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A systematic review of thrust manipulation combined with one conservative intervention for rotator cuff and related non-surgical shoulder conditions

Amy L Minkalis, DC, MS[1]
Robert D Vining, DC[1]
Cynthia R Long, PhD[1]
Cheryl Hawk, DC, PhD[2]
Katie de Luca, M Chiro, PhD[3]

Objective: *To determine effects of thrust manipulation plus one conservative intervention for non-surgical shoulder pain and disability due to rotator cuff dysfunction.*

Methods: *This review followed PRISMA guidelines. The databases searched were PubMed, PEDro, ICL, CINAHL, and AMED. Included were randomized trials with at least one group assigned to receive thrust manipulation and one adjunct conservative therapy. The*

Objectif : Évaluer *les effets de la manipulation avec impulsion associée à une intervention conservatrice pour traiter la douleur à l'épaule ne nécessitant pas d'intervention chirurgicale et l'incapacité causée par une pathologie de la coiffe des rotateurs.*

Méthodologie : *La présente revue a été réalisée conformément aux lignes directrices PRISMA. Les bases de données interrogées sont PubMed, PEDro, ICL, CINAHL et AMED. Sont compris dans la revue des essais avec répartition aléatoire réalisés avec au moins un groupe de sujets devant subir une manipulation avec impulsion et une thérapie conservatrice d'appoint. On a utilisé l'échelle PEDro pour évaluer la qualité de la*

[1] Palmer Center for Chiropractic Research
[2] Texas Chiropractic College
[3] Private Practice, South West Rocks, Australia

Corresponding author:
Amy L Minkalis
Palmer Center for Chiropractic Research. 741 Brady St., Davenport, IA 52803
E-mail: amy.minkalis@palmer.edu
Tel: 563-884-5199

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PEDro scale was used to assess methodological quality and GRADE for analysis.

Results: *The search yielded 2088 articles with one meeting eligibility criteria. The trial examined thrust manipulation with exercise compared to sham. Statistically significant improvements in pain and disability were reported within but not between groups. Evidence quality according to the PEDro scale was good; GRADE was moderate.*

Conclusion: *Few trials have been conducted studying thrust manipulation plus another conservative intervention for rotator cuff conditions rendering available evidence of thrust manipulation plus exercise insufficient to determine effects of this combined treatment.*

(JCCA. 2018;62(1):5-17)

KEY WORDS: chiropractic, thrust manipulation, manual therapy, rotator cuff, shoulder

méthodologie et la méthode GRADE pour analyser la littérature.

Résultats : *La recherche a permis de repérer 2 088 articles dont un satisfaisant les critères d'admissibilité. L'essai visait à comparer les effets de la manipulation avec impulsion associée à des exercices à ceux d'un traitement fictif. Des améliorations significatives sur le plan clinique de la douleur et de l'incapacité ont été signalées* à l'intérieur des groupes, mais non pas entre les *groupes. La qualité des preuves était bonne selon l'échelle PEDro; la qualité de la méthode GRADE* était moyenne.

Conclusion : *Il existe peu d'essais sur la manipulation avec impulsion associée* à une intervention *conservatrice pour traiter les pathologies de la coiffe des rotateurs; par conséquent, les données probantes sur la manipulation avec impulsion associée à des exercices sont insuffisantes pour évaluer les effets de ce traitement associatif.*

(JCCA. 2018;62(1):5-17)

MOTS-CLÉS : chiropratique, manipulation avec impulsion, coiffe des rotateurs, épaule

Introduction

Shoulder pain is a prevalent condition with a lifetime occurrence of 1 in 3 people.[1] In the U.S., patients with rotator cuff disease comprise the majority (65%) of shoulder pain-related visits to physicians[2,3], and the incidence of rotator cuff conditions is expected to increase in an aging population of active patients with a low tolerance for dysfunction or physical restrictions[3,4]. Rotator cuff conditions are typically diagnosed as tendinopathy which includes external or internal impingement, tendinitis, tendinosis with degeneration, and partial-thickness tendon tears.[5]

It is important to use and further develop non-surgical interventions for rotator cuff conditions to reduce risk and cost.[6-8] Systematic reviews have been conducted evaluating manual therapies (including manipulation) for shoulder pain and conditions such as rotator cuff disease, and several have reported a moderate level of evidence supporting effectiveness.[9-11] However, some reviews have included studies with limitations such as small randomized controlled trials without statistical differences between intervention groups or lacking the analyses or power to detect differences, and case reports and series.[12-15] Additionally, previous systematic reviews do not adequately isolate the clinical effect of single or multiple conservative interventions (defined as those without medications, injections, or surgery) for shoulder conditions. This is particularly problematic for manual therapists including doctors of chiropractic because they often use multimodal treatments, combining therapies such as manipulation, mobilization, exercise, and massage.[16,17] Without this knowledge, clinicians must ask important questions for each patient with shoulder pain such as: How many treatment interventions should be employed? What combinations of treatments are most effective? and What treatment combinations are ineffective or counterproductive? Though they generally endorse many conservative therapies, former systematic reviews don't answer these questions. Thus, clinicians must make

Table 1. *Article eligibility criteria*.

Inclusion	Exclusion
• Randomized controlled trials • Studies including human participants of any age • Studies with the following interventions: thrust manipulation plus one conservative therapy in at least one study group • Studies reporting a confirmed diagnosis of or systematic diagnostic procedures categorizing shoulder symptom(s) as a rotator cuff or related disorder	• Studies involving thrust manipulation under anesthesia • Studies including pharmaceuticals or injections included in treatment protocols • Studies lacking procedural descriptions of treatments • Studies including a single intervention • Studies including manipulation plus 2 or more conservative treatments • Studies involving participants requiring surgical evaluation or post-surgical conditions

important intervention choices for common shoulder conditions without the support of strong scientific evidence.

Recently, Minkalis *et al*. performed a systematic review of thrust manipulation as a solitary treatment for shoulder pain and related disorders.[18] The review identified only a few studies using spinal or extremity thrust manipulation alone for the treatment of shoulder impingement syndrome. Due to the paucity of evidence, the review concluded there is insufficient data to support or refute thrust manipulation as a singular intervention for shoulder pain and disability. Thrust manipulation was not significantly more effective than sham. However, patients receiving thrust manipulation consistently reported reduced pain suggesting there is a mild therapeutic benefit. Given the small therapeutic effectiveness of this individual treatment, it is reasonable to question whether combining it with another intervention can contribute to an additive or synergistic effect. Therefore, the next logical question in this line of research should ask whether adding an additional conservative therapy to thrust manipulation demonstrates greater therapeutic effect. The purpose of this systematic review is to evaluate clinical trial evidence to determine the effectiveness of thrust manipulation plus one conservative intervention for the non-surgical management of shoulder pain and/or dysfunction associated with the rotator cuff.

Methods

This systematic review was conducted and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Literature search

The electronic databases PubMed, Physiotherapy Evidence Database (PEDro), Index to Chiropractic Literature (ICL), Cumulative Index to Nursing and Allied Health Literature (CINAHL), and the Allied and Complementary Medicine Database (AMED) were searched from inception to May 2017. The search strategies were developed with a health sciences librarian and an example strategy is included in Appendix 1. References from articles that met the eligibility criteria and systematic reviews retrieved during the electronic search were hand-searched for studies potentially missed initially. The WHO International Clinical Trials Registry Platform (www.who.int/ictrp/en/) and U.S. National Institutes of Health (https://clinicaltrials.gov/) were also searched to identify unpublished trials to evaluate the presence and magnitude of publication bias. This approach is consistent with the updated method guideline for systematic reviews published by the Cochrane Back and Neck Group.[19]

Eligibility criteria

Articles published in any language in peer-reviewed journals were screened for eligibility and included based on the criteria outlined in Table 1. Thrust manipulation was defined as high-velocity low-amplitude (HVLA) or Grade V mobilization, characterized by a single thrust directed to a specific joint and often resulting in an audible cavi-

Figure 1. *Search results and screening*

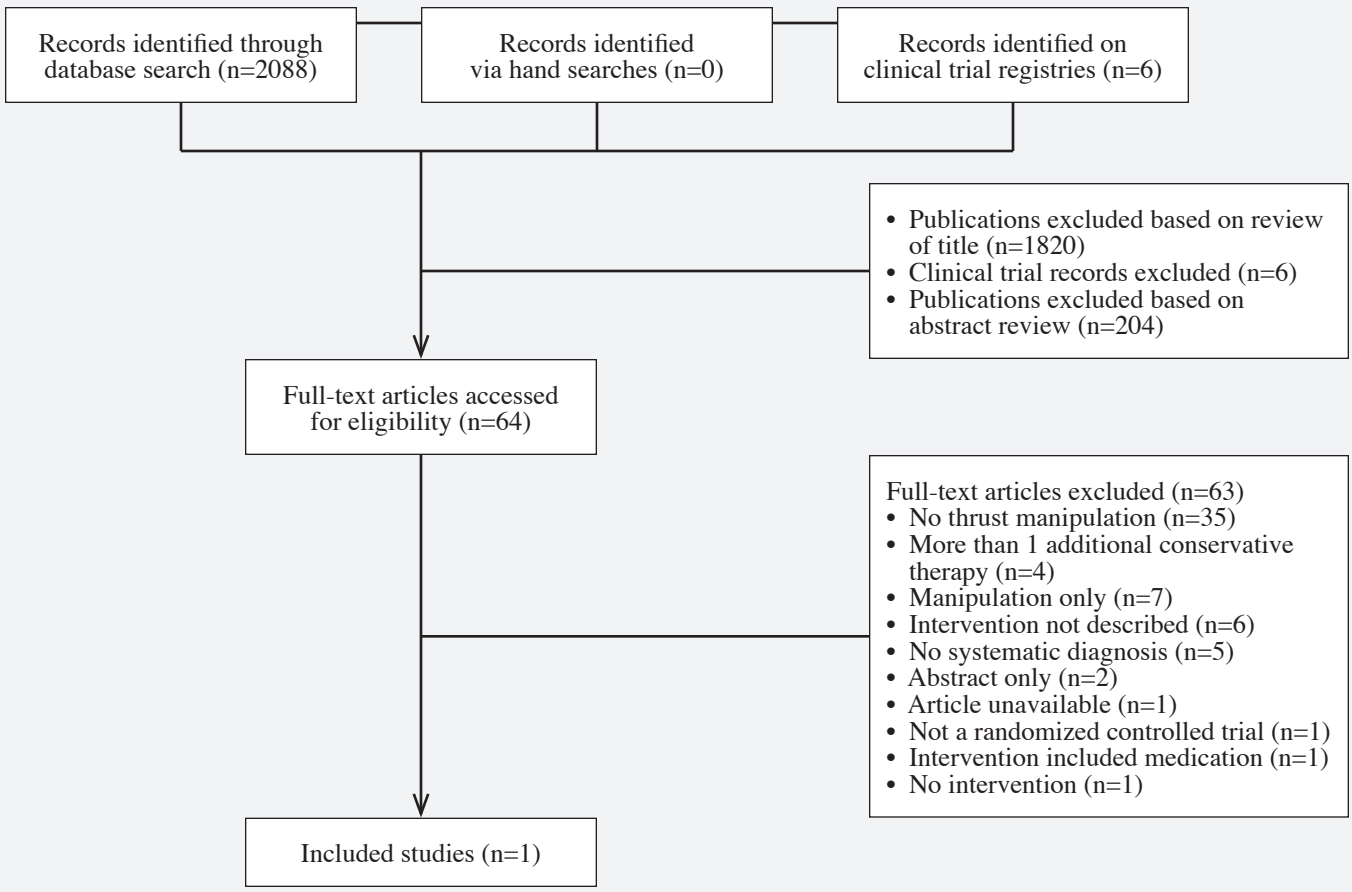

Table 2.
Characteristics of the included study for treatments for the management of rotator cuff or related disorders.

Author & Year	Participants	Diagnostic confirmation procedures	Intervention	Comparison	Treatment frequency	Data collection	Outcome Measures	Results	Conclusion
Riley et al. 2015[26]	n=88 Mean age 49, both groups Mean duration 6 mo	Shoulder pain ≥2/10 but ≤8/10; at least 1 positive Hawkins-Kennedy, Neer Impingement, painful resisted abduction, or painful resisted external rotation at 0^0 of abduction with elbows bent to 90^0	Group 1: TTM,[a] positive message and home exercise program Group 3: TTM, neutral message and home exercise program	Group 2: STM,[b] positive message and home exercise program Group 4: STM, neutral message and home exercise program	1 treatment	Pre, immediate post-treatment and 1-week follow-up	NPRS[c] (1-10) SPADI[e] (0-130)	Pre-post mean change present pain combined group*: 1.76 (0.99-2.54)**; pain with AROM[d] combined group: 1.36 (0.63-2.10)** Pre-post mean change combined group: 8.74 (6.00-11.49)**	No statistically significant differences between treatments or type of message

[a]Thoracic thrust manipulation; [b]Scapular thrust manipulation (sham); [c]Numeric Pain Rating Scale; [d]Active range of motion; [e]Shoulder Pain and Disability Index (higher score reflects more disability); *Inferential statistical analysis was done with TTM vs STM, messaging and treatment allocation as the grouping variable; **Means (95% confidence interval)

tation.[20] The manipulation could be directed to one of the shoulder joints, a cervical or thoracic spine joint, or a combination of the three. Conservative treatment was defined as manual therapy, electrotherapy, cryotherapy, heat therapy and exercise. Procedures including medication (e.g., prescriptions, over-the-counter, and injections) or surgery were ineligible.

Study selection and data extraction

Two independent reviewers (AM and KD) conducted article screening and determined eligibility. First, titles and abstracts were screened, and those that were irrelevant were excluded. Abstracts which appeared to meet review criteria were recorded and the full-text version of the article was retrieved. A final review of eligibility was performed and results were recorded in an Excel spreadsheet. Reviewers agreed on eligibility status of all but 4 articles initially; discussion between the 2 reviewers resulted in consensus.

A priori, we designated pain and function or disability outcomes as the primary outcomes of interest as these are clinically relevant and reported in most clinical trials studying conservative interventions for musculoskeletal conditions. The primary author (AM) extracted study characteristics/data from the included articles. Another author (CH) performed a secondary evaluation of the data extraction. Consensus agreement was reached through personal discussion.

Critical appraisal

The eligible study was assessed (AM) for its methodological quality using the PEDro scale. The score was consistent with the scoring for this study as listed in the PEDro database. The PEDro scale has been validated as a measure of the methodological quality of clinical trials[21] assessing internal validity and sufficient statistical information for interpretability. The tool uses an 11-point scale based on items from the Delphi list developed by Verhagen *et al*.[22] The first point pertains to external validity and is not counted toward the overall score, leaving a possible total score of 10. If the trial did not report on a particular PEDro criterion, it was scored as if the criterion was not met. Methodological quality scores are interpreted as follows: 9 to 10 is considered excellent, 6 to 8 is good, 4 to 5 is fair, and 3 or below represents poor quality.[23]

Evaluation of the strength of evidence

A quality analysis for the strength of evidence was performed on the included article by 2 reviewers (AM and KD) using the GRADE (Grades of Recommendation, Assessment, Development, and Evaluation) approach.[24] This approach represents the level of confidence one can have in the estimate of treatment effect to support a recommendation. The GRADE tool evaluates factors such as study methodology, consistency and precision of results and the directness of the treatment comparisons. After developing an overall summary of quality by considering GRADE factors, a judgment is made to assign a study with 1 of 4 possible categories: high, moderate, low and very low. Once each study has been categorized, a recommendation is generated from a reflection of all available evidence for each trial. Four elements are then considered to generate the strength of the recommendation: the magnitude of the difference between the desirable and undesirable consequences of the treatment, quality of the supporting evidence, certainty about patient values and preferences, and costs associated with compared management options.[25]

Results

Figure 1 shows the study selection process from the initial database searches to final article inclusion. A total of 2088 citations were retrieved from the literature search, of which 1820 were excluded after title screening. Abstract review excluded 204 articles. A review of the remaining 64 full-text articles resulted in identifying one clinical trial that fulfilled inclusion criteria. The 63 studies excluded and reasons for exclusion are reported in Appendix 2. The most common reason for exclusion was due to thrust manipulation being absent from the study intervention (n=35). Searching the 2 trial registry platforms resulted in 6 trials; however, published results were not available for any of these studies. Five trials' descriptions were explicit enough on the registry to determine their ineligibility. An attempt to contact the principal investigator for the 6th potentially eligible trial was made, but elicited no response. Important characteristics of the included study are shown in Table 2.

Outcomes

Riley *et al*.[26] evaluated the effectiveness of a single thrust manipulation for patients with diagnoses consistent with supraspinatus tendinosis and/or impingement. The auth-

Table 3. *PEDro scale criteria and scoring*.

	Riley *et al*. 2015[26]
Random allocation	✓
Concealed allocation	
Baseline comparability	✓
Subject blinding	
Therapist blinding	
Assessor blinding	✓
Follow-up	✓
Intention-to-treat	
Between-group analysis	✓
Point estimates and variability	✓
Total	6/10

ors measured present pain using a Numerical Pain Rating Scale (NPRS) and disability using the Shoulder Pain and Disability Index (SPADI). These measures were obtained pre-treatment, immediately post-treatment and one week post-treatment. The thrust manipulation applied to the thoracic spine was compared to a sham thrust manipulation applied to the scapula. Both interventions included a home exercise program. For both outcomes, statistically significant changes were found in all groups from baseline to short-term follow-up, but did not meet the minimum clinically important change threshold. Also, no statistically significant differences were found between the groups.

Methodological quality

The included study scored 6/10 on the PEDro instrument leading to a quality classification of 'good.' The sources of potential bias included: failure to conceal allocation, unblinded subjects and therapists, and no descriptions of an intention-to-treat analysis. Table 3 reports criteria used to score the included article and results.

GRADE

Based on the GRADE measure, the trial included in this systematic review was classified as having a 'moderate' strength of evidence. The moderate classification is based on limitations concerning the inability to calculate relative risk and absolute effects (as a result of imprecision). Also, further research is likely to have an important impact on confidence of the estimate of effect.

The strength of a recommendation for the use of thrust manipulation combined with exercise was not classified. Even though a moderate-quality rating was given, the evidence came from a single clinical trial reporting a single intervention session with no between-group differences. There was uncertainty between benefit and burden due to the lack of adverse event reporting for thrust manipulation and exercise. Although it is likely the benefits outweigh the risks for this clinical approach, the magnitude of the benefit is unknown. There is potential variability in patient's values and preferences regarding the importance and safety of exercise and thrust manipulation, and patient attitudes may change the perceived effect. Cost effectiveness of the interventions is also unknown. Patients may be willing to receive the interventions in light of uncertain benefit; however, a recommendation of any strength is not appropriate given the available evidence.

Discussion

This systematic review sought to evaluate clinical trial evidence studying thrust manipulative therapy applied to the shoulder, cervical or thoracic spine combined with one additional conservative intervention for the treatment of rotator cuff disorders.

One randomized controlled trial with a good methodological rating and a moderate quality rating met the eligibility criteria. The study included a single treatment session, which is not typical of how thrust manipulation is delivered or recommended. Because most management plans involve multiple sessions of thrust manipulation, using a single treatment session substantially limits the clinical interpretation of findings regardless of the magnitude of effect.[27,28] Additionally, scapular manipulation (labeled as a sham) was delivered as a HVLA thrust similar to the "active" treatment described in the upper to mid-thoracic spine. Thus, the sham treatment may not have differed enough from the active intervention both in its mode or anatomical region of application to be physiologically distinct. Both groups received an exercise intervention that could have been responsible for improved outcomes.[29] Previous studies suggest adding manipulation with exercise is more optimal than when the treatments are provided exclusively.[30-32]

The limitations of the included study underscore the

need for high-quality studies with well described interventions, rigorously collected safety data, and pragmatic treatment schedules to understand the clinical effects of combined conservative interventions for patients with rotator cuff disease. This systematic review identified an important knowledge gap regarding the use of combined conservative treatments for rotator cuff or associated disorders. Because this gap exists, clinicians are unable to obtain research-based guidance to inform specific treatment strategies for patients suffering from common shoulder conditions.

A possible limitation of this systematic review is that some studies may have been missed despite a guided literature search and hand searching references. Also, a grey literature search (e.g., conference abstracts or graduate projects) was not conducted. However, studies available in the grey literature are difficult to systematically assess in terms of methodology. Validated appraisal tools require details in reporting that are typically lacking in these publications. Further, based on the search of the trial registries, the overall number of trials relative to possibly unpublished material suggests there is a low risk for publication bias in this study. Another limitation is that we cannot provide conclusions regarding tolerance or safety of treatments due to the fact that no adverse events were reported in the included study.

Though there was one study included, it was of good quality according to the PEDro scale and moderate according to GRADE. Nevertheless, it had significant methodological and pragmatic limitations, which prevent the ability to interpret findings and apply them to clinical settings. Additional clinical trial data is very likely to have an important impact on the estimate of the treatment effect and future recommendations for treatment.

