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JCCA April 2022 Chiropractic Sciences Special Issue: 3rd Edition

JACC, Avril 2022 – Numéro spécial des sciences chiropratiques : 3e édition

Brynne E. Stainsby, BA, DC, FCCS(C)[1], Assistant Editor

(JCCA. 2022;66(1):6)

KEY WORDS: chiropractic, clinical

MOTS CLES : chiropratique, clinique

It is my great honour and privilege to present this third Chiropractic Sciences issue of the JCCA. This issue includes practical case reports, reviews and important original research papers covering a great breadth of topics. I hope the content presented in this issue helps to inform your clinical practice as well as future research endeavours for each of us as individuals and collectively as a profession.

The growth of research and scholarly activity in chiropractic in Canada has been fueled by dedicated researchers, Chiropractic Sciences Fellows, faculty members, residents, and students. I would like to thank Dr. Kent Stuber for his support of the ongoing Chiropractic Sciences edition, and his leadership through the JCCA. I would also like to thank all of the contributing authors and peer reviewers who have helped make the JCCA Chiropractic Sciences issue possible. I am so grateful to each of you for committing to read this important work and for working so hard to advance health care for our patients and all Canadians.

At the time of our inaugural edition, the world was in the early stages of a global pandemic and felt incredibly uncertain. As we move towards a hopeful future, we have the opportunity to reflect on the lessons we have learned during these challenging times. We have seen the importance of allowing research to progress and inform our decisions and policies. I believe that the world and our profession are better when we allow ourselves to evolve as we learn more. I am reminded of Maya Angelou's beautiful words: "Do the best you can until you know better. Then when you know better, do better." I hope this issue of the JCCA allows you to learn and grow.

I encourage you to get involved in research. Be inquisitive and ask questions. If you have an interesting case, set of data or research ideas or questions that you would like to further investigate and need any help, please do not hesitate to contact me, one of the JCCA's Editorial Board members, or a member of the College of Chiropractic Sciences (Canada).

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Risk of bias in chiropractic mixed methods research: a secondary analysis of a meta-epidemiological review

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Objective: *To examine the risk of bias in chiropractic mixed methods research*.

Methods: *We performed a secondary analysis of a meta-epidemiological review of chiropractic mixed*

Risque de biais dans la recherche sur les méthodes mixtes chiropratiques : une analyse secondaire d'un examen méta-épidémiologique.

Objectif : *examiner le risque de biais dans la recherche sur les méthodes mixtes chiropratiques*.

Méthodologie : *nous avons effectué une analyse*

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methods studies. We assessed risk of bias with the Mixed Methods Appraisal Tool (MMAT) and used generalized estimating equations to explore factors associated with risk of bias.

Results: *Among 55 eligible studies, a mean of 62% (6.8 [2.3]/11) of MMAT items were fulfilled. In our adjusted analysis, studies published since 2010 versus pre-2010 (adjusted odds ratio [aOR] = 2.26; 95% confidence interval [CI], 1.39 to 3.68) and those published in journals with an impact factor versus no impact factor (aOR = 2.21; 95% CI, 1.33 to 3.68) were associated with lower risk of bias.*

Conclusion: *Our findings suggest opportunities for improvement in the quality of conduct among published chiropractic mixed methods studies. Author compliance with the MMAT criteria may reduce methodological bias in future mixed methods research.*

(JCCA. 2022;66(1):7-20)

KEY WORDS: methodological review, risk of bias, mixed methods research, chiropractic

secondaire d'un examen méta-épidémiologique d'études de méthodes mixtes chiropratiques. Nous avons examiné le risque de biais avec The Mixed Methods Appraisal Tool, MMAT (l'outil d'évaluation des méthodes mixtes), et utilisé des équations d'estimation généralisées pour explorer les facteurs associés au risque de biais.

Résultats : *parmi 55 études admissibles, une moyenne de 62 % (6,8 [2,3]/11) des items du MMAT ont été remplis. Dans notre analyse ajustée, les études publiées depuis 2010 versus celles d'avant 2010 (rapport de cotes [aOR] ajusté = 2,26; intervalle de confiance [IC] à 95 %, 1,39 à 3,68), et celles publiées dans des revues avec un indice de citations versus aucun indice de citations (aOR = 2,21; IC à 95 %, 1,33 à 3,68) étaient associées à un risque de biais plus faible.*

Conclusion : *nos résultats suggèrent des opportunités d'amélioration de la qualité de la conduite parmi les études publiées sur les méthodes mixtes chiropratiques. La conformité des auteurs aux critères MMAT peut réduire les biais méthodologiques dans les futures recherches sur les méthodes mixtes.*

(JCCA. 2022;66(1):7-20)

mots clés : examen méthodologique, risque de biais, recherche par méthodes mixtes, chiropratique

Introduction

Mixed methods research involves combining quantitative and qualitative approaches in a single study. With multiple methods of data collection and analysis, research questions are answered with a greater breadth and depth of understanding than what could be achieved with only a quantitative or qualitative approach.[1-4] As such, the use of mixed methods designs in research involving the chiropractic[5] and allied health care professions[1,2] has increased in recent years. For instance, in the PubMed database alone, there has been an exponential rise in the number of "mixed methods" articles published since 2001 (Figure 1). However, despite the added value of mixed methods approaches, these studies can become complex investigations requiring additional time and resources and a research team with expertise in quantitative, qualitative, and mixed methodologies.[1,2]

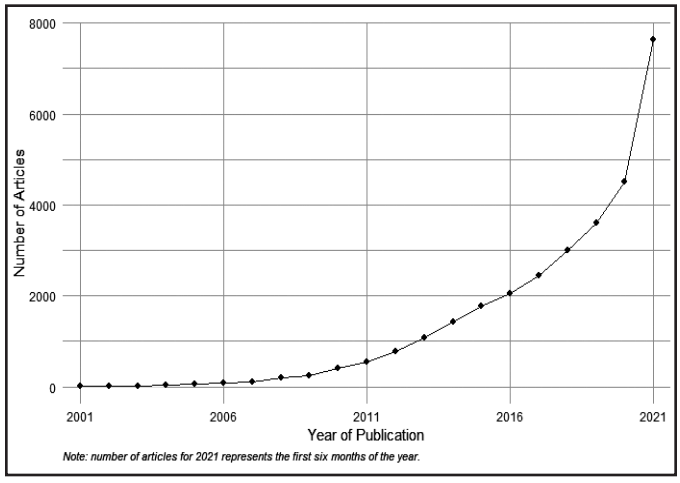


Figure 1.
Frequency of "mixed methods" articles published over the last 20 years in PubMed.

The explicit mixing or linking of qualitative and quantitative approaches within a mixed methods study is particularly useful for assessing multilevel programs and interventions[3,6-8], and is therefore a methodology well-suited to address research problems in health professions including chiropractic. For example, Maiers *et al*.[9] used a multistage, experimental mixed methods design[2], where interviews (qualitative) were conducted to help explain differences in outcomes (quantitative) in a randomized controlled trial of elderly patients with chronic neck pain. The four main types of study designs used in mixed methods research, namely convergent, explanatory sequential, exploratory sequential, and complex / multistage, are described in Table 1.

Previous methodological reviews have examined the mixed methods literature in healthcare fields outside chiropractic[10,11] and have highlighted areas for improvement. One review[10] of complementary and alternative medicine literature (excluding studies on chiropractic) found that most mixed methods studies did not contain adequate details on qualitative analysis, or quantitative and qualitative sampling and recruitment procedures. To date, no reviews have investigated the extent of methodological bias among published mixed methods studies involving chiropractic research. To address this knowledge gap, we undertook a secondary analysis of a meta-epidemiological review of reporting quality in chiropractic mixed methods research[5] to examine the risk of bias among chiropractic mixed methods studies. Methodological bias is a serious threat to the internal validity of studies and limits the strength of inferences generated from primary research. As such, our findings will inform areas for improvement regarding the methodological quality of chiropractic research employing mixed methods designs.

Methods

Reporting

Our review is reported in accordance with an adapted version of the PRISMA (Preferred Reporting Items for

Table 1.
Types of mixed methods study designs.[1,2]

Study design	Description [a]
Convergent	A mixed methods design in which the researcher collects and analyzes two separate databases – quantitative and qualitative – and then merges the two for the purpose of comparing the results or adding transformed qualitative data as numeric variables into the quantitative database.
Explanatory sequential	A two-phase mixed methods design in which the researcher starts with the collection and analysis of quantitative data, which is then followed by the collection and analysis of qualitative data to help explain the initial quantitative results.
Exploratory sequential	A three-phase mixed methods design in which the researcher starts with the collection and analysis of qualitative data, which is then followed by a design phase of translating the qualitative findings into an approach or tool that can be tested quantitatively. Then, in the third phase, this approach or tool is tested quantitatively. This means that the approach or tool will be grounded in the views of participants.
Complex / multistage	
1. Experimental (or intervention)	A complex mixed methods approach in which the researcher combines the collection and analysis of both quantitative and qualitative data and integrates the information within an experimental quantitative research design.
2. Case study	A type of complex mixed methods study in which both quantitative and qualitative data collection and their results are used to develop a case or multiple cases for further analysis and comparisons.
3. Participatory-social justice	A type of complex mixed methods design in which the researcher adds a core design (i.e., convergent, explanatory sequential, or exploratory sequential) to a theoretical framework.
4. Evaluation	A type of complex mixed methods design in which one or more core designs (i.e., convergent, explanatory sequential, exploratory sequential) are added into the steps of an evaluation procedure.

[a] Source: adapted from Creswell JW, Plano Clark VL. Designing and Conducting Mixed Methods Research. 3rd ed. Thousand Oaks, CA: Sage 2018.

Systematic Reviews and Meta-Analyses) guidelines for meta-epidemiological research.[12]

Information sources

In line with our published protocol[5], we searched the Medical Literature Analysis and Retrieval System Online (MEDLINE), the Excerpta Medica Database (EMBASE), the Cumulative Index to Nursing and Allied Health Literature (CINAHL), and the Index to Chiropractic Literature (ICL) to identify all published chiropractic mixed methods studies from database inception to December 31, 2020. An academic librarian (RJC) assisted with the development of our search strategy (Online Supplementary File 1).[5] We also hand-searched the reference lists of eligible articles and contacted two mixed methods experts to identify any additional citations. The eligibility criteria for our review are listed in Table 2.

Study selection

Two independent reviewers (PCE, CC) screened titles and abstracts of identified citations, and full texts of potentially eligible studies. Disagreements were resolved by discussion or, when needed, with the help of an adjudicator (KJS). We used online systematic review software (DistillerSR, Evidence Partners, Ottawa, Canada; https://www.evidencepartners.com) to facilitate literature screening.

Data extraction and assessment of risk of bias

Pairs of reviewers (PCE, KJS, PSN, JVN, CAB) independently extracted data and assessed risk of bias of included articles using standardized, pilot-tested data extraction forms.[5] Discrepancies were resolved by discussion to achieve consensus or, if needed, adjudication by a third reviewer with expertise in mixed methods (PCE, KJS, LM, or MO). We extracted the following information from all eligible studies: (1) first author, (2) number of authors, (3) journal name, (4) year of publication, (5) country where the study was conducted (or country of residence of the corresponding author when the country of conduct was unavailable or when the study was international), (6) type of mixed methods design, and (7) inclusion of a methodologist among the authors (rated as "yes," "no," or "unclear/not reported").

We defined a methodologist as a contributing author with training in qualitative and/or mixed methods research, public health, epidemiology, health technology assessment, health services research, knowledge translation/implementation science, or biostatistics. The involvement of a methodologist was determined by examining each article for authors' qualifications or affiliations and information reported in the methodology section. In instances where authorship reporting of methodological expertise was "unclear or not reported," we used a conservative approach and combined these counts with the "no" responses. When available, we also obtained the impact factor at the time of publication for each journal in which an eligible study was published, either directly from the journal's website or from the Journal Citation Report (https://jcr.clarivate.com/).

We assessed risk of bias of included articles using the Mixed Methods Appraisal Tool (MMAT).[13,14] The MMAT

Table 2.
Article inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
1. Published in English in a peer-reviewed journal;	1. Study protocols, letters, editorials, or commentaries;
2. Authored by one or more chiropractic researchers;	2. Case reports or series;
3. Was an empirical study reporting primary data collection;	3. Books and book chapters;
4. Involved any type of chiropractic research (e.g., therapeutic, educational, policy, or scope of practice); and	4. Grey literature (e.g., conference proceedings, abstracts, lectures, dissertations or unpublished manuscripts); and
5. Reported the use of both qualitative and quantitative methods, or mixed qualitative methods, in the same research study.[a]	5. Secondary sources of evidence, including clinical practice guidelines, systematic, scoping or narrative reviews.

[a] 'Mixed' surveys (i.e., those with both closed- and open-ended questions) were only included if the use of "mixed methods" was explicitly stated in the title or abstract.

(version 2011) has been validated as a quality appraisal tool for systematic reviews of mixed studies (i.e., qualitative, quantitative, and mixed methods studies).[14] This tool is comprised of two screening items for mixed methods research, followed by 11 appraisal items in three sections, including: (1) four items on the qualitative component, (2) four items on the quantitative component (i.e., randomized controlled, non-randomized, or descriptive), and (3) three items on mixed methods.

Reviewers independently evaluated the risk of bias of all selected articles with the MMAT, on an item-by-item basis, rating each item with a "yes" (if the item was addressed), "can't tell/partial" (if the item was partially addressed), or "no" (if the item was not addressed).[14,15] Before assessing the risk of bias of articles, reviewers completed the online tutorial by Pluye *et al*.[15] to rate MMAT items. We assigned a score for each of the eleven items as follows: 1 = "yes"; 0.5 = "can't tell/partial"; 0 = "no", for a total score ranging from 0 to 11.

Synthesis of results

Agreement on full-text screening was assessed using the adjusted kappa ($\varkappa$) statistic.[16] Values of 0 to 0.20 represented slight agreement, 0.21 to 0.40 represented fair agreement, 0.41 to 0.60 represented moderate agreement, 0.61 to 0.80 represented substantial agreement, and greater than 0.80 represented almost perfect agreement. For the purpose of analysis, studies reporting quantitative and qualitative results in separate papers were combined and considered as a single article. We summarized article characteristics and MMAT score data across included studies using mean and standard deviation (SD) for continuous variables that were normally distributed, and median and inter-quartile range (IQR) for continuous variables that were not. All distributions were analyzed for normality by examining the data histograms, probability and quantile-quantile plots, and the Kolmogorov-Smirnov test.

We built a generalized estimating equation (GEE) to explore the association between risk of bias and article characteristics including publication date, authorship, and journal impact factor. Based on previous literature[17,18], we hypothesized that studies published since 2010 (i.e., ≥ 1 year after the first publication of the MMAT criteria[13]), studies published in journals with an impact factor, those with a greater number of authors, and those that included a methodologist would be associated with lower risk of bias.

We modelled our dependent variable as the number of MMAT items addressed in each article (maximum value of eleven) divided by the total number of MMAT items (eleven), and used the 'events/trials' function in SPSS to generate a binary outcome. We regressed the dependent variable on the year of article publication (2010 and later versus pre-2010), availability of a journal impact factor (yes versus no), number of authors (higher versus lower), and inclusion of a methodologist (yes versus no). These factors have previously been shown to be associated with reported methodological quality.[17,18] We dichotomized author number at the median value (four) calculated across included studies. In our original protocol[5], we planned to explore inclusion of a mixed methodologist as an independent variable; however, we modified our approach because most studies did not clearly report mixed methodological expertise.

