaller rooms by short circuit television

At the beginning of the academic year technique tutors were given attendance binders containing the names of the 16 students in their group, a course outline with lesson plans for each day (developed by the course coordinator) and shown the designated area in one of the technique rooms to which they were assigned. (Authors' note: All technique tutors at CMCC were licensed chiropractors. Other chiropractic educational programs may refer to them as technique instructors. There were no student technique instructors).

On the first day of class the course coordinator would take center stage and welcome the class to the technique lab. Technique tutors were introduced, and a brief overview of the course was given. Students were asked to find their tutor and attendance was taken. In what would

years later be called an 'icebreaker', students were asked to introduce themselves and to share with the group the name of the university they attended and their area of study. Students were asked if they had ever been to a chiropractor before enrolling at the college (at that time all of them had) and what made them decide to apply to the program.

The next class the course coordinator would again take center stage and proceed to provide a central demo of the lesson plan for that day. All 160 students in the same academic year attended technique class at the same time. When the college relocated in 2004 to a larger, modern facility at 6100 Leslie Street (also in Toronto) this format continued, the only difference being there were now six technique rooms and enrolment increased from 160 to 192 students, climbing to 200 over the next few years.

Central demos often took up the majority of class time, based on the premise that it would set the 'gold standard' of how each procedure ought to be performed. The students mimicked what was being shown in the central demos; however, if tutors attempted to correct students as the central demo was occurring, it was distracting to the other students in the room. The other problem was that the central demos had to be delivered twice so that each student got a chance to be the doctor.

If there was time after the central demo, each tutor would provide a 'mini central demo', allowing their students to see each procedure more easily and to ask questions for clarification. Once completed, students used what little time remained to practice what they were shown, taking turns as one student assumed the role of 'doctor' and the other student assuming the role of 'patient'. Tutors would coach the students, providing real-time feedback on their performance. Each class ran basically the same way, with some classes set aside for practice time without central demos. Students changed groups every three months from one tutor to another.

Unlike many other chiropractic educational programs that are divided into trimesters or quarters, CMCC is scheduled on a yearly basis (e.g. Year I, Year II), running from August to May. For many years, each of the three pre-clinical academic years was divided into four modules. Examinations of lecture-based courses were scheduled during each module. Technique exams were scheduled prior to the exam periods in each module. For technique exams, students were instructed to sign up for a 15-minute time slot with a classmate and would be tested by the tutor they had been with for the previous several weeks. If the procedure to be tested was something simple such as identifying superficial spinal or postural landmarks the tutor used a grading checklist. If the procedure to be tested was more complex, such as mobilizations or spinal manipulations, students were assessed using a more detailed grading checklist populated with a group of subskills commonly used at all chiropractic programs (Figure 1). This observation is based on the involvement some of the authors had with the Technique Consortium, a group of technique faculty representatives from American and Canadian chiropractic programs under the auspices of the Association of Chiropractic Colleges.[1] Using this checklist, student performance was converted to a numerical grade, and a student had to achieve a passing grade of 60% to proceed to the next academic year. If a student received a failing grade – less than 60% - they were required to be re-tested by the next tutor until they received a passing grade.

- Indications/ contraindications
- Patient position
- Doctor position
- Contact Hand
- Stabilization Hand
- Line of Drive
- Joint Slack/ Pre-manipulative tension
- Thrust

Figure 1.
Subskill rubric used to grade spinal manipulation c1994

Areas of concern

Over the years, the technique faculty in general, and the authors of this article in particular, identified three main areas of concerns during tutor meetings. These were: length of central demos; lack of consistency between tutors with respect to demonstrating each chiropractic manual skill and; lack of consistency between tutors during testing.

Refining central demos

Although they filled an important pedagogical role, it was hard to argue that most central demos in courses that had practical labs (technique, orthopedics, clinical diagnosis,

anatomy) monopolized too much class time. Moreover, having to do central demonstrations twice meant that individual student/tutor interaction time was not being optimized. The second issue was that when the central demos was over, tutors demonstrated their own version of the procedure. Of course, the tutor version was based on optimizing their own anthropometrics (e.g. height, weight) and not necessarily those of the individual students in the group. Alternately the versions may have been based on injuries acquired by the tutor. Finally, because of these variations, tutor assessment of student performance was based partially on the tutor's version of the procedure. Therefore, it was difficult for a student to know what was expected of them

This led Ross, the technique department chair at the time, to declare central demos would be eliminated. Unfortunately, this had the unforeseen consequence of making the variability between tutor demonstrates worse. Each tutor conducting central demos of different content and different time lengths and demonstrating each procedure differently. Even though this is arguably the best way to teach technique since it reflects the variability of how each chiropractor provides manual care to patients in the real world, it seemed to us that some students were not ready to try to assimilate various versions of the same procedure and then determine what worked best for their own anthropometrics. A hybrid solution was needed.

Central demos would be reserved only for complex psychomotor skills, such as high velocity, low amplitude spinal manipulative therapy (HVLA-SMT), deferring simpler procedures to the tutors to demonstrate on their own and at their own pace. To further enhance the learning opportunity during central demos different tutors would be invited to demonstrate how they performed each procedure, since the delivery of some procedures, most notably anterior thoracic and side-posture lumbopelvic manipulations (SPLM), varied significantly between tutors based on the anthropomorphic differences between the doctor and the patient. Moreover, some tutors had accrued various injuries throughout their career providing patient care (e.g., shoulder problems, discopathies) and had to modify their delivery of this or that procedure, modifications deemed worthwhile to share with students. In order to minimize any confusion among students, very few variations were demonstrated in Years I and II, reserving the introduction of the majority of these variations to Year III, as students approached their internship.

During the summer months when classes were not in session, tutors were video recorded, demonstrating how they performed each procedure. When technique classes resumed, these recordings were televised to each room on a continuous loop, allowing students to observe them during class time after a central demo. Students were also able to access these videos on their own time. As the broadband of the college expanded, these video recordings became the equivalent of a virtual library that students could access at home. Eventually these recordings were embedded into course outlines and linked to daily lesson plans and, years later, were used to create a technique manual in DVD format that showed stationary photos as well as the real time videos.

Lack of consistency between tutors during student assessment

As tutors assessed the performance of students, it was recognized that there were inconsistencies from one tutor to another. This problem was captured by Robert Cooperstein, Chair of Research and Technique at Palmer West Chiropractic College for over 30 years when he famously opined during a meeting of the Technique Consortium:

> *"I alone grade all the students in my technique class. This means it has 100% reliability… but 0% validity."* (Gleberzon, personal communication).

This lack of consistency of how each procedure was performed could lead, in turn, to different grading scores by each tutor, with some tutors developing a reputation as being overly lenient (the 'doves') and other being overly harsh (the 'hawks'). This problem was solved by two interwoven solutions: (1) Refining CMCC-centric technique manuals and (2) Grading by Panel.

Refining CMCC-centric technique manuals

Chiropractic has been described as a science, a philosophy and an art, and the artistic element of the profession is nowhere more evident than how each practitioner approaches patient management, from care planning to the selection of the multitude of permitted treatment options to how each procedure ought to be optimally delivered. Although it is expected that no two tutors would deliv-

er a complex procedure such as HVLA-SMT identically each tutor could not set their own expectations on how each procedure in the curriculum ought to be performed. The solution was to create and continually refine versions of technique manuals that described and illustrated how each procedure taught at CMCC should be performed, allowing for certain variations, thus creating a gold standard against which all students were judged.

The first CMCC technique manual demonstrating spinal adjustments offered in the program was authored by Szaraz[2] in 1984 (Figure 2). Tilted *'Compendium of Chiropractic Technique'* it incorporated soft tissue therapies, mobilizations and adjustive procedures of the cervical, thoracic and lumbopelvis, including the coccyx. Each procedure was described in terms of patient position, doctor position, contact hand, stabilization hand, line of drive and type of thrust. Each procedure description was accompanied with photographs using live subjects. Around that time, Jamie Laws authored a manual for extremity procedures, which the authors believe may have been the first time these procedures were taught at CMCC. A few years later, Daniel Proctor and Greg Ruhr updated the extremity manual and Jane Mannington, who was the department chair for many years, updated the Szaraz Compendium.

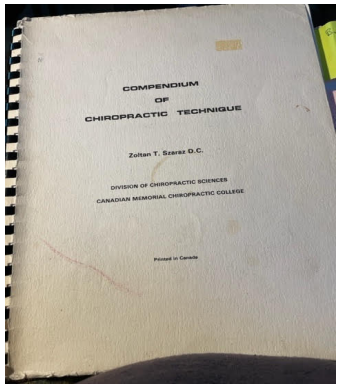

Figure 2.
Compendium of Chiropractic Techniques[2]

As the curriculum changed a new, updated manual was needed. Over the summer of 2008, Gleberzon and Ross created an inventory of each technique procedure taught during the undergraduate program at CMCC. Similar to how Part IV of the National Board of the Chiropractic Examiners (NBCE) exam was created, they described each procedure in generic terms and, with input from the rest of the faculty, included as many variations as deemed appropriate. Due to technological limits, the first published manual only had photographs alongside each written description. In 2014, with changes in technology the aforementioned video library was added to an updated version of the Manual (Figure 3) included a DVD, and later a flash-drive, containing real-time videos of all mobilizations and manipulation taught in the program.[3]

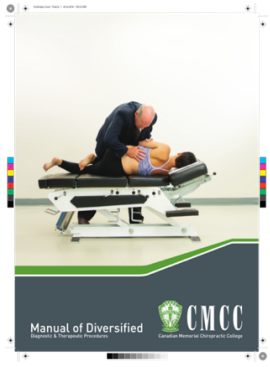

Figure 3.
Manual of Diversified Diagnostic and Therapeutic Procedures (2014)[3]

Grading by panel

Over the years the faculty agreed there were two types of exam content: simple and complex. Examples of simple content would be spinal and postural landmarks, motion palpation and joint play analysis. Testing of those procedures would continue to be conducted by a single tutor during class time. However, for the more complex content of myofascial treatments, mobilizations and HVLA manipulations of the spine and peripheral joints, a three-person panel would be used during designated examination periods (Authors' note: According to Kinsinger, a two-person team was used to test students during high stakes exams in the mid-1980s but had been discontinued over time for unknown reasons (Kinsinger – personal communication)).

During the higher stakes testing periods there were four testing stations in one room. Typically, one station examined cervical and thoracic procedures, one station examined lumbar and pelvic procedures, one station examined procedures directed to peripheral joints and one station

used the Force Sensing Table Technology (FSTT®) (discussed in Part 2 of this series of articles). All 12 tutors in each course were involved in testing and grouped into four groups of three.

During the testing cycle, a pair of students moved from station to station. A designated amount of time was set aside for completion of all tasks at each station (typically five minutes for both students). In an attempt to increase the fairness of grading at each station, course coordinators would mix the 'hawk' and 'dove' tutors together. It was hoped both the 'hawks' and the 'doves' would become more objective over time, lest they continue to be seen as outliers. Tutors were asked to grade each student independently and not consult with each other during testing. In this manner tutor a would not be influenced by the other two assessors opinions. The mark was then the summation of all three tutors assessment of student performance.

Determining course content

Course content of technique labs at CMCC was essentially a chimera of historical elements, a reflection of the preferences of academic decision-makers at any given point in time and an homage to authoritative textbooks such as the 'Technic Manual' authored by Al States[4] or, years later, textbooks by Bergman and Peterson[5] or by Byfield[6].

An iterative approach was also used, whereby 'homegrown' procedures deemed clinically dubious were gradually marginalized and procedures used by the majority of chiropractors were emphasized, based on the inventory of testable procedures from Part IV of the NBCE. The results of a series of surveys conducted by Gleberzon and Kent Stuber were also used.[7,8] Those surveys asked CMCC graduates to indicate, based on a provided list of all diagnostic and therapeutic procedures taught in the undergraduate program, which they used and how often they used them.[7,8]

Content was scaffolded over the three undergraduate years, where simpler procedures (postural assessment, palpation, joint play analysis) were introduced at the beginning of Year I and more complex procedures introduced later in the program, as students accrued more psychomotor skill.

The 1990s witnessed the elevation of muscle-based therapies across the profession. While Nimmo technique and trigger point therapy were mainstays in clinical practice for decades myofascial-focused procedures such as Active Release Techniques ® and instrument-assisted techniques such as Graston® became tremendously popular (see [9] for description of these technique systems). Since these specific techniques were not offered at CMCC students sought them out at weekend seminars at their own expense. In private practice, offering these techniques became *de rigueur* at athletic-focused or rehabilitation-based clinics. CMCC included manual (myofascial) and instrument-assisted (Graston) procedures in technique class starting in 2005, although the latter was terminated once the agreement with the organization donating the Graston tools ended a decade later. After that, depending on the academic year, a few technique labs were set aside for instruction in instrument assisted soft tissue mobilization (IASTM), and IASTM was often taught in rehabilitation courses.

To thrust or not to thrust

In the early 1990s, it was CMCC technique policy that students were not allowed to deliver an HVLA thrust to other students during class time or during examinations until midway through Year II. This meant faculty were grading students on 'mock' thrusts absent the most important components of spinal manipulation: speed and force. By the late 1990s, however, it was agreed this 'no-thrust' policy had to be lifted

At first, two prone thoracic manipulations (Cross- bilateral and Carver manipulations) were introduced toward the end of Year I, and students were permitted to deliver a full thrust during both class time and testing. Each subsequent year more HVLA-SMT procedures were introduced earlier and earlier in the program. By the 2020s students were taught prone thoracic manipulations by week six of Year 1 and were introduced to over 10 different spinal manipulations that year, excluding cervical SMTs.