Conclusion

This review identified one moderate-quality clinical trial reporting the efficacy of thrust manipulation plus one conservative intervention for a rotator cuff condition (shoulder impingement). Neither the clinical effectiveness of thrust manipulation plus exercise nor the relative contribution of individual therapies could be sufficiently evaluated to warrant clinical recommendations. We propose that clinical trials be conducted to study thrust manipulation plus an additional intervention to definitively determine the effectiveness of these treatments over a series of visits as used in clinical settings. Articles presenting clinical trial results from studies involving manipulation should follow the most recent guideline on reporting[33], provide rationale for therapy use, detailed descriptions of intervention techniques, and quantitative data including both short and long-term clinical outcomes and comprehensive safety data.

Authors' contributions

AM and KD conducted the literature search as well as the screening and selection of the included articles. AM completed the data extraction as the primary reviewer and CH evaluated the extraction as secondary reviewer. AM, RV, KD and CL prepared the manuscript. RV, CL, and CH oversaw the design of the study. All authors read and approved the final manuscript.

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Appendix 1.
Search terms used for PubMed

(((((clinical trial[Publication Type]) OR random*) OR ((((single or double) near (blind* or mask*))))) OR placebo*)) AND (((((“Shoulder Impingement Syndrome”[Mesh] OR shoulder impingement syndrome)) OR (“Rotator Cuff”[Mesh] OR “rotator cuff”))) AND ((((((((((“Manipulation, Chiropractic”[Mesh] OR chiropractic manipulation)) OR (“Musculoskeletal Manipulations”[Mesh] OR (musculoskeletal manipulation))) OR (“Manipulation, Spinal”[Mesh] OR (spinal manipulation))) OR exp physical therapy techniques) OR exp rehabilitation) OR “Ultrasonography, Interventional”[Mesh]) OR ((rehabilitat* or physiotherap* or physical therap* or manual therap* or ultrasound or ultrasonograph* or TNS or TENS or shockwave or electrotherap* or mobili*))) OR mobilization) OR “Physical Therapy Modalities”[Mesh])) NOT exercise)

Appendix 2.
Articles excluded at full-text review.

Author	Reason for exclusion
Kukkonen[34]	Intervention not described
Bialoszewski[35]	No thrust manipulation
Taheriazam[36]	Intervention included NSAIDS/injections
Winters[37]	No thrust manipulation
Bennell[38]	No thrust manipulation
Holmes[39]	No thrust manipulation
Coombes[40]	Intervention not described
Rahme[41]	No thrust manipulation
Atkinson[42]	Manipulation only
Munday[43]	Manipulation only
McCreesh[44]	No thrust manipulation
Lenker[45]	No thrust manipulation
Ginn[46]	No thrust manipulation
Littlewood[47]	No thrust manipulation
Surenkok[48]	No thrust manipulation
Coronado[49]	Manipulation only
vanRensburg[50]	More than one additional conservative therapy
Knebl[51]	No thrust manipulation
Bergman[52]	No description of diagnostic procedure
Bergman[53]	No description of diagnostic procedure
Bergman[54]	No description of diagnostic procedure
Winters[55]	Manipulation only
Riley[56]	Intervention not described
Moosmayer[57]	No thrust manipulation
Eslamian[58]	No thrust manipulation
Delgado-Gil[59]	No thrust manipulation
Rhon[60]	No thrust manipulation
Kromer[61]	Intervention not described
Heredia-Rizo[62]	No thrust manipulation
Vas[63]	No thrust manipulation
Cook[64]	No thrust manipulation
Walther[65]	No thrust manipulation
Kardouni[66]	Manipulation only
Kukkonen[67]	Abstract only
Kukkonen[68]	No thrust manipulation

Author	Reason for exclusion
Millar[69]	No thrust manipulation
Garrison[70]	No thrust manipulation
Kachingwe[71]	No thrust manipulation
Conroy[72]	No thrust manipulation
Kromer[73]	No thrust manipulation
Harshbarger[74]	No thrust manipulation
Kaya[75]	No thrust manipulation
Aytar[76]	No thrust manipulation
Harris[77]	No intervention
Negahban[78]	No thrust manipulation
Dickens[79]	No thrust manipulation
Littlewood[80]	Intervention not described
Boorman[81]	No thrust manipulation
Hall[82]	Abstract only
Redman[83]	Article unavailable
Bang[84]	More than one additional conservative therapy
Vinuesa-Montoya[85]	More than one additional conservative therapy
Lirio[86]	No thrust manipulation
Apeldoorn[87]	Intervention not described
Camargo[88]	No thrust manipulation
Haik[89]	Manipulation only
Kahlenberg[90]	Not a randomized controlled trial
Pekyavas[91]	No thrust manipulation
Go[92]	No description of diagnostic procedure
Kardouni[93]	Manipulation only
Lambers[94]	No thrust manipulation
Mintken[95]	No description of diagnostic procedure
Wright[96]	More than one additional conservative therapy

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Impacting public health by affecting individual health: A focus group study with chiropractic students after an international clinical experience

James Boysen, DC, MS[1]
Stacie A. Salsbury, PhD, RN[2]
Dana J. Lawrence, DC, MMedEd, MA[3]

Purpose: *To describe chiropractic students' perceptions of their future role in public health following an international service-learning experience.*

Methods: *Four, 60-minute focus groups were held with 17 upper-level students from 1 U.S. chiropractic college after a mentored clinical experience in 4 international settings. Two investigators analyzed the transcribed focus group interviews.*

Results: *We identified 3 themes where chiropractic students emphasized the public health contributions of chiropractors, usually through one-on-one interactions with patients. The primary theme was the* ***prevention and treatment of spine and musculoskeletal conditions***

Objectif : *Décrire la façon dont les* étudiants en chiropratique *perçoivent leur futur rôle dans la santé publique suite à une expérience d'apprentissage par le service menée à l'échelle internationale.*

Méthodologie : À *la suite d'une expérience clinique encadrée dans 4* établissements reconnus à l'échelle internationale, on a tenu q*uatre séances de discussion de 60 minutes avec 17* étudiants inscrits au programme d'études supérieures d'un collège de chiropratique des É-U. *Deux investigateurs ont examiné les transcriptions des entrevues avec les groupes de discussion.*

Résultats : *Voici les trois points sur lesquels les étudiants en chiropratique ont insisté en parlant de l'apport des chiropraticiens à la santé publique, habituellement au moyen de rencontres personnalisées avec les patients. Premier point : les soins chiropratiques contribuent à la* ***prévention et le traitement des troubles de la colonne vertébrale et des affections musculosquelettiques.*** *Deuxième point : les*

[1] Naval Branch Health Clinic, Naval Air Technical Training Center, Pensacola, Florida
[2] Palmer Center for Chiropractic Research, Palmer College of Chiropractic, Davenport, IA
[3] Center for Teaching and Learning, Parker University, Dallas, TX

Corresponding author:
James Boysen
6088 Forest Green Road, Pensacola, Florida 32505
Tel: 563-212-6325
E-mail: jcbdc953@yahoo.com

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*through chiropractic care. Next, chiropractors might improve patients' **access to health services** through screenings, referrals, and monitoring acute and chronic conditions. Lastly, **patient education** could help patients manage spinal health and make lifestyle modifications.*

Conclusion: *Incorporating service learning strategies within chiropractic curriculum may increase student awareness and participation in public health activities.*

(JCCA. 2018;62(1):18-25)

KEY WORDS: chiropractic; public health; focus group; education

*chiropraticiens facilitent **l'accès aux services de santé** en faisant des dépistages, en dirigeant des patients vers des ressources appropriées et en surveillant les troubles aigus et chroniques. Enfin, le troisième point : l'**information au patient** peut l'aider à prendre en charge sa santé vertébrale et à modifier son mode de vie.*

Conclusion : *L'intégration de stratégies d'apprentissage par le service au programme d'études en chiropratique peut permettre de mieux sensibiliser l'étudiant et d'accroître sa participation à des activités de santé publique.*

(JCCA. 2018;62(1):18-25)

MOTS-CLÉS : chiropratique; santé publique; groupe de discussion; information

Introduction

Professional identity formation is the process through which a student transforms into a practitioner by the internalization of professional values, beliefs, and obligations.[1,2] Medical professionals recognize that developing an identity as a physician is as important for student growth as gaining knowledge and mastering clinical skills.[3] The formation of a professional identity within chiropractic is less well-understood, particularly as it relates to aspects of the practitioner role beyond the delivery of chiropractic techniques. One such area of professional identity formation for chiropractors is in our developing role as public health advocates.[4,5]

Public health is defined as "the science and art of promoting health, preventing disease, and prolonging life through the organized efforts of society"[6]. Doctors of chiropractic (DCs) are encouraged to engage in public health initiatives.[4,5,7] However, DCs and chiropractic students alike demonstrate a limited awareness of the public health concerns faced by patients.[8-10] While chiropractic accrediting bodies specify public health competencies[11], the impact of didactic coursework on students' attitudes toward and engagement in public health work is not well understood[12].

Derby and colleagues[13] noted that participation in an international service learning experience (SLE) contributed to the development of a professional identity as a DC for some students, but it is unclear whether such training may also influence students' perceptions of themselves as public health advocates. Our previous survey showed differences in the intention to provide counseling on public health topics between chiropractic students who did or did not participate in a SLE, but did not assess the students' development of a professional identity that includes a public health perspective.[14] The purpose of this follow-up study was to explore the perceptions of chiropractic students toward their future role in public health following participation in an international SLE.

Methods

We have described the research methods for this project elsewhere.[15] Briefly, focus group methodology allowed for multiple interviews, with participants who were knowledgeable about their personal views of the SLE, and in a time-efficient manner.[16] The collegiate Institutional Review Board approved this study (IRB Assurance # X2012-9-14-B). All participants signed a written informed consent document.

Study context

At the time of this study, chiropractic students from the 3 Palmer College of Chiropractic campuses (Davenport,

Table 1.
Focus group interview schedule.

Opening question:
Please tell us who you are, where you went and how you decided to go on Clinic Abroad.

Key questions:
1. How do you define public health?
2. As far as public health, what experiences during Clinic Abroad will help you keep people well as a chiropractor?
   a. Probing questions:
      i. Tell me about a time when you felt a patient needed to be screened for something other than a back, neck or joint problem?
      ii. Thinking about your trip, what else besides the adjustment do you feel someone needed for their health?
      iii. What experiences about Clinic Abroad will change the way you screen people for health problems?
3. It has been said that chiropractors are in a good position to improve public health. Can you describe how your trip may have altered your idea of public health?
4. How would you change Clinic Abroad to increase public health attitudes?

Ending questions:
(Summarize interactions)
Is this an accurate summary of what we talked about? Have we missed anything?

West and Florida) could enroll in an optional SLE to provide chiropractic care to underserved populations in international settings under the mentorship and supervision of volunteer faculty.[13,14] Students self-financed their trips and earned clinical credits for graduation by providing patient care. SLEs lasted 12-20 days, varied by locale, used chiropractic equipment donated by the college, and were attended by 70-100 students annually. Students in this study travelled to 4 international sites [Fiji (n=5), Vietnam (n=1), Honduras (n=4), and India (n=7)] and reported delivering chiropractic services to a mean number of 113 patients of all age categories, in settings such as hospitals, clinics, commuity buildings, and schools[15].

Participants

We recruited a purposive sample of current students who completed a SLE in June 2011 or June 2012. Eligible participants included students of all genders and ethnicities who had travelled to any SLE location and who willing to participate in an audiorecorded group interview about their experiences in the program. The study was limited to students from the Davenport campus as the face-to-face focus groups were held in person, precluding enrollment from the other campuses. The principal investigator (JCB) recruited 9th trimester students from 2 didactic courses, while 10th trimester students were recruited from among clinic interns at the academic health center. Approximately 25-30 students expressed interest in the study, with 17 students showing up to their scheduled sessions to participate. Participant demographics largely represented that of the college population with a mean age of 29.1 years, 59% male, 82% white, and 12% Hispanic.

Data collection

The focus group interview schedule is presented in Table 1. The questions were informed by our previous survey[14] and a review of the literature on SLEs in the health sciences. We sought to understand how the SLE impacted student perceptions of the role of chiropractic in public health. Questions were refined through iterative feedback from both research staff and clinical faculty who participated in mock focus groups to assess the understandability of the questions and from chiropractic students who had participated in previous service-learning trips, who reviewed the questions to assess face validity.

Data collection included standard focus group tech-

niques.[16] We conducted 4 focus groups that included 60-minute structured conversations with 4 and 5 participants per group for students from 2011 and 3 and 5 participants per group for students from 2012. Sessions were held in a private conference room between morning classes as the most convenient time and location for students. Moderators completed an informed consent process with each student which stated participation was voluntary and students could skip any question or discontinue participation at any time. Participants also completed a de-identified demographic survey.

As the students were classmates known to one another, the importance of keeping each other's responses confidential was discussed as a group before the session and verbally agreed to by all participants. The moderator (JCB) led the discussion while the assistant moderator (SAS) took notes in which participants were identified by trip location, gender and seat position, but not by name or other personal identifier. Question order was not strictly followed, such as when topics were discussed earlier in the session. Sessions were documented on 2 digital audio recorders with anonymized, verbatim transcriptions completed by a professional transcriptionist not associated with the college. Participants received no financial compensation but were offered light snacks and donated college-related gifts (cost less than $10) in appreciation of their time.

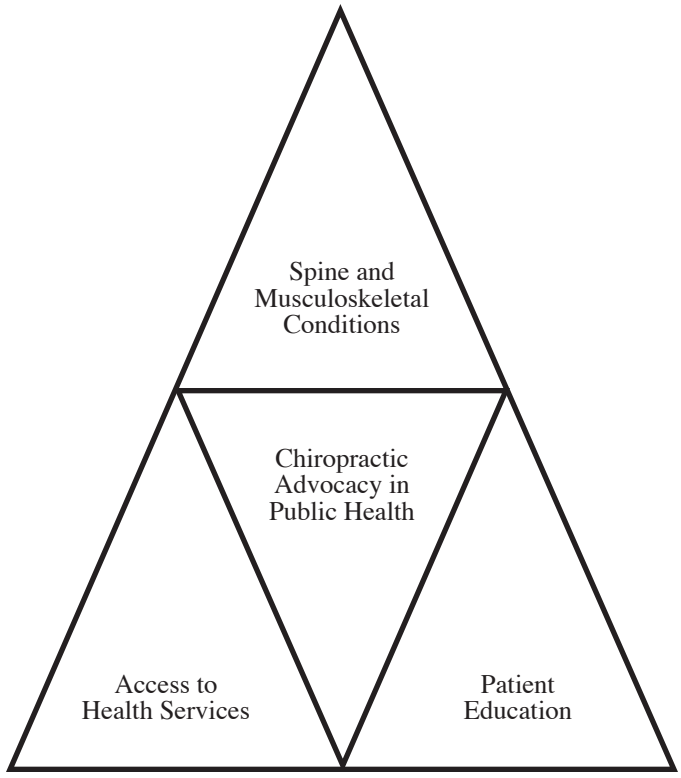

Figure 1.
Key themes in chiropractic advocacy in public health.

Data analysis

Demographic data were analyzed with descriptive statistics. We used a modified classical approach to focus group analysis.[16] The data analysts included the principal investigator (JCB), a DC who was completing this study as a practicum project for a clinical research master's degree program, and a doctorally-prepared qualitative researcher (SAS) who had extensive experience in conducting focus group studies. The data analysts independently read each transcript as electronic documents and coded key passages and representative quotes using unique text colors.[16] The lack of previous research on this topic precluded the use of an a priori coding template, so the "editing style" of qualitative data analysis was used.[17] This process involved the analysts independently highlighting passages of the participants' words that stood out as meaningful, affixing preliminary codes to those passages based on the participants' discussion, and then coming together to review jointly each coded transcript. The analysts would identify any areas of incongruity in their coding and discuss our differences until consensus was achieved.[17] Data analysis continued iteratively through each transcript, with continued consolidation of the coding framework toward a global analysis that identified the major themes presented here as findings.[16,17] Verbatim quotes are identified in the results by the gender and trip location of the participant (e.g., Male – India).

Results

Our results first describe the challenges participants had in articulating a public health advocacy role for the chiropractic profession. We identify 3 themes where chiropractic students thought DCs might best impact public health: preventing and treating spine and musculoskeletal conditions, providing access to health services, and offering patient education (see Figure 1).

Defining a public health role for chiropractic

Participants offered equivocating comments in their attempts to define public health (*I guess, I don't know,* Female – Fiji; *I don't know how to put it,* Male – Fiji; *I don't know how to describe it,* Female – Honduras). Others viewed the professions of chiropractic and public health as separate entities with differing priorities:

> *I don't really think of public health having much of anything to really do with MDs, DOs, and DCs. I think we're healthcare and it's a little bit different.* (Male – India)

However, student awareness of public health issues were raised during the SLE through direct observations of health disparities between patients in the U.S. and the host countries:

> *Public health to me includes the healthcare system, but also hygiene and sanitation, which were vastly different in the countries we were in versus America.* (Male – India)

> *I didn't expect to see kids with decaying teeth.* (Female – Fiji).

While some students stated that DCs might participate in international or community-level public health initiatives, most agreed that their primary professional contributions to public health would come from providing chiropractic care to individual patients:

> *We can affect public health by affecting individual health... Organizations have started to make large pushes in public education but, for the most part, chiropractors as individuals stand to make a difference in our immediate patient load and helping those patients to change on their health.* (Male – India)

Preventing and treating spine and musculoskeletal conditions

Participants expressed enthusiasm for the role that DCs might play in the prevention and treatment of spine and musculoskeletal conditions. Some hypothesized that the unavailability of chiropractic care in their host countries may have worsened the back conditions of these patients:

> *I just put a little click in your spine, but extrapolate that 20 years down the road, you made a big difference. You just don't necessarily get to see it. But we saw the lack thereof I think.* (Male – Honduras)

Students thought DCs could help patients prevent back problems by recommending lifestyle modifications such as proper lifting, weight management, and physical fitness:

> *Educate him on how to bend... and hopefully won't have back pain in the future...* (Female – Honduras)

In addition, chiropractors might also improve public health by addressing the chronic back conditions of their patients:

> *If we can educate and keep them well-adjusted and inspire them to good health in the earlier years so that they aren't so debilitated... We know the ramifications of just subluxations and musculoskeletal problems. If we can help them early on with good posture, good stability... all these big problems that keep them so down (later in life), (these problems) won't even exist.* (Male – Honduras)

Access to health services

Exposure to different healthcare settings during the SLE allowed students to serve patients both as a chiropractor addressing their spinal health and as an interdisciplinary team member. Students reflected that they could impact public health by providing access to general healthcare services in addition to spine care for patients with limited financial resources. The student who made the following comment had several heads nodding in agreement:

> *If this person comes in and I'm the more affordable option and I can tell them for sure, you need to go to this person, then... you're helping healthcare in general... I never really had that view.* (Male – India)

Many students recognized the public health significance of monitoring their patients' new and existing

health problems. Through the communication challenges in these international settings, many students realized they should take comprehensive health histories, in addition to spine-focused evaluations, to screen their own patients for common conditions and potential "red flags" no matter how healthy a patient might appear:

> *You had to ask questions, because you're thinking, "Okay. Do you need to refer them somewhere... because they're having chest pain?" But it ended up being GERD. So history... is very important.* (Female – Honduras)

Patient education

Students identified such activities as serving as hospital staff, providing health talks or podcasts, and joining panel discussions on health topics as ways chiropractors could contribute to the public health of their communities. However, most thought DCs could best impact public health through one-on-one consultations and patient education on individualized health topics:

> *If you spend an extra two minutes with that patient, look them in the eye, build that trust with them, then when you say, "I want you to lose ten pounds. It's going to help your back pain" I think they're going to be more willing to listen to you.* (Female – Vietnam)

The SLE sparked an interest in how patient education might occur with in community settings like the schools and fire stations where they provided care abroad. One student noted that a video playing in waiting rooms could inform patients about chiropractic care, how to prepare for an adjustment or other health topics (Male-India). Others commented that many patients had similar jobs (e.g., farming) and might benefit from group learning on occupational topics and through the use of visual aids:

> *They were taught to bend over that way (from the waist) from the field work that they did, so they didn't know any better. We had a dry spine there, and I showed them what they're doing to themselves and if they could bend at the knees, what the spine does then, and this would help. They loved it.* (Male – Fiji)

Discussion

This focus group study explored how engagement in an international SLE influenced chiropractic student perceptions on their future role as public health advocates. Previous research with chiropractic students who went on similar SLEs found an enhanced professional identity as doctors of chiropractic[13] and an expanded view of services chiropractors might provide toward disease prevention and public health[14]. The students who participated in this focus group study explored the possible contributions the chiropractic profession might make as advocates of public health. Students emphasized the practitioner role of prevention and treatment of spinal conditions of individual patients. However, insights gained through the SLE included opportunities to expand patient access to healthcare services and to offer community- or population-based educational programs to patients and other healthcare providers.