For our GEE, we employed a binomial distribution and logit link function to generate a crude and adjusted odds ratio (OR), and a 95% confidence interval (CI) and corresponding *p*-value, for each independent variable. We assessed goodness-of-fit by comparing our model's deviance to its degrees of freedom and by examining the associated residual plot. We addressed over- or under-dispersion by re-running our model with a scale parameter calculated by dividing the deviance by its degrees of freedom. To account for potential clustering or similarity of articles published in the same journal, we assumed an exchangeable working correlation matrix and specified the journal name as a grouping factor.

A minimum sample of 40 chiropractic mixed methods articles was required to guard against over-fitting of our regression model (i.e., minimum of 10 observations per independent variable).[19] We also explored variance inflation factors (VIFs) to assess for multicollinearity among independent variables, and considered a VIF ≥ 10 as problematic.[20] The two-sided statistical significance level (α) was 5%, and all data and comparative analyses were performed using SPSS v26.0 (IBM SPSS Statistics©).

Results

We identified 1,040 citations, and 65 articles met our eligibility criteria for review. Ten studies reported quantitative and qualitative results in separate articles. As such, 55

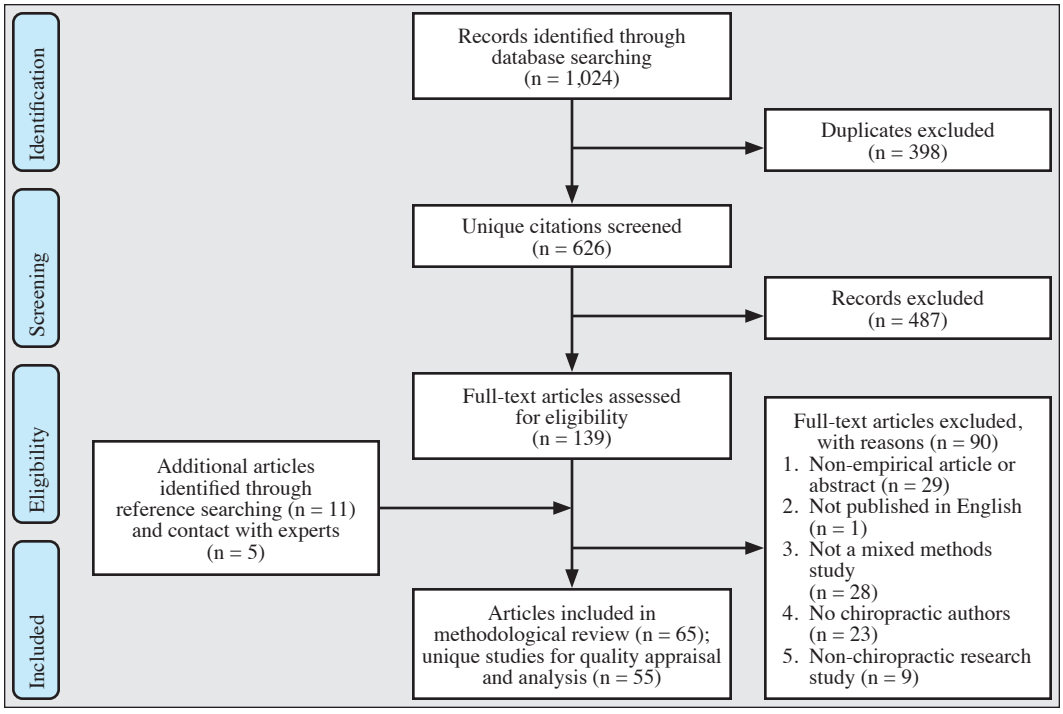


Figure 2.
Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.

unique mixed methods studies were analyzed (Figure 2). There was substantial agreement at the full-text screening stage between reviewers ($\kappa = 0.70$).

Study characteristics

Of the 55 eligible studies, most (80%) were conducted in, or had corresponding authors from, three countries – the United States, Canada, or Australia; over half (53%) had four or fewer authors and three-quarters (75%) were published after 2010 (Table 3). Two-thirds of studies employed a complex/multistage (34%) or convergent (33%) mixed methods design, and the remainder used sequential explanatory (20%) or exploratory (13%) designs. Over half of eligible studies (29 of 55; 53%) were published in journals that had an impact factor (median impact factor at the time of publication = 1.9 [IQR: 1.2 to 2.6]) and just under half (25 of 55; 45%) included a methodologist among their authors.

Risk of bias of included studies

Referring to the eleven MMAT criteria, items pertaining to qualitative data (i.e., archives, documents, informants, observations) (89%); the qualitative analysis (86%); the mixed methods design, in terms of its relevance to ad-

Table 3.
Characteristics of the 55 included studies.

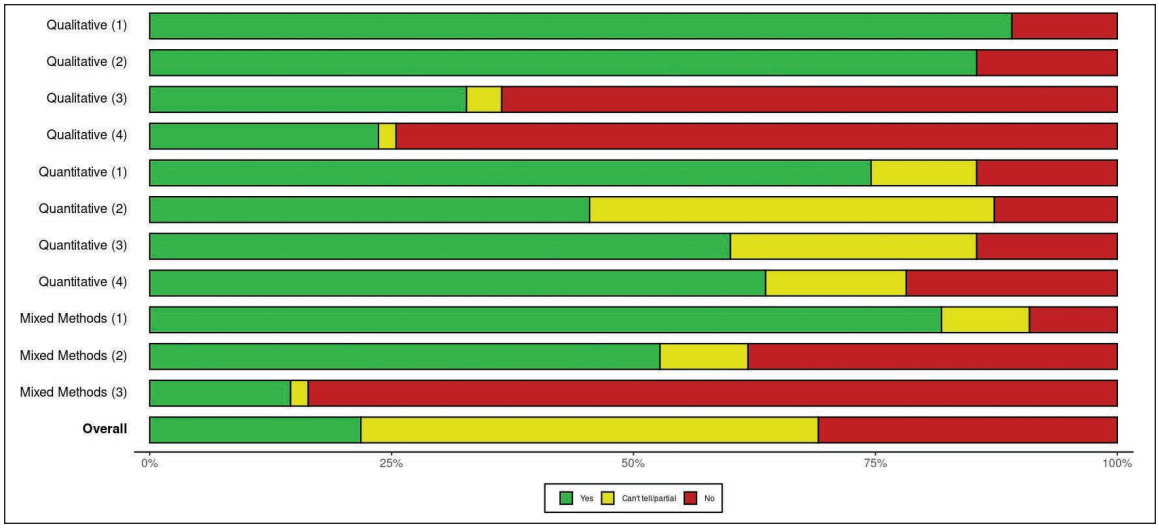
Study characteristic	Category	n (%)
Year of publication	Pre-2010	14 (25.5)
	Post-2010	41 (74.5)
Number of authors [a,b]	≤ 4	29 (52.7)
	> 4	26 (47.3)
Country	USA	28 (50.9)
	Canada	10 (18.2)
	Australia	6 (10.9)
	Other [c]	11 (20.0)
Mixed methods design	Complex / multistage	19 (34.6)
	Convergent	18 (32.7)
	Explanatory sequential	11 (20.0)
	Exploratory sequential	7 (12.7)
Methodologist	Yes	25 (45.5)
	No/unclear [d]	30 (54.5)
Journal impact factor	Yes	29 (52.7)
	No	26 (47.3)

USA = United States of America.
[a] Average values were used when studies reported quantitative and qualitative results in separate articles.
[b] The cut-off point for author number was derived from the median value measured across eligible studies.
[c] Included studies from Denmark (n = 3), United Kingdom (n =3), Switzerland (n = 2), Germany (n = 1), South Africa (n = 1), and Sweden (n = 1).
[d] Inclusion of a methodologist was "unclear" in 15 (27.3%) of the 55 included studies.

Table 4.
Risk of bias of the 55 eligible studies according to the Mixed Methods Appraisal Tool (MMAT), version 2011.[15]

MMAT Item	Description	Risk of Bias Score and Percentage of Studies (n = 55) fulfilling each MMAT Item	
		Score (0-55) [a]	Percentage
1. Qualitative	Are sources of qualitative data (archives, documents, informants, observations) relevant to address the research question (objective)?	49.0	89.1%
2. Qualitative	Is the process for analyzing qualitative data relevant to address the research question (objective)?	47.0	85.5%
3. Qualitative	Is appropriate consideration given to how findings relate to the context, e.g., the setting, in which the data were collected?	19.0	34.5%
4. Qualitative	Is appropriate consideration given to how findings relate to researchers' influence, e.g., through their interactions with participants?	13.5	24.5%
5. Quantitative	a) *Randomized controlled (trials)*: Is there a clear description of the randomization (or an appropriate sequence generation)? b) *Non-randomized*: Are participants (organizations) recruited in a way that minimizes selection bias? c) *Descriptive*: Is the sampling strategy relevant to address the quantitative research question (quantitative aspect of the mixed methods question)?	44.0	80.0%
6. Quantitative	a) *Randomized controlled (trials)*: Is there a clear description of the allocation concealment (or blinding when applicable)? b) *Non-randomized*: Are measurements appropriate (clear origin, or validity known, or standard instrument; and absence of contamination between groups when appropriate) regarding the exposure/intervention and outcomes? c) *Descriptive*: Is the sample representative of the population under study?	36.5	66.4%
7. Quantitative	a) *Randomized controlled (trials)*: Are there complete outcome data (80% or above)? b) *Non-randomized*: In the groups being compared (exposed vs. non-exposed; with intervention vs. without; cases vs. controls), are the participants comparable, or do researchers take into account (control for) the difference between these groups? c) *Descriptive*: Are measurements appropriate (clear origin, or validity known, or standard instrument)?	40.0	72.7%
8. Quantitative	a) *Randomized controlled (trials)*: Is there low withdrawal/drop-out (below 20%)? b) *Non-randomized*: Are there complete outcome data (80% or above), and, when applicable, an acceptable response rate (60% or above), or an acceptable follow-up rate for cohort studies (depending on the duration of follow-up)? c) *Descriptive*: Is there an acceptable response rate (60% or above)?	39.0	70.9%
9. Mixed Methods	Is the mixed methods research design relevant to address the qualitative and quantitative research questions (or objectives), or the qualitative and quantitative aspects of the mixed methods question (or objective)?	47.5	86.4%
10. Mixed Methods	Is the integration of qualitative and quantitative data (or results) relevant to address the research question (objective)?	31.5	57.3%
11. Mixed Methods	Is appropriate consideration given to the limitations associated with this integration, e.g., the divergence of qualitative and quantitative data (or results) in a triangulation design?	8.5	15.5%
		Risk of Bias Score and Percentage of Studies (n = 55) fulfilling all 11 MMAT Items	
		2.0	3.6%

MMAT = Mixed Methods Appraisal Tool. [a] Count scores are summed as 1 = "yes"; 0.5 = "can't tell/partial"; and 0 = "no".



Legend:

Qualitative (1):
Are sources of qualitative data (archives, documents, informants, observations) relevant to address the research question (objective)?

Qualitative (2):
Is the process for analyzing qualitative data relevant to address the research question (objective)?

Qualitative (3):
Is appropriate consideration given to how findings relate to the context, e.g., the setting, in which the data were collected?

Qualitative (4):
Is appropriate consideration given to how findings relate to researchers' influence, e.g., through their interactions with participants?

Quantitative (1):
a) *Randomized controlled (trials)*: Is there a clear description of the randomization (or an appropriate sequence generation)?
b) *Non-randomized*: Are participants (organizations) recruited in a way that minimizes selection bias?
c) *Descriptive*: Is the sampling strategy relevant to address the quantitative research question (quantitative aspect of the mixed methods question)?

Quantitative (2):
a) *Randomized controlled (trials)*: Is there a clear description of the allocation concealment (or blinding when applicable)?
b) *Non-randomized*: Are measurements appropriate (clear origin, or validity known, or standard instrument; and absence of contamination between groups when appropriate) regarding the exposure/intervention and outcomes?
c) *Descriptive*: Is the sample representative of the population under study?

Quantitative (3):
a) *Randomized controlled (trials)*: Are there complete outcome data (80% or above)?
b) *Non-randomized*: In the groups being compared (exposed vs. non-exposed; with intervention vs. without; cases vs. controls), are the participants comparable, or do researchers take into account (control for) the difference between these groups?
c) *Descriptive*: Are measurements appropriate (clear origin, or validity known, or standard instrument)?

Quantitative (4):
a) *Randomized controlled (trials)*: Is there low withdrawal/drop-out (below 20%)?
b) *Non-randomized*: Are there complete outcome data (80% or above), and, when applicable, an acceptable response rate (60% or above), or an acceptable follow-up rate for cohort studies (depending on the duration of follow-up)?
c) *Descriptive*: Is there an acceptable response rate (60% or above)?

Mixed Methods (1):
Is the mixed methods research design relevant to address the qualitative and quantitative research questions (or objectives), or the qualitative and quantitative aspects of the mixed methods question (or objective)?

Mixed Methods (2):
Is the integration of qualitative and quantitative data (or results) relevant to address the research question (objective)?

Mixed Methods (3):
Is appropriate consideration given to the limitations associated with this integration, e.g., the divergence of qualitative and quantitative data (or results) in a triangulation design?

Figure 3.

Summary of risk of bias assessments of the 55 eligible studies according to the Mixed Methods Appraisal Tool (MMAT), version 2011.[15] Overall judgements are based on methods by Pluye et al.[15] (Risk-of-bias plot was created using: McGuinness LA, Higgins JPT. Risk-of-bias VISualization (robvis): An R package and Shiny web app for visualizing risk-of-bias assessments. Res Syn Meth. 2020; 1-7.)

dressing the research questions (86%); and the quantitative randomization, recruitment, or sampling procedures (for randomized, non-randomized, or descriptive study components, respectively) (80%) were commonly addressed. Authors' descriptions of the integration of qualitative and quantitative data (57%); how qualitative findings related to the context (e.g., the setting, in which the data were collected) (36%) or to the researchers' influence (e.g., through their interactions with participants) (26%); and specific limitations arising from the integration of qualitative and quantitative components (16%) were the most poorly addressed items (Table 4). Only two (4%) of the 55 studies met all eleven MMAT criteria for methodological quality in mixed methods research. Six studies (11%) met ten criteria, 11 studies (20%) met at least eight criteria, and most studies (36 of 55; 65%) met seven criteria or less.

The mean (SD) number of the eleven MMAT items fulfilled across studies was 6.8 (2.3). The Kolmogorov-Smirnov test was not significant for the frequency of item scores on the MMAT instrument ($p = 0.173$), confirming the approximation to a normal distribution. See Figure 3 and Appendix 1 for summaries of the risk of bias scores for the 55 included studies.

Table 5.
Unadjusted and adjusted odds ratios for the proportion of Mixed Methods Appraisal Tool (MMAT) items fulfilled among the 55 eligible studies.

Factor		Unadjusted OR (95% CI)	*P*-value	Adjusted OR (95% CI)	*P*-value
Year of publication					
1.	Post-2010	2.64 (1.60-4.34)	< 0.001	2.26 (1.39-3.68)	0.001
2.	Pre-2010	Reference		Reference	
Journal impact factor					
1.	Yes	2.23 (1.45-3.44)	< 0.001	2.21 (1.33-3.68)	0.002
2.	No	Reference		Reference	
Number of authors [a]					
1.	> 4	2.01 (1.29-3.14)	0.002	1.20 (0.76-1.91)	0.441
2.	≤ 4	Reference		Reference	
Inclusion of methodologist					
1.	Yes	1.64 (1.03-2.60)	0.036	0.79 (0.48-1.31)	0.355
2.	No/unclear	Reference		Reference	

CI = confidence interval, *OR* = odds ratio.
[a] This factor was dichotomized at the median value (i.e., 4), calculated across eligible studies.