Toward qualitative evaluation methods

Question: What exactly does a 74% in technique class signify? Does it mean that 74% of the procedures were done correctly. Or does it mean that the student was 74% as good as the gold standard. But what is the gold standard? Is it a practicing chiropractor or is it an ideal Year I student?

Answer: The authors of this article do not know. There is no logical answer. Hence the students did not have a

requisite knowledge to know what was expected of them to be classified as competent. Ross was also troubled by the fact a student could demonstrate excellence in one procedure, perform poorly during another, and yet still pass the examination because the grades from both procedures were averaged together. In other words, even though a student had not demonstrated minimal competence in all procedures in the course outline they could still proceed to the next academic year.

Recognizing this conundrum, Ross conceived a qualitative grading rubric that required students demonstrate minimal competency in all tested procedures. Criteria in this rubric were converted to a numerical grade. The goal here was to make sure that the tutor graded based on whether or not they observed expected behaviors. The danger of the tutor assigning an actual number was that the doctor may have a number in mind and grade according to that overall numerical assessment.

After its inaugural implementation, the conversion to a numerical grade was abandoned since it caused more problems than it solved and students' performance was assessed only qualitatively. Students received either a pass or fail grade on their academic transcripts.

There were three qualitative categories used to score a student's performance: No correction (NoC); Minimal Correction (MiC) and; Major Correction (MaC). As implied, if a tutor assigned a grade of NoC to a demonstrated procedure it meant they perceived it was performed to a standard of minimal competence, and that all the subskills of that demonstrated procedure were performed adequately. A procedure assigned a MiC meant that the tutor perceived the procedure could be performed somewhat better, but any deficiencies observed were not significant enough to trigger the necessity of it being retested. Lastly, if a tutor assigned a MaC to a demonstrated procedure – or to a subskill of that procedure – it meant there was something significantly problematic with its delivery and that the student would be required to be retested.

To reinforce the MaC category a set of 'fatal flaws' were developed, flaws deemed so problematic that, if demonstrated during testing, they automatically required the procedure be retested (Figure 4). Additionally, if the tutor perceived the student acting as the doctor failed to maintain a professional boundary with the student acting as the patient the tutor would immediately stop the student from continuing to perform the procedure. This presaged the ascension of competency-based evaluation methodology in education.

- No procedure demonstrated
- Incorrect procedure demonstrated
- Procedure may have no clinical effect
- Procedure may potentially injure the patient
- Procedure may potentially injure the doctor
- Doctor failed to maintain a professional boundary with the patient

Figure 4.
Fatal flaws necessitating retesting

The 'Two out of Three' rule

Imagine a student who learns they must be retested because they were ascribed a MaC to a particular procedure. Upon review of their test sheet, they learn that one tutor gave them a MaC in one subskill (e.g., line of drive) whereas another tutor gave them a MaC for another subskill (e.g., spinal contact). Understandably, the student would be confused and frustrated, not knowing which subskill to focus on in order to pass the retest.

To address this dilemma, Gleberzon, who became department chair after Ross, enacted a failsafe process whereby a student only had to reperform a particular procedure if two out of three tutors not only ascribed a MaC to a particular procedure but they had to identify the same subskill of that procedure as a MaC.

Robust remediation

A new curricular design was implemented around 2003. Rather than be offered at different times throughout the academic year all courses offered in Year III were grouped into nine pain-based modules. In addition to other problems (e.g. a number of courses were not pain-focused), no specific plan was developed to remediate students who failed a module. Similar to chiropractic programs with quarters or trimesters, when a student failed a course within a module they were put on a 'special schedule' that allowed them to attend the classes of the next module while auditing and being retested in the course(s) in the previous module they failed. There was no set limit on the number of opportunities a student was given to pass a previous course in a module, ultimately becoming a burden on the faculty.

To solve this problem in technique, Gleberzon developed a robust remediation system, adopting elements from his experience on the provincial regulatory body (the College of Chiropractors of Ontario (CCO)), which included a Specified Continuing Education or Remediation Plan (SCERP) (Figure 5).

During Step 1 of the remediation process, students were required to attend one hour of out-of-class technique class with a faculty member (most often with senior tutor Greg Ruhr) and one hour in the Force Sensing Table Technology and Simulation Lab (FSTT®Sim Lab) (described in Part 2 of this series of articles). They were graded by a new group of three tutors and only had to perform the procedure(s) they were ascribed MaCs for, with one exception: If they received MaC for four or more procedures they had to repeat the entire test.

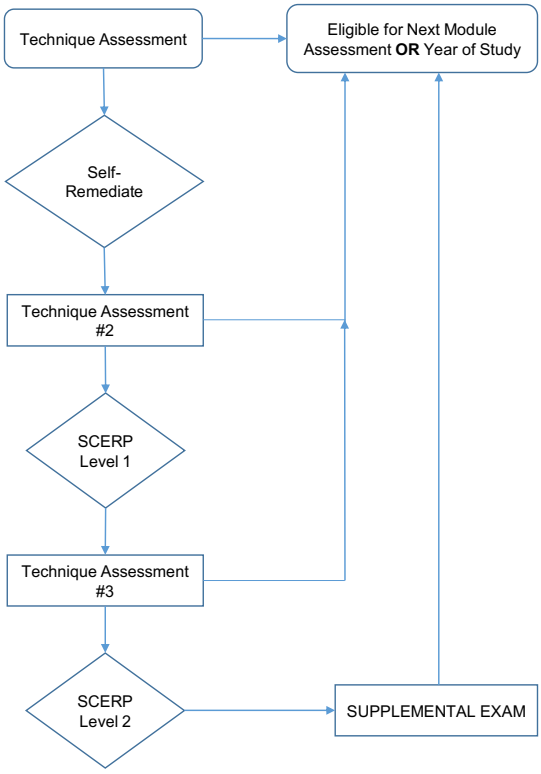

Figure 5.
Technique remediation flow-chart

If two out of three tutors ascribed MaC to a student during retesting they moved to Remedial Step 2, which was similar to Step 1 except they had to attend more practice time prior to being tested. The third evaluation was video recorded. If unsuccessful again students were eligible to be re-tested one more time before being assigned a failing grade and, barring successful appeal, had to repeat the academic year. This is why video recording the student's performance was important - students facing repeating an academic year typically appealed the grade or pursued legal action, sometimes both.

To feedback or not to feedback

Initially, test feedback was given at the beginning of the next module, during which time the testing sheets were given to students for their review; however, the time between their performance and this feedback could be a few weeks. Understandably, by that time the student did not remember what they did during the performance assessment and had to take the word of the assessors as an accurate reflection of their performance.

The tutors experimented with giving students immediate feedback, during testing. Each of the three tutors would give contemporaneous feedback to students while they were at that station immediately after their performance, prior to moving to the next testing station. Well. This was of bereft of benefit to any party.

While the vast majority of students appreciated the immediate feedback and accepted it as a learning experience whether it was positive or negative, receiving negative feedback evoked a strong emotional response from some of them. Some students were so distraught it effected their performance at subsequent stations. Clearly a new plan had to be conceived and implemented, one that maintained the elements of contemporaneous feedback while avoiding the potential of evoking negative reactions from students during testing.

A new feedback mechanism was implemented. Immediately after they completed their entire technique assessment, the course coordinator (who was not involved in testing) would meet with each student privately to review their grading form with them. This allowed students to receive immediate feedback on their performance from the testing tutors and it allowed them to know whether or not they had to be retested on this or that procedure, or if they had to reperform the entire test, provided the procedure in question met the 'two out of three' rule.

Assessing our new evaluation process

From the perspective of the faculty, the changes made

to course structure, evaluation and remediation was successful; however we lacked any hard data to support the faculty's perspectives. In order to do a deeper dive into students' perception of the new testing process a unique 11-item paper questionnaire was developed and distributed to students immediately after they received feedback from the course coordinator.[10] The questionnaire used a five-point Likert scale anchored on the left with 1 (very unsatisfied) to 5 (very satisfied) on the right. We obtained ethics approval and ensured student responses were anonymous. The results of this survey were presented at DC17, a joint ACA-WFC-ACC conference held in Washington, DC.[10]

The response rate for Year II was 80% and for Year III was 100%. When asked, over 80% of both Year II and III students 'Strongly Agree or Agreed' that the new testing format was '*more fair*', and over 80% of Year II and two thirds of Year III students thought it better graded their skills. At least half of all students 'Strongly Agreed/Agreed' the new testing format better identified poor performers and their sub-skills that needed improvement, that it was more objective, and that it held students to a higher academic standard and would make them better chiropractors.[10]

In addition, roughly three-quarters of Year II and III students 'Strongly Disagreed/Disagreed' the new format was '*too confusing*' or '*too complicated*'. More than half of students did not want to return to the previous assessment format.[10]

Acknowledgement of risk

During a visit of the Technique Consortium to the chiropractic program at the University of Bridgeport in 1999, Gleberzon learned there was an administrative requirement to have students read and sign a consent form prior to embarking on technique classes, similar to the requirement to have a patient sign an informed consent form prior to beginning care.

After clearing several legal and curricular hurdles, a similar requirement was passed by CMCC's curriculum committee in 2018. Going forward, students were required to read and sign a broader "Acknowledgment of Risk" form during their first week of class, prior to beginning any course with a practical lab that had a material risk of harm (e.g. technique, orthopedics, clinical diagnosis and anatomy). The form outlined all the potential injuries a student could experience during participation in any of these practical labs.

Technique class during Covid

It is certainly trite to say Covid changed everything. From how we work, play, learn, access services (especially healthcare) and goods of all kinds all underwent fundamental changes.

de Luca and her colleagues surveyed 16 separate faculty at 13 different chiropractic programs (including CMCC) to ascertain how they each managed the challenges created by the pandemic.[11] They identified five, interconnected themes: immediate response; move to online delivery; impact on learning and technology; additional challenges faced by educators and; ongoing challenges post lockdown.

CMCC was fortunate since it could leverage the academic calendar to its advantage when the pandemic started. The lockdown in Ontario began March 17, 2020. The March Break was scheduled to begin the next week and exams were scheduled two weeks after that. In the undergraduate technique classes, three of the four scheduled formative practical exams had already been conducted, which was deemed sufficient to assign final grades to students.

In-person written exams in courses without practical labs were conducted online. When classes resumed in April, lectures and facilitated small group tutorials were easily converted to virtual video platforms such as Zoom or Panopto, although this did require a steep learning curve by those faculty who were not especially tech-savvy. But teaching hands-on psychomotor skills during Covid presented a challenge since it was not conducive to an online learning platform.

To continue instruction in technique a series of online tutorials facilitated by technique tutors were scheduled. Tutors led students through discussions of various topics germane to technique. Topics included: injuries to students during technique class; valid methods to identify a clinical target; ability to specifically target a vertebral segment during HVLA-SMT and; clinical alternatives to HVLA-SMT (e.g. instrumented-assisted adjusting, pelvic blocking, flexion-distraction).

The return to in-person labs was a very complex, multi-step process, since it required abiding by changing directives by the provincial Ministry of Education, the prov-

incial Ministry of Health and requirements from CCO, since all faculty were licensed chiropractors. Class sizes had to be reduced from 36 student in a room to nine. This required hiring additional technique faculty and adding several teaching hours to the 2020-21 academic year curriculum for Years II and III. Curricular planners also had to repurpose the gym and lecture rooms to accommodate the additional student groups necessitated by these changes. As the reader can no doubt imagine, this proved to be an enormous challenge to curricular planners tasked with scheduling so many technique classes to accommodate all these requirements.

In each group of nine, student pairs had to maintain social distancing of two meters from each other. Students and tutors had to wear Personal Protective Equipment (PPE) including gowns, masks, latex gloves and googles, as well as the liberal use of disinfectant. It took over a year before technique classes returned to a pre-Covid format.

Discussion

This study used a qualitative research design, a design being used more and more in research of all kinds, including education of health professionals.[12] Qualitative research can be essential to the development, testing and implementation of interventions and is integral to evidence-based practice.[13] Qualitative methods provide an important source of well-grounded and rich descriptions, providing meaningful explanations of processes and allow for an exploration of beliefs, values and motives that explain why behaviour occurs, as compared to quantitative research that focuses on frequency, intensity and duration of behaviour.[12,13] Castlebury and Nolen opined the primary aim of qualitative research is "*to gain a better understanding of phenomenon through experiences of those who have directly experienced the phenomenon, recognizing the value of participants' unique viewpoints that can only be fully understood within the context of their experience and worldviews*."[12p807-808.] Overall, qualitative research allows for gaining perspective of issues by investigating them in their specific context and focusing on drawing meaning from the individuals who experienced them.[14]

Limitations

This study has many limitations, chief among them is it relied on the collective memories of the four authors. It is possible the authors misremembered some of the circumstances surrounding certain topics explored in this article. Recall bias is also a possibility, since there is a tendency for individuals describing past events to deny less attractive aspects of their behaviour.[15] It is also possible certain milestones were not discussed because the authors did not consider them sufficiently relevant. In other words, a different group of authors may have prioritized different events in their narrative review.