The key themes identified in this study (Figure 1) align with 3 public health initiatives of *Healthy People 2020* that are relevant to the chiropractic profession: impacting arthritis, osteoporosis and chronic back conditions; improving access to health services; and providing education and community-based programs.[18] Our findings also echo recommendations that doctors of chiropractic lead efforts to address public health through the early assessment, prevention and treatment of musculoskeletal disorders.[4,19,20] Problematically, many chiropractors are not familiar with national public health initiatives[21] which may signal a need for increased exposure to public health concepts during chiropractic education[12]. Evans and associates found that education programs to increase health promotion within a chiropractic teaching clinic are effective.[22] Our previous survey found significant differences in chiropractic students who completed a SLE with those who did not in their opinions on whether chiropractors should provide counseling services on public health topics.[14] Our current findings suggest that service learning also may at least increase student recognition of health promotion opportunities with their patients. However, research from other healthcare disciplines reveals students who are involved in public health activities during their education may or may not model this behavior after graduation.[23,24] More research is needed to understand how chiropractic education can increase public health involvement and advocacy of its future doctors.

Koh and colleagues advocated for interdisciplinary opportunities in public health, yet little is known about developing this perspective within chiropractic education.[25] Even though the chiropractic students who participated in these focus groups spoke readily about how their trip experiences gave them the opportunity to develop a scope of practice, collaborate within the local healthcare system, and provide chiropractic care with patients of all ages in varied settings, they did not identify initiating these activities outside of their future office setting unless probing questions were employed. Investigating pragmatic models of interdisciplinary collaboration in chiropractic education may prove fruitful to increase future public health involvement.

Limitations

One limitation of focus group methodology is the potential influence of the moderator and participants on the discussions.[16] The moderating team worked together to offer all participants the opportunity to speak in session, reviewed main topics with participants at the end of the sessions to assess our understanding of meaning, and achieved consensus on the main themes presented here. Recruitment was another challenge, as many potential participants were unable to attend the groups due to course schedules and clinic duties. Other chiropractic students may hold different opinions about the role of chiropractors in public health.

Conclusions

Chiropractic students involved in an international service learning experience identified 3 themes for their future engagement in public health activities:

1) preventing and treating spine and musculoskeletal conditions,
2) providing access to health services, and
3) offering patient education. Incorporating service learning strategies within chiropractic curriculum may increase student awareness and participation in public health activities.

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A comparison of the clinical manifestation and pathophysiology of myofascial pain syndrome and fibromyalgia: implications for differential diagnosis and management

Sheryl Bourgaize, BSc HHK[1]
Genevieve Newton, DC, PhD[1]
Dinesh Kumbhare, MD, MSc, FRCPC, DABPMR[2]
John Srbely, DC, PhD[1]

Two prominent forms of chronic musculoskeletal pain disorders are fibromyalgia (FM) and myofascial pain syndrome (MPS). Inconsistent diagnosis of chronic musculoskeletal pain is an important clinical issue, as MPS is often mistaken for FM. Distinction between the two diagnoses depends largely on identification of either tender points or myofascial trigger points in FM and MPS, respectively. However, there currently is no standard diagnostic protocol for MPS. Consequently, this results in a lack of consistency across health care practitioners diagnosing both FM and MPS. Therefore, developing sensitive and reliable mechanism-based diagnostic criteria is imperative

La fibromyalgie (FM) et le syndrome de douleur myofasciale (SDM) sont deux formes de douleur musculosquelettique chronique. Le SDM est souvent confondu avec la FM; un manque de cohérence dans l'établissement d'un diagnostic de douleur musculosquelettique constitue un problème clinique grave. La différence entre les deux diagnostics dépend en grande partie de l'identification des points sensibles ou des points déclencheurs de FM et du SDM, respectivement. Mais il n'existe toujours pas de protocole normalisé pour diagnostiquer le SDM, ce qui explique le manque de cohérence observé chez les professionnels de la santé qui posent des diagnostics de FM ou de SDM. Il est donc primordial d'établir des critères diagnostiques fondés sur un mécanisme cohérent et fiable pour ce qui est de la douleur musculosquelettique. La présente revue vise à examiner

[1] Department of Human Health and Nutritional Sciences, University of Guelph,
[2] Department of Medicine, University of Toronto, Toronto ON

Corresponding author:
John Srbely
Assistant Professor, Department of Human Health and Nutritional Science, University of Guelph, Guelph, ON
E-mail: jsrbely@uoguelph.ca
Tel: (519) 824-4120 x 52058

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to the field of musculoskeletal pain. The focus of this review is to discuss the common and unique features of FM and MPS in the context of their epidemiology, clinical features, and pathophysiology. This review will address inconsistency among health care practitioners' diagnoses, and present alternative diagnostic tools with potential for inclusion into a mechanism-based diagnostic protocol.

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KEY WORDS: chiropractic, myofascial pain syndrome, fibromyalgia, treatment, differential diagnosis

*les caractéristiques communes et particulières de la FM et du SDM en tenant compte de leur épid*émiologie, leurs caractéristiques c*liniques et leur physiopathologie. Dans la présente revue, nous abordons l'incohérence des diagnostics posés par des professionnels de la santé et présentons d'autres outils diagnostiques permettant l'inclusion d'un protocole fondé sur un mécanisme.*

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MOTS-CLÉS : chiropratique, syndrome de douleur myofasciale, fibromyalgie, traitement, diagnostic différentiel

Introduction

Musculoskeletal pain is an extremely prevalent clinical condition affecting up to 80% of the general population, 10-20% of which are classified as chronic.[1,2] Two of the most common forms of chronic musculoskeletal pain encountered by chiropractors in daily practice include fibromyalgia (FM) and myofascial pain syndrome (MPS). In the general United States population, the reported prevalence of FM and MPS is 6 million and 9 million, respectively.[1,3] Although the specific Canadian prevalence is unclear, it is likely to show similar prevalence to that of the United States. The prevalence of FM has been reported as high as 15% in clinical populations, while the reported prevalence of MPS in clinical populations varies widely, ranging from 9%-85%.[1,2,4-7] Clinically, FM and MPS present themselves very similarly, although there are significant differences that substantially impact their respective diagnosis and treatment. Chiropractors play an important role in primary care management of chronic musculoskeletal pain. Accurate and reliable differential diagnosis between FM and MPS is essential to ensuring optimal management and patient outcomes.

The greatest societal burden associated with chronic musculoskeletal disorders stems from chronic pain suffering.[1,2] Given its widespread prevalence, it is not surprising that chronic musculoskeletal pain is one of the leading burdens of illness in Canada, with a total financial cost (direct and indirect) of $5.8 billion CAN in 2008.[8] Similarly, the annual national economic burden of chronic pain in the United States in 2010 (healthcare expenses, lost income, lost productivity) is estimated at $560 - $635 billion USD.[9] Given the inconsistency of diagnosis[10,11], the financial burden of FM and MPS are difficult to ascertain from the current literature. Based on a 9% estimated prevalence of MPS in general internal medicine practices[1,7], the estimated contribution of MPS to the financial burden of illness in Canada is $522 million CAN and $50.4 - $57.15 billion USD in the United States. The economic burden of FM alone has been estimated at $10,000 USD per patient over 12 months (2002-2005) in the United States, resulting in an overall cost of $60 billion USD annually.[12]

The existing body of literature suggests that the diagnostic accuracy and reliability of FM and MPS is inadequate.[10,11] Although the two conditions present with some distinctive characteristics, MPS is commonly mistaken for FM.[1,13-15] Similarity in the clinical presentation between myofascial trigger points (MTrP) and tender points (TP) has been suggested as a primary reason for this.[13] Additional explanations include the lack of reliable differential diagnostic laboratory tests[14], potential co-morbidity of FM and MPS[15] and the potential for widespread MPS to present with clinical similarity to FM[1]. Previous research has reported that FM was correctly diagnosed in only 34% of patients presenting with musculoskeletal pain[10], based on the American College of Rheumatology (ACR) 1990 criteria. This poor diagnostic accuracy has been attributed to inconsistent awareness of the 1990 ACR diagnostic criteria between practitioner subspecialties.[16] While up to two-thirds of patients with musculoskeletal

pain complaints are misdiagnosed as FM[10], the proportion of those who exhibit MPS has not yet been established. Moreover, common musculoskeletal complaints such as rheumatoid arthritis and inflammatory spinal disease are also mistaken for FM.[10] This prevalence in FM misdiagnosis raises awareness of the need to consider other differential diagnoses, such as MPS, in patients presenting with chronic musculoskeletal pain.[10]

Poor diagnostic sensitivity and specificity for the differential diagnosis of FM and MPS is an important current limitation in the field of chronic musculoskeletal pain research and clinical practice. Previous research suggests that this may largely be due to inadequate insight into the similarities and differences between the pathophysiology and clinical manifestation of these two conditions.[10,11,13,17] These differences reflect the important differences in clinical management. MPS is largely a regional pain condition which is often managed using conservative interventions including manual and physical therapy, along with exercise.[5] FM, on the other hand, is a more complex condition of widespread pain which, in addition to conservative measures above, often requires a multidisciplinary approach including cognitive-behavioural and psychological interventions along with a wide-scope of potential pharmaceutical interventions that may include tricyclic antidepressants or serotonin reuptake inhibitors.[18]

The objective of this review is to address this gap by comparing and contrasting the clinical presentation and pathophysiology of FM with MPS. The PubMed database was searched using the following main key terms: 'Myofascial Pain Syndrome', 'Fibromyalgia', 'Trigger Points', and 'Tender Points'. Further terms were combined with main key terms including; 'Classification', 'Diagnosis', 'Prevalence', 'Epidemiology', and 'Clinical Decision Rule'. Several of the articles that were included use language such as 'chronic widespread' and 'chronic regional' pain as surrogates for FM and MPS, respectively. Inclusion was determined based on relevance to the primary objectives of the scoping review.

This review emphasizes the urgent need for research in the field of musculoskeletal pain to assist in the development of objective, mechanism-based criteria to properly diagnose FM and MPS. An improved understanding of the clinical and physiologic differences between FM and MPS could help to inform the development of objective diagnostic criteria to reliably distinguish these two prevalent conditions clinically. Increasing awareness of the similarities and differences between FM and MPS is a timely and important priority in the areas of musculoskeletal pain diagnosis and management, given the significant impact of misdiagnosis on unnecessary medical tests and referrals, prolonged time to diagnosis, patient frustration, poor patient outcomes, and increased burden on the health care delivery system.[9,19,20]

Comparison of myofascial pain syndrome and fibromyalgia

Pathophysiology

The etiology and pathophysiology of MPS is still poorly understood. Current prevailing consensus among practitioners is that MPS is characterized by the expression of regionally distributed muscular pain associated with the manifestation of palpable regions of hypersensitivity known as a myofascial trigger point (MTrP). According to the Integrated Hypothesis[21], MTrPs form within the motor endplate region of the muscle[5,21,22] and their pathophysiology is believed to be initiated by local injury from gross or repetitive micro-trauma[5,13]. Local injury leads to an excessive release of acetylcholine and resultant increase in motor endplate activity to mediate the manifestation of a discrete, palpable, hyperirritable locus within the peripheral muscle.[5,21,23,24] Persistent contraction leads to a cascade of biochemical responses, including the release of vasoactive components and inflammatory factors[13,21,23,24] such as bradykinin, that contribute to the expression of localized muscle pain. Concurrently, persistent peripheral nociceptive input releases substance P into the dorsal horn, leading to neuroplastic changes (increased excitability) within the central nervous system, known as central sensitization.[23,25] Alternative hypotheses suggest that neurogenic mechanisms may play an important role in mediating the pathophysiology of MTrPs and MPS, including the expression of sensitized spinal circuits[26] and sensitized motor neurons following the induction of central sensitization[27]. Recent work suggests that neurogenic inflammation, subsequent to central sensitization, could initiate and facilitate the formation of the localized hyperirritable MTrP locus in the absence of local peripheral muscle injury.[28]

The pathophysiology of FM is similarly poorly understood. In contrast to the regionally distributed pain and

Table 1.
Summary of the pathophysiology of fibromyalgia and myofascial pain syndrome.

Characteristic	Fibromyalgia	Myofascial Pain Syndrome
Initiation	• Unknown etiology[13,17,29]	• Initiated by local injury from gross or repetitive micro-trauma[5,13]
Location	• Bilateral, systemic expression of tender points[13,30,31]	• Myofascial trigger points observed at the motor end plate[21,22]
Nature of Pain	• Tender points are an expression of central neural maladaptation	• Increased spontaneous release of acetylcholine[5,23,24] • Increased vasoactive components and inflammatory factors[13,23,24]
Mechanistic Hypothesis	• Central sensitization[33,34] ○ Hyperalgesia ○ Allodynia	• Central sensitization[25,27] ○ Hyperalgesia ○ Allodynia
Symptoms Timeline	• Widespread pain for greater than three months[29,30,31]	• Persisting pain for more than three months[1,3,6,13]

palpable tender nodules associated with MPS, consensus amongst clinicians is that the diagnosis of FM is predicated on the presence of widespread pain greater than three months[29-32] with the expression of symmetrically distributed tender points (TPs) within muscle[13]. Although the etiology of FM is still poorly understood[13,17,29], it is believed that maladaptive central processing[13] may be an important underlying mechanism driving the clinical features of FM. This is supported by the commonly reported expression of generalized muscle soreness[13] and symmetrically arranged tender points in FM sufferers[13,30,31]. Consistent with this theory, it is believed that TPs reside within regions of secondary hyperalgesia[33,34], as increases in the levels of synaptic modulators, such as substance P, have been observed in cerebrospinal fluid samples[35,36]. A potentially key determinant in the differential diagnosis of FM and MPS might include the fact that TPs do not typically express inflammatory factors[13], whereas changes in the biochemical milieu of MTrP regions have been previously reported in MPS[23].

Epidemiology

Prevalence

Both MPS and FM are highly prevalent conditions of chronic musculoskeletal pain, demonstrating broad distribution across populations (Table 2). The prevalence of MPS in chronic pain clinics has been estimated to be as high as 90%[2,5], and 30% of pain-related visits to general internal medicine and orthopedic clinics have been reported to meet the diagnostic criteria for MPS[5]. MPS represents one of the most common reasons for patients to visit a clinic[7] as it affects more than 9 million Americans[1,3]. FM is also highly prevalent in the general population of the United States, presenting in approximately 2% of the general population[1,3] and 15% of hospitalizations in internal medicine[4].

Gender

The reported gender distribution of FM and MPS is similar between men and women (Table 2); however, significant gender differences exist in the development and maintenance of these conditions. It was originally believed that females were more commonly affected by FM than males[1]; however, recent data challenges this belief[29]. While data collected from a Swedish cross-sectional survey determined a two-fold higher prevalence of chronic widespread pain (FM) in women (15.3%) compared to men (7.5%)[37], more recent observations from a survey of the general population in Germany found that FM was not statistically more common in women than men (2.4% versus 1.8%)[29]. As explanation, it was suggested that previously reported gender differences for FM may be attributed primarily to behavioural differ-

Table 2.
Summary of the epidemiology discussed for fibromyalgia and myofascial pain syndrome.

Characteristic	Fibromyalgia	Myofascial Pain Syndrome
Prevalence	• 6 million Americans[1,3] • 15% of hospitalizations in internal medicine[4]	• 9 million Americans[1,3] • 30% of pain-related visits to general internal medicine[5]
Financial Burden	• Contributes approximately $60 billion USD annually in the United States	• Contributes approximately $50.4 – $57.15 billion USD in the United States
Gender	• Similar prevalence between men and women[29]	• Similar prevalence between men and women[37]
Age	• Positively correlated with age • Peak prevalence observed in the 50-74 year age range[41]	• Positively correlated with age • Peak prevalence observed in the 59-74 year age range[37]
Ethnicity	• Not specific to one geographical location	• Not specific to one geographical location

ences between males and females.[29] Women demonstrate health seeking behaviours more frequently than men, a factor that may partially explain the reported 90% female dominance in FM seen in clinics.[29] Moreover, self-report surveys based on the ACR 2010 criteria showed that although men and women report similar widespread pain index (WPI), significant increases in symptom severity score (SS) exist in females versus males.[29,38] One suggested explanation for this observation is that males with FM have lower health awareness[1,29,38] and are socialized to suppress outward signs of pain[38]. In contrast, females with FM exhibit greater pain sensitivity, greater impact on daily life, more frequent work absenteeism and lower quality of life.[1,29,38] The increased pain sensitivity in females is thought to reflect a number of factors including higher levels of trait and state anxiety, increased prevalence of depression, use of maladaptive coping strategies, and increased behavioural activity in response to pain.[38] In comparison to FM, while MPS distribution is balanced between genders, females report greater disease severity over males. A Swedish cross-sectional survey showed that no significant differences exist in the prevalence of chronic regional pain (MPS) between men (23.8%) and women (24.1%).[37] Despite this similarity, females tend to report greater disease severity as measured through higher pain scores, reduced pain thresholds and more frequent work absenteeism.[2,39] Rollman and Lautenbacher[39] noted that women also report greater pain severity, characterized by a greater number of regions affected by pain[37,39]. Rollman and Lautenbacher[39] also postulated that these differences may reflect an underlying gender-dependent state of enhanced sensitivity to deep tissue pain, predisposing women to the development and maintenance of chronic regional musculoskeletal pain such as MPS.

Therefore, recent data suggest that FM and MPS affect men and women equally, although, females with either musculoskeletal condition exhibit greater pain sensitivity, more interference with regular activities, and lower quality of life. Women are more limited by musculoskeletal pain with increased pain scores and more frequent absences from work and other commitments.[1,29] These collective findings suggest that despite the lack of gender effect on the prevalence of MPS and FM, significant gender-differences likely exist in the development and maintenance of chronic musculoskeletal pain due to social and behavioural factors.[1,29,38,39]

Age

Current research suggests that chronic musculoskeletal pain is strongly influenced by age. The number of cases of MPS and FM is positively correlated with age, with the highest prevalence most frequently seen in adults over the age of 60 (Table 2).[29,37] Bergman *et al*.[37] studied a target population of 20-74 years and reported a strong association between the incidence of chronic regional pain (MPS) with age, with the highest occurrence be-

Table 3.
Summary of the clinical presentation of fibromyalgia and myofascial pain syndrome.

Characteristics	Fibromyalgia	Myofascial Pain Syndrome
Distribution	• Widespread muscle pain[29,30]	• Regional muscle pain[1]
Palpatory Findings	• Tender points[1,13,29,30,31] • Discrete areas of soft tissue that are painful in response to 4kg of palpatory pressure[1,13,46]	• Myofascial trigger points[1,5,13,46] • Palpable taut band of muscle containing hyperirritable nodules[21,22]
Associated Observations	• Indistinguishable from normal tissue[13]	• Weakness without atrophy[21,22] • Reduced range of motion[21,22] • Local twitch response [21,22]
Secondary Symptoms	• Fatigue[13,32] • Cognitive dysfunction[13,32] • Depression[13,32] • Headache[13,32] • Numbness[13,32]	• Diaphoresis[5] • Lactrimation[5] • Flushing[5] • Pilomotor activity[5] • Temperature changes[5]

tween 59–74 years. Although FM can occur at any age for either gender, it is typically considered a disorder of women between the ages of 20-50 years of age.[38,40] A recent general population survey in Germany confirmed the strong association between FM and age, with peak prevalence in women reported between 60-70 years.[29] Less is known about the prevalence of MPS and FM among adolescents and children.[41] Gran[41] summarized the evidence relating to population studies from 1991-2001 across several age groups, reporting a peak prevalence of chronic widespread musculoskeletal pain (FM) among those in the 50-74 year age group, highlighting the distinct lack of data in the prevalence and incidence of widespread pain complaints among children and adolescents. However, previous research has reported that young athletes subjected to training overload can experience symptomatic presentation similar to FM.[42]

The aging societal demographic[43] is setting the stage for chronic musculoskeletal pain to be one of healthcare's greatest challenges in the future. Additionally, further research is urgently needed in young and adolescent populations to inform our understanding of the emergence and pathophysiology of these two conditions.