Factors associated with risk of bias

In our univariate GEE analyses, studies published since 2010 (OR = 2.64; 95% CI, 1.60 to 4.34), studies published in journals with an impact factor (OR = 2.23; 95% CI, 1.45 to 3.44), those that included more than four authors (OR = 2.01; 95% CI, 1.29 to 3.14), and those that had a methodologist among the study team (OR = 1.64; 95% CI, 1.03 to 2.60) were associated with lower risk of bias (Table 5). In our multivariable GEE analysis, we found that studies published since 2010 (adjusted OR = 2.26; 95% CI, 1.39 to 3.68) and those published in journals with an impact factor (adjusted OR = 2.21; 95% CI, 1.33 to 3.68) remained associated with lower risk of bias (Table 5). As a sensitivity analysis (not reported), we ran the same model but with author number included as a continuous variable rather than a dichotomous variable and this did not change the results. All VIFs were less than 1.9, suggesting no important multicollinearity among the independent variables.

Discussion

Summary of main findings

The methodological quality among chiropractic mixed methods studies published in the biomedical and allied health literature is suboptimal. According to the MMAT[14,15], an average of only 60% of the quality criteria in mixed methods research were addressed across the 55 eligible studies. Considerations of reflexivity (i.e., the impact of research setting, or of the researchers themselves, on the qualitative methods and/or findings), as well as the limitations of combining qualitative and quantitative methods, were poorly addressed in approximately 75% of articles. Forty percent of studies also failed to either provide adequate details about allocation concealment, instrument validation, or assessment of selection bias (for studies that employed randomized, non-randomized, or descriptive quantitative components, respectively), or describe the mixing or integration of quantitative and qualitative methods. In addition, follow-up or response rates were inadequate in one-third of studies (see Table 4 for follow-up/response rate thresholds) and a similar number that employed non-randomized or descriptive study components used non-standardized outcome measures. Of the 55 eligible studies, only 4% addressed all eleven MMAT criteria.

Comparison with relevant literature

Our findings are consistent with the results of meth-

odological reviews of mixed methods research in other healthcare fields, including complementary and alternative medicine[10] and nursing[11]. Similar to our findings, the methodological rigour of many of the mixed methods studies in these reviews was found to be unsatisfactory across various MMAT domains. As most journals have yet to adopt mixed methods quality appraisal guidelines[5,15], authors of chiropractic mixed methods studies have not been required to comply with published methodological standards[13-15]. However, with the growing number of mixed methods studies being published within the chiropractic profession in recent years, the findings of our review indicate a need to improve the methodological quality in chiropractic mixed methods research.

In our adjusted analysis, we found that publications in journals with an impact factor and those published in 2010 or later were more than twice as likely to have reported the incorporation of stronger methodological rigour in their mixed methods compared to publications in journals without an impact factor or those published before 2010. Associations between study quality and journal impact factor or year of publication have also been reported in previous reviews.[17,18] It is possible that authors of chiropractic mixed methods studies, particularly those who submit articles to higher impact journals, are increasingly using available risk of bias tools and methodological guidelines to assist in the conduct and reporting of their research. In contrast with previous research[17,18], we did not find a statistically significant association between lower risk of bias and a higher number of authors or inclusion of methodologists. However, methodological scope was broadened in our review to include additional areas of methodological expertise such as qualitative research, epidemiology, or statistics because most studies did not clearly report the inclusion of a mixed methodologist. As mixed methods research requires specialized skills in qualitative and quantitative data integration and analysis[1-4], reporting of mixed methodological expertise would ideally be examined in future studies. Despite our lack of finding a significant association, chiropractors conducting mixed methods studies may wish to undertake training in mixed methods research or collaborate with researchers possessing expertise in mixed methods. Details on the inclusion of mixed methodologists should also be made explicit in future publications.

Strengths and limitations

Our review methodology has several strengths.[5] First, we conducted a comprehensive search to identify all eligible studies involving chiropractic mixed methods research. Second, we specified the anticipated direction of association for each independent variable in our regression models *a priori* to give reassurances that significant associations were unlikely to be spurious. Third, we controlled for between-group differences when exploring associations and used GEE modelling to account for hierarchical clustering of articles within journals. Fourth, we performed article screening, data extraction and quality appraisals in duplicate, and all reviewers underwent training in the assessment of MMAT items.

A limitation of our review is we may not have accounted for all important variables (e.g., country of authorship), or interactions between variables[18], relevant to the methodological quality of chiropractic mixed methods research. In addition, the 'methodologist' variable as we defined it does not guarantee training in mixed methods. We originally intended to explore the inclusion of a mixed methodologist as an independent factor, but only one of the 55 included studies in our review provided this level of detail. The risk of bias assessments in our review were also limited by the reporting quality of included studies. For instance, some methodologic safeguards may have been implemented by authors but unreported[21], possibly due to journal restrictions of mixed methods manuscript word counts[18,22], and some methodologic safeguards that were reported may not have been implemented[23]. Another limitation of our review is the exclusion of non-English publications, which may have led to selection bias.

Implications for authors and chiropractic journals

To reduce the risk of bias in chiropractic mixed methods research, authors of such studies should be required by journal editors to comply with the MMAT criteria.[15] Compliance with critical appraisal guidelines has been associated with reduced methodological bias in research studies[17,18], particularly if authors are required to meet these standards as a condition of submission. Therefore, editorial review boards of journals within the chiropractic profession could play an important role in improving the quality of conduct in chiropractic mixed methods studies by incorporating mixed methods appraisal tools, such as the MMAT checklist[15], into the peer review process. For

example, the MMAT could be a supplementary review checklist, completed by peer reviewers, for each mixed methods journal submission (see MMAT version 2011 checklist in Online Supplementary File 2).[15] Editors of chiropractic journals could highlight the MMAT in their online submission instructions to peer reviewers and prospective authors, and cite well-conducted mixed methods studies involving chiropractic research (e.g., Maiers *et al*.[9], Evans *et al*.[24]) to serve as exemplars of good methodological quality. Chiropractic journals should also ensure they have at least one mixed methodologist on their editorial board.

Conclusion

Despite a reduction in the risk of bias among chiropractic mixed methods studies in recent years, our findings suggest there is room for improvement. Adoption and utilization of the MMAT criteria by chiropractic journals is one strategy that may reduce methodological bias in future mixed methods studies.

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Appendix 1.

Article characteristics and Mixed Methods Appraisal Tool (MMAT) item scores for the individual and combined 55 chiropractic mixed methods studies.

First author	Year of publication	Journal	IF at year of publication	MMAT score n = 0-11 (%)
Jamison	1996	Chiropr Tech	NA	1.5 (13.6)
Peterson	1996	J Manipulative Physiol Ther	NA	4 (36.4)
Jamison	1998	Chiropr J Aust	NA	3.5 (31.8)
Perle	1999	J Chiropr Educ	NA	5.5 (50.0)
Waalen	2000	J Chiropr Educ	NA	2 (18.2)
Ammendolia	2002	J Manipulative Physiol Ther	1.041	4.5 (40.9)
Evans/Bronfort	2003/2004	J Manipulative Physiol Ther	0.950/0.457	10 (90.9)
Russell/Page	2004/2006	Vaccine/J Manipulative Physiol Ther	2.824/0.918	8 (72.7)
Pincus	2006	Eur J Pain	3.333	5.5 (50.0)
Evans	2007	J Am Chiropr Assoc	NA	6 (54.6)
Spegman	2007	J Chiropr Educ	NA	6 (54.6)
Garner	2008	Explore (NY)	0.712	5 (45.5)
Rowell	2008	J Manipulative Physiol Ther	1.102	4 (36.4)
Talmage	2009	J Chiropr Med	NA	2 (18.2)
Jones-Harris	2010	Chiropr Man Therap	NA	10 (90.9)
Bronfort/Haanstra	2011/2013	Spine J/Eur Spine J	3.290/2/437	10 (90.9)
Smith	2012	J Manipulative Physiol Ther	1.647	6 (54.6)
Evans	2012/2014	Spine/Eur Spine J	2.159/2.066	11 (100)
Khorsan	2013	Evid Based Complement Alternat Med	2.175	5.5 (50.0)
Palmgren	2013	J Chiropr Educ	NA	8.5 (77.3)
Pohlman	2013	J Chiropr Educ	NA	4.5 (40.9)
Wong	2013	J Can Chiropr Assoc	NA	5 (45.5)
Maiers	2014/2014	Spine J/J Rehabil Med	2.426/1.683	11 (100)
Wong	2014	J Chiropr Educ	NA	6.5 (59.1)
Maiers	2014/2015	Spine J/Man Ther	2.426/1.869	8 (72.7)
Myburgh	2014/2016	J Interprof Care/Chiropr Man Therap	1.399/NA	8 (72.7)
Evans	2015	Glob Adv Health Med	NA	7 (63.6)
Gudavalli	2015	Trials	1.859	8 (72.7)
Bronfort/Maiers	2014/2016	Ann Intern Med/Man Ther	17.810/2.158	10 (90.9)
Testern	2015	Chiropr Man Therap	NA	4.5 (40.9)
Lyons/Goertz	2013/2017	BMC Complement Altern Med/BMC Geriatr	1.877/2.866	8.5 (77.3)
Amorin-Woods	2016	Chiropr Man Therap	NA	3.5 (31.8)
Miller	2016	J Clin Chiropr Pediatr	NA	8.5 (77.3)

BMC = BioMed Central, *IF* = Impact Factor, *MMAT* = Mixed Methods Appraisal Tool, *NA* = Not Applicable, *NY* = New York

(Appendix 1 continued)

First author	Year of publication	Journal	IF at year of publication	MMAT score n = 0-11 (%)
Amorin-Woods	2017	Chiropr J Aust	NA	7 (63.6)
Hawk	2017	J Chiropr Educ	NA	4.5 (40.9)
Goertz/Salisbury	2017/2018	BMC Geriatr/Gerontologist	2.866/NA	9 (81.8)
Eilayyan	2018	BMC Musculoskelet Disord	2.002	7.5 (68.2)
Langenfeld	2018	Spine	2.903	5.5 (50.0)
Stuber	2018	Complement Ther Med	1.979	7 (63.6)
Goertz/Wells	2017/2020	BMC Geriatr/J Patient Exp	3.077/NA	10 (90.9)
Stochkendahl	2018/2019	Chiropr Man Therap	NA/1.512	7.5 (68.2)
Amorin-Woods	2019	J Chiropr Educ	NA	7.5 (68.2)
Hestbaek	2019	Chiropr Man Therap	1.512	10 (90.9)
Peterson	2019	Chiropr Man Therap	1.512	7 (63.6)
Whitley	2019	J Manipulative Physiol Ther	1.230	7.5 (68.2)
Cockrell	2020	Gerontol Geriatr Med	NA	5.5 (50.0)
Connell	2020	J Can Chiropr Assoc	NA	9 (81.8)
Emary	2020	Chiropr Man Therap	1.512	7.5 (68.2)
Kim	2020	CMAJ Open	NA	3.5 (31.8)
Major	2020	J Chiropr Educ	NA	7 (63.6)
Pohlman	2020	Chiropr Man Therap	1.512	8.5 (77.3)
Pohlman	2020	J Manipulative Physiol Ther	1.230	5.5 (50.0)
Rae	2020	J Chiropr Med	NA	7 (63.6)
Rist/Connor	2020/2021	Cephalgia/J Manipulative Physiol Ther	4.868/1.230	8.5 (77.3)
Peterson	2021	J Chiropr Educ	NA	7.5 (68.2)

BMC = BioMed Central, *IF* = Impact Factor, *MMAT* = Mixed Methods Appraisal Tool, *NA* = Not Applicable, *NY* = New York

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Student attitudes toward the International Clinical and Professional Chiropractic Education Position Statement and Evidence-based practice: a survey of UQTR chiropractic students

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Objective: *The aim of this study is to describe the attitude of Université du Québec à Trois-Rivières (UQTR) chiropractic students toward the International Clinical and Professional Chiropractic Education Position Statement and evidence-based practice (EBP) beliefs.*

Methods: *A cross-sectional survey was administered to all the UQTR chiropractic students. Using a five-point Likert scale, students were asked to rate their level of*

L'opinion des étudiants à l'égard de l'Énoncé de position international sur l'enseignement clinique et professionnel de la chiropratique et des pratiques fondées sur des données probantes : un sondage des étudiants en chiropratique de l'UQTR.

Objectif : *L'objectif de cette étude est de décrire la position des étudiants en chiropratique de l'Université du Québec à Trois-Rivières (UQTR) à l'égard de l'Énoncé de position international sur l'enseignement clinique et professionnel de la chiropratique (ICEC) ainsi que les croyances associées aux pratiques fondées sur les données probantes (EBP).*

Méthode : *Une enquête transversale a été menée auprès de tous les étudiants en chiropratique de l'UQTR. À l'aide d'une échelle de Likert de cinq points,*

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agreement with the position statement (10 items), EBP (2 items), interprofessional collaboration (2 items) and vitalistic philosophy (2 items).

Results: *Survey response rate was 71%. Students most frequently reported strong agreement with the position statement, EBP and interprofessional collaboration. They also most frequently disagreed with vitalistic philosophy. The attitude toward the position statement was positively correlated with the year of study in the program (r=0.10, p=0.019), EBP (r=0.56, p<0.001) and interprofessional collaboration (r=0.45, p <0.001).*

Conclusions: *UQTR chiropractic students demonstrate high levels of agreement with EBP and the Education Position Statement.*

(JCCA. 2022;66(1):21-32)

KEY WORDS: attitude; chiropractic; cross-sectional studies; students; surveys and questionnaires

les étudiants devaient indiquer leur niveau d'accord avec l'ICEC (10 éléments), les EBP (2 éléments), la collaboration interprofessionnelle (2 éléments) et la philosophie vitaliste (2 éléments).

Résultats : *Le taux de réponse était de 71 %. De façon générale, les étudiants étaient fortement en accord avec les énoncés de l'ICEC, l'EBP et la collaboration interprofessionnelle. Ils étaient également en désaccord avec la philosophie vitaliste. L'opinion des étudiants à l'égard de l'ICEC était positivement corrélée avec l'année d'études dans le programme (r=0.10, p=0.019), l'EBP (r=0.56, p<0.001) et la collaboration interprofessionnelle (r=0.45, p <0.001).*

Conclusion : *Les étudiants en chiropratique de l'UQTR démontrent des niveaux élevés d'accord avec l'EBP et l'ICEC.*

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MOTS CLÉS : opinion; chiropratique; études transversales; étudiants; enquêtes et questionnaires

Introduction

The chiropractic profession consists of heterogenous clinicians with diverse attitudes toward healthcare identity, role, scope and application of evidence-based practice.[1-4] In Canada, approximately 19% of chiropractors report unorthodox clinical attitudes and behaviours toward X-ray use, drug and vaccine interventions, and conform to beliefs that vertebral subluxation is an obstruction to the expression of human health.[5] Broad adoption of an evidence-based paradigm has been identified as an opportunity for the chiropractic profession to integrate into mainstream healthcare, including within the Canadian Forces Health Services.[6] While non-evidence-based practises remain a professional barrier to healthcare integration, Puhl *et al*.[7] found the strongest predictor of unorthodox professional practice characteristics for English-speaking Canadian chiropractors is the chiropractic program that they attended.