Summary

Over our collective 120 years in the technique trenches, the authors of this paper had the honor and privilege of working alongside over 50 dedicated technique faculty. Together, they have educated a large majority of all Canadian chiropractors in practice. At the risk of being obsequious, it safe to say the profession owes them all a great deal of gratitude.

It is our sincere hope faculty and curricular planners at other accredited chiropractic educational programs will learn from our experiences and potentially strengthen their pedagogical approach to teaching chiropractic manual skills.

What will technique classes look like in the years to come? It is hard to predict. But one thing is for certain. To paraphrase Arthur C Clarke, the future will not only be different than we imagine, it will be different from what we *can* imagine.

References

1. Gleberzon BJ, Cooperstein R. The Technique Consortium of the Association of Chiropractic Colleges: the first twenty years. J Chiro Educ. 2002;16(1): 12-13.
2. Szaraz, Z. Compendium of Chiropractic Technique'. Self-published 1984.
3. Gleberzon BJ, Ross K. Manual of Diversified Diagnostic and Therapeutic Procedures. Self-Published (CMCC). Second Edition. 2014.
4. States AZ. Spinal and Pelvic Technics. National College of Chiropractic. 2nd ed. Sept 1967.
5. Bergman TF, Peterson DH. Chiropractic Technique, Churchill-Livingston, 1993.
6. Byfield D (editor). Chiropractic Manipulative Skills. Elsevier, 2012.
7. Gleberzon BJ, Stuber K. Frequency of use of diagnostic and manual therapeutic procedures of the spine taught at the Canadian Memorial Chiropractic College. A preliminary study of Ontario chiropractors. Part 1 - Practice Characteristics and Demographic Profiles. J Can Chiro Assoc. 2013; 57(1): 32-41.

8. Gleberzon BJ, Stuber K. Frequency of use of diagnostic and manual therapeutic procedures of the spine taught at the Canadian Memorial Chiropractic College. A preliminary study of Ontario chiropractors. Part 2- Procedure Usage Rates. J Can Chiro Assoc. 2013; 57(1): 32-41.
9. Cooperstein R, Gleberzon BJ (editors). Technique Systems in Chiropractic. Churchill-Livingston (Elsevier). March, 2004.
10. Gleberzon BJ, Giuliano D. Survey of student opinions with respect to changes made to technique testing during the 2015-16 academic year at CMCC. Poster presentation DC2017. Washington D.C. March 2017.
11. de Luca K McDonald M, Montgomery L, *et al*. COVID-19: how a global pandemic changed manual therapy technique education in chiropractic programs around the world? Chiropr Man Ther. 2021:29:7.
12. Castlebury A, Nolen A. Thematic analysis in qualitative research data: is it as easy as it sounds? Methodology Matters. 2018;10: 807-815.
13. Sandelowski M, Leeman J. Writing usable qualitative health research findings. Qualitative Health Res. 2012;22(10):1404-1413.
14. Almalki S. Integrating quantitative and qualitative data in mixed methods research- challenges and benefits. J Education Learning. 2016;5(3): 288-296.
15. Bengtsson M. How to plan and perform qualitative study using content analysis. Nursing Plus Open 2016;2: 8-14.

ISSN 0008-3194 (p)/ISSN 1715-6181 (e)/2024/160–171/$2.00/©JCCA 2024

The evolution of teaching chiropractic manual skills: part 2 – a narrative review and discussion of the impact of research evidence authored by faculty of the Canadian Memorial Chiropractic College

Brian J. Gleberzon, DC, BA, MHSC, PhD (cand)[1]
J. Kim Ross, DC, PhD[2]
F. Stuart Kinsinger, DC, MA[3]
Zoltan Szaraz, BA, DC, FIACA, FCCRS (C)[4]

The objectives of this article, Part 2 of a two part series, are twofold: (i) To provide a narrative review of the research evidence authored by faculty of the Canadian Memorial Chiropractic College (CMCC) and; (ii) discussion of the impact this research evidence had on teaching chiropractic manual skills at CMCC and – theoretically - to the broader chiropractic educational community. Research evidence discussed are in the areas of: Experimental studies linked to biomechanics; Measuring Force – Integration of Force Sensing Table Technology (FSTT®) into technique labs; Characteristics of injuries sustained by chiropractic students during technique labs; Finding

L'évolution de l'enseignement des compétences manuelles en chiropratique: la deuxième partie - examen narratif et une discussion de l'impact des données probantes de recherche rédigées par le corps professoral du Canadian Memorial Chiropractic College

Les objectifs de cet article, la deuxième partie d'une série en deux parties, sont doubles : (i) fournir un examen narratif des données probantes de la recherche rédigées par le corps professoral du Canadian Memorial Chiropractic College (CMCC) et; (ii) discuter de l'impact de ces données probantes de la recherche sur l'enseignement des compétences manuelles en chiropratique au CMCC et - théoriquement - sur la communauté éducative en chiropratique plus large. Les preuves de recherche qui ont fait l'objet de discussions portent sur les domaines suivants : Les études expérimentales liées à la biomécanique; la mesure de la force - L'intégration de la Technologie de la table de détection de force (FSTT®) dans les laboratoires de techniques; les caractéristiques des blessures subies par les étudiants en chiropratique pendant les laboratoires de techniques; trouver la cible clinique pour l'intervention thérapeutique et; les recommandations

[1] Australian Chiropractic College, Adelaide, Australia
[2] Canadian Memorial Chiropractic College, Toronto, ON
[3] Faculty, Northeastern College of Health Sciences
[4] Retired from Private Practice

Corresponding author: Brian Gleberzon, 306-3335 Yonge Street, Toronto, ON, M4N 2M1
Tel: 416 277 8612
E-mail: Brian.gleberzon@gmail.com

The authors have no disclaimers, competing interests, or sources of support or funding to report in the preparation of this manuscript.

the clinical target for therapeutic intervention and; Recommendations toward a model technique curriculum. The intent of this article is for faculty at current and future accredited educational programs to incorporate this research evidence into their technique curricula and to potentially strengthen the pedagogical approach used to teach chiropractic manual skills.

(JCCA. 2024;68(2):160-171)

KEY WORDS: chiropractic manual skills, biomechanics, student injuries, site of care, Force Sensing Technique Tables ®

pour un programme de technique modèle. L'objectif de cet article est que les professeurs des programmes d'enseignement accrédités actuels et futurs intègrent ces données de recherche dans leurs programmes d'études techniques et renforcent potentiellement l'approche pédagogique utilisée pour enseigner les compétences manuelles en chiropratique.

(JCCA. 2024; 68(2) : 160-171)

MOTS CLÉS : compétences manuelles en chiropratique, biomécanique, blessures des élèves, site de soins, la Technologie de la table de détection de force ®

Introduction

Starting from the early 19th century, four factors influenced the development of the chiropractic profession: the bonesetters of Europe (which gave chiropractic its method), magnetic healing (which gave chiropractic its original theory), popular health reform and orthodox science.[1] Starting in the late 1890s, these factors would influence the curriculum at the Palmer School of Chiropractic (PSC) and be further undergirded by the theories developed by its founder, Daniel David (DD) Palmer and later by his son Bartlett Joshua (BJ) Palmer who assumed ownership of PSC in 1906.[2] Over the next 50 years, new theories, often based on research evidence, would emerge, leading to curricular changes not only at PSC but also at the myriad of other chiropractic educational programs that opened – some still in existence today - each with their own ideological view and distinctive cultural approach to chiropractic.[3]

Founded in 1945, the Canadian Memorial Chiropractic College (CMCC) has undergone several ideological and cultural changes, reflected in changes in its curricula over the decades.[4] Starting in either the late 1970s or mid 1980s, the authors of this study witnessed many curricular changes first-hand as students and later as CMCC technique faculty. During their collective 120 years as faculty in the 'technique trenches' at CMCC they and many other faculty members published research evidence that directly led to curricular changes as to how chiropractic manual skills were taught to students.

Part 1 of this two Part 2 series provided a narrative review of the evolution of teaching and evaluating chiropractic manual skills as chronicled by the same authors as this study.[5] The objectives of this study - Part 2 of the two part series - are to: (i) provide a narrative review of the research evidence authored by faculty at CMCC germane to teaching and evaluating chiropractic manual skills and (ii) discuss the impact of this research evidence had, continues to have and may theoretically have on teaching manual chiropractic skills at CMCC and, theoretically, at the broader chiropractic educational community.

To achieve these objectives, topics discussed in this article are: *Experimental Studies Linked to Biomechanics*; Measuring *Force – Integration of Force Sensing Table Technology®* into *technique labs; Characteristics of injuries sustained by chiropractic students during technique labs; Finding the Clinical Target – The Site of Care Study* and; *Recommendation Toward a Standardized Chiropractic Technique Curriculum*.

Methods

For this narrative review, articles had to meet the following inclusion criteria:

(i) Research evidence published by authors while faculty at CMCC; (ii) research evidence published in indexed, peer-reviewed journals or presented at national or international conferences and (iii) research evidence that directly impacted teaching chiropractic manual skills at CMCC or that may

theoretically impact teaching chiropractic manual skills to the broader chiropractic educational community. Since no human subjects were involved in this review, ethics approval was not required.

Results

(i) Experimental studies linked to biomechanists

In the late 1990s Kim Ross, then chair of the technique department at CMCC and CMCC faculty member David Bereznick began a PhD program in biomechanics under the supervision of esteemed biomechanist Dr. Stuart McGill from the University of Waterloo. They sought to apply the laws of biomechanics to established chiropractic ideological hegemony, focusing on: the validity of motion palpation to identify dysfunctional vertebral segments requiring manual therapy; the necessity to optimally apply manipulative forces in a particular direction (line of drive) based on the location of a targeted vertebral segment and; the ability of a practitioner to target a specific vertebral segment during high velocity, low amplitude spinal manipulative therapy (HVLA-SMT).

Facet asymmetry

There are many diagnostic procedures chiropractors use to select the clinical target (synonyms include subluxation, joint dysfunction, manipulable lesion and many others[6]) for clinical intervention. Among these methods motion palpation (MP) is one of the most commonly used. MP is predicated on the assumption that the bony architecture on the left side of a joint is sufficiently symmetric to the right, such that the same force would be needed to move one segment relative to the other. If the examiner perceived the forces needed were different to move a vertebral joint from one side to the other, they would conclude that segment required a manual procedure (e.g., mobilization or spinal manipulation) to re-establish optimal joint motion.

It has been well established that motion palpation lacks reliability, calling into question it's clinical usefulness.[7] What has been investigated to a much lesser degree is the validity of motion palpation with respect to identifying vertebra requiring manipulation to restore normal motion. The assumption is that any perceived restrictions in joint motion would be amenable to HVLA-SMT; however, if facets are indeed asymmetrical, then the anatomical asymmetry would contribute to apparent restrictions in motion during palpation, negating the need for therapeutic intervention.

Furthermore, it had been well established that facet asymmetry at C1-C2 was the rule rather than the exception, but it was unknown if that asymmetry was sufficient to affect the forces needed to move one segment on the other. Ross, Bereznick and McGill theorized they would. To test this underlying theory, they examined six cadaver specimens to determine if the asymmetry would result in an asymmetry of forces required to move C1 laterally on C2.[8]

As they theorized, the facet with the steeper angle resisted lateral translation more so than a shallow angle. As an example, the right facet would resist the C1 from translating to the left if the angle was relatively steeper and the left facet would offer less resistance to right lateral translation if the angle was relatively more shallow. Hence, they concluded, when a clinician is challenging vertebrae to the left and the right *in vivo*, any differences felt may in fact be due to different facet angles rather than the presence of a reversible fixation reducible through manipulation. Furthermore, the facet angles vary greatly from individual to individual.[8] This meant a clinician could not know if resistance to MP is caused by anatomy or by joint fixation.

Line of drive

For many years it was traditional to instruct CMCC students and, based on the authors' experience with the Technique Consortium, students at other chiropractic programs[5] to thrust along the joint planes (angulation) while performing prone thoracic HVLA-SMT. For the upper thoracic region students were instructed to thrust straight down (posterior to anterior) and for the lower thoracic region they were instructed to thrust headward at a 45° angle.

Using specialized equipment to test if this was the most effective way to adjust a person's thoracic spine ('most effective' in terms of maximizing the force transmitted from the doctor to the patient) the researchers reported that the skin-fascia interface over the thoracic spine exhibited negligible friction, meaning the only forces transmitted to the targeted vertebrae are those applied perpendicular to the surface.[9] From a clinical perceptive, this meant it would be ineffective to thrust in any direction other than perpendicular to the surface. If a chiropractor thrusted cephalad as they had been taught to do, it merely tugged the skin which would, in turn, move the entire

body and give the illusion that forces had been translated to the patient. That being said, a slight cephalad force was required to remove the skin slack - otherwise it was difficult to maintain a static contact during the thrust because the doctor's hand and patient's skin could slide as a unit to the point where the doctor would no longer be over the intended target (Ross- personal communication).