Ethnicity

The body of literature on the relationship between ethnicity and chronic musculoskeletal pain is limited and equivocal (Table 2). Research has shown that ethnic background is an important confounder for the prevalence of FM in Europe but not the US. A Swedish cross-sectional survey by Bergman *et al*.[37] reported significant increases in the prevalence of chronic widespread pain (FM) in immigrant European women (20%) compared to native Swedes (10.2%). These authors also reported higher rates of sick leave and disability pension payouts in Sweden among immigrants from southern Europe when compared to native Swedes.[37] Felson *et al*.[44] found similar findings, with an increased prevalence of widespread pain (FM) in both American and European women, in comparison to Chinese women. In contrast, however, Gansky and Plesh[45] did not report any significant differences in the prevalence of FM (using the ACR 1990 criteria) within 21-29 year old African-American women when compared to Caucasian women (3% vs 2%). Despite this similarity, increased subjective pain and tenderness were reported in Caucasian women when compared with African-American women, who tend to internalize pain more.[45] In contrast to their own findings with chronic widespread pain (FM), Bergman *et al*.[37] did not observe differences in regional pain (MPS) prevalence between immigrants (23.3%) and native Swedes (23.9%). Gansky and Plesh[45], however, did report contrasting findings by demonstrating a significant effect of race on chronic regional pain (MPS) between African-American and Caucasian women.

While the limited research in this area remains equivocal, it does suggest that chronic widespread pain (FM)

Table 4.
The 1990 Criteria for the diagnosis of Fibromyalgia (adapted from Wolfe et al.[30]).

Criteria	Definition
History of Widespread pain for at least 3 months	1. Pain is on both sides of the body 2. Pain is above and below the waist 3. Axial skeletal pain is present (neck, chest, thoracic or low back)
Pain in 11 of 18 tender points on palpation	Pain upon palpation of approximately 4 kg of pressure in 11 of the 18 following points: 1. Occiput: at the suboccipital muscle insertion. 2. Low cervical: at the anterior aspects of the intertransverse spaces C5-C7. 3. Trapezius: at the midpoint of the upper border. 4. Supraspinatus: above the spine of the scapula near the medial border. 5. Second Rib: upper lateral aspects of the 2nd costochondral junction. 6. Lateral Epicondyle of the Humerus: 2cm distal to the epicondyles. 7. Gluteal: upper quadrant of buttocks in anterior fold of muscle. 8. Greater Trochanter: posterior to the trochanteric prominence. 9. Knee: at the medial fat pad proximal to the joint line.

and chronic regionalized pain (MPS) may be related to ethnicity, however, the strength of this association is still unclear.

Clinical presentation

MPS and FM differ primarily in the anatomic distribution and clinical characteristics of muscle pain (Table 3). MPS typically manifests as regional muscle pain[1] associated with abnormalities in both motor and sensory function. It is characterized clinically by the presence of a palpable taut band of muscle containing localized, hyperirritable nodules known as a MTrP.[1,5,13,46] Muscles expressing MTrPs also exhibit altered function in the form of weakness without atrophy and loss of range of motion.[13] A local twitch response (LTR) is also often observed in association with MTrPs, identified as a rapid and transient twitch of the taut band, but not the entire muscle[1], subsequent to dynamic physical stimulus (plucking) or intramuscular needle insertion[1,23]. Although some consider the LTR a confirmatory diagnostic sign of a MTrP[1,13,23], others consider it to be less reliable, adding to the diagnostic confusion[13,17,24,47]. In comparison, FM is a syndrome defined by chronic widespread musculoskeletal pain and the presence of palpable TP.[1,13,29-31] TPs are defined as discrete areas of soft tissue that are painful to less than four kg of palpatory pressure[1,13,46]; however, in contrast to MTrPs, they do not present as overt palpable, nodular structures within the muscle[13]. Other than their discrete tenderness, TPs are indistinguishable from the normal surrounding tissue.[13] Therefore, an important clinical distinction between MPS and FM is the palpatory findings in involved muscles, with MPS presenting with MTrPs and FM presenting with localized TPs.

Another important clinical distinction between FM and MPS is the presence of unique and secondary findings commonly observed in the clinical manifestation of FM including sleep disorders, irritable bowel syndrome, nervous bladder, fatigue, cognitive dysfunction, anxiety, depression, headaches, temporomandibular joint disorders, numbness, tingling, and Raynaud's phenomenon.[13,31,32] These findings are important contributors to the significantly decreased quality of life often reported by FM sufferers[13,29-32], when compared with MPS. Although less commonly, MPS patients have also reported autonomic dysfunction including diaphoresis, lacrimation, flushing, dermatographia, pilomotor activity, and temperature changes[5], which adds to the uncertainty surrounding the sensitivity and specificity of differential diagnosis of FM versus MPS.

Diagnosis of fibromyalgia and myofascial pain syndrome

Current diagnostic criteria for fibromyalgia

The diagnosis of FM is currently based on the ACR 1990 and 2010/2011 diagnostic criteria. The first set of criteria was initially developed by Wolfe *et al.*[30] in 1990, and included the implementation of both clinical history and physical examination (Table 4). These criteria include a

Table 5.
The 2010 Criteria for the diagnosis of Fibromyalgia (adapted from Wolfe et al.[31]).

Criteria	Definition
Scores	1. WPI ≥ 7/19 and SS score ≥ 5/12 or 2. WPI is 3–6/19 and the SS ≥ 9/12 or 3. PSD ≥13 (combined WPI and SS score)
Duration	Symptoms persisting for more than 3 months duration
Differential Diagnosis	Patient does not have a disorder that would otherwise explain the pain (hypothyroidism, rheumatoid arthritis, other autoimmune disorders)

history of widespread pain lasting at least three months along with the clinical presence of palpable tender points in at least 11 out of 18 standardized bilateral tender points.[30] Widespread pain is defined as bilateral pain, above and below the waist, with or without axial skeletal pain.[30] The sensitivity and specificity of the 1990 ACR criteria was reported as 88.4% and 81.1%, respectively.[30] A significant limitation to this conclusion, however, is that these criteria were tested against FM patients previously diagnosed by "usual method of diagnosis" from investigators at 16 medical centers throughout North America. Participating investigators underwent physical examination training prior to study recruitment but no details in the training or diagnostic criteria were provided.

Over the next two decades, it became apparent that the 1990 criteria were inadequate for the diagnosis of FM. In particular, the physical examination requiring the identification of at least 11 of 18 TPs was arbitrary and did not address the complete clinical presentation of FM patients.[48] Even when the physical examination was performed, it was often incorrectly implemented, especially by non-specialists, and there was poor inter-examiner reliability for the identification of the TP locus.[46,48] For instance, results reported by Tunks *et al*.[46] found the inter-examiner and intra-examiner reliability of physical examination for tenderness was not a reliable method to accurately distinguish MPS patients from FM patients. Furthermore, these criteria could not be used for epidemiological studies given the need for physical examination.[49-51] For this reason, Wolfe *et al*.[31] proposed a new set of diagnostic criteria in 2010 which removed the requirement for TP identification via physical examination (Table 5). The 2010 self-report criteria were not designed to replace the 1990 criteria, but instead to provide an alternative for those practitioners who do not perform a physical examination.[31] This set of diagnostic criteria additionally consisted of a SS scale and a WPI.[31] The SS was aimed at addressing the pain and secondary symptoms presenting with FM, including fatigue and cognitive dysfunction, while the WPI employs a questionnaire and body diagram for patients to record the pattern of pain, including local pain at any of the 19 sites associated with FM.[6] A combined WPI and SS score ≥13, known as the Polysymptomatic Distress scale (PSD), is considered threshold for the diagnosis of FM. While these criteria require physician assessment, modified criteria were adopted in 2011 to create a patient self-report version that could be applied experimentally, without the need for practitioner intervention.[32] The reliability of these criteria was reported to be very high, with a sensitivity of 96.6% and specificity of 91.8%[31], and patients previously diagnosed by a physician according to the 1990 criteria[30] were accurately diagnosed with FM 93% of the time using the combined WPI and SS scores[31].

Several additional studies have investigated the sensitivity and specificity of the 2010 criteria. A pervasive limitation to interpreting these data is the fact that the sensitivity and specificity are determined using the gold standard, FM cases diagnosed a priori using 1990 criteria and/or expert clinical assessment, the details of which are often unreported. Ferrari *et al*.[40] reported high sensitivity and specificity of 90.2% and 89.5%, respectively, when applied to 451 subjects diagnosed a priori using a rheumatologist's clinical assessment as the gold standard;

however, the diagnostic criteria employed were not provided. Carrillo-del-la-Pena[52] and Segura-Jimenez[53] also employed FM cohorts diagnosed a priori by rheumatologists, without providing specific details on the diagnostic criteria employed. Other studies have shown contrasting results, however, reporting poor sensitivity (64%)[54] and specificity (67%)[55] when using the 2010 criteria against a priori FM patients diagnosed with the 1990 ACR criteria.

Prevalence studies using the different ACR diagnostic criteria (1990, 2010, 2011), and even within the same criteria, have demonstrated highly variable results. Jones *et al*.[56], reported significant (4-fold) differences in the prevalence of FM between the different criteria, with higher prevalence reported using the modified 2010 criteria, along with differences in sex ratios and rheumatologic comorbidities. Only 12.5% of participants met the criteria for all three sets.[56] Similarly, Vincent *et al*.[57] studied 830 people using the 2010 criteria and determined a prevalence of FM of 6.4% in the general population of Minnesota (USA), while a second study[29] reported a 2.6% prevalence in the general population of Germany; a third study[56] investigating the prevalence of FM in a Scottish general population reported a prevalence of 5.4%. Reasons for this variability may be due to bias from variable response rates, misclassification, or variability in the actual prevalence of FM within sample populations. Additionally, Wolfe *et al*.[58] reported that the 2010/2011 criteria are not used effectively on patients with asymmetrical or regional pain who do not satisfy a widespread pain criterion. Clearly, further research is needed in this area. A recent 2016 revision[58] to the 2010/2011 criteria was proposed which aims to mitigate the misclassification of regional pain disorders. The 2016 revisions emphasize the chronic widespread pain aspect of FM, which is required for diagnosis.[58,59] These revisions continue to employ the WPI and SS scales, with the added criterion stipulating the presence of pain for at least three months in at least four of five anatomic regions (left and right upper extremity, left and right lower extremity, and axial). Jaw, chest, and abdominal pain are no longer included as a component of the generalized pain presentation when applying these criteria.[59]

Canadian diagnostic criteria pertaining to FM have also been established. Fitzcharles *et al*.[14] put forth the 2012 Canadian Guidelines for the diagnosis and management of FM, which consists of five domains: clinical evaluation, testing and confirming the diagnosis, differential diagnosis and coexisting conditions, the health care team, and education. This set of criteria makes reference to the ACR 1990 and 2010 diagnostic criteria, however the Canadian guidelines are focused on clinical application rather than being utilized for research purposes. These guidelines emphasize that the diagnosis of FM should be made in the primary care setting, and strongly suggest that examination of tender points should not be used to either confirm or validate a diagnosis of FM, such that the TP examination is too subjective of a technique. However, most of the development of the Canadian guidelines stems from clinical experience, expert opinion, and consensus among the health care professionals who contributed to the guidelines. Evidence to support these guidelines is sparse and highly variable, therefore it is suggested that these guidelines merely be used as a template for diagnosing FM.

Although FM diagnostic criteria appear to be well established in the literature, there are limitations attributed to each subset of criteria. For example, study design limitations are present when testing the 1990 criteria sensitivity and specificity; the 1990 criteria is based on an arbitrary physical examination; the 2010/2011 criteria was tested against the gold standard, FM cases diagnosed a priori using 1990 criteria; prevalence studies have demonstrated highly variable results among all subsets of criteria; and many aspects of the Canadian guidelines are not strongly supported. For these reasons, further research is required to validate the existing FM diagnostic criteria, thus allowing for a clearer distinction between FM and MPS diagnoses.

Current Diagnostic Criteria for Myofascial Pain Syndrome

Travell and Simons' landmark publication, the "Trigger Point Manual"[21,22], proposed the original set of diagnostic criteria for MPS which included essential features of point tenderness within a palpable taut band of muscle, LTR, referred pain, weakness without atrophy, autonomic symptoms and restricted range of motion (Table 6). At the core of this diagnosis is confirmation of the presence of a MTrP, a palpable, hyperirritable nodule within the target muscle. Despite these clearly defined signs and symptoms, there is still no uniformly accepted diagnostic protocol for MPS, and the reliability of the current pro-

Table 6.
MPS diagnostic material according to Travell and Simons Trigger Point Manual (adapted from Travell and Simons[21,22]).

Criteria	Definition
Major Criteria	1. Regional pain complaint 2. Pain pattern follows a known distribution of muscular referred pain 3. Palpable taut band 4. Focal tenderness at one point or nodule within taut band 5. Restricted range of motion or slight muscle weakness
Minor Criteria	1. Manual pressure on MTrP nodule reproduces chief pain complaint 2. Snapping palpation of the taut band at the MTrP elicits a local twitch response 3. Pain is diminished or eliminated by muscular treatment

posed diagnostic criteria for MPS is still largely based on clinical judgement.[60,61]

In an attempt to address this controversy, Lucas *et al*.[60] published a systematic review in 2009 on the reliability of the various physical examination diagnostic criteria for MTrPs. A total of nine studies were included in this review, despite none of the studies satisfying all inclusion criteria and the presence of significant limitations in study design, blinding, reporting, statistical integrity and clinical applicability. Only one study reported interrater agreement on the presence of a MTrP (κ=0.66-0.95)[62] and two studies reported location agreement of less than 21%[63,64]. Of these studies, none reported the interrater reliability of identifying the location of a MTrP in symptomatic muscle; however, good reliability estimates were noted for individual diagnostic signs including local tenderness (κ=0.22 to 1.0) and pain recognition (κ=0.57 to 1.0). In contrast, lower reliability estimates were observed for referred pain (κ= -0.13 to 0.84), taut band (κ= -0.08 to 0.75), jump sign (κ=0.07 and 0.71), and LTR (κ= -0.05 to 0.57). These collective results suggest that the reliability was greater for the subjective signs of tenderness, and pain recognition; counter intuitively, reliability estimates for objective signs of a taut band and twitch response were lower. Although some components of the physical exam appear to be better diagnostic indicators than others, their detection in isolation is inadequate for diagnosis of MTrPs. At present, physical examination is not adequately reliable for diagnosing MTrPs in MPS.

An important consideration in the interpretation of the findings of Lucas *et al*.[60] is that in two of these studies[62(A&B)], the examiners participated in pre-study training sessions in order to enhance reliability of MTrP identification. Only three studies[65,66,67] used standard representative examiners, and this was considered a limitation as it does not reflect the reality of daily practice. Given that practicing clinicians do not typically receive specialized training in the identification of MTrPs, the results of these studies should be interpreted with caution as they likely overestimate the reliability of diagnosis by representing the upper limits of expertise.[6]

In 2015, Rivers *et al*.[6] conducted an international study of 214 pain specialists to explore the consensus on the clinical features and presentation of MPS. The majority of practitioners (76%) agreed that MPS is distinct from other conditions of chronic musculoskeletal pain, with an estimated prevalence of 31.6%. The consensus amongst these clinicians was that a tender spot, with or without pain referral (72%), and pain recognition (58%) are essential diagnostic criteria for the identification of MTrP in MPS. However, commonly adopted criteria including palpable taut band (36%), palpable nodule (34%), and/or referred pain (35%) were not considered essential for the diagnosis of MPS. Confirmation of the diagnosis should include a combination of any three of the following signs: muscle stiffness/spasm, limited range of motion, symptoms that are aggravated with stress, and/or a palpable taut band/nodule. In addition, they emphasized that the diagnosis of MPS should be contingent upon the presence of pain for greater than three months, and that both local and broader regional pain expression may be present. However, a significant limitation to this study is that, despite

Table 7.
Summary of the diagnosis of fibromyalgia and myofascial pain syndrome.

Criteria	Fibromyalgia	Myofascial Pain Syndrome
Diagnostic Criteria	• American College of Rheumatology 1990 and 2010/2011 Diagnostic Criteria proposed by Wolfe *et al*.[30,31,32] • The 2012 Canadian Guidelines for the diagnosis and management of fibromyalgia syndrome developed by Fitzcharles *et al*.[14]	• "The Trigger Point Manual" by Travell and Simons[21,22]
Challenges in Proper Diagnosis	• Differentiating between TP and MTrP is challenging[6,46,60] • No agreement on the essential criteria for MTrP diagnosis in MPS ○ Poor reliability in detection of taut band[3,6,13,24,46,60,61,68] ○ Agreement on 'tender spot and recognizable pain stimulation' as criteria between pain specialists overlaps with the features of FM[6] • MPS has the potential to become widespread, mimicking the appearance of FM[1,3,13]	

its international scope, it selectively canvassed pain specialists predominantly comprised of anesthesiologists and physiatrists (75%) from the United States. Furthermore, this survey contained only published criteria; accordingly, the responses may be largely biased by awareness of the published material and may not reflect clinically relevant observation.

The current research in the area of MPS diagnostics is sparse and highly variable[46,47,61,68,69], with significant limitations in design that preclude unequivocal conclusions on the diagnostic reliability of physical examination. Two recommended criteria include local tenderness and pain reproduction, while in contrast, taut band and LTR responses show poor clinical reliability.[61,68,70] For this reason, the evidence supporting the diagnosis and treatment of MTrPs is insufficient[60], and therefore, physical examination alone should not be used in the diagnostic workup of the chronic musculoskeletal pain patient.

Challenges in the Differential Diagnosis of Myofascial Pain Syndrome and Fibromyalgia

Despite the acknowledgement and clinical application of a spectrum of diagnostic criteria for FM and MPS in the literature, a validated gold-standard set of differential criteria has yet to be established.[6,60,71] For this reason, clinically differentiating between FM and MPS is challenging. The clinical distinction between these two conditions is presently determined by careful clinical history or physical examination, or a combination of both (Table 7). In the case of physical examination, the clinician aims to identify a discrete hyperirritable locus within the muscle, a key feature used to distinguish the MTrP from the TP. Despite the fact that distinguishing between the MTrP and TP is a primary diagnostic consideration in the differential diagnosis of MPS from FM (1990 ACR criteria)[30], clinically differentiating between the two points is challenging[6,60]. A key distinguishing feature is the presence of a palpable taut band with a MTrP, but not TP; however, previous research has shown that a taut band is not viewed as an essential criterion for the diagnosis of MPS[6]; as well, there is poor inter-examiner reliability in its manual detection[3,6,13,24,46,60,61,68]. Additional challenges in the differential diagnosis of MPS from FM include the fact that the localized tender point and associated pain are non-discriminatory, being common to a broader profile of clinical conditions associated with chronic musculoskeletal pain. Adding further to the diagnostic difficulty is the fact that MPS, although largely considered a regional pain phenomenon, has the potential to become widespread, in addition to persisting for more than three months as is commonly observed with FM.[1,3,13,29] Furthermore, while some research groups and clinicians believe that FM and MPS are two very distinct and separate conditions[6,72], there is speculation that FM and MPS may occur concurrently[6,73]. Debate regarding MPS and FM coexistence promotes further confusion in distinguishing between the

Table 8.
Summary of potential novel diagnostic tools.

Diagnostic Tool	Fibromyalgia	Myofascial Pain Syndrome
Biomarkers	• Similar inflammatory factors are not typically observed at the TP site in FM patients[13]	• Altered biochemical milieu of inflammatory factors at active MTrP sites[13] • Increased proton concentrations (lower pH), substance P, bradykinin, serotonin, calcitonin gene-related peptide, and Interleukin 1β[23]
Ultrasound Imaging	• TPs do not express changes in local muscle stiffness, and do not have similar echotextural characteristics to MTrPs	• Elliptically shaped, hypoechoic regions within the muscle corresponded to focal areas of reduced vibration amplitudes[76]
Magnetic Resonance Elastrography	• Tissues without altered mechanical properties are expressed as planar wave fronts[3]	• Taut bands in muscle uniquely present as a chevron pattern at higher wave velocities within the central band[3]
Electromyography	• TPs do not present as a local contracture, and therefore do not exhibit the same spontaneous electrical activity as MTrPs	• MTrP regions exhibit enhanced spontaneous electrical activity at the motor endplate region in the absence of voluntary muscular contraction[77]

two conditions, as well as an ongoing controversy over the nature of a MTrP.[72,74,75]

These combined factors collectively limit the reliability of using physical examination alone to differentiating MPS from FM (Table 7). Recent advancements in the ACR criteria for FM (2010)[31] have aimed to address this issue by eliminating the requirement for physical examination. Furthermore, an urgent need exists to identify and advance novel, objective diagnostic criteria that can be reliably used to in the differential diagnosis of chronic musculoskeletal pain.