Students of chiropractic can also demonstrate both traditional and progressive attitudes toward chiropractic professional practice.[8] Within geographical regions and countries chiropractic students can vary on a philosophical spectrum of healthcare beliefs[9,10], which is predicted by the chiropractic educational institution[10]. As one example, Gleberzon *et al*.[11], compared two educational institutions in the United States and Canada and found differences in chiropractic students' attitudes on the expert role of chiropractors. Gleberzon *et al*.[11] assessed the likelihood that chiropractic students would use 'conservative'(vertebral subluxation, innate intelligence, disease, spinal misalignment and nerve flow interference) and 'liberal'(spinal lesion, impingement and joint dysfunction) terms. Through different lexicons, it was noted that the Canadian Memorial Chiropractic College (CMCC) teaches 'conservative' chiropractic concepts from a historical perspective whereas Parker University teaches both 'conservative' and 'liberal' concepts as part of their core curriculum.[11] While chiropractic student attitudes have been studied and characterized throughout English-speaking Canada and the United States[9,12], Australia and New Zealand[10], England and Europe[13,14], there remains a paucity of research from Quebec's French speaking Canadians.

Inherently linked to professional attitudes and perhaps the most contentious concept in chiropractic and relat-

ed degree program curricula worldwide is the vertebral subluxation complex. The existence and definition of the vertebral subluxation complex have been the center of numerous debates within the chiropractic profession worldwide.[15-17] Funk *et al*. [18], analyzed 46 chiropractic programs and found the term subluxation eight times more frequent in US than non-US chiropractic course catalogues. In Canada, the term subluxation occurred in 2.7% of course descriptions at Université du Québec à Trois-Rivières (UQTR) versus 0% at CMCC.[18] Similarly, the accrediting body's 2011 standards for both programs, the Canadian Federation of Chiropractic Regulatory and Educational Accrediting Boards (FCC) includes mention of subluxation in the context of joint dysfunction.[18] Since 2014, sixteen chiropractic programs and one student union have formed The International Chiropractic Education Collaboration (ICEC) and have clearly delineated their Position Statement on Clinical and Professional Chiropractic Education standards.[19] The ICEC ten position statements endeavor to deliver curricula that focus on patient-centered care, founded in evidence-based principles, and aligned with contemporary expectations of healthcare systems.

In Canada, the chiropractic profession maintains a French-language clinical training program within a public university setting at UQTR. It is currently unclear how frequently French-language chiropractic students identify toward orthodox and unorthodox professional tenets. Given this and the potential to influence future clinical practices, the aim of this study is to describe the attitudes of UQTR chiropractic students toward the International Clinical and Professional Chiropractic Education Position Statement and statements about evidence-based practice.

Methods

Ethical review for this study was approved by the Human Research Ethics Committee of Université du Québec à Trois-Rivières (CER-19-260-07.23).

Study design and setting

A Web-based cross-sectional survey of UQTR chiropractic students was conducted between January and March 2021. Participant recruitment involved the first author sending an initial e-mail invitation to all students enrolled into the chiropractic program, with two subsequent weekly e-mail reminders. In order to increase the response rate, the first author conducted a presentation of the project during virtual courses of every cohort of the program. Study data were collected using a web-based survey tool developed by UQTR (https://confluence.uqtr.ca/display/AOPSP/BIQ).

Survey instrument

The survey instrument included 19 items. Three were demographic questions, ten measured students' attitude toward the education position statement, two the evidence-based practice construct, two the interprofessional collaboration construct and two toward the vitalistic philosophy constructs.

Demographic profile

Information regarding gender, age and year of study in the program was collected at the beginning of the survey.

Attitude toward the education position statement

The International Clinical and Professional Chiropractic Education Position Statement[19] was translated into Canadian-French and divided into ten statements. The Canadian-French translation was initially performed by a professional translator and then revised by a bilingual professor from the chiropractic department with experience in cross-cultural adaptation. The respondents were asked to rate their agreement with each statement on a 5-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree). A summary score of attitude toward the education position statement, ranging from 5 to 50, was obtained by adding the level of agreement of each statement.

Evidence-based practice, interprofessional collaboration and vitalistic philosophy constructs

We selected five items from the questionnaire developed by Gliedt *et al*.[9] and translated them into Canadian French. The following item was created specifically for this project: "All chiropractic programs should be associated with academic institutions that also include other health care programs". Participants rated their agreement with each item on a 5-point Likert scale. Evidence-based practice, interprofessional collaboration and vitalistic construct scores were created by adding the level of agreement of the two items related to each construct.

Test-retest reliability

To test whether student attitudes were stable over time, a sub-sample of students in the last year of the program were invited to complete our survey for a second time, two weeks after their initial completion. Finishing students were specifically selected to provide insight on the reliability of their attitudes at the end of the program before entering practice.

Statistical methods

The sample and responses to statements about the education position statement, evidence-based practice, interprofessional collaboration and vitalistic philosophy were analyzed using descriptive statistics (mean and standard deviation or frequencies and percentage). The internal consistency of students' summary scores were evaluated using Cronbach's alpha. Ceiling and floor effects (subject'scores at either extreme of the scale) were analyzed using descriptive statistics. A floor or ceiling effect was considered when more than 15% of respondents obtained the minimal or maximal score respectively.[20]

Bivariate analyses were conducted between all variables. The Student t-test was used to describe associations by gender. Pearson's coefficient was used to describe correlations between continuous variables including the construct summary scores. The correlation coefficients were interpreted as follows: very high ≥0.90, high 0.70-0.89, moderate 0.50-0.69, low 0.31-0.49, and little if any correlation ≤0.30.[21]

Test-retest reliability of our survey instrument was assessed using Intraclass Correlation Coefficients (ICC) based on a single measurement, absolute-agreement, 2-way mixed-effects model. For ICC estimate, values less than 0.5, between 0.5 and 0.75, between 0.75 and 0.9, and greater than 0.90 were interpreted as poor, moderate, good, and excellent reliability, respectively.[22]

Statistical significance was accepted at the 5% level. All analyses were conducted using SPSS Statistics for Mac version 27.0 (IBM Corp., Armonk, NY).

Results

A total of 165 students completed surveys, but eight were excluded because the respondents withdrew consent to share their responses for research purposes. One hundred and fifty-seven questionnaires were analyzed leading to a response rate of 70.7% (Figure 1). Respondent demographics are reported in Table 1. The majority of respondents were women (63%) and the average age was 22 years old. The participants were evenly distributed across the five cohorts of the program.

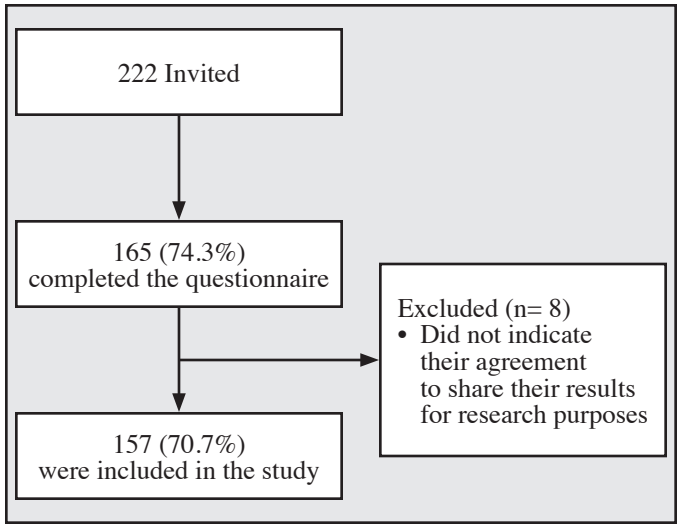

Figure 1.
Flowchart of the students' selection.

Table 2 shows the respondents' attitude toward the educational position statement. The majority of the respondents (60.5% to 84.7%) strongly agreed with all the items of the position statement with the exception of item #5 (related to the exclusive use of vertebral subluxation

Table 1.
Respondent demographics (n = 157).

		n (%)
Gender	Women	99 (63.1)
	Men	58 (36.9)
	Other	0
Year of study in the program	1	31 (19.7)
	2	31 (19.7)
	3	34 (21.7)
	4	28 (17.8)
	5	33 (21.0)
		Mean (SD)
Age [years]		22.4 (2.0)

SD = standard deviation

Table 2.
Respondent attitudes toward the Clinical and Professional Chiropractic Education Position Statement; n (%).

	Strongly Disagree [1]	Disagree [2]	Neutral [3]	Agree [4]	Strongly Agree [5]	Mean (SD)
1. Chiropractic education and training must acknowledge the biopsychosocial model of health care and be underpinned by biologically plausible theories and peer-reviewed research. It should embrace the value of clinical experience, shared decision-making and a patient centered approach to care.	—	1 (0.6)	11 (7.0)	58 (36.9)	**87 (55.4)**	4.5 (0.7)
2. Upon graduation, chiropractic students should be equipped to work effectively and collaboratively to deliver improved quality of life outcomes for patients with musculoskeletal disorders. This will, of necessity, incorporate:						
• An evidence-based approach to the case history, physical examination, diagnostic imaging, diagnosis, report of findings and management plan that may include a range of clinical interventions	—	—	2 (1.3)	18 (17.8)	**127 (80.9)**	4.8 (0.4)
• Effective communication in a language that is clearly understood by all stakeholders in healthcare, thereby facilitating interprofessional practice and promoting effective collaboration between health care teams	—	—	1 (0.6)	24 (15.3)	**132 (84.1)**	4.8 (0.4)
• Knowledge of preventative measures including but not limited to musculoskeletal care, encompassing wider public health and health promotion initiatives	—	1 (0.6)	2 (1.3)	25 (15.9)	**129 (82.2)**	4.8 (0.5)
3. Wherever possible, chiropractic educational programs should form or develop affiliations with established public and private universities preferably within a medical or health science faculty. Such links may develop opportunities for interprofessional education and collaborative practice.	—	—	4 (2.5)	45 (28.7)	**108 (68.8)**	4.7 (0.5)
4. Chiropractic educational institutions should support their faculties in the provision of innovative models for the development of knowledge, learning and skills. These should focus on facilitating scholarly activity including research, interprofessional education and teaching within the context of emerging health care models. [missing = 1 (0.6%)]	—	—	7 (4.5)	56 (35.9)	**93 (59.6)**	4.6 (0.6)
5. The teaching of vertebral subluxation complex as a vitalistic construct that claims or implies that it is the cause of or contributes to disease is unsupported by evidence. Its inclusion in a modern chiropractic curriculum in anything other than an historical context is therefore inappropriate and unnecessary.	11 (7.0)	35 (22.3)	35 (22.3)	31 (19.7)	**45 (28.7)**	3.4 (1.3)
6. Chiropractic education should reflect ethical practice and professional standards throughout the curriculum. Upon graduation, students must understand their responsibilities to their patients, their communities and to the profession	—	—	1 (0.6)	23 (14.6)	**133 (84.7)**	4.8 (0.4)
7. Practice styles[3], which may contribute to inappropriate patient dependence, compromise patient confidentiality or require repeated exposure to ionizing radiation are not part of an undergraduate chiropractic curriculum. Students should be taught to recognize that such approaches are not acceptable in terms of the best interests of patients or the chiropractic profession.	2 (1.3)	8 (5.1)	18 (11.5)	48 (30.6)	**81 (51.6)**	4.3 (0.9)
8. The chiropractic programs should support the World Health Organization 'WHO's vision and mission in immunization and vaccines.	—	4 (2.5)	23 (14.6)	35 (22.3)	**95 (60.5)**	4.4 (0.8)
Summary score of agreement with the position statement (/50) [Cronbach α=0.78)						46.5 (3.4)

SD = standard deviation, **Bold** = mode

Table 3.
Participants responses to statements about evidence-based practice, scope of practice, identity and setting; n (%).

	Strongly Disagree [1]	Disagree [2]	Neutral [3]	Agree [4]	Strongly Agree [5]	Mean (SD)
Evidence-based practice						
It is important for chiropractors to be educated in evidence-based practice	—	2 (1.3)	11 (7.0)	46 (29.3)	**98 (62.4)**	4.5 (0.7)
Contemporary and evolving scientific evidence is more important than traditional chiropractic theory	—	6 (3.8)	18 (11.5)	52 (33.1)	**81 (51.6)**	4.3 (0.8)
Evidence-based practice construct score (/10) [Cronbach α=0.68)]						8.9 (1.3)
Interprofessional collaboration						
Inclusion of clinical chiropractic training internships in integrative medical settings is important to the progression of the chiropractic profession	2 (1.3)	4 (2.5)	13 (8.3)	43 (27.4)	**95 (60.5)**	4.4 (0.8)
All chiropractic programs should be associated with academic institutions that also include other health care programs	—	4 (2.5)	18 (11.5)	44 (28.0)	**91 (58.0)**	4.4 (0.8)
Interprofessional collaboration construct score (/10) [Cronbach α=0.34)]						8.8 (1.3)
Vitalistic philosophy						
The primary purpose of the chiropractic examination is to detect vertebral subluxations [missing = 1 (0.6%)]	35 (22.4)	**76 (48.7)**	31 (19.9)	12 (7.7)	2 (1.3)	2.2 (0.9)
It is appropriate for the chiropractic profession to distinguish and promote two separate subgroups of broad scope (providing manual and other non-drug procedures) and limited scope (providing subluxation correction only) [missing = 2 (1.3%)]	36 (23.2)	**54 (34.4)**	37 (23.9)	20 (12.9)	8 (5.2)	2.4 (1.1)
Vitalistic philosophy construct score (/10) [Cronbach α=0.004)]						4.6 (1.5)

SD = standard deviation, **Bold** = mode

complex in anything other than an historical context) for which 28.7% of the respondents strongly agreed. Responses to statements regarding evidence-based practice, interprofessional collaboration and vitalistic philosophy are outlined in Table 3. The majority of the respondents strongly agreed with all the evidence-based practice (51.6% to 62.4%) and interprofessional collaboration (58.0% to 60.5%) items. Most of the respondents disagreed (34.4% to 48.7%) or strongly disagreed with the vitalistic philosophy (22.4% to 23.2%) items. The internal consistency of the attitude toward the education position statement was good (Cronbach α=0.78), moderate for the evidence-based practice construct (Cronbach α=0.68), and low for the interprofessional collaboration construct (Cronbach α=0.34). The vitalistic philosophy construct did not seem to demonstrate internal consistency (Cronbach α=0.004). Ceiling effects , when >15% of respondents report the maximum scores across items, were present for the attitudes toward the education position statement (n = 35, 22%), the evidence-based practice construct (n = 69, 44%), and the interprofessional collaboration construct (n = 64, 41%). The vitalistic philosophy construct did not demonstrate either a ceiling or floor effect.

Results of the bivariate analyses are presented in Table 4 for gender and Table 5 for continuous variables (age, year of study in the program, evidence-based practice, interprofessional collaboration, vitalistic philosophy, attitude toward the position statement). The students' year

in program was positively correlated with their attitudes toward the education position statement and negatively correlated with the vitalistic philosophy construct. The attitude toward the education position statement, the evidence-based practice construct and the interprofessional collaboration construct were all positively and statistically significantly correlated with each other. None of the measured variables significantly differed between men and women.

During the test-retest assessment, the constructed score for the attitude toward the education position statement (ICC = 0.70; p <0.001), the evidence-based practice construct (ICC = 0.78; p <0.001), the interprofessional collaboration construct (ICC = 0.67; p = <0.001), and the vitalistic philosophy construct (ICC = 0.55; p = 0.001) demonstrated moderate to good test-retest reliability. The detailed test-retest assessment of each item of our survey instrument is presented in Appendix 1.