A frictionless skin-fascia interface also meant that the ability to 'hook' a thoracic transverse or spinous process in the superior-inferior direction during HVLA-SMT may be greatly over-rated. In practical terms, this meant students ought to be instructed to only thrust perpendicular to the surface during prone thoracic adjustments to optimally transmit the forces they generated.[9] The research emphasized that if the doctor thrusts perpendicular to the surface of the skin, the vertebrae would not travel cephalad, since it would follow the facet surfaces, not unlike a train on its tracks. (Ross – personal communication)

Target specificity

A third study authored by Ross, Bereznick and McGill investigated the ability of doctors to specifically cavitate a contacted vertebral segment during thoracic HVLA-SMT and during side posture lumbopelvic manipulation (SPLM).[10]

Sixty-four asymptomatic participants received HLVA-SMT delivered by 28 different chiropractors (including many CMCC technique tutors). Based on data collected by accelerometers secured to the participant's skin that calculated the distance between the source of vibration from the cavitation site to the target location, the researchers' reported cavitation was at least one segment away from the target during thoracic HVLA-SMT or SPLM, with a range of 0 to 14cm. The site of cavitation during thoracic HVLA-SMT was also found to be distant from the point of contact with the doctor accurately hitting their target slightly more than half the time.[10]

How then to increase the likelihood of cavitating the targeted joint? Simply put, the biomechanists recommended the more joints that cavitate the greater the probability that the targeted joint would cavitate as well.[10] Looked at another way, if it is important to cavitate the targeted joint, the best strategy is to cavitate multiple joints since the targeted joint would cavitate by default.

It would appear that manipulating the targeted joint may not matter with respect to patient outcome. A systematic review by Sorensen *et al*.[11] concluded: "Targeting a specific vertebral level when administering SMT for patients with nonspecific low back pain did not result in improved outcomes on pain intensity and patient-reported disability compared to a nontargeted approach."[11p39] The caveat to this conclusion is it is unknown that, even if a particular vertebra were targeted, it experienced the forces delivered. To do so, a study would require the technology developed by Gregory Cramer, Dean of the Department of Research at National University of Health Sciences to determine which joints gapped (discussed below).

Refractory period following cavitation

Bereznick, Ross and CMCC technique tutor Gary Pecora investigated other presumptions related to HVLA-SMT. They investigated the '20 minute refractory period cavitation rule', which stated a joint could only 're-cavitate' after a 20 minute pause.[12] Put succinctly, they discovered that the refractory period was quite variable but was subject specific.

Quantifying joint gap during SPLM

Using magnetic resonance imaging (MRI), Cramer, Ross and their colleagues sought to quantify the amount of joint gap during SPLM.[13] They discovered that the joints on the upside were the ones that gapped the most and using accelerometer technology developed by Ross, they determined that these joints were the ones that cavitated.[13]

One may ask: Why all the focus on cavitation? In the authors' experience, it is because technique tutors and students alike consider cavitation to be the hallmark of manipulation success. This of course is a contentious issue. As mentioned above, a recent systematic review concluded that the audible pop (cavitation) does not appear to be related to successful manipulation if success is considered to be a reduction in pain.[14]

(ii) Measuring force – force sensing table technology®

Despite the best efforts of technique faculty, they are unable to accurately judge the force a student generated during HVLA-SMT by observation, a key subskill graded during technique testing.[5] A method was therefore needed to (i) augment a students' ability to consistently generate sufficient force for HVLA-SMT (ii) instruct students how to modify forces generated during HVLA-SMT as clinic-

al circumstances dictated and (iii) provide a valid method for faculty to grade forces students generated during technique testing.

Various types of transducers, used to measure force, had been used in research studies for many years, and entrepreneurs had attempted to harness this technology for teaching purposes. One early entrée was the Dyna-Adjust, a 12-inch cylindrical metal device containing instrumentation that could measure the users' force and speed produced by OrthoNeuro Technologies.[15] The data could be coded such that an individual user could access their performance.

Jay Triano, then Dean of Graduate Education and Research at CMCC, Ross and CMCC technique tutor Brian Gleberzon (who became chair of the technique department after Ross) were involved in research studies investigating the potential teaching benefits of using the Dyna-Adjust in technique class, which also included creating a revised version of the CMCC technique manual (discussed in Part 1[5]) using the device.

Unfortunately, the results from the in-class studies indicated students did not improve their manual skills using the device. A significant confounding factor was the way the study was designed since it used an early version of a force sensing table that compromised students' ability to perform HVLA-SMT. As an example, students could not contact the patient's upper torso during SPLM as is customary; instead, they had to contact a metal arm of the table. The data was also compromised if the student bumped into the table, requiring the student to step away from the table when performing HVLA-SMT.

According to the study protocols, students only used the device twice - once at baseline and once after several weeks of practicing; however, students did not practice using the force sensing table, meaning they were not able to become comfortable with the limitations in performing SMT required. The study's results, along with concerns about the cost of the device and accompanying software, led to project being abandoned, at least at CMCC.

In 2009, the Higher Education Quality Council of Ontario (HEQCO) issued a request for proposals that focused on innovative technology and its use in classroom setting.[16] The goal was to provide academic institutions with an opportunity to evaluate the effectiveness of pedagogical approaches that aim to enhance the quality of student learning through the introduction and integration of new technologies. Through the auspices of the Knowledge Infrastructure Program (KIP) of Industry Canada, as overseen by the Ministry of Industry and in consultation with the Minister of State (Science and Technology), CMCC received a grand that established its simulation ('sim') laboratory. There were two components to the 'Sim lab'; one was the use of computerized and interactive mannequins that could be used in various real-life scenarios (i.e., patient emergencies such as heart attack or diabetic comas) and the other was the use of mannequins for Force Sensing Tables (FSTT®).[16]

Developed by Triano, FSTT® are standard chiropractic tables that are specially equipped with force plates that record force-time profiles which are projected onto a computerized screen immediately after the delivery of each procedure, providing objective and quantifiable real time feedback (Figure 1). Rather than thrust on the table or on each other, students perform HVLA-SMT on specially designed mannequins that are positioned on the FSTT®. Students received instructional training using the FSTT® during lab sessions outside of regular technique laboratory times. The intent of implementing FSTT® into the curriculum was to provide students with an opportunity to rehearse the application of manual skills on mannequins prior to (or in addition to) progressing to volunteer subjects (i.e., other students), especially since there a number of studies that have demonstrated chiropractic student are commonly injured during undergraduate technique training, as discussed below.

With respect to quantitative outcomes, on average, the cohort of students using the FSTT® achieved statistically significant gains in force amplitude and speed by the end of a two-hour session. In addition, learners who did not obtain notable changes during FSTT® labs were self-motivated to voluntarily participate in unscheduled lab sessions and, upon re-evaluation, were found to achieve gains in performance compared to their peers. Most importantly, these gains in performance were sustained through a seven-month (for Year II students) and five-month (for Year III students) interval between FSTT® sessions, as determined by formative assessment.[16] Lastly, FSTT® users were found, on average, to be able to achieve statistically significant modulations of forces on demand.[16]

With respect to qualitative outcomes, students' ratings of their confidence and competence in performance increased during the final year of training.[16] A similar study

Figure 1.
Force Sensing Table Technology ®

involving students in all three technique classes found they perceived themselves to be more competent to deliver the cross bilateral adjustment after FSTT® sessions, with more senior students reporting the highest level of self- perceived competence.[17]

A companion study sought to determine what method of teaching FSTT® would result in the most optimal classroom experience for students.[18] For this study, 'structured FSTT®' classes, during which students were assigned designed times and tasks to use the FSTT® was compared to an 'unstructured FSTT®' class system, during which students could use the FSTT® at will. All students receiving 'structured FSTT®' training during technique labs perceived class time to be the most efficient. This effect was most pronounced among Year I students.[18]

A slew of studies has been published investigating the FSTT® on topics as diverse as clinical outcomes, education, biomechanics and basic sciences.[19] Examples include: the ability of first year CMCC students to retain the ability to modulate forces generated SMT using FSTT® after a 12 week detraining period[20]; the ability of experienced clinicians to be taught to recalibrate the peak forces generated for children using mannequin simulators[21] and; improved peak-force control demonstrated by students on mannequins following a one hour training session using FSTT®.[22] Although beyond the scope of this study, the authors encourage academics, researchers and other subject matter experts undertake a narrative review of the research evidence pertaining to FSTT® to share with the broader healthcare educational community.

Lastly, since the mid 2010s, CMCC has marketed FSTT® to other programs that teach psychomotor skills. To date, 21 educational programs have purchased FSTT® throughout North America as well as the United Kingdom, France and Australia.[23]

(iii) Characteristics of injuries sustained by chiropractic students during technique labs

It was widely acknowledged that students were injured during technique class. This was not surprising since novice students were repeatedly applying several hundred Newtons of force to essentially healthy (e.g., fully functional) joints during technique labs. But the characteristics of these injuries (e.g., frequency, location, duration, sequelae) were unknown.

To investigate whether students were injured during technique class and, if they were, what were the characteristics of these injuries, Gleberzon spearheaded a cross-sectional retrospective cohort study that administered a unique survey to undergraduate CMCC students during class time.[24] The survey was unique in the sense that a review of the literature revealed this would be the first research project of its kind.[24]

The study was approved by CMCC's Ethics Review Board. Students were assured their responses would be anonymous. In addition to gathering basic demographic data (age, gender) students were asked to indicate if they had been injured during technique class. If the answer was 'yes', they were asked where they were injured (e.g., what region of their body), the symptoms they experienced (e.g., sharp pain, dull or achy pain, numbing, tingling), how severe it was (e.g., mild, moderate, severe), how long it lasted and what treatment, if any, they sought out. They were also asked to indicate which year of study they were in when they were injured.[24]

Overall, 55% of students reported being injured during technique class, the same frequency patients report being injured after their first chiropractic treatment.[25,26] The majority of injuries (62.6%) were described as light to moderate in intensity, lasting less than 72 hours (66.5%). The most common anatomic location of injury was the low back (35.0%) followed by the cervical spine (27.5%). Most students (59.0%) reported being injured during their

second year of study – not surprising since that is when they were first introduced to cervical and lumbopelvic manipulation. 55% of student did not seek any care for the injury.[24]

Gleberzon approached colleagues at other chiropractic programs to administer the same survey to their students. His colleagues informed him they were not permitted to do so because administrators feared the potential political fallout if the results at their programs were the same as at CMCC. Even so, representatives at four chiropractic programs were willing to participate in the project. The data from those chiropractic programs were very similar to the data we collected at CMCC.[27]

Over the next few years, a number of other studies characterizing student injuries at other chiropractic programs were conducted and published[28-31] with results mirroring those from CMCC. Some of those studies addressed an oversight in our original study and asked respondents if they were the 'doctor' or the 'patient' when they were injured. Most commonly the person injured was the 'doctor', most commonly delivering a SPLM.

Finding the clinical target – the site of care study

In 2006 Triano and Brian Budgell, the Director of Life Sciences Laboratories at CMCC, were asked to lead a study that sought to assess the evidence investigating the validity of the various methods manual therapies such as chiropractors use to determine the clinical target for therapeutic intervention, such as HVLA-SMT.[32] Research participants ranked the quality of evidence using the QUADAS (Quality Assessment of Diagnostic Accuracy Studies) checklist for validity and the QAREL (Quality Appraisal of Reliability Studies) checklist for reliability, as appropriate. Once the data was extracted and synthesized, the studies that met the inclusion criteria were evaluated in terms of their 'strength of evidence' and the degree to which the method under investigation was favoured for clinical use.[32]

The researchers agreed the quality of evidence was high for pain provocation, postural asymmetry, range of motion, certain specialized tests, thermography of lower limbs in confirming frank sciatica and the recommendation was favorable for all of them, meaning they was deemed a valid method of finding a clinical target.[32]

Conversely, many of procedures such as leg length analysis and manual muscle testing had mixed results, whereas x-ray line marking had a high level of evidence that concluded it was not a valid method to find a clinical target.[32] As one might imagine, this did not go over well with a substantial segment of the profession, especially those who use Gonstead, Upper Cervical or Chiropractic Biophysics/ Clinical Biomechanics of Posture protocols.[6]

Recommendation toward a standardized chiropractic technique curriculum

Starting in 2014, Cooperstein, Christopher Good, Christopher Roecker, Charles Blum – all technique faculty at American chiropractic programs - and Gleberzon convened four facilitated workshops at ACC-RAC with the objective of developing a standardized chiropractic technique curriculum[33] using a modified Nominal Group Technique protocol.[34,35]

Based on the best available evidence, including the 'site of care' study[32] they sought consensus opinion from workshop participants as to which diagnostic and therapeutic procedures ought to be included in a standardized chiropractic technique curriculum. Where evidence was lacking, participants agreed a procedure must have, at a minimum, face validity and biological plausibility for it to be included in a technique program.[33]

With respect to diagnostic procedures, workshop participants reached consensus that chiropractic students should be taught to use postural assessment, gait analysis, palpation (static, motion and joint play analysis), global ranges of motion, and evidence-based orthopedic/neurological tests. No consensus could be reached with respect to the use of x-ray line marking (spinographs) for the purpose of identifying a clinical target (especially serial or repeated x-rays), although there was agreement a baseline x-ray during patient intake was reasonable to screen for various pathologies.[33]

For therapeutic procedures, all participants agreed the following should be taught soft tissue therapy (both manual and instrument assisted); mobilizations and HVLA manipulation of the spine and peripheral joints; handheld instrument-assisted adjusting (i.e., Activator); pelvic blocking and; use of drop piece and flexion-distraction tables.[33]

Discussion

The studies included in this narrative review have had either a direct or theoretical impact on teaching chiro-

practic manual skills within CMCC and in the broader chiropractic educational community.