Potential Novel Diagnostic Tools

Emerging research has identified several objective diagnostic tools with potential to provide enhanced reliability in the diagnosis of FM and MPS. Although this is not a complete review of available diagnostic tools this section provides an overall sense of the biomarkers and imaging techniques that are currently being developed in the field of musculoskeletal pain (Table 8). For instance, biomarkers may be used as objective indicators of normal and/or pathologic biological processes. Previous research has demonstrated an altered biochemical milieu of inflammatory factors at active MTrP sites of MPS patients.[13] These factors, which include increased proton concentrations (lower pH), substance P, bradykinin, serotonin, calcitonin gene-related peptide, and Interleukin 1β[23], are not typically observed at the TP site in FM patients[13], which suggests that these inflammatory biomarkers could play an important role in the objective differential assessment of the chronic musculoskeletal pain patient. Ultrasound imaging is another tool with significant potential for use in the objective assessment of a chronic pain patient. Research conducted by Sikdar *et al*.[76] demonstrated that elliptically shaped, hypoechoic regions within the muscle corresponded to focal areas of reduced vibration amplitudes. These findings suggest that echotextural characteristics could be a reliable and objective indicator of changes in local muscle stiffness that is commonly thought to represent MTrP loci, but not TP. Similarly, magnetic resonance elastography (MRE) employs phase contrast imaging to assess the mechanical properties of tissues. A recent study has shown that taut bands in muscle uniquely present as a chevron pattern at higher wave velocities within the central band in comparison to controls, which demonstrate planar wave fronts.[3] Given the poor reliability of manual detection of taut bands, MRE may prove to be a valuable tool for enhancing the detection of taut bands from normal tissue. Needle electromyography (EMG), which consists of electrodes inserted subcutaneously to record action potentials directly from the muscle fibers, has been used to identify abnormal motor neuron activity associated with changes in muscle tissue. A characteristic attribute of the MTrP locus is enhanced pain sensitivity and lo-

cal contracture due to increased excitability of the motor endplate region. Couppe *et al*.[77] demonstrated that MTrP regions exhibit enhanced spontaneous electrical activity at the motor endplate region in the absence of voluntary muscular contraction, suggesting that this may be a valuable objective measure of focal regions of hyperirritability within the muscle. Despite the potential of these tools in the diagnostic workup of the chronic musculoskeletal patient, the clinical utility of these modalities to assess MTrPs is limited. Biomarkers often require off-site analysis while MRE, EMG, and ultrasound require expensive, specialized equipment with advanced user training in data collection and processing; thus, limiting their feasibility in clinical practice.

It should be noted that these tools focus on identifying a physically distinguishable MTrP locus, characterized by increased acetylcholine release, regional sarcomere shortening and persistent contractile activity.[22,24] A recent review by Rivers *et al*.[6], however, challenges the requirement for including a taut band and tender nodule as confirmatory signs in the diagnosis of MPS, casting doubt on the relevance of the MTrP in the pathophysiology of the MPS. This is a foundational gap in our understanding of the pathophysiology of MPS; future research must focus on elucidating the underlying mechanisms of MTrP formation, and its relevance in the pathophysiology and clinical manifestation of MPS.

Summary

Chronic musculoskeletal pain is an extremely prevalent condition and a leading burden of illness in Canada.[8] While FM and MPS are the two most common forms of chronic musculoskeletal pain, they typically respond to distinctive treatment protocols. MPS is often managed conservatively using manual and physical therapy and exercise while, in contrast, FM is managed using a multidisciplinary strategy that may include cognitive-behavioural therapy, and pharmaceutical interventions that may include tricyclic antidepressants or serotonin reuptake inhibitors.[18] Ensuring consistent and reliable diagnosis between practitioners and specialties would hasten the delivery of appropriate treatment and expedite recovery for patients. Chiropractic treatment has been shown to be an important approach to the cost-effective management of chronic musculoskeletal pain conditions.[78-80]

Inadequate awareness of the underlying mechanisms, pathophysiology, and clinical manifestation is a current challenge in clinically differentiating MPS from FM. The current best practice for diagnosing either FM or MPS is the differential identification of TPs or MTrPs through manual palpation; however, research has shown this to be unreliable and should not be considered as the sole differential diagnostic criteria. This review emphasizes the urgent need for research in the field of musculoskeletal pain to advance the reliability of differentially diagnosing FM from MPS.

Considering the aging demographic[43], chronic musculoskeletal pain is poised to becoming healthcare's greatest challenge in the future. Chiropractic plays a major role in the daily ongoing management of chronic musculoskeletal pain. Advancing the diagnostic sensitivity and specificity will enable chiropractors, and all specialists managing chronic musculoskeletal pain, to improve diagnostic accuracy, reduce inappropriate treatment and ultimately improve patient outcomes and quality of life.

Abbreviations

ACR – American College of Rheumatology
EMG – Electromyography
FM – Fibromyalgia
LTR – Local Twitch Response
MPS – Myofascial Pain Syndrome
MTrP – Myofascial Trigger Point
MRE – Magnetic Resonance Elastography
PSD – Polysymptomatic Distress Scale
SS – Symptoms Severity
TP – Tender Point
WPI – Widespread Pain Index

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Effect of whole body vibration on cervical (neck) proprioception in young, healthy individuals serving as their own control: a pilot study

Joseph Morley, DC, PhD[1]
David M. Sikorski, DC, Professor Emeritus[1]

Objective: *The objective of this pilot study is to determine the effects of whole body vibration on head repositioning accuracy.*

Methods: *Twenty-one participants had a bicycle helmet with an attached laser pointer placed on their heads while standing on a vibration platform. After aligning the laser beam to their determined neutral position on wall-mounted chart paper, they were instructed to close their eyes, flex their neck maximally then return to their perceived neutral position. The point where the laser beam stopped as close to the neutral position as possible was marked on the chart and the sequence was repeated for extension, left and right rotation and left and right lateral flexion. The vibration platform was then activated and the process was repeated for the same six neck movements.*

Results: *T-tests showed significant differences ($p < 0.01$) for head repositioning errors between normal and vibration data for all neck movements (in mm),*

Objectif : *La présente étude pilote vise à examiner les effets de la vibration transmise* à l'ensemble du corps sur la précision du repositionnement de la tête.

Méthodologie : *On a demandé à vingt et un participants de se tenir en station debout sur une plateforme vibrante en portant un casque de cycliste équipé d'un pointeur au laser. Après avoir aligné le faisceau laser avec leur position neutre sur un tableau à feuilles mural, on a demandé aux participants de fermer les yeux, de fléchir le cou au maximum et de revenir* à la position qu'ils percevaient comme neutre. *Le point auquel le faisceau laser s'est arrêté le plus près possible de la position neutre a été marquée sur le tableau; on a recommencé la séquence pour l'extension, la rotation vers la gauche et vers la droite et la flexion latérale vers la gauche et vers la droite. On a mis en service la plateforme vibrante et repris la séquence pour les six mêmes mouvements du cou.*

Résultats : *Les tests T ont révélé d'importants écarts ($p < 0,01$) pour ce qui est des erreurs de repositionnement entre les données normales et les*

[1] Southern California University of Health Sciences

Corresponding author:
Joseph Morley
4384 Gore Road, Conneaut, Ohio 44030 USA
Tel: 512-277-0349
E-mail: jmorley11@hotmail.com
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except flexion, with vibration trials exhibiting greater re-positioning errors. Data tabulated from the four Cartesian quadrants demonstrated a preponderance of overshoot re-positioning errors in which the laser stopped in individual Cartesian quadrants for each movement and each subject.

Conclusions: *Whole body vibration contributes to greater head repositioning errors in young, healthy, asymptomatic individuals. Larger scale trials should establish a normal data base for head re-positioning with vibration. Future studies might investigate the relationship between whole body vibration on neck proprioception as an indicator of therapeutic efficacy in neck disorders.*

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KEY WORDS: neck, proprioception, whole body vibration, re-positioning errors

données sur la vibration pour tous les mouvements du cou (en mm), sauf la flexion, les essais avec vibration étant ceux pour lesquels les erreurs de repositionnement étaient les plus graves. Les données totalisées à partir des quatre quadrants cartésiens révélaient une prépondérance d'erreurs de repositionnement lorsque le faisceau laser s'arrêtait dans les quadrants cartésiens individuels pour chaque mouvement et chaque sujet.

Conclusions : *La vibration transmise à l'ensemble du corps contribue à une hausse du nombre d'erreurs de repositionnement de la t*ête chez des sujets jeunes, en bonne santé et *asymptomatiques. On devrait faire des essais à plus grande échelle pour créer une base de données sur le repositionnement de la tête après l'exposition à des vibrations. On pourrait faire d'autres études sur le lien existant entre la vibration transmise* à l'ensemble du corps et la *proprioception cervicale servant d'indicateur de l'efficacité des traitements dans les troubles de la colonne cervicale.*

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MOTS-CLÉS : cou, proprioception, vibration transmise à l'ensemble du corps, erreurs de repositionnement

Introduction

Proprioception is the sense of the position of the body and its parts, and is crucial to body balance and posture. This awareness depends on various specialized neuroreceptors located in muscles, tendons, skin and fascia. The afferent information provided by various proprioceptors helps the body perform its coordinated movements and involuntarily control posture.[1-3]

Static proprioception is concerned with orientation of one body part to another, while dynamic proprioception involves neuromuscular feedback about the rate and direction of movement to allow for proper joint function and reflexive stabilization of joints. Information regarding position and movement of the head in relation to the trunk is provided in part by neck proprioceptors.

Vestibular reflexes are influenced by visual information, neck proprioceptors, auditory reflexes and the cerebellum. All of this sensory information helps in the stabilization of eye, head and body posture and in maintaining proper spatial orientation to the environment.[4,5] If visual, vestibular and neck proprioceptors provide conflicting sensory information, a sensory mismatch occurs.[6] Ligament injury may cause direct or indirect alterations in sensory information from mechanoreceptors and/or proprioceptors.[5] Neck injury, especially whiplash, can result in a variety of symptoms, including oculomotor dysfunction. This is explained by alteration of the neck proprioceptive system.[6] Damaged muscular and articular receptors can affect afferent integration and motor output, as can neuroreceptors in fascia[7], a structure often overlooked in soft tissue injuries.

Heikkala[8] showed that whiplash patients were less able to relocate initial head position for all neck movements. Improvement in proprioception in sports injuries and back pain has been used as one criterion for treatment success and proprioceptive rehabilitation in musculoskeletal complaints has been concerned with protecting the affected joint from future injury, while maximizing a return to

normal function.[5] Laskowski[4] showed that low back pain patients had greater postural sway and were less able to balance themselves than subjects who had no low back pain, while Persson[9] demonstrated the positive effects of neck surgery on aberrant neck proprioception secondary to cervical root compression. In his study, Persson[9] postulated that the decrease in muscular tension was due to a reduction of neck pain after surgery and the normalization of neck proprioception. This resulted in improved postural control.

The objective of this pilot study was to investigate whether whole body vibration affects neck proprioception in healthy, asymptomatic participants. Vibration or vibratory sense is not a specific sensory modality, but rather a temporal summation of rapidly repeating tactile sensations. Vibration travels in the same afferent pathway as proprioception, i.e. the gracile and cuneate fasciculi, and thus may interfere with proprioception. This theory is supported in studies by Brumagne[10], Radovanovic[11], Patel[12] and Shanahan[13]. Motor control disorders may be caused or influenced by altered proprioception[14] and how patients adapt to proprioceptive disturbances such as vibration, initially and following therapy, may be useful in diagnosis and in assessing therapeutic efficacy.[15]

Methods

This study was approved by the Institutional Review Board of Southern California University of Health Sciences. Male and female participants were recruited from the college staff, students and faculty and those participating were informed of the risk that normal neck movements, as performed in this experiment, could possibly lead to complications ranging from mild transient soreness to stroke involving the vertebra-basilar artery (VBA).[16-19]

To manage the theoretical risk of VBA stroke, a methodology offered by the Canadian Chiropractic Association (CCA)[20] was used in this study. It provided a partial list of exclusion criteria. Participants with any of the following were excluded:

- History of cervical artery dissection
- History of stroke
- Acute neck, occipital or head pain that is severe and unlike any previously experienced
- Active or existing vertebral artery disease (VAD) as evidenced by at least 1 of 4 signs or symptoms of neurovascular impairment: unilateral paresthesia of the face, objective cerebellar defects, lateral medullary signs or symptoms (such as dysphagia, dysphonia, dysarthria, diplopia, ataxia, vertigo, nystagmus, hemianesthesia or unilaterally narrow pupil) or visual field defects
- Active cervical spine cord injury
- Acute cardiac disease
- Past history of, or current smoking.
- Current or recent neck pain

In addition, no one was accepted as a participant if there was a history of any of the following:

- Cervical radiculopathy or myelopathy
- Cervical arthritis of any type
- Vestibular dysfunction
- Sensorimotor disease
- Tumors or infection of the cervical spine

All participants recruited were informed of the risks of neck motion, were required to sign a form indicating that they had none of the exclusion criteria and were required to sign an informed consent form before beginning the study. All participants signed a form allowing their data to be used in a future publication.

Data Collection Procedure

Each participant was instructed to wear comfortable clothing that would not inhibit movement, especially of the head and neck region. The only restriction was removal of shoes so vibration would not have to pass through footwear. Each participant was assigned a number and was identified only by that number, not by name. In the study laboratory, a bicycle helmet with mounted laser pointer was fitted onto the participant's head, as per the method devised by Revel.[21] The participant then stood, without shoes, on the vibration platform (Power Vibe Pro II Whole Body Vibration (Figure 1, manufactured by PowerVibe LLC)), with hands on the platform handles and facing a Cartesian coordinate chart mounted on the wall. The platform was situated so that all study participants were 60 cm from the wall. The participant was instructed to place his/her head in the neutral position (looking straight ahead). The Cartesian chart was adjusted to the participant's neutral position so that the laser beam was at a 90

Table 1.
Summary of the study procedure.

Step	Description
1	Helmet/laser pointer fastened on participant's head.
2	Participant stands on vibration platform without shoes – vibration off.
3	Laser beam centered on 0,0 point on wall chart.
4	Participant closes eyes.
5	Participant told to flex head maximally.
6	Participant told to bring head back to perceived neutral 0,0, point.
7	Laser beam point marked with a blue pen dot
8	Head re-positioned to 0,0 point by study investigator.
9	Same procedure repeated for other five neck movements.
10	Procedure for six neck movements repeated – points marked with red pen.
11	Procedure for six neck movements repeated – points marked with blue pen.
12	Now, three sets of neck movements have been collected.
13	Entire procedure for three sets of neck movements repeated with vibration platform turned on to 20 Hz.

degree angle to the Cartesian chart and focused on the 0, 0 point. The participant was instructed to keep his/her eyes closed during each of the six neck movements, then to flex the head as far as possible and return to what he/she felt was neutral. All participants moved their head at their preferred speed.

The position where the participant first stopped was marked with a dot and a vertical line, using a blue pen for later identification. The participant's head was then manually returned to the neutral position by the investigator. Next, the participant was told to extend the head and return to the neutral position. This point was marked with a dot and an associated horizontal blue line. Left rotation and return to neutral was marked with a \ blue line, right rotation and return was marked with a / blue line, left lateral flexion and return was marked with a left-facing bracket symbol] in blue and right lateral flexion and return was marked with a right-facing bracket symbol [in blue. The same procedure was repeated, with all six neck movements marked with a red pen. Then, the same procedure was repeated a third time, but six neck movements were marked with a pencil. The participant was then instructed to open his/her eyes, the laser was turned off, and the marked and labelled chart taken down.

The above steps were then repeated using vibration, so that three complete trials were done. Vibration was set at 20 Hertz (Hz), the lowest possible frequency setting. The setting of 20 Hz and all protocols were initially determined by trial, using the authors as subjects. Both authors reported that vibration was felt in the neck. In addition, all study participants verified that vibration was felt in their neck region prior to continuing with the trial. When finished, the helmet was removed and the inside cleaned with alcohol. Each participant was then scheduled for 3 more sessions at weekly intervals.

Because any point marked on a Cartesian chart has unique x and y coordinate, the x and y values for each study participant were recorded in millimeters and entered into an Excel spreadsheet for later analysis. Data was later changed to centimeters, for statistical analysis and presentation.

Figure 1.
The vibration platform used in the study.

Data Analysis

All participants were free from neck pain and served as their own control. Since active ranges of neck motion were not being measured and no participant had neck pain, neck ranges of motion were not taken.

The x and y coordinates previously marked on the participant's Cartesian chart, were used to calculate the distance between the 0,0 starting point and the point where the study participant stopped, i.e. the position that the participant felt was the starting neutral position. These x and y values were squared and added, and the square root of their sum was calculated, as per the Pythagorean method. This value was a straight line and hence represented the actual direct distance between the 0,0 point and where the study participant stopped his/her movement. This distance in cm was the repositioning error. It was the length of this repositioning error that allowed for a statistical comparison between normal head repositioning and that done under whole body vibration.

Twelve columns of neck motion data were collected, one each for extension (EX), flexion (FL), right rotation (RR), left rotation (LR), right lateral flexion (RLF) and left lateral flexion (LLF), first without vibration, then the same 6 movements in the whole body vibration mode. Each column of data contained 252 samples (12 for each study participant x 21 participants = 252). For clarity, when referring to rotation in general, R will be used and when referring to lateral flexion in general, LF will be used.

The reliability of the measurement device, a laser pointer mounted on a bicycle helmet, was dependent upon the laser attachment to the helmet and the rigidity of the helmet fit to the participant's head. Ideally, the head/helmet/laser unit should move as one. The laser pointer used in this study was rigidly attached to the helmet with layers of gorilla tape, which were checked after each trial, but remained unchanged throughout the study. The helmet had internal webbing with adjustable chin straps and an external ratchet device to secure the helmet's internal lining to the head.

Results

Transformation of Raw Data

Observation of histograms showed that our initial raw data was not normally distributed and variances were unequal. This raw data could have been analyzed via non-parametric methods; however, there are several reasons for preferring parametric analysis over non-parametric analyses:

1) drawing inferences about population distribution and predictability regarding future outcomes are only met with parametric statistical analysis;
2) parametric statistics have greater power;
3) parametric statistics are robust to modest violations of normality (non-equality of variances, samples from non-normally distributed populations) and thus can be used with non-normal distributions, as long as the normality violations are not excessive.

It was decided to transform the data via square roots, an acceptable technique when desiring to shift the data towards a normal distribution.[22] The square root transformed data proved to be much closer to normal distributions than the raw data.

Skewness is an asymmetric distribution of data along the horizontal x axis and is negative if concentrated to the right and positive if concentrated to the left.[22] All sets of raw data exhibited considerable positive skewness. As can be seen in Table 2, the skewness was reduced in the transformed normal data by 75%, and in the transformed vibration data by 79%.

Table 2.
Skewness and kurtosis comparison between normal and transformed data.

	Mean – Normal Raw Data N = 1512	Mean – Normal Transformed Data N = 1512	% Reduction	Mean – Vibration Raw Data N = 1512	Mean – Vibration Transformed Data N = 1512	% Reduction
Skewness	0.88	0.22	75%	0.87	0.18	79%
Kurtosis	4.14	2.66	36%	4.1	2.77	32%

Kurtosis, the flatness or peakedness of a distribution[22], occurs along the y axis and was also evident in the raw data. The raw study data, both normal and vibratory, were platykurtotic. As can be seen from Table 2, the platykurtotic nature of both the normal and vibratory raw data was reduced by 36% and 32% respectively, in the transformed data.

Coefficients of variation (standard deviation/mean) for all 12 neck movement columns (six normal and six vibration) are shown in Table 3. As large standard deviations can affect statistical analysis, the large standard deviations and coefficients of variation seen in the original data were reduced considerably, post- square root data transformation. Coefficients of variation averaged 54.5% of the mean in the normal raw data and were reduced to 28.3% of the mean in the transformed data. Coefficients of variation averaged 52.5% of the mean in vibration raw data and were reduced to 27.2% of the mean in the transformed data.

In summary, the square root transformed data reduced the skewness and kurtosis in the raw data, modified the differences in normal and vibratory variances in the raw data, decreased standard deviations in the raw data and altered the distribution curves in the raw data, allowing them to more closely approximate normal curves.

Main Study Findings and Statistical Analysis

There were 21 study participants, 14 men and 7 women. Mean age was 29.14 (4.3) years, mean height was 68.7 (3.9) inches or 1.745 (0.099) meters and mean weight was 167.3 (34.1) lbs. or 75.89 (15.47) kg.

The original raw data were positively skewed and not normally distributed. Acceptable corrections include data transformation techniques. Different transformations were tried and it was found that square root transformation was best for moving the data towards a more normal distribution. Therefore, it was decided to use parametric

Table 3.
Coefficients of variation.

Movement	Coefficients of variation raw data normal	Coefficients of variation square root data normal	Coefficients of variation raw data vibration	Coefficients of variation square root data vibration
Extension	57%	28%	56%	28%
Flexion	53%	29%	47%	25%
Right rotation	54%	29%	54%	28%
Left rotation	54%	28%	50%	27%
Right lateral flexion	52%	27%	56%	28%
Left lateral flexion	57%	29%	52%	27%
Averages	**54.5%**	**28.3%**	**52.5%**	**27.2%**

Table 4.
Pairwise comparisons showing statistically significant repositioning errors.