Table 4.
Gender analysis

	Women		Men		p-value
	Mean	SD	Mean	SD	
Age [years]	22.4	2.0	22.5	2.2	0.796
Year of study in the program	3.1	1.4	2.9	1.5	0.613
Evidence-based practice	8.8	1.4	9.0	1.1	0.211
Interprofessional collaboration	8.8	1.4	8.9	1.1	0.810
Vitalistic philosophy	4.5	1.3	4.7	1.6	0.334
Agreement with the position statement	46.1	3.5	47.0	3.2	0.113

SD = standard deviation

Discussion

In this study, French-Canadian speaking chiropractic students most frequently reported very strong attitudes that agreed with the ICEC education position statements, evidence-based practice and interprofessional collaboration. The same students most frequently disagreed with statements on vitalistic philosophy. We found the internal consistency of construct domains were good for the ICEC education position statements, moderate for evidence-based practice and low for interprofessional collaboration statement scores. The vitalistic philosophy statements score was not internally consistent in our analysis. Current UQTR students report moderate and low correlation between attitude summary scores for the ICEC education position statements, statements about evidence-based practice and interprofessional collaboration, respectively. We found moderate stability of final

Table 5.
Bivariate analysis of continuous variables

		Age [years]	Year of study in the program	Evidence-based practice	Inter-professional collaboration	Vitalistic philosophy	Attitude toward the position statement
Age [years]	r	1					
	p-value						
Year of study in the program	r	**0.73**	1				
	p-value	**<0.001**					
Evidence-based practice	r	0.10	0.18	1			
	p-value	0.206	0.029				
Interprofessional collaboration	r	-0.02	-0.01	**0.42**	1		
	p-value	0.804	0.935	**<0.001**			
Vitalistic philosophy	r	-0.15	**-0.39**	-0.09	0.01	1	
	p-value	0.071	**<0.001**	0.254	0.936		
Attitude toward the position statement	r	0.07	**0.10**	**0.56**	**0.45**	-0.04	1
	p-value	0.429	**0.019**	**<0.001**	**<0.001**	0.591	

r = Pearson correlation coefficient; **Bold** = Statistically significant correlation

year student construct scores of attitudes toward the ICEC education position statement, interprofessional collaboration and vitalistic philosophy and good stability for the evidence-based practice score.

Our findings show French-Canadian speaking chiropractic students can most commonly be characterized as orthodox/liberal according to continuums of chiropractic professional attitude.[7,8,23] This finding differs from recent studies of English-speaking chiropractic students in North America, Europe and Australia/New Zealand who most commonly report attitudes somewhere between the two ends of the spectrum.[8,11,24] Not only did UQTR students demonstrate orthodox attitudes, but there also was a consistent pattern of attitudes across construct domains for ICEC agreement, evidence-based practice, interprofessional collaboration and vitalistic philosophy. This differs from some Australian and New Zealand institutions studied by de Luca *et al*.[10], where student attitudes varied across domains of identity, role/scope, setting and future. Moreover, a recent study by Swain *et al*.[8], showed a relatively large proportion of chiropractic students internationally report contradictory ideological attitudes, which does not seem to be the case at UQTR. We speculate that differences found in our sample could be potentially explained by the UQTR program being based in a public university. Integrated chiropractic students have basic sciences and interprofessional courses with students of other healthcare programs (biomedical sciences, kinesiology, medicine, midwifery, nursing, occupational therapy, podiatry, speech language therapy). The research obligations of professors are also the same within all the departments of the university. These factors might lead to an orthodox institutional lexicon and curriculum. In addition, because the number of chiropractic student places are limited to 47 per year, students are selected based on academic results and individual interviews. Approximatively 20 to 25% of the applications for the program will receive an admission offer leading to the selection of academically performant students. In Quebec, students can directly access the chiropractic program and most of the university-based healthcare programs after completing their college (CEGEP) degree.

The distribution of UQTR student attitudes reported in the vitalistic philosophy domain of this study most notably contrasts against previous research conducted in North America[9]. Gliedt *et al*.[9] surveyed students enrolled at 12 Doctor of Chiropractic degree programs in 2013-14 and found 44.6% of respondents agreed with the statement "The primary purpose of the chiropractic examination is to detect vertebral subluxations" compared to 9% in the current study. For the statement "It is appropriate for the chiropractic profession to distinguish and promote two separate subgroups of broad scope (providing manual and other non-drug procedures) and limited scope (providing subluxation correction only)" Gliedt *et al*.[9] reported 37.2% of respondents disagreed versus 57.6% of respondents in the current study. For both studies the latter statement had the highest proportion of respondents (approximately one-quarter) reporting a neutral response. While the implications of the different rates to the first statement are clear, the frequency of responses to the latter statement suggest French-Canadian speaking students might not have a clear position on whether or not the chiropractic profession should divorce[25] despite much uncertainty in the group.

Our operationalization of the ICEC education position statement into a questionnaire leading to a summary score has produced an internally consistent and moderately reliable tool that was significantly correlated with interprofessional collaboration and evidence-based constructs suggesting a promising concurrent validity. This tool might be informative for future research. Nearly two decades ago, it was suggested that measuring chiropractic philosophy is complex and that further methodological developments would be required to adequately achieve this goal.[26] Since then, many researchers have attempted to measure components of chiropractic or vitalist philosophy with tools of suboptimal or unknown psychometric properties.[5,9,11,26] Our results make no exception, although the vitalistic philosophy construct demonstrated moderate reliability, the two items composing it were not internally consistent. This suggests that attitudes toward vitalistic philosophy is a complex construct that requires more sophisticated evaluation. Future research should develop a valid and reliable tool to adequately assess the vitalistic philosophy within the chiropractic profession.

Strengths and limitations

The recruitment strategy has produced a response rate three-fold higher than previous studies in North America[9], and Australia and New Zealand[10]. We cannot completely rule out the possibility that the non-responders might have

different attitudes than responders to our survey. Due to the anonymous nature of the survey, we cannot conduct a responder/non-responder analysis. Our response rate is sufficient to generalize our findings to seven out of 10 UQTR chiropractic students. However, it might not be generalizable to all French speaking chiropractors in Quebec since they might have graduated from different institutions or during a different time period at UQTR. Our data were collected during the COVID-19 pandemic, and it is not clear how this might have influenced student's attitudes. The internal consistency and reliability of the survey instrument used were all found to be satisfactory, with the exception of the internal consistency of the vitalistic philosophy construct; thus, limiting the possibility of information bias. Since previous studies using the many identical questions in English did not report frequent use of the end of the scale[9,10], we suggest that the ceiling effects observed are inherent to the particular characteristics of our population. The adaption of the ICEC education position statement items proved to be a novel and internally consistent measure of student attitudes. However, the transformation of the ICEC education position statement into questions has produced a few items with complex statements. The psychometric properties of our tool might potentially be improved by dividing the complex items into multiple items.

Conclusion

UQTR chiropractic students demonstrate high levels of agreement with evidence-based practice, interprofessional collaboration and the ICEC education position statement. These attitudes seem to be stable at the end of the program. Further research is required to adequately quantify the attitude of chiropractic students toward vitalistic philosophy.

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Appendix 1.
Test-retest reliability

	Intraclass Correlation Coefficients	95% Confidence Interval	P-value
Demographics			
Age	0.99	[0.98 - 0.99]	<0.001
Attitude toward the Clinical and Professional Chiropractic Education Position Statement			
1. Chiropractic education and training must acknowledge the biopsychosocial model of health care and be underpinned by biologically plausible theories and peer-reviewed research. It should embrace the value of clinical experience, shared decision-making and a patient centered approach to care.	0.40	[0.06 - 0.66]	0.008
2. Upon graduation, chiropractic students should be equipped to work effectively and collaboratively to deliver improved quality of life outcomes for patients with musculoskeletal disorders. This will, of necessity, incorporate:			
a) An evidence-based approach to the case history, physical examination, diagnostic imaging, diagnosis, report of findings and management plan that may include a range of clinical interventions	0.36	[0.02 - 0.64]	0.022
b) Effective communication in a language that is clearly understood by all stakeholders in healthcare, thereby facilitating interprofessional practice and promoting effective collaboration between health care teams	0.46	[0.13 - 0.70]	0.005
c) Knowledge of preventative measures including but not limited to musculoskeletal care, encompassing wider public health and health promotion initiatives	0.14	[-0.24 - 0.48]	0.233
3. Wherever possible, chiropractic educational programs should form or develop affiliations with established public and private universities preferably within a medical or health science faculty. Such links may develop opportunities for interprofessional education and collaborative practice.	0.39	[0.05 - 0.65]	0.015
4. Chiropractic educational institutions should support their faculties in the provision of innovative models for the development of knowledge, learning and skills. These should focus on facilitating scholarly activity including research, interprofessional education and teaching within the context of emerging health care models.	0.36	[-0.00 - 0.64]	0.027
5. The teaching of vertebral subluxation complex as a vitalistic construct that claims or implies that it is the cause of or contributes to disease is unsupported by evidence. Its inclusion in a modern chiropractic curriculum in anything other than an historical context is therefore inappropriate and unnecessary.	0.39	[0.27 - 0.66]	0.018
6. Chiropractic education should reflect ethical practice and professional standards throughout the curriculum. Upon graduation, students must understand their responsibilities to their patients, their communities and to the profession	0.28	[-0.10 - 0.59]	0.071
7. Practice styles, which may contribute to inappropriate patient dependence, compromise patient confidentiality or require repeated exposure to ionizing radiation are not part of an undergraduate chiropractic curriculum. Students should be taught to recognize that such approaches are not acceptable in terms of the best interests of patients or the chiropractic profession.	-0.01	[-0.37 - 0.36]	0.510

	Intraclass Correlation Coefficients	95% Confidence Interval	P-value
8. The chiropractic programs should support the World Health Organization 'WHO's vision and mission in immunization and vaccines.	0.45	[0.11 - 0.69]	0.003
Summary score of attitude toward the position statement	0.70	[0.46 - 0.85]	<0.001
Evidence-based practice			
It is important for chiropractors to be educated in evidence-based practice	0.66	[0.40 - 0.83]	<0.001
Contemporary and evolving scientific evidence is more important than traditional chiropractic theory	0.56	[0.24 - 0.77]	<0.001
Evidence-based practice construct score	0.78	[0.59 - 0.89]	<0.001
Interprofessional collaboration			
Inclusion of clinical chiropractic training internships in integrative medical settings is important to the progression of the chiropractic profession	0.62	[0.33 - 0.80]	<0.001
All chiropractic programs should be associated with academic institutions that also include other health care programs	0.66	[0.36 - 0.83]	<0.001
Interprofessional collaboration construct score	0.67	[0.41 - 0.83]	<0.001
Vitalistic philosophy			
The primary purpose of the chiropractic examination is to detect vertebral subluxations	0.56	[0.24 - 0.76]	<0.001
It is appropriate for the chiropractic profession to distinguish and promote two separate subgroups of broad scope (providing manual and other non-drug procedures) and limited scope (providing subluxation correction only)	0.52	[0.19 - 0.75]	0.002
Vitalistic philosophy construct score	0.55	[0.23 - 0.76]	0.001

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The one-week prevalence of overuse-related shoulder pain and activity limitation in competitive tennis players living in Toronto: a feasibility study

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Objective: *We aimed to determine the feasibility of conducting a cross-sectional study to estimate the one-week prevalence of overuse-related shoulder pain and activity limitation in competitive tennis players.*

Methods: *Eligible for the study were competitive adult tennis players who reside in Toronto. Using a convenience sample, the Oslo Sports Trauma Research Centre Overuse Shoulder Injury Questionnaire (OSIQ) was administered online to provide preliminary estimates of the prevalence of shoulder pain and activity limitation, injury severity and pain intensity. Feasibility outcomes included evaluating participation rate and missing data in the questionnaire.*

La prévalence sur une semaine des douleurs à l'épaule et des limitations d'activité liées à la surutilisation chez les joueurs de tennis de compétition vivant à Toronto : une étude de faisabilité

Objectif : *nous avons cherché à déterminer la faisabilité de mener une étude transversale pour estimer la prévalence sur une semaine de la douleur à l'épaule et de la limitation d'activité liée à la surutilisation chez les joueurs de tennis de compétition.*

Méthodologie : *les joueurs de tennis adultes compétitifs qui résident à Toronto sont admissibles pour l'étude. À l'aide d'un simple échantillon, l'Overuse Shoulder Injury Questionnaire, OSIQ (questionnaire sur les blessures à l'épaule), du Centre de recherche sur les traumatismes sportifs d'Oslo a été mis en ligne pour obtenir des estimations préliminaires de la prévalence de la douleur à l'épaule et de la limitation des activités, de la gravité des blessures et de l'intensité de la douleur. Les critères de faisabilité comprenaient l'évaluation du taux de participation et des données manquantes dans le questionnaire.*

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Results: *Forty-three tennis players were included in the questionnaire (68.3% participation rate, 100% completion rate). There was no missing data. The one-week proportion of those with shoulder pain and activity limitation was 41.9% with a mean injury severity of 33/100. Mean pain intensity was 1.9/10.*

Conclusion: *Our study demonstrates that it is feasible to conduct a cross-sectional study to measure the one-week prevalence of shoulder pain and activity limitation in tennis players.*

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KEY WORDS: tennis, shoulder, injury, feasibility, shoulder pain, chiropractic

Résultats : *quarante-trois joueurs de tennis ont été inclus dans le questionnaire (taux de participation de 68,3 %, taux d'achèvement de 100 %). Il n'y avait pas de données manquantes. La proportion sur une semaine de personnes souffrant de douleur à l'épaule et de limitation d'activité était de 41,9 % avec une gravité moyenne des blessures de 33/100. L'intensité moyenne de la douleur était de 1,9/10.*

Conclusion : *notre étude démontre qu'il est possible de mener une étude transversale pour mesurer la prévalence sur une semaine de la douleur à l'épaule et de la limitation d'activité chez les joueurs de tennis.*

(JCCA. 2022;66(1):33-42)

MOTS CLÉS : tennis, épaule, blessure, faisabilité, douleur à l'épaule, chiropratique

Introduction

Tennis is a demanding aerobic and anaerobic sport with repeated overhead motions placing significant loads through the dominant shoulder.[1–3] The shoulder is one of the most common body parts affected when it comes to injuries in tennis.[4,5] Despite injury, many players continue playing through pain rather than adjusting their training schedules or taking time off.[6,7] This often results in an increase in injury severity.[8]

Previous epidemiological studies have reported that the prevalence of shoulder pain in overhead athletes ranges from 21.4% to 41.6%.[9] The prevalence of shoulder pain in recreational adult tennis players in one particular study in the United States was 10.0%.[10] Unfortunately, the pain rating score for the shoulder specifically was not described in the study nor were the impacts of shoulder pain on tennis performance. To our knowledge, shoulder pain in adult competitive tennis players in Canada has not yet been reported. Shoulder pain is a contributing factor in injury reports with the prevalence of shoulder injury in tennis ranging from 1.5% to 27.2%.[5,11–17] Previous studies reporting shoulder injury in tennis used inconsistent criteria to define injury severity and used time loss (complete inability to train or compete) to define injury.[5,11–17] Using "time loss" to define injury likely resulted in an underreporting of injuries as players often do not take time off for injuries.[7] We currently lack information on the prevalence of shoulder injuries in Canadian tennis players.