Curricular revisions at CMCC

Prior to 2000, courses that taught students 'biomechanics' principally focused on the functional anatomy of joints of the spine and peripheral joints. When Ross and Bereznick completed their PhDs and returned to the faculty at CMCC around 2000, these courses were revised to include instruction on what they characterized as 'hard core biomechanics', teaching concepts such as moment arms and resultant force vectors, concepts that had hitherto never been taught. Over the years, instruction in these courses were transferred to then-CMCC faculty Steven Lester and, more recently, to CMCC faculty member Simon Wang.

The five principles of achieving cavitation

As is often the case in science, the findings from the research evidence linked to biomechanists led to other discoveries that culminated in the 'five principles to successfully produce cavitation during SMT', developed by Ross (Figure 2).

Principle 1. Shorten moment arm on doctor.

It was found that it was the magnitude of the moment applied to the patient, rather than the magnitude of the force, that resulted in cavitation (see text box below). Thus, students were recommended to increase the moment arm on the patient to increase the moment. However, the moment arm on the doctor needed to be shortened to reduce the deleterious effects of the moment on the doctor's shoulders. Hence students were recommended to mimic a 'T Rex' posture when learning SPLM. A collateral benefit was, by keeping the arms as close to the body as possible, it was postulated the doctor was less likely to injury the shoulder of the thrusting arm.

Text box:
Moment of force is a measure of its tendency to cause a body to rotate about a specific point or axis.

Principle 2. Lengthen moment arms on patient

Using slow motion video-analysis of the tutors as they performed SPLM, it was discovered they all impacted the patient's upside buttock or thigh with their own hip or

1. **Shorten moment arms on doctor** (T-Rex) – keep the body directly behind the contact hand/impact region of the doctor and keep the arms close to the body, like a T-Rex. This reduces the counter moment seen by the doctor's joints. This in turn increases energy efficiency and protects the doctor.
2. **Lengthen moment arms on patient** (Use thigh, knee) – utilize long moment arms of the patient when attempting to create a moment/torque. Impact the doctor's body along the thigh/knee during side posture lumbar manipulation to produce the required moment, thereby decreasing the force needed (increasing patient comfort).
3. **Use momentum of doctor and patient** (Drop, don't stop) – when the doctor starts to move, momentum is built up. Transfer this momentum to the patient, to produce the required force. If the doctor hesitates during the maneuver, he/she loses their momentum.
4. **Use impact whenever possible** (Drop and impact) – if the doctor's body collides against the patient's body, then maximum energy can be transferred. This produces the required force for the manipulation without relying on large amounts of muscle force. This in turn can reduce the doctor's muscle fatigue and injury risk.
5. **Minimize energy leaks through doctors' joints** (Tighten core and say "BAM" or "POW"). As momentum is built up by the doctor and impact is made onto the patient, the momentum needs to be transferred. If the doctor does not contract their core and shoulder muscles, the built-up momentum will be transferred to the doctor's upper body instead of the patient. Energy (momentum) is then not transferred to the patient and is essentially lost/leaked.

Figure 2.
Five principles to successfully produce cavitation during SMT

thigh. The impact is analogous to what happens when one billiard ball hits another billiard ball, where the impacted ball almost instantly accelerates to the velocity of the impacting ball, in accordance with Newton's First Law of Mechanics. Hence, it is easier to overcome the inertia of the patient's body weight if the doctor generates momentum and transferred it to the patient by impact, rather than the doctor essentially standing still and trying to deliver HVLA-SMT to the patient relying only on upper body strength. Ross and his colleagues investigated this principle and concluded that force ought to be generated by the doctor impacting the patient rather than by using the doctor's hand alone. They found that cavitation would *not* occur if more than 25% of force was solely generated by the doctor's hand. Or, looked at another way, cavitation *only* occurred when less than 25% of force was delivered directly to the vertebra itself by hand. (Ross- personal communication)

Principle 3 - Use of momentum of doctor and Principle 4 - Patient and use of impact whenever possible

Another strategy to improve the likelihood of cavitation is to use momentum of the doctor/patient unit. To accomplish this, the doctor starts by initiating the movement of the patient, and then applies the actual thrust when joint slack has been reached. The thrust would primarily be generated by the aforementioned impact. It must be emphasized, however, that these two principles are neither necessary nor recommended in situations where the patient is much smaller (such as a child or infant) than the doctor.

Principle 5. Minimize energy leaks through doctors' joints

In circumstances where impacting the patient during SPLM was deemed optimal, it is critical to 'stiffen' the trunk of the doctor so that the impact does not result in deformation of the doctor. This can be achieved by tightening the doctor's core muscles. This stiffening removed what were termed 'energy leaks' – the loss of generated force or energy - allowing for the force generated by the doctor to be optimally transferred to the patient, increasing the likelihood of cavitation.

Inclusion of Force Sensing Table Technology® into the undergraduate curriculum

Part 1 of this series described the evolution of teaching and testing manual skills at CMCC over the years.[5] As the data emerged demonstrating students accrued technique skills faster with the use of the FSTT® than without it, and that these skills were retained even after a period of no instruction, the FSTT® was included during technique classes and during technique testing. Currently, students are provided 6 lab experiences that focus on prone thoracic, supine thoracic, side posture, cervical-thoracic, lower cervical and upper cervical procedures.[36]

Bearing in mind FSTT ® has now been included in 21 other accredited chiropractic educational programs, it is reasonable to theorize its use has had a significantly positive impact on teaching technique at those programs as well.

Student injuries during technique class

Recognizing the frequency of injuries among students during technique class, and based on the experience Gleberzon had while visiting another chiropractic programs as chronicled in Part 1 of this series[5], CMCC student were required to read and sign an 'acknowledgment of risk' form prior to beginning technique classes in the undergraduate program, starting in 2018. This form was quickly expanded to include other courses with instructional laboratories that could potentially result in student injuries, namely orthopedics, clinical diagnosis and anatomy.

A study protocol for a randomised clinical trial (RCT) investigating if a strength and conditioning program can prevent the injuries chiropractic students commonly experience during technique training has recently been published.[37] At the time of this writing, no further information on the status of this RCT is available.

Diagnostic procedures

Since CMCC did not teach leg length checking, x-ray line marking to either identify subluxation or to calculate a uniquely appropriate line of drive to correct it, or procedures favoured by specific chiropractic technique systems, the results of the site of care study pertaining to those diagnostic procedures were inapplicable.[32] It is unknown if the site of care study had any impact on those chiropractic educational programs that do teach those diagnostic procedures.

Combing the results of the 'facet asymmetry'[8] and 'site of care'[32] studies CMCC students were taught that selecting a clinical target should not only rely on where the spine feels most restricted; rather, students should rely on both joint restrictions and pain on palpation (tenderness), especially bearing in mind the spine should not be overly tender.

Furthermore, If the site of contact of the doctor's hand was too tender for the patient, students were instructed it was rational to move the contact to a less tender region because the vertebra under the contact was no more likely to cavitate than those somewhat remote from the site. Finally, the students were taught to thrust perpendicular to the surface of the patient's spine when appropriate.

The authors of this study observed these instructions often resulted in friction between some technique faculty. Based on their clinical experience, some technique faculty found the use of motion palpation in the absence of pain provocation to be a good indicator of where to direct therapy and taught students in their technique groups accordingly.

Therapeutic procedures

With respect to therapeutic procedures, CMCC had already included manual and, to a lesser extent, instrumented soft tissue therapy in the core technique curriculum. Mobilizations as well as HVLA and drop piece manipulations of the spine and peripheral joints have also been taught for many years. However, at the time of this writing (winter, 2024) CMCC does not teach instrumented adjusting, use of traction tables and provides no more than one or two lab session on the use of pelvic blocking, contrary to the 'recommendation toward a standardized technique curriculum' study.[33]

By way of contrast, the Australian Chiropractic College, located in Adelaide, Australia, better aligns with the recommendations toward a standardized technique curriculum by including the following chiropractic technique systems[6] in its core curriculum: Diversified, Gonstead (both of which use HVLA-SMT), Thompson Terminal Point, Toggle Upper Cervical, Activator, Advanced Bio Structural Correction (ABC™), and Sacro-Occipital Techniques (Chanelle Vaughan, Stream Coordinator – Technique: Personal communication).

Knowledge translation at the grassroot level

It is widely recognized there is a knowledge-to-action (KTA) gap between the time of publication of research evidence and its uptake and utilization by healthcare professionals in clinical practice.[38] Using various strategies, some success has been achieved with respect to closing the KTA gap pertaining to performing manual skills in Ontario, Canada. The research evidence from the biomechanical[8-10], student injury[24,27] and site of care[32] studies has been shared with chiropractors on a grassroots level in the form of presentations at professional conferences[39,40], continuing educational programs[41,42] and in-person, hands-on technique workshops[43,44].

Limitations

There are several limitations to this study. Similar to Part 1 of this series,[5] a different group of authors may have selected a different group of studies to review. Since only a brief synopsis of each study was provided in this narrative review, some important details of each study may have been missed. With very few exceptions, the authors purposefully avoided discussing articles that were related to this topic but outside of this study's inclusion criteria. We encourage interested parties undertake either a broader narrative review or a systematic review to capture other studies germane to chiropractic manual skills.

Summary

This article provided a narrative review of the research evidence authored by faculty at CMCC as well as a discussion of the impact this research has had on teaching chiropractic manual skill within the college and, theoretically, to the broader chiropractic educational community. It is the authors' hope faculty and curricular planners at current and future accredited educational programs may potentially incorporate this research evidence to strengthen the pedagogical approach to how they teach chiropractic manual skills.

References

1. Kaptchuk TJ, Eisenberg DM. Chiropractic. Origins, controversies and contributions. Arch Intern Med. 1998;158: 2215-2224.
2. Keating JC Jr. Several pathways in the evolution of chiropractic manipulation. J Manipulative Physio Ther. 2003;26(5): 300-321.

3. Montgomery PD, Nelson MJ. Evolution of chiropractic theories of practice and spinal adjustment, 1900-1950. Chiro Hist. 1985;5: 71-77.
4. Keating JC Jr. Chronology of the Early History of the Canadian Memorial Chiropractic College. Source unknown.
5. Gleberzon BJ, Ross JK, Kinsinger FS, Szaraz Z. The evolution of teaching chiropractic skills: Part 1 – a narrative review of lessons learned during the 120 collective years of four tutors in the technique trenches at the Canadian Memorial Chiropractic College. J Can Chirop Assoc. 2024.
6. Cooperstein R, Gleberzon BJ. Towards a Taxonomy of Subluxation-Equivalents. Top Clin Chiropr. 2001;8(1): 49-58.
7. Nolet PS, Yu H, Cote P, Meyer A, *et al*. Reliability and validity of manual palpation for the assessment of patients with low back pain: a systematic and clinical review. Chiropr Man Therap. 2021;29:33.
8. Ross JK, Bereznick DE, McGill SM. Atlas-axis facet asymmetry. Implications in manual palpation. Spine. 1999;24(12):1203-1209.
9. Bereznick DE, Ross JK, McGill SM. The frictional properties at the thoracic skin-fascia interface: Implications in spinal manipulation. Clin Biomech. 2002;17(4):297-303.
10. Ross JK, Bereznick DE, McGill SM. Determining cavitation location during thoracic spinal manipulation: is spinal manipulation accurate and specific? Spine. 2004;29(13): 1452-1457.
11. Sorensen PW, Nim CG, Poulsen E, Juhl CB. Spinal manipulative therapy for nonspecific low back pain: does targeting a specific vertebral level make a difference?: A systematic review with meta-analysis. J Orthop Sports Phys Ther. 2023;53(9):529-539.
12. Bereznick D, Pecora CG, Ross JK *et al*. The refractory period of the audible 'crack' after lumbar manipulation: a preliminary study. J Manipulative Physio Ther. 2008;31(3):199-203.
13. Cramer GD, Ross K, Raju PK *et al*. Quantification of cavitation and gapping of lumbar zypapophyseal joints during spinal manipulative therapy. J Manipulative Physio Ther. 2012;35(8): 614-621.
14. Moorman AC, Newell D. Impact of audible pops associated with spinal manipulation on perceived pain: a systematic review. Chiropr Man Therap. 2022;30:42.
15. Leathers K. How and why you can utilize Dynadjust even before matriculation to grad school! https://www.youtube.com/watch?v=wesGIK3YyPA
16. Triano, J., Giuliano, D., McGregor, M., & Howard, L. (2014). Enhanced Learning of Manipulation Techniques using Force-Sensing Table Technology (FSTT). Toronto: Higher Education Quality Council of Ontario.
17. Azad A, Ellul N, Gleberzon BJ. Computerized Text Analysis of Emergent Themes from Responses to Curricular Change. Platform Presentation, Association of Chiropractic Colleges and Research Agenda Conferences, March 14, 2016
18. Ellul N, Azad A, Gleberzon BJ. Student perceptions of Force Sensing Table Technology integration in the classroom: A Controlled Cohort Study at CMCC. Platform Presentation, Association of Chiropractic Colleges and Research Agenda Conferences, March 14, 2016
19. CMCC- FSTT® Technology – Publications. https://www.cmcc.ca/research/fstt-publications
20. Starmer DJ, Guist BP, Taylor TT *et al*. Changes in manipulative peak force modulation and time to peak thrust among first-year chiropractic students following a 12-week detraining period. J Manipulative Physiol Ther. 2016;39(4):3111-3117.
21. Triano JJ, Lester S, Starmer D, Hewitt EG. Manipulation peak forces across spinal regions for children using mannequin simulators. J Manipulative Physiol Ther. 2017;40(3): 139-146.
22. Duquette SA, Starmer DJ, Plener JB *et al*. A pilot study to determine the consistency of peak forces during cervical spina manipulation utilizing mannequins. J Chirop Educ. 2021;35(1): 8-13.
23. CMCC: FSTT® Technology – Global Presence. https://www.cmcc.ca/research/fstt-technology
24. Macanuel K, Deconinck A, Sloma KC, LeDoux M, Gleberzon BJ. Characteristics of injuries sustained by chiropractic students during their undergraduate training in technique class at a chiropractic college: a pilot retrospective study. J Can Chiro Assoc. 2005;49(1):46-55.
25. Senstad, O, Lebeouf-Yde, C, Borchgrevink, C. Frequency and characteristics of side effects of spinal manipulative therapy. Spine 1997;22(4): 435-441.
26. Cagnie B., Vinck E, Beernaert A, *et al*. How common are side effects of spinal manipulation and can these side effects be predicted? Manual Ther. 2004;9(3):151-156.
27. Kuehnel E, Beatty A, Gleberzon BJ. An intercollegiate comparison of prevalence of injuries among students during technique class from five chiropractic colleges throughout the world: a preliminary retrospective study. J Can Chiro Assoc. 2008;52(3): 169-174.
28. Bisiacchi DW, Huber LL. Physical injury assessment of male versus female chiropractic students when learning and performing various adjustive techniques: a preliminary investigative study. Chiropractic Osteopath. 2006;14:17.
29. Ndetan HT, Rupert RL, Bae S *et al*. Epidemiology of musculoskeletal injuries among students entering a chiropractic college. J Manipulative Physio Ther. 2009;32: 134-139.
30. Kizhakkeveettil A, Sikorski D, Tobias G *et al*. Prevalence of adverse effects among students taking technique classes: a retrospective study. J Chiro Educ. 2014;28(2): 139-145.
31. Hodgetts CJ, Walker BF. Testing a strength and