Movement	Greater or Lesser	Comparison Movement	Statistical Significance (p)
Extension	<	Flexion	.003
Extension	>	Left lateral flexion	.047
Flexion	>	Left rotation	.001
Flexion	>	Left lateral flexion	.001
Right rotation	>	Left lateral flexion	.001
Left rotation	<	Right lateral flexion	.045
Left rotation	>	Left lateral flexion	.035
Right lateral flexion	>	Left lateral flexion	.001

tests, since they are robust to minor violations of normality assumptions.

Normality tests (Kolmogorov – Smirnov and Shapiro-Wilk) demonstrated that only two (FL normal and FL vibrating) out of 12 variables failed normality tests ($p = .01$, $p = .02$ respectively).

Repeated measures ANOVAs were run under two separate conditions. In the first condition, the means were calculated of the 12 repetitions per study participant, ($N = 252$; 12 repetitions per participant x 21 participants) for each of the 6 neck movements, in both normal and vibration conditions. A two-way ANOVA was used to assess the main effects (condition, movement) and interaction effects. In the second condition, the same procedure was used as in the first condition with repetition number being used as an additional factor. A three-way ANOVA was used to assess the main effects (condition, movement, repetition) and interaction effects. For the first condition, the assumption of sphericity (verified by Mauchly's W test) was violated ($p = .002$), therefore, Greenhouse-Geisser adjusted statistics are reported.

No statistically significant interaction effect was found – $F(4.74,1189.15) = 1.33$, $p = .25$. This suggests the difference between normal and vibration modes does not depend on movement type. Re-running repeated measure ANOVA with only main effects, showed that there was a statistically significant difference between normal and vibration modes, $F(1,251) = 42.52$, $p < .001$, partial $\eta^2 = .15$. We observed that repositioning error is significantly higher for vibration than for normal.

There were also statistically significant differences between movements, $F(5,1194.19) = 12.34$, $p < .001$, partial $\eta^2 = .05$. A pairwise comparison (Table 4) showed statistically significant differences in repositioning errors between the following movements, regardless of vibration.

In summary, LLF movement resulted in the smallest repositioning error compared to all other movements. The effect size for platform vibration (vs normal) is larger than the effect size for movement, suggesting that the repositioning error is more related to vibration than to type of movement. ANOVA under the second condition – with 3 factors; normal vs vibration, movement type (6 levels), and repetition number (12 levels), was performed. The repetition effect was used to see if repetitions had any effect based on fatigue or learning. Experiments in which study participants must perform a number of tasks can lead to fatigue, or to a learning effect. Both of these can affect results.

The assumption of sphericity (verified by Mauchly's W test) was violated ($p = .04$ and $p < .001$ for movement and repetition respectively); therefore, Greenhouse-Geisser adjusted statistics are reported.

A statistically significant difference was found between normal and vibration mode, $F(1,20) = 15.87$, $p = .001$, partial $\eta^2 = .44$. A pairwise comparison indicated that repositioning error is significantly higher for vibration mode compared to normal mode and a statistically significant difference between movements was also indicated – $F(5,71.11) = 3.34$, $p = .018$, partial $\eta^2 = .14$. Pairwise comparison showed statistically significant differences in repositioning errors between the following movements regardless of vibration:

- FL has larger repositioning error than LR, $p = .018$
- FL has larger repositioning error than LLF, $p = .015$

The repetition number was not statistically significant, $F(11,88.92) = 1.95$, $p = .10$. This suggests no difference in

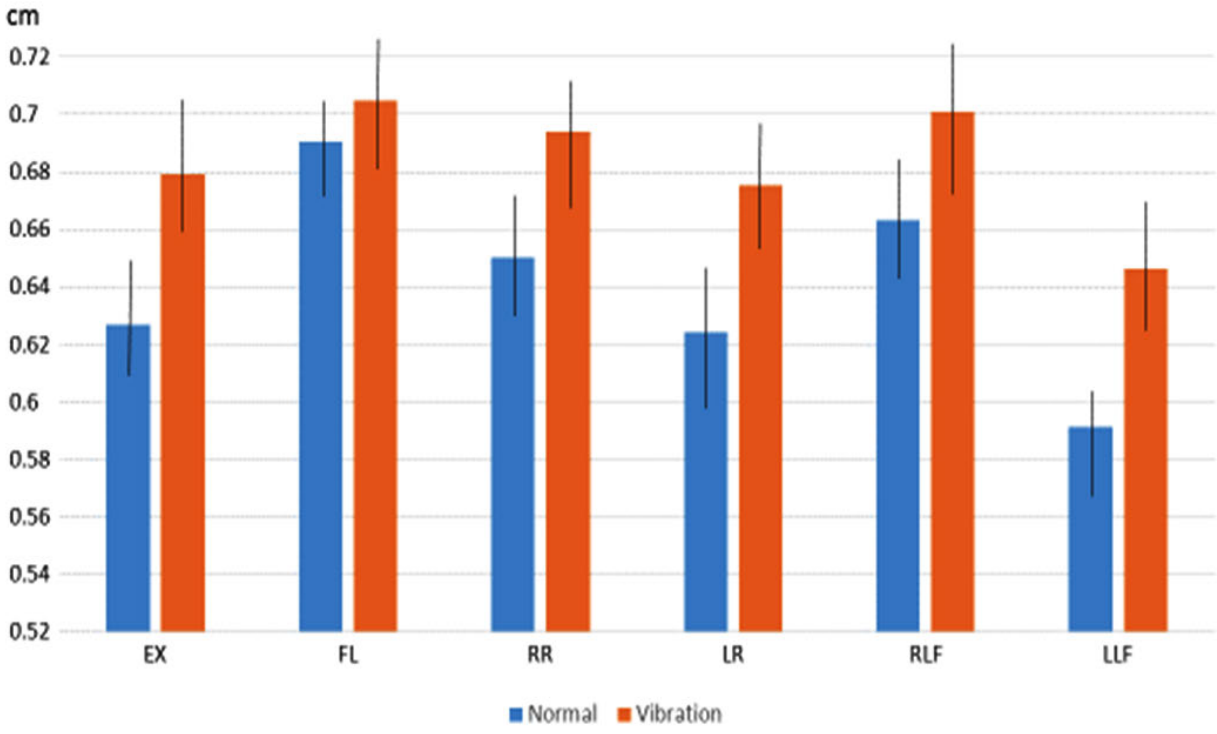

Figure 2.
Comparison of means of repositioning errors for all six neck movements. Error bars are for standard deviations.

repositioning error between repetitions; thus there was no fatigue or learning effect.

Finally, a statistical analysis of the 6 neck movements was done, treating each paired movement of normal with vibration individually, i.e., NEX vs VEX only, NFL vs VFL only, etc. A one-tailed, paired sample T-test was performed (Table 5). Since each neck movement was independent of the other movements, no Bonferroni correction was used.

Secondary Findings

The Cartesian chart used to mark data points is divided into 4 quadrants, with each quadrant assigned a number (Figure 3).

After preliminary analysis of the square root transformed data, it was noticed that each Cartesian quadrant in which individual study participants had repositioned their heads, could be determined. It was decided to tabu-

Table 5.
p-values for each paired neck movement.

Movement Comparison	P Value
NormalEX vs. VEX	p < .01
NFL vs. VFL	p = .20
NRR vs. VRR	p < .01
NLR vs. VLR	p < .01
NRLF vs. VRLF	p = .01
NLLF vs. VLLF	p < .01
Legend: Conditions that begin with an 'N' are under normal conditions, those that begin with a 'V' are under vibration conditions.	

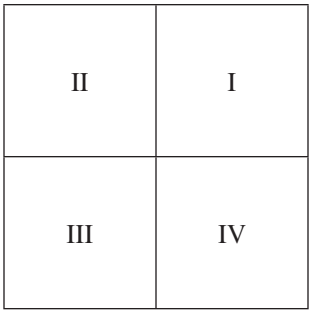

Figure 3.
Numbering of the Cartesian coordinate system.

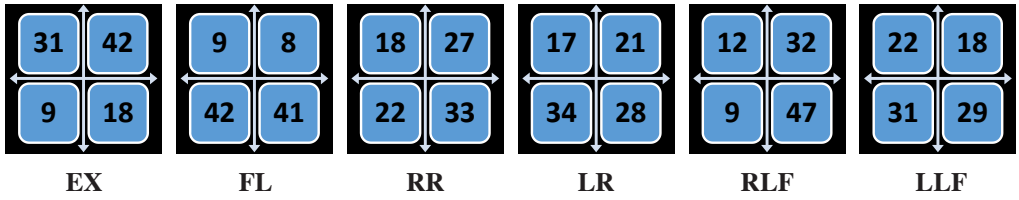

Figure 4.
Normal quadrant summary data (%).

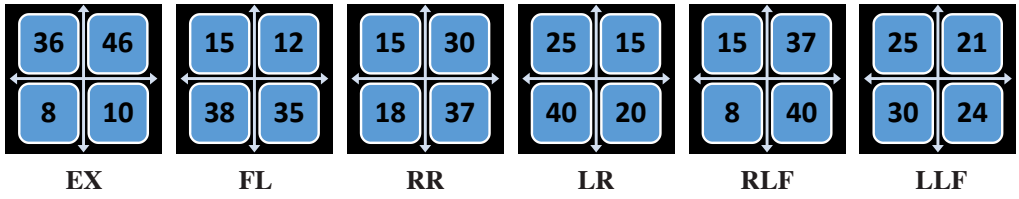

Figure 5.
Vibration quadrant summary data (%).

late the number of times repositioning had ended in each of the 4 quadrants (Figures 4 and 5). It was thought that this might provide additional useful data to the data related to main study objective.

Data extracted from these figures was used to show head repositioning errors of overshoot or undershoot of the 0,0 neutral point. Each repositioning attempt involves specific muscle groups. From the above, which neck muscle groups were used most often (flexors, extensors, etc.), can be determined.

The first Cartesian diagram in Figure 4 is for NEX. It can be seen that in 73% of cases, the repositioning error was in quadrant 1 or 2, and in 27% of cases, the repositioning error was in quadrant 3 or 4. An EX trial ending in either quadrant 1 or 2 would indicate a repositioning error involving the neck extensor muscles, since the laser pointer would be up above the x axis. An EX trial ending in either quadrant 3 or 4 would indicate a repositioning error involving the neck flexor muscles, since the laser pointer would be below the x axis.

The third Cartesian diagram in Figure 4 is for NRR. In 60% of the cases, the repositioning error was in quadrant 1 or 4, to the right of the Y axis, and in 40% of the cases, the repositioning error was in quadrant 2 or 3, to the left of the Y axis. A RR trial ending in either quadrant 1 or 4 would indicate a repositioning error of the right neck rotators/right lateral flexors, since the laser pointer would be to the right of the y axis, while a RR rotation trial ending in either quadrant 2 or 3 would indicate a repositioning error of the left neck rotators/left lateral neck flexors, since the laser pointer would be to the left of the y axis.

Overshoot or undershoot of the 0,0 target in head repositioning is useful for demonstrating which neck muscle groups come into play most often.

Discussion

Our study appears to be the first one reported in which healthy, asymptomatic participants were tested without vision for their accuracy in returning their heads to a neutral position, under normal conditions and while experiencing whole body vibration. Part of the method used in this study, a laser pointer mounted on a bicycle helmet, has been used successfully in previous studies.[21, 23-25]

Previous studies have also confirmed that vibration af-

Table 6.
Percentage of time trials stopped in individual quadrants.

Movements	Percent in quadrants above or below x axis	Neck muscles used	Percent in quadrant to right or left of y axis	Neck muscles used
NEX	73% (1,2)	Extensors	42% (1)	Right Rotators / Lateral flexors
VEX	82% (1,2)	Extensors	46% (1)	Right Rotators / Lateral flexors
NFL	83% (3,4)	Flexors	42% (3)	Left Rotators / Lateral flexors
VFL	73% (3,4)	Flexors	38% (3)	Left Rotators / Lateral flexors
NRR	60% (1,4)	Right rotators	33% (4)	Flexors
VRR	67% (1,4)	Right rotators	37% (4)	Flexors
NLR	51% (2,3)	Left Rotators	34% (3)	Flexors
VLR	65% (2,3)	Left Rotators	40% (3)	Flexors
NRLF	79% (1,4)	Right Lateral Flexors	47% (4)	Flexors
VRLF	77% (1,4)	Rightt Lateral Flexors	40% (4)	Flexors
NLLF	53% (2,3)	Left Lateral Flexors	31% (3)	Flexors
VLLF	55% (2,3)	Left Lateral Flexors	30% (3)	Flexors
Legend: Conditions that begin with an 'N' are under normal conditions, those that begin with a 'V' are under vibration conditions.				

fects proprioception[10-13] and that proprioception is diminished in injury[4,6-9]. Vibration, by travelling in the same pathway as proprioception, can alter muscle spindle output and may affect efferent output and contribute to aberrant motion patterns, such as increasing head re-positioning errors.[1-6]

Statistical results in this study showed that head re-positioning errors were statistically significantly different (greater) in whole body vibration in EX, RR, LR, RLF AND LLF. Only FL failed to show a statistically significant difference when comparing normal vs vibration. Repeated measure ANOVA demonstrated that these statistically significant differences were not due to interaction of movement type, fatigue or numbers of repetitions, but to whole body vibration. These results justified the use of a one-tailed, paired sample T-test to determine the p value for comparing the normal vs. vibration trials for each of the 6 movements. These values are seen in Table 5.

Since this study is believed to be the first one to use whole body vibration for assessing head repositioning accuracy, it is important to consider whether results obtained with localized vibration applied to the upper thoracic, shoulder or neck areas, can be compared with results seen in whole body vibration, or if such a comparison would be a matter of apples versus oranges. Proprioceptive information from the trunk and lower limbs (T7 and below) is carried to the brainstem via the gracile tract. Proprioceptive information from the arms and from T6 and above is carried to the brainstem via the cuneate tract. Localized vibration applied to the upper thoracic, shoulders or neck area obviously does not travel through feet, legs, and lower to mid-spine, whereas whole body vibration does. Important proprioceptive receptors involving balance, head alignment and postural control are thus bypassed with locally applied vibration above T6. There is also good evidence of the influence of cervical and head receptors on lower limb and trunk activity. Sasaki[26] demonstrated that vibratory stimuli of the neck resulted in an

increase in spinal reflex excitability of the triceps surae muscle complex in seated subjects. Parfrey[27] showed that changing cervical and limb positions can change the activation levels of the internal and external oblique muscles. Interestingly, Strimpakos[28] demonstrated that head re-positioning while standing resulted in less variable error than did head re-positioning while sitting. Based on the evidence, it would seem that future vibration trials assessing head re-positioning would be better performed with whole body vibration, so that important sensory information would not be excluded.

A comparative test for head repositioning accuracy, having the same subjects tested by both methods, would shed light on whether results can be compared directly, or whether results varied significantly, making direct comparisons invalid. Until this is done, caution is imperative when comparing results from these two different forms of a similar test, both of which can be used to assess the effects of vibration on head repositioning accuracy.

Before discussing overshoot/undershoot in head re-positioning involving R or LF, it is necessary to discuss coupled neck motions. This study and previous studies using the laser pointer method of Revel[21] or a modification to assess accuracy of head repositioning, have analyzed neck movements separately. One question that needs to be addressed is whether treating neck movements in isolation is in conflict with what is known about coupled neck movements. Coupled movements are defined by Levangie[29] as the consistent association of one motion about an axis, with another motion around a different axis. Motions from neck (cervical) vertebrae C2 through C7 are coupled. FL and EX are coupled with translation, a sliding movement of one vertebrae upon the adjacent vertebra. They are not coupled with R or LF, so it is certainly justified to treat flexion and extension separately.

However, Bergman[30] points out that initiation of LF of the cervical vertebrae is coupled with ipsilateral R. At cervical vertebra C2 there are approximately two degrees of ipsilateral R for every three degrees of LF. This gradually changes so that for every 1 degree of R there are 7.5 degrees of ipsilateral LF at cervical vertebra C7. Similarly, initiation of R of the lower cervical spine results in ipsilateral LF.

The existence of coupled motion of LF and R does not negate assessing these movements separately. They share some motion together, but they also have unique motion. LF to the limit of its range of motion will not result in the neck being rotated to the limit of its range of motion. Standard Kinesiology and Anatomy textbooks show that only three muscles are involved in a single neck movement and most muscles participate in more than one neck movement. Either neck R or LF muscles can cause the head repositioning to deviate to the right or left of the Y axis. Without doing EMG or other studies, we cannot pinpoint which one.

Looking at quadrant data to see the percentage of times head repositioning stopped in each of the four quadrants was not an original objective of this study; however, recording head re-positioning data resulted in Cartesian quadrant data being generated. It was decided to analyze the data and as a result, determine if head repositioning was equally distributed throughout the four quadrants, or if there was a preference. Active motions, such as head/neck movements, depend upon muscle activity and specific movements such as head/neck flexion, depend upon specific muscle groups. At this stage, it appears, with admittedly limited data, that vibration affects only the degree of movement, not the kind of movement, i.e., more re-positioning error, but no change in which quadrants the greater error occurs. Whether our results are normal can only be determined by future, larger scale studies that would establish a normative data base. Future studies may show that not only do people suffering from neck pain show more head re-positioning errors with vibration, but normal quadrant data might also be altered. This could allow rehabilitation plans to place emphasis on the specific muscles involved in the re-positioning error, since quadrant patterns indicate which muscle groups are involved.

The various studies using cervical vibration and head repositioning utilize different methods and thus make comparisons of the different laser/ head repositioning error studies difficult. One other factor that has not been mentioned in previous studies is the influence of subject-target distance on results. Our study used a 60 cm distance between subject and chart, whereas other studies have used 40 cm or 90 cm. When measurements are kept in cm and subject to target distances vary, no direct comparison can be made. The distance between subject and the Cartesian chart target alters the repositioning error, so calculations need to be performed to equalize the study results obtained with different subject-target distances. Standardizing subject to target distances would avoid this

problem. Subject to target distance does not affect data derived from studies reporting repositioning errors in radians or degrees.

Reliability is another issue that needs to be addressed in studies involving head repositioning accuracy with the laser pointer method. It is defined as repeat measure testing, the consistency of a measure or method over time[22]. Revel[21], the first to publish a study using the laser pointer method, mentioned two reliability checks used; 1) head repositioning measurements of study participants were checked by two investigators viewing the same participant on the same day; 2) and different investigators measured participants repositioning accuracy on different dates, i.e. investigator one measured participant one's responses on one date and investigator two measured participant one's response on a different date. Unfortunately, there were no details provided about how the study participants' charts were recorded or marked by two investigators.

The inclusion of examiner reliability assessment in studies involving head re-positioning is lacking in studies by Rix[24], Palmgren[25], Heikkila[8], Beinert[31], and our current study. This is a problem and has been highlighted by Strimpakos[28], who stated that reliable measures and conclusive observations have been lacking in neck proprioception studies. Future studies could include a second trial prior to vibration which would enable the study investigators to calculate reliability.

Our chart for marking repositioning error was a graph sheet, divided into 1 mm squares. The diameter of the dots made by the study investigators' pens/pencils was about 1 mm; thus, our error of measurement would be 1 mm. Figuring this into our data did not alter any of the results. The main criteria for examiner accuracy in marking are good visual acuity and very sharp pencils or small point pens.

Twenty one participants, 14 men and 7 women, entered and completed our study. One question that arose was whether to treat the genders as separate groups, or to combine them into one group. It was decided not to group male and females separately. Differences in muscle use patterns between males and females have been demonstrated in previous studies by Fedorowich[32], Johansen,[33] Tierney[34], and Brophy[35]. Our study did not separate participants by gender because the studies noted involved fatiguing tasks, sports injuries or repetitive tasks carried on for lengthy periods, and these conditions were not present in our study. Demaille-Wlodyka[36] showed that gender had no effect on the ability to return the head to the neutral position under normal conditions, i.e. when these fatiguing or repetitive tasks were not present.

One pattern that has appeared in studies by Heikkila[8], Rix[24], and Palmgren[25] is the fairly large standard deviations seen in raw data. As mentioned previously, this was also seen in the raw data from our current study. Square root data transformation smoothed this study's data considerably and perhaps should be a consideration for researchers in future studies involving head repositioning and laser pointers.