The definition of injury from the 2009 Consensus Statement on standardized injury and documentation and reporting in tennis encompasses injury irrespective of time loss and captures a broad spectrum of injuries.[18] The statement recommends to measure injury severity as "the number of days that have elapsed from the date of onset of the medical condition to the date of the player's return to full participation in tennis training and availability for match play".[18] The consensus definition of injury severity is problematic because a player that has not yet returned to full participation in tennis training cannot be accurately classified. Bahr *et al*.[19] in 2009 and Clarsen *et al*.[7] in 2013 addressed this limitation and outlined the importance of severity measures being based on pain, function and the consequences of injury on athletes' participation and sporting performance rather than on the duration of time loss. The Oslo Sports Trauma Research Centre Overuse Shoulder Injury Questionnaire (OSIQ) addresses these issues by classifying injury severity according to pain, function and the consequence of injury on an athlete's participation and sporting performance.[7]

The aim of our study was to determine whether it is feasible to conduct a cross-sectional study to estimate the one-week period prevalence of overuse-related shoulder

pain and activity limitation in competitive tennis players living in Toronto. Our study evaluated the recruitment rate and secondarily described the burden of shoulder pain and activity limitation in a convenience sample of the Toronto tennis population to determine if the OSIQ is feasible to implement in this sample of Toronto tennis players as this has not been studied. Establishing the feasibility of questionnaire administration sets the stage for future larger scale prevalence studies to take place in the Canadian tennis population. Knowledge on the topic is the first step in helping to inform tennis players to adjust their training schedules and to seek early treatment to avoid an increase in the injury severity. Based on estimates from previous studies, we hypothesize that the one-week prevalence of shoulder pain and activity limitation is 12% in the Toronto competitive tennis population.[7]

Methods

This study was performed following the 1964 Declaration of Helsinki principles and was approved by the Canadian Memorial Chiropractic College Research Ethics Board (REB) on March 17, 2020 (REB approval number 2002B03). Informed consent to participate and consent to publish was obtained from all participants.

Study design and source population

A cross-sectional survey feasibility study was conducted in March of 2020. The study sample included competitive adult tennis players at an intermediate level or higher who reside in Toronto and play competitive tennis for the Boulevard Club, the Granite Club, the Toronto Lawn, or the Toronto Mayfair Pro League. All competitive tennis players from the tennis clubs/league at the Boulevard Club, the Granite Club, the Toronto Lawn, and the Toronto Mayfair Pro League were eligible (approximately 15 players per club team). Recruitment initially took place through an email template that was provided to the tennis directors of the Boulevard, Granite, and Lawn tennis clubs as well as the Mayfair Pro League to be distributed to the tennis member email list with the link to the questionnaire on SurveyMonkey (Momentive Inc, San Mateo, 1999). Due to the COVID-19 pandemic, this method of recruitment could not be carried out as the tennis clubs felt it was an inappropriate time to send out a research invitation email and therefore convenience sampling was conducted instead. Our recruitment strategy only included tennis players that the primary investigator knew, including those recruited from the public league website network where names and email addresses were listed. Although we had planned a recruitment strategy that included a representative sample, the COVID-19 pandemic interfered with our recruitment strategy. Known members of the respective tennis clubs as well as non-members on the club league teams were recruited through social media or direct recruitment. If the individual agreed to participate, they were sent the questionnaire via email. Participation was voluntary.

Study Sample:

To be included, players had to be 18 years of age or older with a history of competing in an intercounty league, Pro League, or tournament in the last year. Players were excluded if they were younger than 18 years old and or had a current shoulder injury due to a known acute mechanism or pathological cause (i.e., fracture, dislocation, infection, frozen shoulder, systemic disease, or neoplasm) as the goal was to capture repetitive gradual onset mechanism shoulder problems related to tennis rather than acute sudden onset shoulder problems. Inclusion and exclusion criteria were applied after participants completed the questionnaire. The criteria were applied based off the responses to questions regarding age, the presence of a fracture, dislocation, infection, frozen shoulder, systemic disease, or neoplasm/tumor diagnosis in the dominant shoulder and if the participant had competed in an intercounty league, Pro League or a tournament in the last year. The shoulder was defined as the articulation of the glenohumeral joint as well as the articulations of the acromio-clavicular, sterno-clavicular and scapulothoracic joints.[20]

Questionnaire

An online survey using the SurveyMonkey application was created to collect the data for this study. Demographic questions were made to capture the following: gender, hand dominance, forehand technique preference (double or single handed), backhand technique preference (double or single handed), age, height, weight, and competition level (intercounty, pro league, or tournament). The OSIQ questionnaire (see Appendix 1) was formatted into SurveyMonkey, where the primary feasibility outcomes of participation rate and missing data were collected. The questionnaire evaluates injury severity as well as the

one-week prevalence of shoulder activity limitation and pain. This questionnaire is a reliable and valid tool used to measure physical function and pain in sport. It was originally developed in Oslo, Norway on junior and senior athletes from five different sports including cross-country skiing, floorball, handball, road cycling and volleyball.[7] The questionnaire consists of four questions. The level of participation, extent of reduction in training volume, extent of affected performance and level of pain are subjectively quantified. The OSIQ is a validated, pilot tested questionnaire with established face validity and internal consistency with a Cronbach's α score of 0.91.[7]

Pain intensity scoring was added to the questionnaire and was measured using the 11-point Numeric Pain Rating Scale (NPRS). The scale consists of numerical values 0-10, 0 indicating no pain and 10 indicating the worst pain imaginable. The NPRS is a validated outcome measure for shoulder pain with a test-retest reliability of 0.74, a Pearson correlation coefficient score of 0.26.[21]

Statistical analysis

For categorical variables (gender, hand dominance, double-handed or single-handed backhand) counts and percentage were calculated. For continuous variables (age, height, weight) the mean and the standard deviation (SD) with a 95% confidence interval (CI) were computed. All outcomes were calculated in percentage. The completion rate was calculated by dividing the number of respondents that fully completed the questionnaire by the total number of submitted questionnaires both complete and partially complete. The participation rate of those that met the inclusion criteria was calculated by dividing the number of respondents that met inclusion criteria by the total number of respondents that the questionnaire was sent to. Overall participation rate was calculated by dividing the number of participants who consented to participate (i.e. clicked "yes" to participate in the survey) by the number of respondents that the questionnaire was sent to. Missing data was calculated for each of the four OSIQ questions with the numerator representing the number of missing responses and the denominator representing the number of respondents overall. The prevalence could not be calculated due to an inadequate denominator; instead, the proportion of those with shoulder pain and activity limitation was recorded by dividing the number of players that reported a shoulder problem in question 1 by the total number of players that completed the questionnaire. Of those that reported a shoulder problem in question 1, the same method was applied to questions 2-4 of the OSIQ to determine the percentage of shoulder problems that resulted in reduced training volume, an effect of performance and pain as well as the extent of the limitations/pain.

Injury severity was calculated using the allocated numerical values (0 to 25) for each of the answers to the four questions in the OSIQ. The values were summed in order to calculate a severity score from 0 to 100 for each shoulder problem. The response values were allocated such that 0 represented no problems and 25 represented the maximum level for each question. Questions 1 and 4 were scored 0-8-17-25, and questions 2 and 3 were scored 0-6-13-19-25.[7]

The mean pain intensity score from the NPRS was calculated by multiplying the number rating of pain intensity by the number of responses for that rating, taking the sum and dividing it by the total number of responses.

Results

Sixty-three participants were invited and fifty-six completed the questionnaire. Thirteen participants were excluded as they did not meet the inclusion/exclusion criteria. Of those, nine were excluded as they had not competed in an intercounty league, Pro League, or tournament in the last year and four were excluded as they had been diagnosed with a shoulder dislocation on the symptomatic side. Forty-three players were included in the study. Forty-three complete surveys were recorded. There were no incomplete surveys present. Participation rate of those who met inclusion criteria was 68.3%, overall participation rate was 88.9%, and completion rate was 100%.

In our sample of tennis players, participants completed the questionnaire in an average of three minutes with no missing data present. Participants 18-30 years of age represented 69.8% of the study participants followed by 23.3% between the ages of 31-40, 4.6% between 51-60 and 2.3% between 61-70. Participant characteristics revealed that 62.8% of the tennis players were males while right-handed players represented 90.7% of the sample. All participants had a single handed forehand while 83.7% had a double handed backhand and 16.3% had a single-handed backhand. The mean height, and weight were 1.8m (SD: 0.10, CI: 1.75, 1.82) and 74.6kg (SD:13.61, CI: 70.42, 78.80), respectively.

The one-week proportion of shoulder activity limitation and pain was 41.9% (CI: 27.1%, 56.6%). Of those with a shoulder problem, reduction in training volume, effect on performance and extent of pain were recorded (figure 1 & 2). Participants with minor reductions in training volume were reported at 61.1% (CI: 46.5%, 75.7%) while 27.8% (CI: 14.4%, 41.2%) had a moderate to major reduction in training volume or could not train at all. A minor effect on performance was reported by 50.0% (CI: 35.1%, 64.9%) of players while 27.8% (CI: 14.4%, 41.2%) reported a moderate to major effect on performance or an inability to perform. Mild pain was reported by 72.2% (CI: 58.8%, 85.6%) of players and moderate to severe pain was recorded in 11.1% (CI: -1.7%, 20.5%). Overall, 77.8% (CI: 65.4%, 90.2%) reported any reduction in training volume, 77.8% (CI: 65.4%, 90.2%) noted an effect on performance and 83.3% (CI: 72.2%, 94.5%) had shoulder pain. Mean injury severity was 33/100 (SD: 11.35, CI: 29.60, 36.39). A higher value indicates greater severity. Mean pain intensity on the NPRS was 1.9/10.

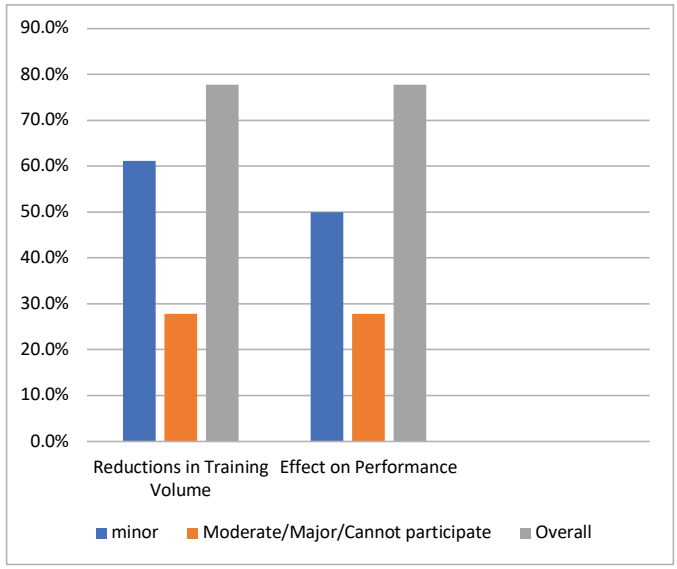

Figure 1.
Individuals reporting a shoulder problem: Extent of shoulder activity limitations

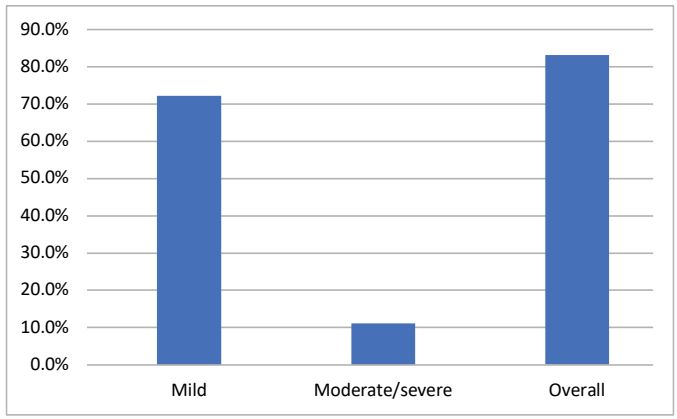

Figure 2.
Individuals reporting a shoulder problem: Degree of pain

Discussion

This study aimed to determine the feasibility of conducting a cross-sectional survey to evaluate the one-week period prevalence of shoulder pain and activity limitation in competitive tennis players living in Toronto. The results suggest that the questionnaire implementation in the Toronto tennis population is feasible and that our recruitment and data collection methodologies are acceptable to administer to tennis players. Therefore, complete data can be collected for the questionnaire in a very reasonable amount of time. Moreover, the participation rate was exceptionally high, suggesting that the participants were interested in the study. Although we had planned a recruitment strategy that included a representative sample, the COVID-19 pandemic interfered with our recruitment strategy. Consequently, our recruitment strategy only included tennis players that the primary investigator knew personally. Therefore, our pre-existing relationship with the included tennis players is a significant confounder to the participation rate, and our results cannot be easily generalized. We did not use an a priori defined sampling frame; therefore, we could not determine who was eligible for the survey before inviting players to participate. Consequently, we applied the inclusion/exclusion criteria after we received the completed questionnaire. Forty-three surveys met inclusion criteria and were included in the study (43/56 = 68.3% participation rate). There were no incomplete surveys recorded resulting in a completion rate of 100% (43/43).

The one-week proportion of shoulder pain and activity

limitation in competitive tennis players was 41.9%. Such a high proportion may support the notion that more shoulder problems can be captured when the injury definition does not require time-loss. Athletes often play through pain in both training and competition and therefore shoulder activity limitation and the degree of pain should be included in questionnaires evaluating injury prevalence and severity. This is in accordance with the International Olympic Committee consensus statement on the methods for recording and reporting epidemiological data on injury and illness in sport 2020.[22]

Among players with moderate to severe reductions in training volume or performance 75% reported mild pain. This finding suggests that minor pain may affect each player's game differently as some players may compensate more effectively. It was interesting to note that nearly 44% of players were still training and competing despite moderate reductions in training volume or performance. Such a finding may be explained by the fact than many tennis players may not be aware of the increased injury severity that can result if adequate modifications to training and competition are not in place.[8]

Sixteen-point seven percent of players with a shoulder problem reported no pain. This emphasizes the importance of not restricting injury prevalence studies to reports of pain as athletes may describe shoulder problems in alternate ways (i.e. discomfort, instability, etc.). Such an approach would capture more shoulder problems that exist in tennis participation.[7]

The feasibility study conducted addresses an important gap in the literature by investigating the prevalence of shoulder pain and activity limitation in tennis irrespective of time loss. Our findings are in line with previous studies that have reported acceptable feasibility of the OSIQ in cross-country skiing, floorball, handball, road cycling and volleyball.[7] The results of our study need further research and cannot be generalized; our study is the first in a series of investigations to better understand the effects shoulder problems may have on training/competition, performance and injury severity.

Post-study modifications to the questionnaire

Based on the feasibility study results, we will modify the questionnaire to include more clarity when asking participants to describe pain intensity. The Numeric Pain Rating Scale (NPRS) measuring pain intensity was inconsistent due to a lack of clarity in the question as those initially indicating no pain in the OSIQ, reported pain greater than 0/10 on the NPRS. We failed to specify that the pain intensity was referring to the current pain experienced in the shoulder. Future pilot investigations including the NPRS for pain intensity should clearly instruct participants to rate their shoulder pain intensity in relation to the current shoulder problem they have described in the previous questions.

Strengths

The OSIQ is standardized and uses valid and reliable tools to measure the prevalence of shoulder pain and activity limitation. Our study was feasible likely due to the brevity of the questionnaire with only 15 questions and an average time to completion of three minutes. Participant familiarity with the investigator as well as the common topic of interest being tennis, likely influenced many tennis players to participate in the questionnaire resulting in a moderately high participation rate of 68.3%.