conditioning program to prevent common manipulative technique training injuries in chiropractic students: a study protocol for a randomised controlled trial. Chiro Manual Ther. 2018;26: 23.
32. Triano JJ, Budgell B, Bagnulo A *et al*. Review of methods used by chiropractors to determine the site of applying manipulation. Chiropr Man Ther. 2013; 21:36.
33. Gleberzon BJ, Cooperstein R, Good C, Roecker C, Blum C. Developing a standard curriculum for teaching chiropractic technique: qualitative analysis of participants' opinions from 4 intercollegiate conference workshops. J Chiro Educ. 2021; 35(2): 249-257.
34. McMillan S, Kelly F, Sav A, *et al*. Using nominal group technique: how to analyze across multiple groups. Heal Serv Outcomes Res Methodol. 2014;14: 92-108.
35. McMillan S, King M, Tully MP. How to use the nominal group and Delphi techniques. Int J Clin Pharm. 2016;38(3): 655-662.
36. CMCC- FSTT® Curriculum. https://www.cmcc.ca/research/fstt-curriculum
37. Hodgetts CJ, Walker BF. Testing a strength training and conditioning program to prevent common manipulative technique training injuries in chiropractic students: A study protocol for a randomized clinical trial. Chiropr Man Therap. 2018;28: 26-33.
38. Graham ID, Logan J, Harrison MB *et al*. Lost in knowledge translation: time for a map? J Contin Edu Health Prof. 2006;26(1): 13-24.
39. Ellul N, Doucet C. Fine-Tuning Force: Modulation for Special Populations, from Pediatrics to Geriatrics. Canadian Chiropractic Association National Convention & Tradeshow (NCT). April 20, 2024
40. Kinsinger FS, Guist B (Moderators). Evolving chiropractic education and research. The Healthcare Evolution. Association of Chiropractic Colleges Educational Conference Research Agenda Conference (ACCRAC 2024).
41. Choi G. Force-Sensing Table Technology Lab. CMCC Continuing Education. May 4, 2024.
42. Wang S. The science of the pop. Exploring expectations, cavitations, and spine biomechanics. Parker Seminars – Invictus Las Vegas. February 22, 2024.
43. Azad A, Draper C, Ellul N, Gates R. Skills for exceptional patient care: An in-person interactive workshop. CCPA-CCA Workshop. Nov 21, 2023.
44. Gleberzon BJ. Hands on Technique Tune-Up. Eastern Ontario Chiropractic Society. April 13, 2024.

ISSN 0008-3194 (p)/ISSN 1715-6181 (e)/2024/172–176/$2.00/©JCCA 2024

Imaging Case Review

Cervical spondylotic myelopathy in a 68-year-old man diagnosed with amyotrophic lateral sclerosis

Peter C. Emary, DC, PhD[1-3]
Angelica J. Turner, DC[4]

Owing to similar clinical presentations, cervical spondylotic myelopathy can mimic other neurological disorders. In this imaging case review (ICR), we describe a case of cervical spondylotic myelopathy in a patient diagnosed with amyotrophic lateral sclerosis. The key clinical features, imaging findings and differential diagnoses of cervical spondylotic myelopathy compared with amyotrophic lateral sclerosis are also presented.

(JCCA. 2024;68(2):172-176)

KEY WORDS: cervical spondylotic myelopathy; amyotrophic lateral sclerosis; differential diagnosis

Examen du cas par imagerie

Une myélopathie spondylotique cervicale chez un patient de 68 ans atteint de sclérose latérale amyotrophique

En raison de présentations cliniques similaires, la myélopathie spondylotique cervicale peut simuler d'autres troubles neurologiques. Une myélopathie spondylotique cervicale (MSC) chez un patient de 68 ans atteint de sclérose latérale amyotrophique. Les principales caractéristiques cliniques, les résultats d'imagerie et les diagnostics différentiels de myélopathie spondylotique cervicale par rapport à la sclérose latérale amyotrophique sont également présentés.

(JCCA. 2024; 68(2) : 172-176)

MOTS CLÉS : myélopathie spondylotique cervicale; sclérose latérale amyotrophique; diagnostic différentiel

[1] Michael G. DeGroote Institute for Pain Research and Care, McMaster University
[2] Chiropractic Department, D'Youville University
[3] Private Practice, Cambridge, Ontario
[4] Radiology Resident, College of Chiropractic, Logan University

Corresponding author: Peter C. Emary, 1145 Concession Road, Cambridge, Ontario, Canada, N3H 4L5
Tel: (519) 653-1470 ext. 352
E-mail: emaryp@mcmaster.ca

The authors have no competing interests, or sources of support or funding to report in the preparation of this manuscript. Dr. Emary is supported by a postdoctoral fellowship with the Michael G. DeGroote Institute for Pain Research and Care at McMaster University, as well as research grants from the Canadian Institutes of Health Research, the NCMIC Foundation, and the Canadian Chiropractic Research Foundation outside of the submitted work. The involved patient provided consent for case publication.

Case presentation

A 68-year-old man presented to a chiropractic clinic with a two-year history of neck and bilateral shoulder pain, progressive full body weakness, clumsiness of the hands, difficulty with balance and walking, and a previous diagnosis of Parkinson's disease which was refuted by a second neurologist who diagnosed amyotrophic lateral sclerosis (ALS). On physical examination, the patient displayed signs of upper motor neuron lesions (spastic L4 and S1 deep tendon reflexes), lower motor neuron lesions (bilateral C5, bilateral L1-2, and left L4 and S1 motor paresis), and dorsal column and spinocerebellar dysfunction (dysdiadochokinesia in the hands, vibratory sensory loss in the feet, and a wide-based gait), signs consistent with cervical myelopathy. Neck flexion also produced pain and parasthesiae down the patient's spine into his upper extremities (i.e., L'Hermitte's sign). Examination of all 12 cranial nerves, including motor testing of the oculomotor, trochlear, abducens, facial and glossopharyngeal nerves, as well as manual muscle testing of the sternocleidomastoid and upper trapezius muscles, was normal, findings also consistent with a diagnosis of myelopathy.

Magnetic resonance imaging (MRI) of the brain and cervicothoracic spine was taken at a hospital 18 months earlier, after the patient had injured his neck falling backwards off a chair. Brain and brainstem images, including T2-weighted, proton density, and flair-weighted sequences, were unremarkable. Cervicothoracic T2-weighted images revealed multiple levels of compression fractures in the upper thoracic spine in addition to moderate vertebral canal stenosis and effacement of the spinal cord at the C3-4 to C6-7 levels (Figures 1 and 2). These imaging findings together with the lack of clinical bulbar involvement supported the diagnosis of cervical spondylotic myelopathy,[1,2] along with possible primary or secondary spinal neoplasia or other pathologic process (e.g., osteoporosis). The key clinical features, imaging findings, and differential diagnoses for cervical spondylotic myelopathy versus ALS are presented and further discussed in Table 1.

Discussion

According to the revised El Escorial criteria[2,3], the diagnosis of ALS requires evidence of progressive upper and lower motor neuron degeneration compatible with a neurodegenerative disorder that cannot be explained by any other disease process (evident on electrophysiological, imaging, cerebrospinal fluid, or other serological studies)[2]. Investigation results alone, such as evidence of chronic denervation on electromyography, are not adequate for achieving a diagnosis of ALS and must be interpreted with consideration of the patient's history and clinical findings.[2] As such, the patient in our case was referred back to his primary care physician for reassessment and management of cervical spondylotic myelopathy including a recommendation for neurosurgical consultation,[1,4] as well as investigation to rule out primary neoplasia or spinal metastasis. The patient was subsequently referred by his primary care physician for laboratory testing (electrophoresis), but this was negative for plasma cell myeloma.

Four years later (or six years after his initial ALS diagnosis), the patient contracted severe pneumonia and died. In a follow-up telephone conversation between the chiropractor and the patient's wife, it was revealed that the patient was never followed up by his primary care physician for myelopathy and consequently did not undergo spine surgical intervention. He continued to suffer from symptoms of myelopathy including ongoing neck pain and muscle weakness, particularly in the upper extremities, along with bowel and bladder dysfunction (i.e., sensory loss and incontinence), while his bulbar function (i.e., breathing, chewing, swallowing, eye movements, and speech) remained intact, further contradicting a definitive diagnosis of ALS.[1-3,5] Additionally, despite several requests by the chiropractor, copies of the patient's medical and imaging records could not be obtained from the primary care physician. Updated MR imaging of the cervicothoracic spine, if ordered, may have shown progressive deterioration. Other diagnostic methods for differentiating cervical spondylotic myelopathy and ALS are emerging,[6,7] but it is unclear if these were utilized in the current case. For example, levels of cerebrospinal fluid neuron-specific enolase have been shown to be elevated in patients with ALS and as a biomarker can distinguish ALS from cervical spondylotic myelopathy with high sensitivity (0.80) and specificity (0.87).[7] However, it is unknown how the patient in the current case was diagnosed with ALS and whether additional neurological or other conditions (e.g., metastasis) were investigated.

Owing to similar clinical presentations, ALS-mimic syndromes such as cervical spondylotic myelopathy re-

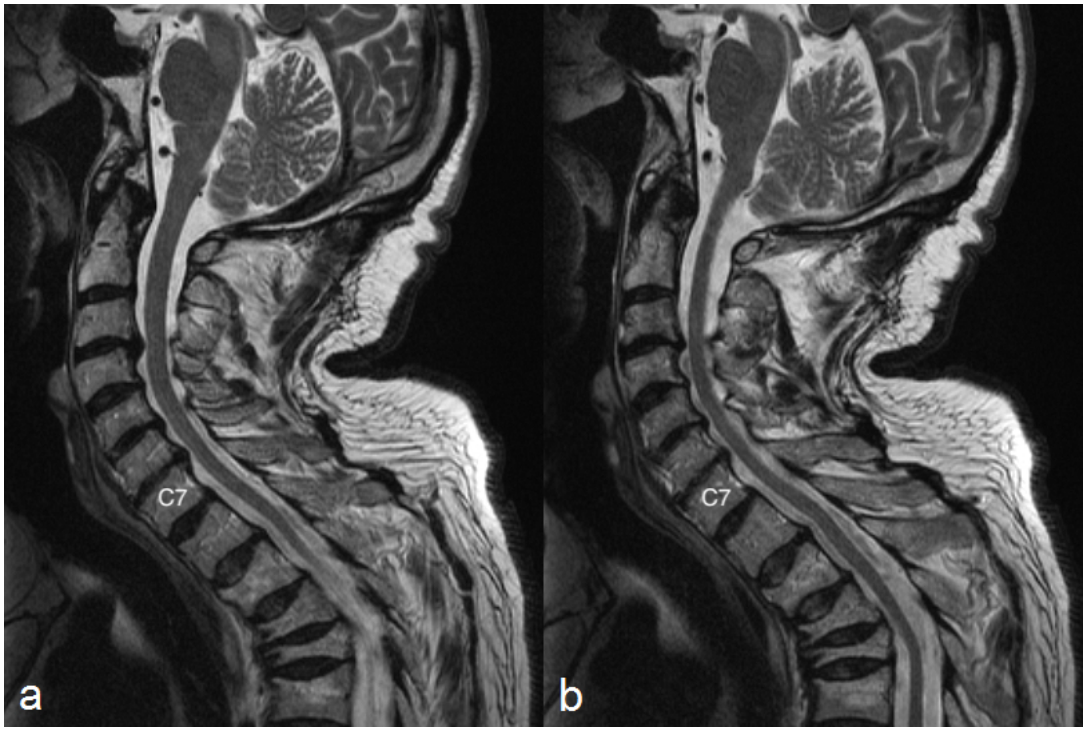

Figure 1.