It was noted about 1/5 of the way through the study, that some participants would return their heads to the presumed neutral position, stop, exhibit a small, very brief oscillatory pattern of the head and then move closer to the presumed neutral position. This oscillation seemed more pronounced in the vibratory sessions, but in all sessions observed, it resulted in the participant moving closer to the neutral point on the Cartesian chart. To the best of our knowledge, this oscillatory period has not been previously addressed in head re-positioning studies. Marking this first point of stoppage, part of our protocol, resulted in large standard deviations in our data. Taking this into account, we felt that future experiments could possibly reduce the large standard deviations seen by allowing participants to complete the brief oscillatory period before marking the stopping point. There is a way to incorporate this oscillatory movement/period and help standardize head re-positioning studies – determine a set time for the re-positioning effort. From our experience, two seconds seems a reasonable period. By incorporating a standardized time for re-positioning movements, all trials, whether normal or vibration, will eliminate time variances not addressed in current studies. In a study involving postural control, Arora[37] demonstrated that the normalized time to reach a maximum distance was increased after WBV exposure, confirming our findings

Future studies assessing the effects of vibration on head re-positioning accuracy might also wish to consider the use of whole body vibration, via a vibration platform. As mentioned previously, Strimpakos[28] demonstrated that head re-positioning while standing resulted in less variable error than did head re-positioning while sitting. As long as standardization of methods and statistical analyses are not in agreement, it will be difficult to compare

data from different studies investigating the effects of vibration on head repositioning. It is proposed that future work adopt a standardized method of conducting head repositioning/vibration experiments and authors should communicate to standardize procedures. There is potential value in establishing a database of end range of motion deviation with vibration in healthy participants. Further development could lead to the use of vibration as a valuable clinical tool in assessing the response to treatments for various musculoskeletal neck pathologies. The cost of conducting such studies is not prohibitive and the experimental procedure is neither time consuming nor difficult.

Rix[24] alluded to this problem and put it best: "The method of measurement and, in particular, its subjective and non-remote nature inevitably involve a degree of experimenter bias and geometric inaccuracy. On this basis, comparing absolute values between different studies should be done with caution".

Conclusions

The limited data from our pilot study have shown that head re-positioning errors are increased by whole body vibration. This is possibly due to altered proprioceptive input from the elements in the neck muscle spindles. Additionally, tabulation of movements ending in the different Cartesian coordinate quadrants can determine overshoot or undershoot of head re-positioning that identifies which muscle groups are responsible for the overshoot or undershoot errors.

Data transformation was used to help normalize the raw data in this study. Large standard deviations (and variances), as seen in the raw data, can affect statistical analysis and may limit statistical analysis to the use of non-parametric statistics. Transformed data, by approximating a normal distribution, allows the use of more robust parametric statistics. This should be a consideration for future investigators.

With what has been learned in this project and what has been suggested for future research, the investigators feel confident that a database of normal head re-positioning data and vibration re-positioning data can be established. Using this database, future studies could investigate the relationship between whole body vibration on neck proprioception and thus determine if it can be used an indicator of treatment efficacy in neck disorders.

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Melanoma in situ: a case report from the patient's perspective

Craig A Bauman, DC[1,2]
Peter Emary, DC, MSc[3]
Tyler Damen, BSc (Kin), DC[4]
Heather Dixon, HBSc, MD[1,2]

Introduction: *Melanoma can be a fatal form of skin cancer. The prognosis rapidly deteriorates from the in situ stage (stage 0) to stage 4. As such, early detection and treatment are key.*

Case Presentation: *A middle-aged patient, who was also a chiropractor, self-identified a small skin lesion using the Chiropractors Guide to Skin Cancer. The primary care physician made a dermatology referral, and biopsy identified melanoma. Surgery was subsequently booked and the lesion was excised with a 5 mm margin. The final pathology report confirmed a diagnosis of melanoma in situ.*

Summary: *As primary contact health care providers chiropractors can play a significant role in the potential*

Introduction : *Le mélanome est un cancer de la peau pouvant* être fatal. *Le pronostic s'assombrit rapidement entre le stade 0 (mélanome in situ) et le stade 4. Un dépistage et un traitement précoces sont essentiels.*

Présentation du cas : *Un patient d'âge mûr, qui était aussi un chiropraticien, a décelé chez lui une petite lésion cutanée* à l'aide du *Chiropractors Guide to Skin Cancer (guide servant à aider le chiropraticien à dépister un cancer de la peau). Un* médecin de premier recours l'a dirigé vers un *dermatologue; l'examen de la biopsie a révélé un mélanome. Un rendez-vous en chirurgie a été pris. La lésion et une marge chirurgicale de 5 mm ont été excisées. Le rapport final du laboratoire de pathologie a confirmé le diagnostic d'un mélanome in situ.*

Résumé : À titre de *fournisseurs de soins de santé primaires, les chiropraticiens peuvent jouer un r*ôle important dans le dépistage de diverses affections

[1] Department of Family Medicine, McMaster University, Hamilton, Ontario.
[2] The Centre for Family Medicine Family Health Team, Kitchener, Ontario.
[3] Private Practice, Cambridge, Ontario.
[4] Private Practice, Strathroy, Ontario.

Corresponding Author:
Craig Bauman
The Centre for Family Medicine, 25 Joseph St., Kitchener, ON N2G 4X6
Tel: (519) 578-2100 ext 255
e-mail: bauman@mcmaster.ca

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identification and initiation of investigations into various possible dermatological disorders including skin cancer. Efforts should be made to diagnose melanoma at the in situ stage to ensure the best outcome.

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KEY WORDS: melanoma, self-exam, skin cancer, chiropractic

cutanées dont le cancer de la peau et l'amorce des examens exploratoires. On devrait déployer des efforts pour que le *mélanome soit diagnostiqué au stade 0 (mélanome in situ) pour assurer la meilleure issue possible.*

(JCCA. 2018;62(1):56-61)

MOTS-CLÉS : mélanome, auto-examen, cancer de la peau, chiropratique

Introduction

Melanoma is the most deadly form of skin cancer (Figure 1).[1] If detected at the in situ stage and properly treated the risk of mortality is essentially negligible.[2] At the in situ stage the malignant tumour is restricted to the outer layers of the skin (epidermis).[3] The cancer cells at this stage are therefore only in the upper layer of the skin and have not seeded into the dermis or beyond.[3]

Chiropractors often see patients on an ongoing basis in clinical practice and are in an excellent position to observe the evolution of skin pathology and initiate the correct referral to the patient's physician. This report documents a case involving a chiropractor who was diagnosed with melanoma in situ. This case is also presented from the patient's perspective to help illustrate the patient experience as well as the steps to proper management of this common but potentially deadly disorder.

Figure 1.
An example of a melanoma (source: https://commons.wikimedia.org/wiki/File:Melanoma.jpg [Accessed April 28 2017]).

Case Presentation

History

I am a 51-year-old male chiropractor. My melanoma in situ experience begins in my youth. I was an avid windsurfer and had frequent sunburns of my feet from standing on the surfboard. I had a small mole on the dorsum of my left foot for as long as I can remember. Having had so much sun exposure from outdoor sports, I realized that I was at risk for skin cancer. I would occasionally check my

Table 1.
The ABCDE's of melanoma.[4-7]

Category	Description
A	**A**symmetry of shape of one half of the lesion compared to the other half
B	**B**order of the lesion is irregular, jagged, notched or may blur pigment into the surrounding skin
C	**C**olour of the lesion may be varied with shades of black, brown, blue and white
D	**D**iameter of the lesion is greater than 6 mm, or larger than the end of an eraser
E	**E**volution of the size, shape, elevation, surface or colour of the lesion has occurred over time
The "Ugly Duckling" sign. One lesion stands out as different from all the others.	

skin for any unusual moles. When I received the *Chiropractors Guide to Skin Cancer*[4] a number of years ago, I read it from cover to cover several times and used the photographs as a resource for checking my own skin.

About 18 months prior to my skin cancer diagnosis, I noticed that the mole on the dorsum of my foot appeared larger. It was flat, multi-coloured, and asymmetrical in shape, had an irregular border and was about 4 mm in diameter. Contained in the *Guide* was information on the ABCDE's of melanoma (Table 1).[4] The mole on my foot had several of these concerning features, but it was smaller than the 6 mm diameter size typical of melanoma lesions.[4]

I decided to make an appointment with my family physician. I showed the physician the lesion, but he was not concerned. I continued to observe the mole and a year later it had grown to 5 mm in diameter. By this time my family doctor had retired and I was taken on by another family physician. I made an appointment with this physician and showed her the area of concern. Again the lesion was deemed unremarkable. I also showed the physician another lesion on my thigh that I had been following and this resulted in a dermatologist referral. At that appointment, the dermatologist used cryotherapy to remove the lesion on my thigh. I asked the dermatologist to perform a full body skin check as well and a lesion on my back was identified along with the one on my foot, and these were subsequently scheduled for biopsy.

Intervention and Outcome

I returned to the dermatologist for the superficial shave biopsies. Briefly, superficial shave biopsies involve removal of a thin disc of tissue, typically by scalpel, yielding a flat thin specimen limited to the epidermis and upper dermis less than 1 mm in total depth.[8] In my case, the dermatologist said that he "wasn't too worried" but was performing the biopsies to be safe. He said they would get the results in four weeks and if I didn't hear anything from them, this would mean that everything was fine. I received a call 10 days later, however, to come in for a follow up appointment. I really wasn't concerned and assumed they just wanted to see how the biopsy sites were healing. The dermatologist walked into the room with a concerned look. He said the lesion on my back was only a dysplastic nevus (i.e. an unusual-looking benign, noncancerous mole).[9] The lesion on my foot however was melanoma in situ. I zoned out hearing those words, knowing the seriousness of melanoma. He said I would require surgery and possibly a skin graft. He gave me a copy of the pathology report. There was no pathology extending to the deep margin on the specimen; but the tumour did extend to one peripheral margin, which meant more tumour may remain with a potentially higher stage and thus a greater risk of death. The dermatologist recommended that I return in four months. He also informed me that in the first two years after diagnosis there is a higher chance of other melanomas appearing. He therefore instructed me to perform regular skin checks and to return sooner than four months if I found anything suspicious.

Two weeks later I saw the general surgeon. He said no graft would be required; however a 5 mm margin of skin surrounding the lesion would have to be removed and several stitches would be needed. The surgeon indicated that the final pathology report from that specimen would confirm if it was in fact melanoma in situ or a higher stage which would then require further surgery. The surgery was performed with a local anesthetic and a piece of skin (about the size of a Canadian loonie) was removed. The stitches made the skin on the dorsum of my foot quite tight. I walked with a limp, not out of pain, but to prevent the stitches from being pulled out. I worked later that day being careful to not stress the area. I had some pain when the freezing wore off, but only required one extra-strength ibuprofen that first night for relief. The skin slowly stretched out and the pain reduced over the next three weeks. I stopped lower extremity exercises until the stitches could be removed.

Three and a half weeks later, I telephoned the surgeon's office and was told the final pathology report confirmed no residual disease and therefore a final diagnosis of melanoma in situ. I felt such relief at hearing that news. The next day I returned to the surgeon and the stitches were removed. Currently, I continue to perform regular monthly skin checks on myself, and I follow-up with the dermatologist every 4 months for ongoing melanoma screening.

Discussion

Melanoma can be screened for using the ABCDE's of melanoma (see Table 1).[4-7] The lesion diameter of 6 mm is an accurate size parameter for determining the risk of melanoma.[5] There is a higher risk of invasive melanoma (i.e. seeding of melanoma beyond the epidermis) when

Table 2.
Survival rates of melanoma based on stage.[2,10,11]

Stage	Survival rate
0 (in situ)	99.9% 5-year survival; 98.9% 10-year survival
I/II	89 to 95% 5-year survival
II	45 to 79% 5-year survival
III	24 to 70% 5-year survival
IV	7 to 19% 5-year survival

Table 3.
The four main types of melanoma.[12]

Type	% of cases
Superficial spreading melanoma	70
Nodular melanoma	15
Lentigo maligna melanoma	13
Acral lentiginous melanoma	2-3

moles are greater than the 6 mm diameter size.[7] In Australia doctors have been screening for and identifying melanomas smaller than 6 mm, however evidence suggests that this method does not necessarily improve diagnostic accuracy or patient prognosis.[5,7] A more important parameter than size in detecting early-stage melanomas may be whether the lesion is evolving (i.e. change of size, shape, elevation, surface or colour of lesion over time).[5,7] In the current case, the melanoma lesion was smaller than 6 mm in diameter yet showed signs of evolution in size over the course of 12 months. The lesion also exhibited signs of asymmetry, border irregularity, and colour variegation.

The basic tumour staging of melanoma includes five stages, stage 0 (in situ) to stage IV.[10] The survival rates based on this staging system are listed in Table 2 and the main types of melanoma are listed in Table 3.[10,11,12] In general, the prognosis deteriorates from the in situ stage (stage 0) to stage IV. There is also a more detailed staging approach that is often used known as the TNM system.[10] **T** describes the thickness of the melanoma, **N** describes how many lymph nodes are affected, and **M** describes metastasis or spread to distant organs of the body.[10] In either case, every effort should be made to diagnose melanoma at the in situ stage as the prognosis rapidly deteriorates with stage increase.[11]

When compared to the final excision pathology report, superficial shave biopsy has a depth accuracy rate for staging in the range of 81-88%.[2,13] For lesions that are less than 1 mm in depth the accuracy is 96%.[8] If the superficial shave biopsy margins are clear (i.e. there are no tumour cells extending beyond the edge of the biopsy specimen, either at the sides or the bottom) the staging accuracy is 93%.[13] In the current case the tumour extended to one peripheral margin of the biopsy specimen, slightly reducing the accuracy rate to 85%.[13] Nevertheless, a diagnosis of melanoma in situ was made.

Surgery to remove the lesion and surrounding skin is the gold standard treatment for melanoma.[14] For melanoma in situ, the surgical margin includes skin removal up to 5 mm around the mole.[14,15] Tumours with a depth of less than 1 mm also do not require sentinel lymph node biopsy.[15] For higher stage/invasive tumours (i.e. stages I to IV) the surgical margin surrounding the lesion can be as great as 10 to 20 mm.[14,15] In addition, sentinel (e.g. inguinal or axillary) lymph node biopsy, with possible surgical removal, is normally required.[14,15]

The frequency of melanoma is increasing.[14,16] Estimates for 2016 in the United States were 76,380 new cases of invasive melanoma and 68,480 new cases of melanoma in situ.[14] The incidence rate and death rate of melanoma have also increased significantly among Canadian men and women over the past 25 years.[16]

The risk of recurrence and higher risk of additional new melanomas after diagnosis warrants long-term skin checks by a dermatologist and self-exams by the patient.[17] A web link to the Skin Cancer Foundation (http://www.skincancer.org/skin-cancer-information/early-detection/step-by-step-self-examination) provides patients with information on how to conduct a self-exam of their skin and how to properly document their findings.[18,19] Taking a dated picture of a suspicious lesion next to a ruler allows patients to monitor for changes and notify their physician as required. In all cases the patient should be proactive and advocate for themselves in the health care system.

Although preliminary, some research has shown an as-

sociation between regular white wine consumption, use of growth hormone, Parkinson's disease, psychosocial stress, or the use of biologic medication (e.g. TNF-alpha inhibitors for Crohn's disease) and increased risk of melanoma.[20-24] Exercise, vitamin D, or coffee consumption may help to reduce the risk of melanoma;[25-28] however further investigations on these and other dietary/lifestyle factors and associated effects on melanoma risk are needed.

Limitations

A key limitation of this paper is the inherent/unintentional bias that the principal author may bring to the report as it is written from the patient's perspective. Moreover, this case report may have biased observations in how the principal author recounted the clinical details.

Summary

The patient in this case (CAB) has returned to exercising and carrying on with normal life. Regular skin checks by the dermatologist will continue to occur on a long-term basis.[17] Three of the authors on this paper (CAB, TD, HD) have been diagnosed with melanoma. We have written this paper to increase chiropractors' awareness of this common skin disorder. Doctors of chiropractic are primary care providers in an excellent position to detect and monitor skin lesions and refer as required. The earlier melanoma is detected, the greater the chance of survival.[29] Hence, chiropractic screening and early detection of suspicious skin lesions in clinical practice could save a patient's life – or as in the current case, the chiropractor's.

Key Points:

- Melanoma is the most deadly form of skin cancer
- Regular skin checks by the physician and patient are recommended
- All efforts should be made to detect melanoma at the in situ stage
- Treatment at the in situ stage has a nearly negligible mortality rate

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History of the CMCC Health Science Library 1945 – present

Margaret Butkovic, LT[1]

This paper traces the development of the CMCC Health Sciences Library from its humble beginning in 1945 to the present day. In the early years of its development the library grew and prospered thanks to the support of early pioneers, the believers in the importance of the library to chiropractic education. In the later years of its growth and in spite of some challenges, with the support of CMCC presidents Dr. Ian Coulter and Dr. Jean Moss, and the academic deans Dr. Al Adams and Dr. John Mrozek, the library prospered. The Library at the new campus is a hub of intellectual life for our students and faculty, and a source of information for chiropractors and other healthcare professionals.

(JCCA. 2018;62(1):62-71)

KEY WORDS: chiropractic, library, history

Cet article relate l'évolution de la bibliothèque des sciences de la santé du CMCC, depuis ses humbles débuts en 1945 jusqu'à ce jour. Durant les premières années de son existence, la bibliothèque a évolué et *s'est enrichie grâce au soutien des premiers pionniers qui croyaient à son importance dans la formation en chiropratique. Plus tard, malgré certaines difficultés, la bibliothèque a prospéré grâce au soutien de deux présidents du CMCC, le D[r] Ian Coulter et la D[re] Jean Moss, et celui de deux directeurs des études, les D[rs] Al Adams et John Mrozek. La bibliothèque du nouveau campus est un centre de vie intellectuelle pour nos étudiants et la faculté et une source d'information pour les chiropraticiens et d'autres professionnels de la santé.*

(JCCA. 2018;62(1):62-71)

MOTS-CLÉS : chiropratique, bibliothèque, historique

History

One of the great privileges in life is to witness and be part of the evolution of an academic institution. I consider myself privileged, as I have been part of CMCC since 1976 and have witnessed a tremendous growth of CMCC and the transformation of the Library. The CMCC Health Sciences Library is an integral part of CMCC and a cornerstone of chiropractic education in Canada.

According to Dr. Herbert K. Lee when the college opened in September 1945, at 252 Bloor St., there was

[1] Director, Library Services, CMCC Health Sciences Library

Corresponding author:
Margaret Butkovic
CMCC Health Sciences Library, 6100 Leslie Street, Toronto, ON M2H 3J1
Tel: 416. 482-2340 ext. 159
E-mail: mbutkovic@cmcc.ca

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no formal or defined library. There was a First Aid room on the second floor with an adjusting table in it and a few books. This area represents the beginning of the library.[1]

The early years of the CMCC library are not well documented. The first indication of the existence of the library was documented in the 1947 and 1948 Backlogs. One can visualize the library in a small room with few books and journals and serviced by student volunteers. Don Middleton, a student, wrote most of the articles on the library. In the November 1947 issue he wrote: "We are pleased to announce the opening of the library again. The hours are from 1:30 p.m. to 4:30 p.m. and the librarian is Art Dilley of the sophomore year. You will find him a very willing guide to all the books at your disposal. A copious supply of book shelves have been added to the library, completely relieving the congestion of last year. In fact, the new additions have made one storeroom of knowledge look rather bare. Unhappily, there have been no new books to date to fill the empty shelves. However, we always remain hopeful. This is an excellent opportunity for the practitioners in the field to contribute the latest editions of all books pertaining to our profession. We have the nucleus of a very splendid library, but with a rapidly growing student body the need for more books becomes greater with every semester."

Books of the day were: *Chiropractic Principles and Technic* by Biron, Wells and Houser, 1939 edition; *The Science and Logic of Chiropractic* by Verner, 1947 edition; *100,000,000 Guinea Pigs* by Arthur Kaller; *Regional Anatomy* by G. McClellan, 1892 edition; *Modernized Chiropractic* by Smith, Langworthy and Paxon, 1906 edition; and *Principles of Roentgenological Interpretation* by L.R. Sante; *The Anatomy of the Nervous System* by Ronson; *The Physiological Basis of Medical Practice* by Best & Taylor, etc.[2]

The outlook for obtaining more books became a little brighter with Bob Long, a second year student, at the helm. He was described as "an ardent book advocate." The Library opened its doors to practicing chiropractors, and this provided an excellent incentive for practitioners to support the library.[3]

By 1948 tremendous advances were made in the library. The books were bought and paid for by the profession. In addition, Bob Long continued to provide the necessary stimulus to get the purchase of library books underway. He devoted much of his time to getting the au-

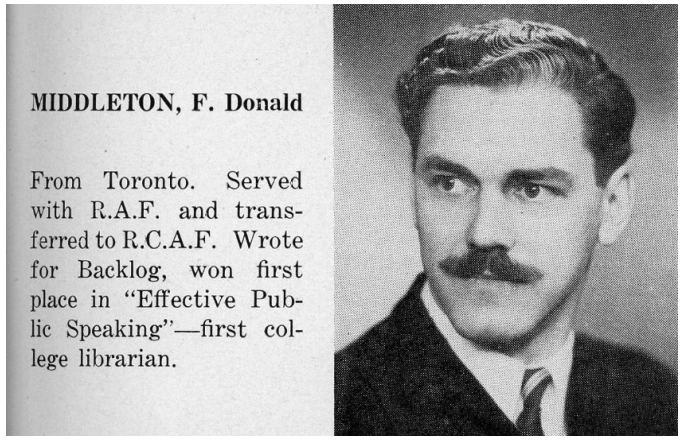

Figure 1.
Donald F. Middleton (source: Cornerstone. 1949; 21).