Limitations

Our recruitment strategy only included tennis players that the primary investigator knew. Although we had planned a recruitment strategy that included a representative sample, the COVID-19 pandemic interfered with our recruitment strategy. Therefore, an unbiased prevalence could not be reported, and our results cannot be generalized. Additionally, we did not use a priori defined sampling frame therefore, we could not determine who was eligible for the survey before inviting players to participate. The purpose was to describe whether it was feasible to conduct a cross-sectional study and obtain a preliminary estimate of the prevalence of shoulder pain and activity limitation in competitive tennis players. Non-responder eligibility could not be reported as data on non-responders was not available. Had Covid-19 not restricted the designated tennis clubs to take part in the study, non-responder data would have been available and non-responder eligibility would have been described. Secondly, the NPRS could not be reported due to ambiguous results however the questionnaire will be modified to ensure clarity in the question for future investigations. The current study did not describe competition level, and therefore rating systems such as the National Tennis Rating Program (NTRP) should be implemented in future studies. The NTRP is

a rating system that was developed to identify and categorize the general characteristics of tennis players in 13 different levels of tennis ability. Currently, NTRP ratings are generated by the United States Tennis Association (USTA), which is committed to providing players with the most accurate rating information. Lastly, since the completion of this study, the creators of the OSIQ have modified question 2, and it now asks about the extent to which athletes have modified their training or competition rather than the extent to which an athlete has reduced their training volume. This change may reflect a greater number of ways in which an athlete can modify sports participation (i.e. reduced intensity, type of training) likely capturing an even larger array of shoulder problems.[23] The updated modification should be tested in a follow up pilot investigation.

Clinical implications

Understanding the prevalence of shoulder pain and activity limitation is necessary to develop future injury prevention strategies and implement early treatment interventions.

Conclusion

It is feasible to conduct a cross-sectional study on the one-week period prevalence of shoulder activity limitation and pain in competitive tennis players living in Toronto. Findings from the feasibility study suggest that the participation rate is adequate while a high proportion of tennis players with shoulder pain and activity limitation were identified. This feasibility study has addressed the changes necessary to improve the clarity of the questionnaire. We recommend future investigations to explore the prevalence of shoulder pain and activity limitation in competitive tennis players.

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Appendix 1.
Questionnaire

1. GENERAL INFORMATION

1. In the last year have you competed in an inter-county league, Pro League or a tournament?
   - ☐ Yes
   - ☐ No

2. Age Category:
   - ☐ <18
   - ☐ 18-30
   - ☐ 31-40
   - ☐ 41-50
   - ☐ 51-60
   - ☐ 61-70
   - ☐ 71-80
   - ☐ 81-90
   - ☐ More than 90

3. Gender
   - ☐ Male
   - ☐ Female

4. Hand Dominance
   - ☐ Right Handed
   - ☐ Left Handed

5. Do you have any shoulder activity limitation/pain in your:
   - ☐ Right side
   - ☐ Left side
   - ☐ None

6. Backhand Technique
   - ☐ Double Handed
   - ☐ One Handed

7. Forehand Technique
   - ☐ Double Handed
   - ☐ One Handed

8. Height (m): _____

9. Weight (kg): _____

10. In your shoulder, have you been diagnosed with any of the following:
    - ☐ Fracture
    - ☐ Dislocation
    - ☐ Infection
    - ☐ Frozen shoulder
    - ☐ Systemic disease
    - ☐ Neoplasm/Tumor
    - ☐ None

OSTRC Overuse Injury Questionnaire: Shoulder Problems

Please answer all questions regardless of whether or not you have problems in your shoulders. Select the alternative that is most appropriate for you, and in the case that you are unsure, try to give an answer as best you can anyway.

The term "shoulder problems" refers to pain, aching, stiffness, looseness or other complaints in one or both of your shoulders.

11. Have you had any difficulties participating in normal training and competition due to shoulder problems during the past week?
    - ☐ Full participation without shoulder problems
    - ☐ Full participation, but with shoulder problems
    - ☐ Reduced participation due to shoulder problems
    - ☐ Cannot participate due to shoulder problems

12. To what extent have you reduced you training volume due to shoulder problems during the past week?
    - ☐ No reduction
    - ☐ To a minor extent
    - ☐ To a moderate extent
    - ☐ To a major extent
    - ☐ Cannot participate at all

13. To what extent have shoulder problems affected your performance during the past week?
    - ☐ No effect
    - ☐ To a minor extent
    - ☐ To a moderate extent
    - ☐ To a major extent
    - ☐ Cannot participate at all

14. To what extent have you experienced shoulder pain related to your sport during the past week?
    - ☐ No pain
    - ☐ Mild pain
    - ☐ Moderate pain
    - ☐ Severe pain

15. Please rate your pain intensity on a scale of 1-10 (0=no pain, 10=severe pain):

☐ 0	☐ 4	☐ 8
☐ 1	☐ 5	☐ 9
☐ 2	☐ 6	☐ 10
☐ 3	☐ 7	

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Exercise rehabilitation for neurogenic thoracic outlet syndrome: a scoping review

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Exercise rehabilitation has been proposed for the management of Neurogenic Thoracic Outlet Syndrome (NTOS). To date there have been no reviews of the literature regarding exercise rehabilitation for NTOS and their proposed clinical rationale. Understanding various exercise protocols and their clinical rationale may help guide rehabilitation clinicians in their exercise selection when managing NTOS. A scoping review was conducted on exercise rehabilitation for NTOS from inception to March 2021 in the PubMed database. Forty-seven articles consisting of literature reviews, non-randomized control trials, prospective and retrospective cohort studies, case series, case studies and clinical commentaries met the inclusion criteria. This scoping review provides a broad overview of the most common exercise protocols that have been published and

Rééducation par l'exercice pour le syndrome du défilé thoracique neurogène : un examen de la portée.
La rééducation par l'exercice a été proposée pour la prise en charge du syndrome neurologique du syndrome du défilé thoraco-brachial neurologique (SDTB). À ce jour, il n'y a eu aucune publication concernant la rééducation par l'exercice pour le SDTB et leur justification clinique proposée. Comprendre divers protocoles d'exercices et leur justification clinique peut aider à guider les cliniciens en réadaptation dans leur sélection d'exercices lors de la gestion du SDTB. Un examen de la portée a été effectué sur la rééducation par l'exercice pour le SDTB depuis sa création jusqu'en mars 2021 dans la base de données PubMed. Quarante-sept articles composés de revues littéraires, d'essais contrôlés non randomisés, d'études de cohorte prospectives et rétrospectives, de séries de cas, d'études de cas et de commentaires cliniques répondaient aux critères d'inclusion. Cet examen de la portée fournit un large aperçu des protocoles d'exercice les plus courants

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examines the purported clinical rationale utilized in the management of NTOS.

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KEY WORDS: exercise, neurogenic , rehabilitation, scoping review, thoracic outlet syndrome

qui ont été publiés et examine la prétendue justification clinique utilisée dans la gestion du SDTB.

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MOTS CLÉS : exercice, neurogène, rééducation, examen de la portée, syndrome du défilé thoracique

Introduction

The term Thoracic Outlet Syndrome (TOS) was first coined by Peet *et al*.[1] in 1956 to describe a compromise of blood vessels or brachial plexus fibers at one or more sites between the base of the neck and axilla. TOS can further be clinically classified into vascular, arterial or neurogenic in nature.[2,3] Neurogenic TOS (NTOS) is thought to be caused by compression of the brachial plexus at the interscalene triangle, the sub-coracoid space, or both, resulting in symptoms which may include pain in the neck and/or arm and paresthesia into the fingers.[4] NTOS can be further classified as "true" or "disputed," in which true NTOS presents with objective findings such as muscle wasting, motor weakness, sensory loss, electrophysiological changes, or radiological evidence of bony abnormalities attributable to the symptoms such as the presence of cervical ribs, whereas disputed NTOS lacks any objective findings.[1-3] There has been much controversy in the field of musculoskeletal medicine surrounding disputed NTOS due to the lack of objective findings associated with the condition. Due to this controversy, some argue that this condition is over-diagnosed[2], with an estimated reported incidence rate of two to three cases per 100,000 people per year[4]. Furthermore, there is a lack of consensus regarding the diagnostic criteria of NTOS among different expert groups, including the Society for Vascular Surgery and the Consortium for Research and Education on Thoracic Outlet Syndrome (CORE-TOS), adding onto the controversy of NTOS.[5-6]

The management of NTOS has typically focused on conservative approaches including exercise rehabilitation, manual therapy, hot/cold therapy, electrophysical modalities, and supportive devices such as strapping/taping as shown by a 2011 systematic review by Lo *et al*.[7] Exercise therapy for NTOS has been hypothesized to decrease symptoms by increasing the thoracic outlet space through stretching and strengthening of certain muscles groups leading to increase joint space and decrease pressure on the brachial plexus.[8] However, despite exercise rehabilitation being a cornerstone in the conservative management of NTOS, there are currently no reviews which aim to specifically describe the various types of exercise protocols that exists in the literature while examining their proposed theories and rationale.

Therefore, the aim of this scoping review was to analyze the literature, from inception to March 2021, on rehabilitative exercises for true and disputed NTOS, to provide a broad and comprehensive overview of different exercise protocols that have been published and to provide an update to the literature from the systematic review by Lo *et al*.[7] Our secondary aim was to review the clinical reasoning behind different exercise protocols which will help guide rehabilitation clinicians such as chiropractors and physiotherapists in their clinical decision-making and exercise prescription in the management of NTOS.

Methods

A scoping review of the literature was conducted using the framework of Levac *et al*.[9] Our research question aimed to capture the breadth of literature regarding rehabilitative exercises for NTOS and their proposed clinical rationale from inception to March 2021. In order to gather a preliminary understanding of the literature, authors DL, RS, and KD briefly searched the literature and team meetings were held to refine the inclusion and exclusion criteria.

The inclusion criteria consisted of peer-reviewed English language primary and secondary articles which included narrative/literature reviews, systematic reviews, Cochrane reviews, randomized controlled and non-randomized controlled trials, retrospective and prospective cohort studies, case series, case reports, clinical commentaries, and consensus development statements. Case ser-

ies, case reports and clinical commentaries were included as the aim of this scoping review was to capture the breadth of the existing literature on this topic and to examine the rationales that different authors have proposed in the literature. Articles that included a diagnosis of true or disputed NTOS and provided a description of rehabilitative exercises were included. Articles that included arterial or vascular TOS, post-operative rehabilitation, cadaveric or animal studies, or did not sufficiently describe the exercise intervention in detail (i.e., only reporting stretching but did not indicate the specific muscle or body region) were excluded.

Team meetings were held with all authors and a health research librarian (KM) to refine the search strategy. The final search strategy (Appendix 1) was eventually formed by combining keywords related to exercise (concept A) and thoracic outlet syndrome (concept B) using both MeSH terms and title/abstract. The search strategy was inputted into the PubMed database on March 22, 2021 and yielded one thousand five hundred and fifty-eight articles. At the time, we believed that utilizing PubMed as our single search database was sufficient to address our research question due to our comprehensive search strategy and the fact that any additional articles included would not likely have changed the results of our findings. After screening for title and abstract, two hundred and twelve articles were eligible for individual article screening. Disagreements on inclusion based on title and abstract were resolved by discussion among the authors DL, RS, and KD. Two reviewers (DL and RS) then screened two hundred and twelve articles individually and any disagreements were settled by a third reviewer (KD). Articles were excluded due to a lack of sufficient detail in describing the exercise intervention, inability to obtain full access or due to articles not being published in English. An overview of our article screening process can be seen in Figure 1. Authors DL, RS and KD reviewed all forty-seven papers and extracted the information in Appendix 2. The extracted data included author and year of the publication, study design, types of treatments that were recommended along with exercise, description of the exercise protocol, and if appliable, the clinical rationale for the exercises chosen. The information in Appendix 2 was extracted by analyzing and combining the common themes of each exercise type and their rationale. Exercises were categorized by their purpose or intent in changing the biomechanics or properties of a particular tissue as described by the author. For example, studies that included stretching and strengthening exercises were included into Peet's protocol[8] as the intent and clinical rationale were similar among studies with slight variations in the protocols, whereas studies that looked specifically at exercises designed to address the physiological relationship between neural and non-neural tissue were categorized into neurodynamic exercises.[14,20,46,53,32] Further detail can be seen in Appendix 2.

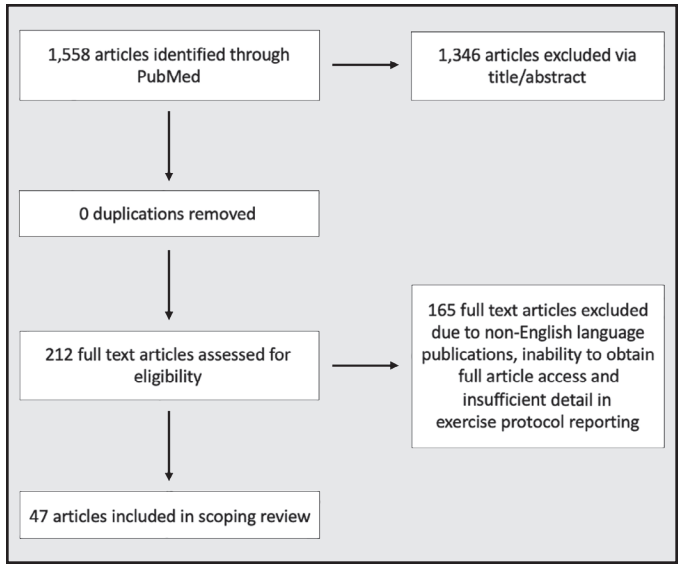

Figure 1.
Article flow through review process

Results

A total of forty-seven articles from 1975 to 2021 met our inclusion criteria and were extracted into Appendix 2. Of the forty-seven articles, twenty-six were narrative and literature reviews, five were retrospective studies, three were prospective studies, three were non-randomized control trials, three were case series, five were case studies, and two were clinical commentaries.[8,10-57] The results of our findings are presented in the following order: exercise alone versus exercise with other treatment modalities, clinical rationale of exercise protocols, and a description of the exercise protocols themselves.

Exercise alone versus exercise with other treatment modalities

A total of twenty-one articles included exercise in addition to other treatment options such as analgesic or anti-inflammatory medications, botox injections, hot/cold therapy, electrophysical modalities such as TENS and ultrasound, manual therapy (joint mobilizations, manipulation, massage and other soft tissue therapy techniques), orthoses, night splinting, and patient education regarding ergonomics and postural awareness.[8,11,13-14,16-17,19-22,24-25,29-31,36,49-50,52,55-56] One quasi-experimental trial looked at combining paracetamol or non-steroidal anti-inflammatory (NSAID) medication with exercise[14], one retrospective study looked at the effects of exercise and manual therapy with optional psychological support[19], and another retrospective study looked at a combination of a night splint with exercise.[26] One case report looked at combining manual therapy with exercise.[36] Two retrospective studies[12,26], one prospective cohort study[28], two case reports[34,37], and one case series[35] looked at the effects of exercise alone on NTOS symptoms.

Clinical rationale of exercise protocols

Thirty-three articles purported the following clinical rationale: i) postural correction, ii) "decompression" of the thoracic outlet by strengthening the muscles responsible for shoulder girdle elevation, iii) establishing normal scapular control, iv) facilitation of weak or inhibited muscles, v) decreasing pressure on the neurovascular bundle by lengthening the surrounding musculature to restore proper muscular balance, vi) decreasing intraneural pressure, vii) "re-energizing" tissues and "reprograming" the central engram to normalize muscle length, viii) enlarging the costoclavicular passage by improving muscular flexibility and joint stability, ix) restoring normal joint motion, and x) decreasing the shortening of muscles to prevent recurrence of trigger points.[8,11,13,15-17,20-22,24-39,40-41,43-47,49,51,53] A detailed outline of each article and the author's rationale for their exercise selection can be seen in Appendix 2.