Right parasagittal (a) and mid-sagittal (b) T2-weighted MR images of the cervical spine without contrast. There is degenerative spondylosis characterized by disc space narrowing and disc contour abnormality. The findings result in moderate vertebral canal stenosis and effacement of the cervical cord at levels C3-4 to C6-7. The Torg-Pavlov ratio ranges between 0.4 to 0.5 at these levels (< 0.8 signifies canal stenosis[9]), further indicating the presence of cervical spinal stenosis. The C7 level is annotated to orient readers to the cervical and thoracic spinal levels. Incidentally noted, there is heterogenous increased signal intensity in the vertebral bodies of T2 to T5 and the T5 superior endplate, indicating normal marrow reconversion. Additionally, there are severe compression fractures consistent with marked compression injuries at levels T3 and T4 and wedge-shaped compression fractures of the T2 and T5 vertebral bodies.

sult in diagnostic error in 5-10% of cases.[2,8] Moreover, the diagnosis of cervical spondylotic myelopathy is often delayed[9], up to an average of 6.3 years in some studies[10], during which time patients' clinical signs and symptoms typically deteriorate[9,10]. As such, clinicians should be aware that cervical spondylotic myelopathy can be confused with, and possibly overlooked in, patients diagnosed with other neurological disorders including ALS. In our case, it remains possible that the patient had diagnoses of both cervical spondylotic myelopathy and ALS. We refer readers to the papers by Wijesekera and Leigh[2] and McCormick *et al*.[9] for additional information on the etiology, diagnosis, clinical management, and long-term prognosis of these conditions.

Key Messages

- Owing to similar clinical presentations, cervical spondylotic myelopathy can mimic ALS in some cases
- Treatable conditions including cervical spondylotic myelopathy should be excluded before ALS is diagnosed

References

1. McCormick WE, Steinmetz MP, Benzel EC. Cervical spondylotic myelopathy: make the difficult diagnosis, then refer for surgery. Cleve Clin J Med. 2003; 70(10): 899-904.
2. Wijesekera LC, Leigh PN. Amyotrophic lateral sclerosis. Orphanet J Rare Dis. 2009; 4: 3.

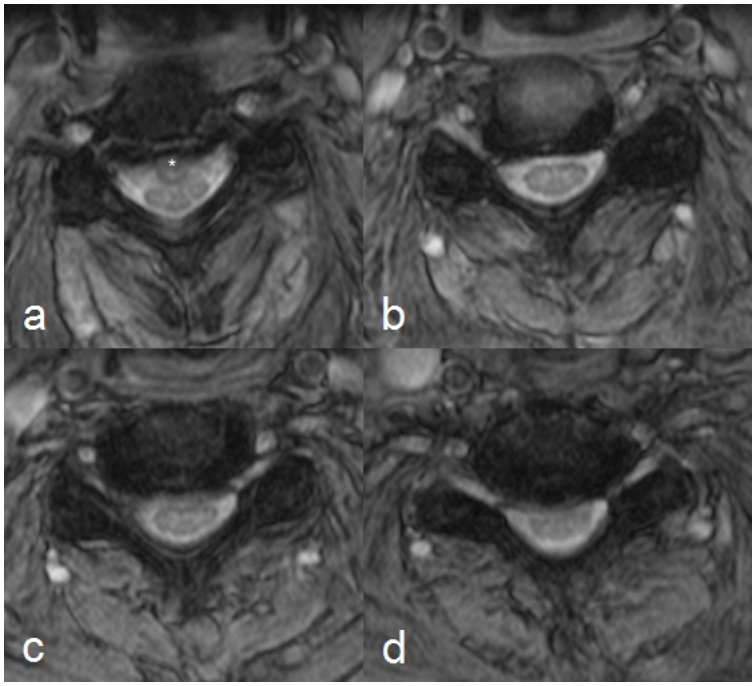

Figure 2.
Axial T2-weighted MR images of the cervical spine without contrast at a) C3-4, b) C4-5, c) C5-6, and d) C6-7. At C3-4, there is a narrow-based posterior central disc extrusion measuring 4.5mm x 3mm (asterisk) causing effacement of the spinal cord. At C4-5 there is disc-osteophyte complex formation with no spinal cord abnormality. At C5-6 and C6-7 there is mild disc contour abnormality with disc-osteophyte complexes causing moderate vertebral canal stenosis and mild effacement of the spinal cord. Other findings include apophyseal hypertrophy and neuroforaminal encroachment demonstrated at all levels.

3. Brooks BR, Miller RG, Swash M, Munsat TL. El Escorial revisited: revised criteria for the diagnosis of amyotrophic lateral sclerosis. Amyotroph Lateral Scler Other Motor Neuron Disord. 2000; 1(5): 293-299.
4. Young WF. Cervical spondylotic myelopathy: a common cause of spinal cord dysfunction in older persons. Am Fam Physician. 2000; 62(5):1064-1070.
5. Kim HJ, Tetreault LA, Massicotte EM, *et al*. Differential diagnosis for cervical spondylotic myelopathy: literature review. Spine (Phila Pa 1976). 2013; 38(22 Suppl 1): S78-S88.
6. Koike Y, Kanazawa M, Terajima K, *et al*. Apparent diffusion coefficients distinguish amyotrophic lateral sclerosis from cervical spondylotic myelopathy. Clin Neurol Neurosurg. 2015; 132: 33-36.
7. Tsukahara A, Hosokawa T, Nishioka D, *et al*. Neuron-specific enolase level is a useful biomarker for distinguishing amyotrophic lateral sclerosis from cervical spondylotic myelopathy. Sci Rep. 2021; 11(1): 22827.
8. Cortés-Vicente E, Pradas J, Marín-Lahoz J, *et al*. Early diagnosis of amyotrophic lateral sclerosis mimic syndromes: pros and cons of current clinical diagnostic criteria. Amyotroph Lateral Scler Frontotemporal Degener. 2017;18(5-6): 333-340.
9. McCormick JR, Sama AJ, Schiller NC, Butler AJ, Donnally CJ 3rd. Cervical spondylotic myelopathy: a guide to diagnosis and management. J Am Board Fam Med. 2020;33(2): 303-313.
10. Sadasivan KK, Reddy RP, Albright JA. The natural history of cervical spondylotic myelopathy. Yale J Biol Med. 1993;66(3): 235-242.

Table 1.
Key clinical features, imaging findings and differential diagnoses of cervical spondylotic myelopathy versus amyotrophic lateral sclerosis.

CERVICAL SPONDYLOTIC MYELOPATHY	AMYOTROPHIC LATERAL SCLEROSIS
Key clinical features[1] • Neck, subscapular, and/or shoulder pain • Upper extremity numbness or parasthesia • Lower extremity sensory (i.e., dorsal column) changes • Upper or lower limb motor weakness • Gait difficulties ("spastic gait") • Upper motor neuron findings (i.e., spasticity, hyperreflexia, clonus, Babinski and Hoffman signs, bowel and bladder dysfunction) • Lower motor neuron findings (e.g., upper limb hyporeflexia and atrophy)	**Key clinical features[3] [a]** • Upper motor neuron signs in the brainstem, cervical, thoracic and/or lumbosacral regions (i.e., clonic deep tendon reflexes [e.g., exaggerated jaw jerk, gag or snout reflexes, Hoffman and/or Babinski responses], pseudo-bulbar features [e.g., dysarthria, dysphagia], forced yawning, spastic facial/upper/lower extremity muscle tone, loss of superficial abdominal reflexes, preserved reflexes in weak wasted limbs) • Lower motor neuron signs in the brainstem, cervical, thoracic and/or lumbosacral regions (i.e., weakness, atrophy, and fasciculations in the jaw, face, palate, tongue, larynx, neck, arm/s, hand/s, diaphragm, back, abdomen, leg/s, foot/feet)
Imaging findings[1,9] • Degenerative spondylosis, including disc space narrowing, disc contour abnormality, posterior disc-osteophyte complex(es), uncinate and articular process hypertrophy • Vertebral canal stenosis and spinal cord effacement • Torg-Pavlov ratio < 0.8 or cervical spinal canal diameter < 12 mm on sagittal imaging • Signal changes in the spinal cord on T2-weighted MR images at the level(s) of spinal cord compression[b]	**Imaging findings[2,3]** • Absence of significant abnormalities of the skull or bones of the spinal canal, brain or spinal cord (suggesting no intra- or extra-parenchymal processes[c], or vascular malformations) on plain x-rays, MR imaging, computed tomography (with or without myelography) or spinal cord angiography that might explain clinical findings • Hyperintensity in corticospinal tracts in the brain, brainstem and/or spinal cord on T2-weighted, proton density-weighted and FLAIR-weighted MR imaging
Differential diagnoses[3,5] • ALS, extrinsic neoplasia (metastatic tumours), hereditary spastic paraplegia, intrinsic neoplasia (tumours of spinal cord parenchyma), multiple sclerosis, normal pressure hydrocephalus, spinal cord infarction, syringomyelia, and vitamin B12 deficiency	**Differential diagnoses[2]** • Cerebral lesions, skull base lesions, cervical spondylotic myelopathy, other cervical myelopathies (e.g., foramen magnum lesions, intrinsic and extrinsic tumours, syringomyelia), conus lesions and lumbosacral radiculopathy, inclusion body myositis, cramp/fasciculation/myokymia syndromes, multifocal motor neuropathy, Kennedy's disease

ALS = amyotrophic lateral sclerosis; *FLAIR* = fluid attenuated inversion recovery; *MR* = magnetic resonance.

[a] A definitive clinical diagnosis of ALS requires the presence of both upper and lower motor neuron signs in the bulbar (i.e., brainstem/cranial motor neuron) region and at least two spinal (i.e., cervical, thoracic, or lumbosacral) regions, or the presence of upper and lower motor neuron signs in three spinal regions.[3]

[b] Signal changes are often but not always present in the cervical cord of patients with cervical spondylotic myelopathy.[1]

[c] Abnormalities confined to the corticospinal tract are consistent with ALS.

ISSN 0008-3194 (p)/ISSN 1715-6181 (e)/2024/177–181/$2.00/©JCCA 2024

Imaging Case Review

Contralateral hip joint degeneration associated with a cam-type deformity of the proximal femur in a retired chiropractor: 10-year follow-up

Peter C. Emary, DC, PhD[1-3]

Cam-type deformities of the proximal femur have long been associated with femoroacetabular impingement (FAI); an orthopedic condition recognized in the etiology of early osteoarthritis (OA) in the non-dysplastic adult hip. However, the optimal clinical management (including the long-term prognosis) of patients with cam-type deformities with or without FAI symptoms remains uncertain. In this imaging case review (ICR), we present the 10-year follow-up of a retired chiropractor with bilateral cam-type femoral deformities who initially underwent total right hip joint arthroplasty for advanced hip joint OA, and subsequently developed advanced hip joint OA on the contralateral side.

Examen du cas par imagerie

Dégénérescence controlatérale de l'articulation de la hanche associée à une déformation en came du fémur proximal chez un chiropraticien à la retraite: Suivi sur 10 ans

Les déformations de type came du fémur proximal ont longtemps été associées à un conflit fémoro-acétabulaire (CFA); une affection orthopédique reconnue dans l'étiologie de l'arthrose précoce de la hanche adulte non dysplasique. Cependant, la gestion clinique optimale (notamment le pronostic à long terme) des patients présentant des déformations de type came avec ou sans symptômes du syndrome du conflit fémoro-acétabulaire (CFA) avec ou sans facteur rhumatoïde reste incertaine. Dans cet examen de cas par imagerie (ECI), nous présentons le suivi sur 10 ans d'un chiropraticien à la retraite avec des déformations fémorales bilatérales de type came qui a initialement subi une arthroplastie totale de l'articulation de la hanche droite pour l'arthrose de l'articulation de la hanche avancée, et a développé par la suite une arthrose de l'articulation de la hanche avancée du côté controlatéral.

[1] Michael G. DeGroote Institute for Pain Research and Care, McMaster University
[2] Chiropractic Department, D'Youville University
[3] Private Practice, Cambridge, Ontario

Corresponding author: Peter C. Emary, 1145 Concession Road, Cambridge, Ontario, Canada, N3H 4L5
Tel: (519) 653-1470 ext. 352
E-mail: emaryp@mcmaster.ca

No funds were received for the preparation of this manuscript. Dr. Emary is supported by a postdoctoral fellowship with the Michael G. DeGroote Institute for Pain Research and Care at McMaster University, as well as research grants from the Canadian Institutes of Health Research, the NCMIC Foundation, and the Canadian Chiropractic Research Foundation outside of the submitted work. The author has no other competing interests to declare. The patient has consented to having his personal health information including radiographs published.