Figure 2.
Library at 252 Bloor Street campus (source: Cornerstone. 1949; 46).

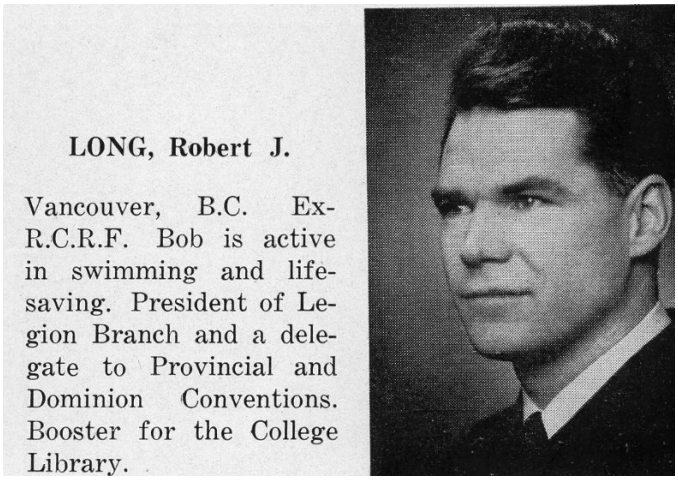

Figure 3.
Robert J. Long (source: Cornerstone. 1949; 28).

Figure 4.
Library staff, 1952: Maja Sivertsen, Lana Wyatt, Nora Stewart and Mary Russon. (source: Cornerstone. 1952; 49).

thorization necessary, ordering and receiving books. Don Middleton paid him this tribute, "It was largely due to his initiative that we have a library now instead of several years from now. That is true, constructive college spirit, Bob."[4]

It was recognized even at that time that a well-equipped library should be a goal for the future, with a strong historical section, but in order to keep abreast of fast moving scientific developments and research, an ever-increasing number of new books and journals must be made available. At most times the library was full to capacity and it appeared that an extension to the library was a necessity. A fine of five cents per day was introduced for overdue books. The Library was closed during summer months, and the re-opening date for the semester was usually unknown.[5]

In the 1950s, the profession still played a vital part in supplying books for the library. In 1952, the librarian Maja Sivertsen wrote in the library column, "Now we are really growing rich. This month we have the pleasure of announcing three donations – 38 books in all. Our contributors of this month are: our much admired President Dr. J. S. Clubine, Dr. Schnick of Hamilton and Dr. R. J. Long of Vancouver."[6] The librarians of the time, Maja Sivertsen and Lana Wyatt dealt with the chronic problem that all libraries suffer throughout the ages – the disappearance of books. A note to students stated: "It is a shame that we have to mistrust any student in this college – a profession as ours ought to be a guarantee for honesty. Books disappear from the library – some to appear after months, others never to return. Where do they go? Who takes them? How can we have confidence in each other, when we know that such happens, and how can we expect future patients to have confidence in us if we know that we are not honest, trustworthy individuals? So – please let us get together and clear the air."[7]

In 1955, the librarian was Marg Harrison. The general rules concerning use of the library were: "A maximum of two books could be borrowed for a two week period. The library opened daily Monday through Friday at 2:00 p.m. Reference books could not leave the library." Some books in the collection were: *Sacro-occipital Technique of Spinal Therapy*, *Sacro-occipital Technique of Chiropractic*, *Reflex Pain*, *Spinal Distortions*, *Low Back Pain and Sciatica*, *Vertebral Column, Principles & Methods of Physical Diagnosis*.[8]

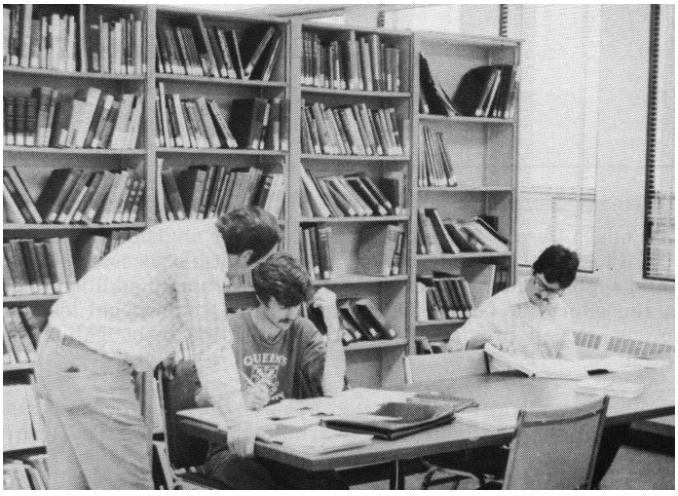

Figure 5.
Library in 1960s (source: CMCC Archives).

In the 1960s students had a small reading room, and "book cards" were in use for the first time. Current journals were kept in the small reading room. The library staff and student relationship was summarized in the following statement: "The library staff are courteous, friendly and helpful, and providing we return their goodwill, our relationship should prove both enjoyable and educational."[9]

With the move to 1900 Bayview Avenue, in 1968, the Library took on the dimensions of one befitting a professional institution. Attractive new shelving was added to house the expanding collection of books and journals. A large filing cabinet contained research papers.

Articles and pamphlets were available in areas from the American College of Chiropractic Radiology reprints to X-ray. The audio aids department had grown as well and records of heart sounds and cardiac diagnosis were available. The library holdings were 2,928 books and subscriptions to 25 journals. Some of the journal titles were *Archives of Neurology*, *Journal of Neurophysiology*, *Archives of Environmental Health*, and *The American Journal of Roentgenology*. Books were purchased through the Walter Sturdy Memorial Fund. One book in particular, *Spinal Manipulation* by Bourdillon was very popular with students.[10]

In 1971 there were two full time library staff, Karin Hammerich a student and Dorothy Kelsoll, the wife of a student. During hours when there was no library staff on duty, the reading room was still open; a partition had been installed separating the reading room of the library from the stacks. When the library moved to the new facility, it seemed immense by comparison with the previous facility. However, by the mid-70s another expansion was necessary.[11]

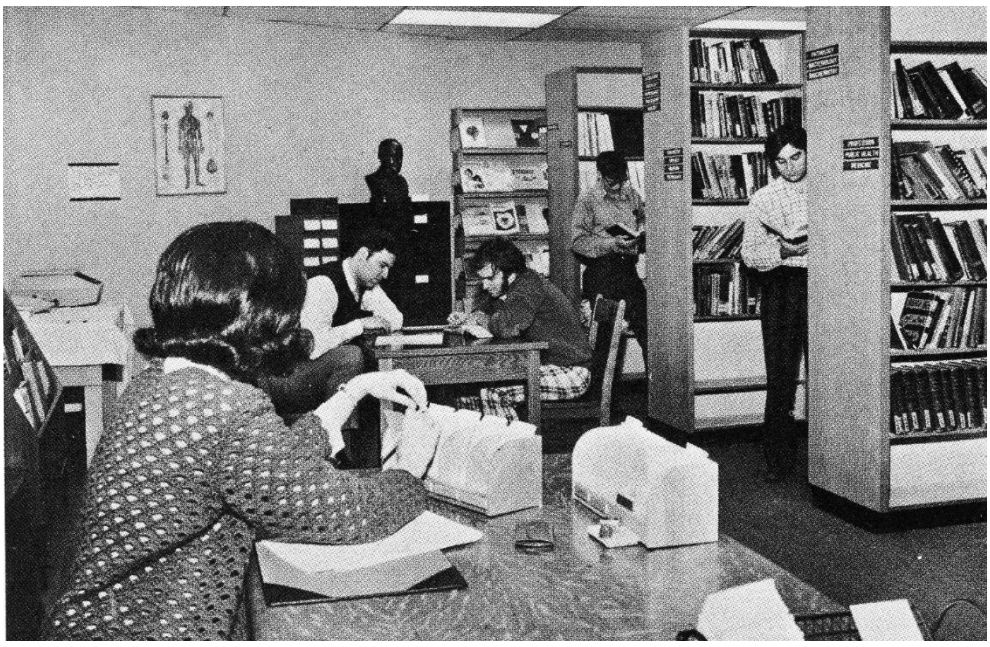

Figure 6.
CMCC Library in 1970s (source: JCCA. 1972; June –July; 22).

In November 1972, during the convention of the Ontario Chiropractic Association at a ceremony in the CMCC Library, the Library was named after Dr. Cecil Clemmer – the C.C. Clemmer Library – in appreciation for his many years of service to the chiropractic profession and a generous donation to the library. Dr. David A. Churchill, President of the Board of Directors of CMCC, made the presentation and both Dr. and Mrs. Cecil Clemmer offered words of appreciation.[12]

Also in 1972, Dr. Donald M. Berry, who was the chairman of the library committee wrote a report on the library for the Board of Directors. The library had 3,250 books of which over half were acquired since 1969, and 50 journal titles. Many rare books on chiropractic were part of this collection. The audiovisual collection was very small, consisting of a few records, some reel-to-reel programs and a few slides. In 1973, a professional library technician was hired for the first time, Diane Klein, followed by Valerie Keshavjee.

During the 1970s Dr. Lyman Johnston and Dr. David Drum were instrumental in producing a large collection of reel-to-reel videos illustrating various chiropractic techniques with prominent chiropractors, and proceedings of symposia held across Canada most notably on chiropractic principles.

CMCC was the first chiropractic college to recognize the need to establish a database on chiropractic research. Consequently, the first comprehensive collection of the chiropractic literature was undertaken in 1974. Published as Archives I in 1975, it was an attempt to index all chiropractic-related clinical and research information. The first editors were Drs. Ron Gitelman, G. Murdock, B. Embree and Gary Dyck. In the 1980s Dr. Gitelman, Dr. Adrian Grice and Claire Callaghan, the library director, developed a proposal for a database for the Archives. They renamed it "Chiropractic Research Archives Collection" or CRAC. CRAC included the original materials as published in ARCHIVES I, as well as an additional 2,000 abstracts. Produced by CMCC, this has been a collaborative effort with contributions from the Foundation for Chiropractic Education and Research (FCER), the Governors' Club of CMCC, and the Federal Government of Canada.[13]

By 1975 the library occupied three quarters of the fourth floor of the Henderson Building. The audiovisual department became an important component of the library operation and in 1976, for the first time, an audiovisual

Figure 7.
Dr. and Mrs. Cecil Clemmer
(source: CMCC Archives. JCCA. 1972; December; 9)

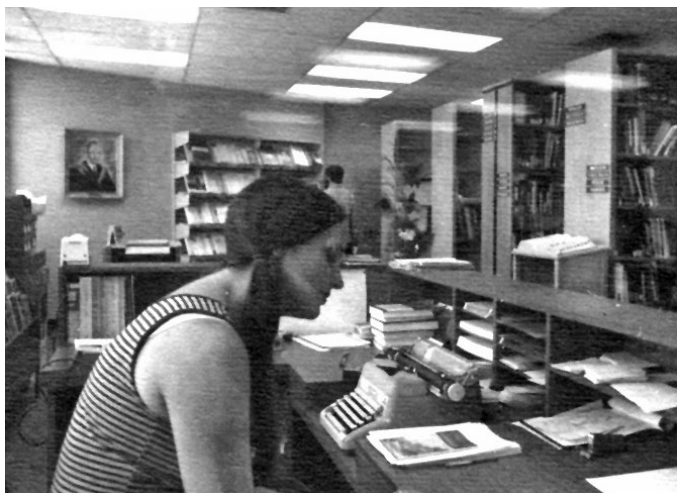

Figure 8.
Diane Klein, library technician
(source: Cornerstone. 1974; 11).

Figure 9.
Margaret Butkovic (source: CMCC Archives).

Figure 10.
New amphitheater (source: CMCC Archives).

librarian, Margaret Butkovic was hired to organize the equipment, start productions and build the AV collection.

In 1977 a three-phase plan for expansion of CMCC was started. Under phase one the library would be considerably enlarged. Renovations in the main library would provide more shelf space and more comfortable seating for students. Prior to opening the new facilities, library business was conducted from the "Mini-library" located in the small technique room.

In 1978, a new amphitheater was built with new equipment. By 1978 the library collection grew to 5,000 books and 173 journals, and had an extensive vertical file collection. For the first time the card catalogue became a reality, and the entire collection was recatalogued according to the NLM and LC classification scheme.[14]

In 1979, an endowment was left to CMCC from the estate of the late Dr. Cecil and Mrs. Myrtle Clemmer. Part of it was applied to increasing and improving both the library's holdings and its facilities. A 3M Tattle tape security system was installed in January 1980, and computer searching commenced on May 29, 1980.

In 1980 for the first time, CMCC hired a Director of Library Services, Claire Callaghan. In the 1980s the library staff comprised the director, technical services and reference librarians, an audiovisual librarian, a library assistant and two students who worked part-time. For the first time the librarians became active participants in the teaching/ learning process.

Figure 11.
Library and Media Services staff, 1980. (Left to right: Greta Algee, Bev Brown, Robin MacDonald, Margaret Butkovic, Dan McGinty, Karen Newman, Claire Callaghan (director) sitting) (source: CMCC Library report 1980. CMCC Archives).

Figure 12.
Dedication ceremony (Left to right: Dr. Al Adams, Hon. Dennis Timbrell, Dr. Don Sutherland, Ms. Claire Callaghan) (source: CMCC Archives).

On December 1, 1980 the CC Clemmer Library reopened under Claire Callaghan's leadership, and flourished in more spacious and attractive surroundings. The Library occupied the entire fourth floor of the Henderson building. For the first time, the library was a learning resource center in the truest sense. It contained 207 journals, 6,000 books and 250 audiovisual programs.[15]

The official dedication ceremony of the CC Clemmer Library took place during Homecoming 1981, and was dedicated by the Hon. Dennis Timbrell, Minister of Health, Province of Ontario.

The advent of computerized data bases, on-line retrieval and new resource sharing technologies enhanced the library's image. The library had access to two computer database systems, Medlars (Medical literature analysis retrieval system), and DIALOG that provided access to other databases. Excerpta Medica, Medline and Science Citation Index were useful databases for accessing health sciences information.[16]

On October 17, 1986 at the annual meeting of the Board of Governors on a recommendation of the Director of Library Services, the name of the library changed to CC Clemmer Health Sciences Library to better reflect its role and its holdings.[17]

In 1987 graphic programs enabled production of titles, slides and transparencies directly from the digitized images stored in the computer. For the first time, a series of computer aided instruction programs in basic sciences and physical examination were implemented. This was a first step in self-directed learning.

That same year the Governors' Club agreed to finance the making of video productions in the Chiropractic Heritage Series. Included were *Anatomy Series* featuring Dr. John Duckworth, *Diagnostic Series* featuring Dr. Lee Arnold, *Historical Series* featuring Drs. Herbert K. Lee and Earl Homewood and *Chiropractic Series* featuring Dr. Herbert K. Lee. In the late 1980s and the 1990s the library operated under the directorship of three different directors, Marilyn Schaefer, Marina Englesakis and Lori Anne Oja.

Figure 13.
Library staff in late 1980s. From left to right: M. Schafer (Director), D. McGinty, B. Brownstein, E. Zalezsak, K. Newman, G. Algee, M. Butkovic. Absent: R. MacDonald. (source: CMCC Archives).

Figure 14.
Campus at CNIB
(source: Cornerstone.1986; 9. CMCC Archives).

Figure 15.
Homecoming 1999. Class of 1949 at 50th anniversary celebration (source: CMCC Archives).

In 1994, when space became available at the Canadian National Institute for the Blind, across Bayview Avenue from CMCC which had expanded beyond what its facilities could hold, the library was relocated to its new home at 1931 Bayview. It occupied three floors. The first floor accommodated a large circulation desk, the technical services department, reference, media, the main reading room, current journals and offices. The student computer laboratory was on the third level, while the journal and book stacks, archives and silent study area were on the lower level.

In 1995 the library participated in the Centennial celebration of chiropractic and the 50th anniversary of CMCC providing historical materials and interviewing prominent members of the chiropractic profession.

In 1999 CMCC celebrated the 50th anniversary of its first graduating class, the Class of 1949. For that celebration and every year since, Margaret Butkovic, Margaret McCallen, the Media Services team, and later members of the Marketing and Communications team, have been involved in the annual production of a video titled *Celebration of Excellence* which highlights the 50th anniversary class. Through the production of these videos, we have been privileged to work with pioneers who have helped build CMCC and the chiropractic profession. The result is a video history of chiropractic and CMCC through the eyes of those who lived it.

Margaret Butkovic, the assistant director at the time, assumed the directorship in September 2000. A new position of collection development librarian/archivist was created with Steve Zoltai at the helm. Anne Taylor Vaisey was hired as a reference librarian. Throughout many years Anne, as a Co-Editor of the Index to Chiropractic Literature, has played on important role in sustaining and maintaining this valuable resource serving our students, chiropractors as well as other professions.

The 2000/2001 academic year started with the implementation of a new automation system, Graphical Library Automation System (GLAS), which enabled installation of the catalogue on the Internet. In the Reference area, access to all new databases created a need for more and newer computers. Through the library's web site clients were able to request a search, and document delivery and interlibrary loan services.

In 2002 the library moved back to the 1900 Bayview facility and stayed there until the move to the Leslie Street Campus. As soon as the building at 6100 Leslie Street was purchased, planning for the new library began. The librarians worked with the architects and had direct input into how the library would look and function. The move to the new facility, the design and arrangement of the furniture was supervised by the director.

The CMCC Health Sciences Library opened in August 2004. It is attractive, well designed, highly functional and is bright with its many windows and atrium glass providing an inviting place where students enjoy studying

Figure 16.
Museum in the library with chiropractic memorabilia (source: CMCC Archives. AV and Communications).

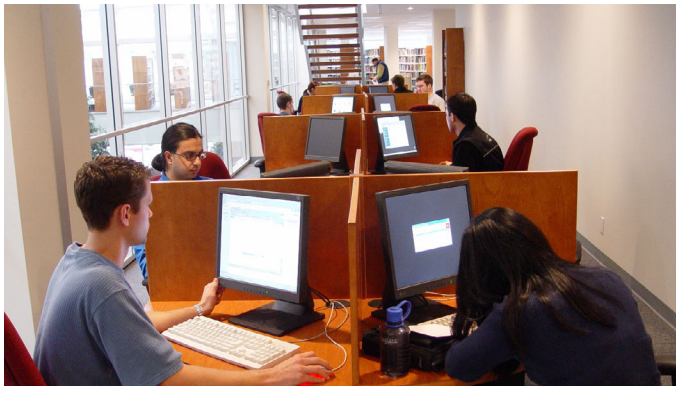

Figure 17.
Library reference computers (source: CMCC Archives. AV and Communications).

Figure 18.
Students in front of book stacks (source: CMCC Archives. AV and Communications).

and spending time with their colleagues. The 9,740 sq. ft. contains 37 computers in the public area, a computer laboratory with 10 computers, six study rooms, a media room, a Museum containing chiropractic memorabilia, an archives storage area, and a silent study area in the mezzanine with 40 study carrels. A meditation room was added in 2016.

The library archives, led by our archivist Steve Zoltai contain historical records of CMCC and the chiropractic profession in Canada and beyond. Over 1,500 photos and records have been uploaded on our Eloquent archives database which is publically accessible through our library web pages.[18] The library provides important service to CMCC members, including unlimited free document delivery, free research assistance and access to some of our electronic resources.

In 2011 the library became a member of the Health Sciences Information Consortium of Toronto, the first not publicly funded institution that has been accepted into the Consortium. The mission of the Consortium is to enhance resource sharing through the coordination of new technology and sharing information resources. Members now include University of Toronto Libraries, fully accredited teaching hospitals, and publicly and non-publicly funded institutions.

The current library collection consists of materials in print and online. Eighty percent of journals are online, and clients have access to a variety of records through 20 databases. Through the Discovery service we have access to thousands of online records.

Figure 19.
Students studying in a relaxed atmosphere (source: CMCC Archives. AV and Communications).

Figure 20.
Current and former library staff (left to right: Steve Zoltai, Deanne Collier, Kent Murnaghan, Anne Taylor-Vaisey, Todd Vasey, Margaret Butkovic (Director), Shabana Siddiqui) (source photo credit: Jay Bowes).

Looking into the future, technology continues to drive the direction in which the library is moving and mobile devices are changing the way information is delivered and accessed. The use of electronic databases and interactive media has created a shift in ways students are studying. Delivery of audio-visual materials has changed from traditional formats to online platforms. These changes are reflected in the library collection and services provided to our clients today.

Many early graduates comment that they wish that the resources we have now were available to them when they were students! CMCC's library has come a long way from its humble beginning to where it is today and has made a significant footprint in the development of CMCC. As we look into the future the Library will continue educating and training doctors of chiropractic, promoting research and continuing education.

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