(JCCA. 2024;68(2):177-181)

KEY WORDS: chiropractic; cam morphology; osteoarthritis; hip joint

(JCCA. 2024; 68(2) : 177-181)

MOTS CLÉS : chiropratique; morphologie de type came; arthrose; articulation de la hanche

Case presentation

Initial presentation

A retired chiropractor (of 42 years) initially presented at age 67 with severe advanced osteoarthritis (OA) of the right hip joint associated with a cam-type deformity and femoroacetabular impingement (FAI) (Figure 1). The details of this case have been previously described.[1] The patient underwent successful total right hip joint arthroplasty and was discharged from orthopedic surgical care following two months of recovery with no complications. At the time of initial presentation, the patient's radiographs exhibited a cam-type (or 'pistol-grip') deformity[2]

Figure 1.

The initial AP pelvis demonstrates a subtle prominence on the anterolateral surface of the femoral head/neck junction and decreased head-neck offset consistent with a pistol-grip deformity indicative of a cam-type morphology. The right femoral acetabular joint reveals a complete loss of joint space with associated subchondral sclerosis, subchondral cysts, osteophyte formation, and superolateral subluxation along with flattening/deformity of the femoral head indicating severe osteoarthritis. The left hip joint exhibits only minimal degenerative changes compared with the right, including mild joint space narrowing and subchondral sclerosis, with no femoral head deformity present.

of the left proximal femur but only minimal degenerative changes involving the left hip joint (see Figure 1). Moreover, the patient's left hip joint was asymptomatic.

10-year follow-up

Six years after undergoing total right hip joint arthroplasty, the patient began to develop insidious onset left hip joint pain. He described the symptoms as a constant stiffness in the gluteal region and lateral hip, which intensified to a "hot, burning sensation" when provoked. The pain severity was graded as a 7-8 out of 10. An intermittent, "twinging" pain would also radiate to the posterior aspect of his left knee. Prolonged standing or sitting (e.g., driving for 10-15 minutes), flexing at the hip (e.g., bending over), and left side-lying (i.e., prolonged left hip joint flexion and adduction) were provocative. Pedalling on an exercise bike for two to three minutes would alleviate the pain in the left hip joint and leg; however, cycling for more than 10-15 minutes (i.e., repeated hip flexion, adduction and internal rotation) would re-aggravate the symptoms. Right antalgic leaning while walking or sitting was palliative. The patient also took over-the-counter naproxen or acetaminophen for pain relief, as needed. He did not pursue chiropractic or other conservative (e.g., physiotherapy) treatment.

The patient's left hip pain progressively worsened over the next four years, resulting in severe limitations to his daily activities (e.g., walking, lifting, bending, driving, and sleeping). Radiographs were ordered by his family physician and revealed severe advanced OA of the left hip joint associated with a cam-type deformity of the proximal femur (Figure 2). Of note, the patient had also participated in high-impact sports (e.g., competitive fast-pitch softball) throughout his childhood, adolescent and early adult years, possibly predisposing his femurs to developing cam-type morphologies. The key imaging features and etiologies of cam-type femoral deformities are listed in Table 1.

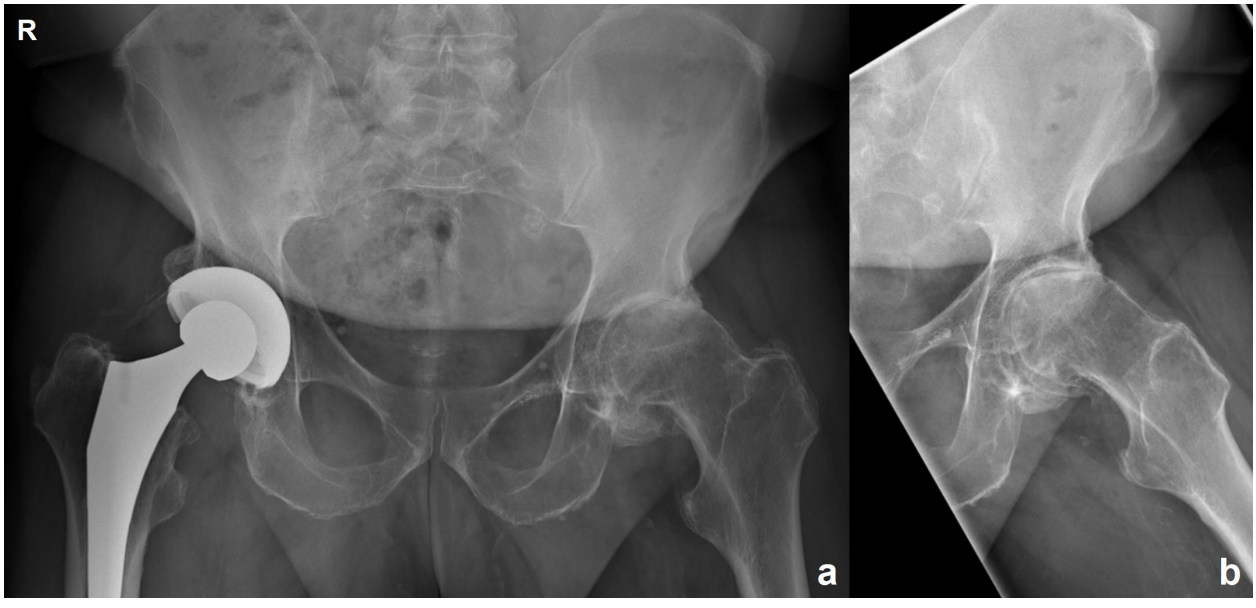

Figure 2.

The AP pelvis (a) and left frog-leg view (b) at 10-year follow-up reveals a total hip arthroplasty of the right femoral acetabular joint with no evidence of hardware failure, loosening, or infection. Additionally, there is mild post-surgical heterotopic ossification, of no clinical significance. The left femoral head/neck junction reveals persistence of the subtle prominence on the anterolateral surface and decreased head-neck offset consistent with a pistol-grip deformity indicative of cam-type morphology. The left femoral acetabular joint also demonstrates severe joint space narrowing, subchondral sclerosis, subchondral cysts, osteophyte formation, and mild flattening and deformity of the femoral head, characteristic of severe osteoarthritis.

Table 1.
Key imaging features and etiologies of cam-type femoral deformities [a]

Key imaging features
• Osseous 'bump' formation at the anterolateral femoral head-neck junction
• A pistol handle appearance to the femoral neck (i.e., 'pistol-grip' deformity) characterized by a decreased or absent femoral head-neck offset
• Alpha angle > 55°
Proposed etiologies[3,4]
• Malunion of a femoral neck fracture
• Slipped capital femoral epiphysis
• Legg-Calvé-Perthes' disease
• Genetic predisposition
• Repetitive, aggressive hip loading (e.g., high-impact sports [b])

[a] Source: adapted and modified from Emary and Taylor.[1]

[b] The patient in our case had been a pitcher in competitive fast-pitch softball throughout his childhood, adolescent and early adult years.

Discussion

Cam-type deformities of the proximal femur have long been associated with FAI, an orthopedic condition recognized in the etiology of early OA in the non-dysplastic adult hip.[2-4] Impingement between an abnormally shaped proximal femur (cam-type) or acetabulum (pincer-type), or both (i.e., 'mixed' FAI), results in repetitive microtrauma and early damage to the cartilage and labrum of the hip joint.[3,4] Originally described in young adults by Ganz *et al*.[2] in 2003, FAI has since been described in cases and observational studies involving middle aged and older adults.[5-8] Regardless of age, the clinical management (e.g., etiology, natural history, diagnostic accuracy, and efficacy of conservative versus arthroscopic or open surgical joint-preservation procedures) in patients with FAI remains uncertain.[2,3,9] The association between cam-type femoral deformities in patients with asymptomatic hip joints and the subsequent development of pain and/or OA is also controversial.[10,11]

Risk of contralateral hip joint degeneration

A 2022 cohort study of 150 patients (mean age = 30.5 years; range, 13-58) with hip joint morphologies consistent with FAI (i.e., cam or combined cam/pincer) treated with hip preservation surgery found that, after 10 years, the contralateral hip had significant symptoms in 52% of cases and 23% had progressed to surgery.[6] One-third (36/111) of patients without contralateral hip symptoms at initial presentation went on to develop significant contralateral hip symptoms within five to 11 (mean = 7.1) years.[6] A 2016 cohort study of 398 patients with a mean age of 54 ± 8 years who underwent total hip joint arthroplasty for unilateral hip OA found that 41% (95% CI, 35 to 47) developed contralateral hip symptoms and 19% (95% CI, 15 to 25) required an arthroplasty on the contralateral hip by 10-year follow-up.[7] The risk of developing OA in the contralateral hip was 86% higher (hazard ratio = 1.86; 95% CI, 1.23 to 2.79) among those with acetabular over-coverage combined with a reduced femoral head-to-neck ratio (i.e., radiographic findings consistent with 'mixed' cam/pincer FAI).[7] A 2013 cohort study found that patients aged 45-65 years with moderate to severe cam-type deformities (i.e., alpha angle > 60° to 83°) and early OA symptoms were between 3.7 and 9.7 times more likely to develop end-stage hip joint OA by five years.[8]

In our case, the patient developed progressively worsening symptoms in his originally asymptomatic contralateral hip, with resultant end-stage OA at 10-year follow-up. It is possible that altered hip biomechanics and compensatory changes, particularly during the years leading up to his right hip joint arthroplasty, contributed to early contralateral hip joint degeneration and subsequent end-stage OA development.[12] However, it is also possible that his hip joint OA was primary (idiopathic) in nature.[11] At age 77, the patient underwent successful left hip joint arthroplasty and attained full recovery within six months. For more information on the pathophysiology, diagnosis, treatment and prognosis of patients with cam-type deformities of the proximal femur with or without FAI symptoms, we refer readers to other publications.[3-11]

Acknowledgement

The author would like to thank Dr. Angelica J. Turner, DC for reviewing the radiographs, drafting the original version of the figure captions, and providing feedback on the manuscript for this imaging case review.

Key Messages

- Current literature suggests that approximately half of patients with cam-type femoral deformities and FAI symptoms will go on to develop progression of OA and significant symptoms in the contralateral hip joint within approximately five to 10 years; however, less than one in four patients will require surgery
- Older adults with severe cam-type deformities may be predisposed to faster progression to end-stage OA
- The most effective clinical management (including the long-term prognosis) of patients with cam-type deformities with or without FAI symptoms remains uncertain

References

1. Emary PC, Taylor JA. Advanced hip joint degeneration associated with femoroacetabular impingement in a retired chiropractor. J Can Chiropr Assoc. 2016;60(3): 260-262.
2. Ganz R, Parvizi J, Beck M, *et al*. Femoroacetabular impingement: a cause for osteoarthritis of the hip. Clin Orthop Relat Res. 2003;(417): 112-120.
3. Khan M, Bedi A, Fu F, *et al*. New perspectives on femoroacetabular impingement syndrome. Nat Rev Rheumatol. 2016;12(5): 303-310.
4. Trigg SD, Schroeder JD, Hulsopple C. Femoroacetabular impingement syndrome. Curr Sports Med Rep. 2020;19(9): 360-366.
5. Allen D, Beaulé PE, Ramadan O, Doucette S. Prevalence of associated deformities and hip pain in patients with cam-type femoroacetabular impingement. J Bone Joint Surg Br. 2009;91(5): 589-594.
6. Khan AZ, Abu-Amer W, Thapa S, *et al*. Factors associated with disease progression in the contralateral hip of patients with symptomatic femoroacetabular impingement: a minimum 5-year analysis. Am J Sports Med. 2022;50(12): 3174-3183.
7. Amstutz HC, Le Duff MJ. The natural history of osteoarthritis: what happens to the other hip? Clin Orthop Relat Res. 2016;474(8): 1802-1809.
8. Agricola R, Heijboer MP, Bierma-Zeinstra SM, *et al*. Cam impingement causes osteoarthritis of the hip: a nationwide prospective cohort study (CHECK). Ann Rheum Dis. 2013;72(6): 918-923.
9. Reiman MP, Goode AP, Cook CE, Hölmich P, Thorborg K. Diagnostic accuracy of clinical tests for the diagnosis of hip femoroacetabular impingement/labral tear: a systematic review with meta-analysis. Br J Sports Med. 2015;49(12): 811.
10. Hartofilakidis G, Bardakos NV, Babis GC, Georgiades G. An examination of the association between different morphotypes of femoroacetabular impingement in asymptomatic subjects and the development of osteoarthritis of the hip. J Bone Joint Surg Br. 2011;93(5): 580-586.
11. Nardo L, Parimi N, Liu F, et al; Osteoporotic Fractures in Men (MrOS) Research Group. Femoroacetabular impingement: prevalent and often asymptomatic in older men: the Osteoporotic Fractures in Men Study. Clin Orthop Relat Res. 2015;473(8): 2578-2586.
12. Watelain E, Dujardin F, Babier F, Dubois D, Allard P. Pelvic and lower limb compensatory actions of subjects in an early stage of hip osteoarthritis. Arch Phys Med Rehabil. 2001;82(12): 1705-1711.