Exercise protocols

Peet's protocol

Peet was the first to design an exercise protocol for managing NTOS in 1956 and his protocol has been used and modified by several others.[57] The protocol by Peet included strengthening of the levator scapulae muscle, stretching of the pectoralis minor and postural correction exercises.[8] A literature review by Vanti *et al*.[8] reviewed several articles that presented modifications of Peet's protocol, including exercises aimed at depressing the first rib and strengthening of the posterior spinal muscles, and isometric exercises for the serratus anterior and pectoralis minor. The exercise protocols varied in their dosages, with one study recommending that the protocol to be done daily with weights up to 1kg in each hand while another study recommended the exercises be done with 0-5lbs for three weeks, five times daily, and a different study recommended daily home exercises be done two to three times per week.[8]

The clinical rationale behind Peet's protocol is to restore muscle balance and achieve postural correction by strengthening muscles that open the thoracic outlet by raising the shoulder girdle (e.g., trapezius, sternocleidomastoid) and stretching muscles that close the thoracic outlet (e.g., lower trapezius, scalene muscles).[8] However, as Vanti *et al*.[8] noted in their review, there was no agreement between authors on which muscles needed strengthening and which muscles needed stretching, with some authors arguing for strengthening muscles responsible for shoulder elevation whereas others argued for stretching muscles of shoulder elevation.

Britt's method

Britt's method involves a similar rationale to Peet's with the addition of shoulder girdle exercises involving a strapping device to elevate the shoulders.[8] Britt's method also includes cervical retraction exercises, a graded stretching program for shoulder girdle elevators, resisted shoulder adduction and extension exercises, and strengthening of the lower scapular stabilizers, shoulder girdle elevators, and small pectoral muscles.[8] It was recommended that exercises be done five to ten times a day in addition to an aerobic conditioning program.[8]

Addressing scapular kinematics

In a narrative review by Watson *et al*.[11], the authors recommended exercises to address the "dropping shoulder" (shoulder girdle depression) that can sometimes be seen in NTOS, as this can lead to altered scapular kinematics and traction stress on the neurovascular bundle of the thoracic outlet. This rehabilitative approach was designed

to elevate the shoulder girdle in order to "decompress" the thoracic outlet and restore scapular control.[11] The first stage focused on establishing normal scapular muscle recruitment and control in the resting position.[11] Once this had been achieved, then the program progressed to adding movement and load while maintaining scapular control.[11] The exercise program begins with lower ranges of shoulder abduction and gradually progresses to larger ranges of shoulder abduction and flexion with the goal of re-training the muscles in more functional movement patterns.[11] The authors noted that there should be an emphasis on facilitating and encouraging sufficient firing in any muscles that may be weak, inhibited, or slow to switch on in their normal movement strategies.[11] However, the authors noted themselves that this was based on their own clinical opinion and that scientific data was lacking to support their views.[11]

Nerve gliding exercises

Crosby *et al*.[14] highlighted the use of tendon and nerve gliding exercises in combination with cervical spine range of motion exercises, shoulder pendulum exercises, stretching of the upper trapezius, scalene group and pectorals, and strengthening of the cervical extensors, scapular adductors and shoulder retractors. The authors proposed that these exercises would help to decrease intraneural pressure, minimize scarring, decrease extrinsic pressure and reduce intrinsic irritation of the surrounding neurovascular structures.[14] However, the authors noted that this was based on clinical opinion and not on any scientific evidence.[14] Christo and McGreevy[20] also proposed nerve gliding exercises with the aim of providing neural mobility in combination with postural correction exercises, shoulder girdle strengthening, relaxation via biofeedback and stretching exercises to help with decompression of the brachial plexus and restoration of muscle balance in the neck. Boezart *et al*. [46] recommended four to six months of conservative therapy with specific neck and shoulder exercises including strength training, neck traction, and nerve gliding exercises which aimed to relieve neural tension on the brachial plexus during arm and neck movements. Press and Young[53] described physical therapy for NTOS with the goal of "opening up" the thoracic outlet by correcting abnormal posture with side-bending and cervical traction exercises, advancing to cervicothoracic stabilization exercises and brachial plexus stretching. Lastly, Wehbe and Schlegal[32] provided a clinical commentary on upper and lower plexus nerve gliding, median nerve gliding at the elbow and wrist, ulnar nerve gliding at the elbow and wrist, and radial nerve gliding at the humeral spiral groove, elbow and wrist. The authors emphasize the importance of slacking one end of the nerve while pulling on the opposite end to avoid tensioning the nerve on both ends and so that "gliding" could ensure.[32]

Restoration of breathing mechanics

Several articles recommended an aerobic conditioning program such as walking or diaphragmatic breathing exercises in combination with stretching and strengthening exercises.[12,16,19,24,26-27,55] Robey and Boyle[41] described a protocol from the Postural Restoration Institute (PRI), where the aim was to restore over-developed faulty respiratory muscles by positioning the pelvis into posterior tilt while encouraging rib depression during breathing exercises to help discourage over-involvement of the paraspinal and neck musculature. Specific exercises and progressions can be seen in Appendix 2

Exercise dosage

Exercise dosage such as frequency, sets and repetitions varied considerably across studies with no agreed upon dosage. For example, Peet's protocol was recommended fives times daily for three weeks, while Britt's method was recommended five to ten times per day.[8] The scapular focused protocol proposed by Watson *et al*.[11] recommended twenty repetitions three times per day for the initial scapular control phase, then once per day with resistance during the loading phase and then four sets of six to eight repetitions once per day for the final hypertrophy phase. A quasi-experimental trial by Hanif *et al*.[14] consisted of strengthening exercises that were prescribed to patients once per day, four times per week for six months, while Crawford *et al*.[18] recommended strengthening exercises of ten repetitions twice per day and Sucher *et al*.[21] recommended stretching five to ten times per day, holding each stretch for ten to thirty seconds. Whereas a case report by Robey and Boyle[41] prescribed three sets of thirty-second-long stretching exercises twice per day for seven days a week and three sets of fifteen repetitions twice per day, daily for four weeks. A non-randomized controlled trial by Lindgren *et a.l*[37] administered NTOS exercises to be

done four to six times a day for five to ten repetitions and instructed the patients to continue the exercises for one year. Sanders and Annest[48] recommended pectoral minor stretching to be done three times per day for three sets of fifteen to twenty second holds. A prospective cohort study by Pesser *et al*.[51] prescribed scapular mobility exercises for six to twelve weeks at least once per week during in-person physiotherapy sessions and daily at-home exercises.

Discussion

In reviewing the literature on exercise rehabilitation for the treatment of NTOS, there were several concerns that are important for clinicians to consider – namely the different clinical rationales that were proposed and the variation in exercise dosage. The clinical rationale proposed by most authors involved postural "correction" and "decompression" of the thoracic outlet via restoring proper muscular balance.[8,11,13,15-17,20-22,24-39,40-41,43-47,49,51,53] However, there appeared to be inconsistencies and at times even contradictions in the clinical reasoning between authors. This was evident from the literature review by Vanti *et al*.[8], in which there was no agreement on which muscles needed strengthening and which muscles needed stretching, where some argued for strengthening muscles responsible for shoulder elevation whereas others argued for stretching muscles of shoulder elevation. This begs the question as to whether specific muscle stretching and strengthening protocols play an important role in the management of NTOS or if exercise in general is a sufficient modality for this condition.

Another concern was the scapular focused program aimed at restoring normal scapular control, proposed by Watson *et al*. [11] To date, there have been no clinical trials examining scapular focused exercises on NTOS compared to other forms of exercise, and it is not known if changing scapular kinematics leads to a change in NTOS symptoms. The authors noted themselves that a scapular focused exercise protocol was based on their own clinical opinion and not on any scientific data.[11] It should also be noted that the literature regarding scapular assessment for dyskinesia in relation to shoulder pain has shown poor interrater reliability and low methodological quality.[60-62] Additionally, several studies have also shown that scapular focused exercises for shoulder pain did not alter scapular kinematics, despite patients demonstrating an improvement in shoulder pain.[63-64] This information calls into question the utility of scapular focused exercises and their ability to alter scapular kinematics in the management of NTOS.

In regard to exercise dosage, there was considerable inconsistency across studies, as is commonly seen in the exercise rehabilitation literature for musculoskeletal pain.[58] However, clinicians can use the variability of the different exercise dosages from this review as a guide to incorporate shared decision making to fit the individual needs and goals of the patient.[59]

Lastly, a majority of articles included in the scoping review advocated for postural correction exercises in the management of NTOS. However, the studies included in the scoping review did not measure or evaluate whether or not postural changes actually occurred despite prescribing exercises with the intent of changing posture. Therefore, changes in pain and function may have been independent from any postural changes.[8,15-16,20-21,24,49,53,56] Additionally, the literature regarding posture and its association with common musculoskeletal disorders such as neck and low back pain have been challenged in the past.[65-69] Therefore, the rationale proposed by many authors regarding restoration of "postural balance" and terms such as "re-energize" and "reprogramming the central engram to restore muscle length"[8,15-16,20-21,24,49,53,56], should be challenged due to the lack of supporting evidence that postural changes actually occur in the management of NTOS.

The purported clinical rationales from the studies in this scoping review have all been developed from a biomechanical viewpoint (e.g., restoring proper posture, correcting muscular imbalances, restoring normal joint motion and correcting faulty breathing patterns). However, we believe that embracing a biopsychosocial approach based on the existing literature for common musculoskeletal disorders such as low back pain, may also help to explain why exercise rehabilitation may be effective for the management of NTOS. These reasons may include, improvements in pain self-efficacy, better pain coping strategies, decrease in fear avoidance behavior, increase in "affordances" or action opportunities that the individual has to perform daily activities, desensitization of nociceptive structures by temporarily avoiding provocative positions, improvements in tissue tolerance and capacity through progressive overload and gradual exposure, exercise-induced analgesia via descending noxious inhibitory

control mechanisms and positive contextual factors related to the clinician-patient interaction.[60,70-73]

Limitations

There were several limitations of this scoping review that are important to consider. Articles that were not published in the English language and articles that involved a post-operative rehabilitation program were not included. Therefore, some articles may have been missed. Additionally, there were disagreements between authors during the article screening processes as to what was deemed "sufficient detail" in the description of exercises for papers to be included in this study. Although this was settled by a third reviewer, there may have been some useful articles not included due to the vague description of exercises provided. Lastly, our search strategy although comprehensive, was done only in the PubMed database. More robust evidence from randomized controlled trials is needed to establish the efficacy of exercise intervention for the management of NTOS. Future research may also seek to compare different exercise dosages, compare the efficacy of one exercise type to another and consider other rationales such as improvements in fear-avoidance behavior, pain coping strategies or contextual factors that may explain the mechanisms behind exercise therapy for the management of NTOS.

Conclusion

In conclusion, our scoping review included forty-seven articles that described various exercise protocols for the treatment of NTOS which included stretching and strengthening of the surrounding thoracic outlet musculature, postural training, nerve gliding, scapular focused exercises, aerobic conditioning and breathing exercises. As the studies in this review consisted mainly of literature reviews, retrospective and prospective cohort studies, case series, case studies, and clinical commentaries with no randomized control trials found, clinicians remain limited to utilizing clinical opinion when formulating and prescribing exercise protocols for the management of NTOS. Future randomized controlled trials are necessary to help delineate whether one form of exercise is superior to another, as well as to determine preferred exercise dosage with respect to the management of NTOS or whether movement in general, coupled with behavior modification and pain coping strategies suffice.

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Appendix 1.
Search strategy keywords

Concept A	**Concept B**
(thoracic outlet syndrome[Title/ Abstract]) OR (((“Thoracic Outlet Syndrome”[Mesh]) OR ((aperture syndrome[Title/ Abstract] OR superior thoracic aperture syndrome[Title/Abstract] OR costoclavicular syndrome[Title/Abstract] OR cervical rib syndrome[MeSH] OR cervical rib syndrome[Title/ Abstract] OR neurogenic syndrome[Title/ Abstract] OR scalene syndrome[Title/ Abstract] OR double crush syndrome[MeSH] OR double crush syndrome[Title/ Abstract] OR crush syndromes[Title/ Abstract] OR thoracic outlet syndromes[Title/Abstract] OR thoracic outlet neurovascular syndrome[Title/Abstract] OR Superior Thoracic Aperture Syndrome[Title/Abstract] OR Costoclavicular Syndromes[Title/Abstract] OR Neurogenic Thoracic Outlet Syndrome[Title/Abstract] OR Scalenus Anticus Syndrome[Title/Abstract] OR Thoracic Outlet Nerve Compression Syndrome[Title/ Abstract] OR Venous Thoracic Outlet Syndrome[Title/Abstract] OR Arterial Thoracic Outlet Syndrome[Title/Abstract] OR Thoracic Outlet Neurologic Syndrome[Title/Abstract]))) OR ((thoracic outlet aperture syndrome[Title/Abstract] OR thoracic outlet aperture syndromes[Title/Abstract])))	(((((physical therapists[MeSH]) OR (physical therapists[Title/Abstract])) OR (physical therapy modalities[Title/Abstract])) OR (physical therapy modalities[MeSH])) OR (physical therapist assistants[MeSH])) OR (physical therapist assistants[Title/Abstract])) OR (physical therapy specialty[Title/Abstract])) OR (physical therapy specialty[MeSH])) OR (rehab*[MeSH])) OR (rehab*[Title/Abstract])) OR (management[MeSH])) OR (management[Title/Abstract])) OR (stretch*[MeSH])) OR (stretch*[Title/Abstract])) OR (chiropract*[MeSH])) OR (chiropract*[Title/Abstract])) OR (osteopath*[MeSH])) OR (osteopath*[Title/Abstract])) OR (postur*[MeSH])) OR (postur*[Title/Abstract])) OR (range of motion[MeSH])) OR (range of motion[Title/Abstract])) OR (physiatr*[MeSH])) OR (physiatr*[Title/Abstract])) OR (treatment[MeSH])) OR (treatment[Title/Abstract])) OR (exercise[MeSH])) OR (exercise[Title/Abstract])) OR (compression/decompression[MeSH])) OR (compression/decompression[Title/Abstract])) OR (traction[MeSH])) OR (traction[Title/Abstract])) OR (rehabilitation[MeSH])) OR (rehabilitation[Title/Abstract])) OR (activities of daily living[MeSH])) OR (activities of daily living[Title/Abstract])) OR (exercise therapy[MeSH])) OR (exercise therapy[Title/Abstract])) OR (motion therapy, continuous passive[MeSH])) OR (motion therapy, continuous passive[Title/Abstract])) OR (muscle stretching exercises[MeSH])) OR (muscle stretching exercises[Title/Abstract])) OR (plyometric exercise[MeSH])) OR (plyometric exercise[Title/Abstract])) OR (resistance training[MeSH])) OR (resistance training[Title/Abstract])) OR (neurological rehabilitation[MeSH])) OR (neurological rehabilitation[Title/Abstract])) OR (occupational therap*[MeSH])) OR (occupational therap*[Title/Abstract])) OR (recreation therapy[MeSH])) OR (recreation therapy[Title/Abstract])) OR (myofunctional therapy[MeSH])) OR (myofunctional therapy[Title/Abstract])) OR (physical therapy modalities [MeSH])) OR (physical therapy modalities [Title/Abstract])) OR (musculoskeletal manipulations[MeSH])) OR (musculoskeletal manipulations[Title/Abstract])) OR (hydrotherapy[MeSH])) OR (hydrotherapy[Title/Abstract])) OR (self-management[MeSH])) OR (self-management[Title/Abstract])) OR (self-care[MeSH])) OR (self-care[Title/Abstract])) OR (disease management[MeSH])) OR (disease management[Title/Abstract])) OR (pain management[MeSH])) OR (pain management[Title/Abstract])) OR (conservative treatment[MeSH])) OR (conservative treatment[Title/Abstract])) OR (posture[MeSH])) OR (posture[Title/Abstract])) OR (postural balance[MeSH])) OR (postural balance[Title/Abstract])) OR (bed rest[MeSH])) OR (bed rest[Title/Abstract])) OR (patient positioning[MeSH])) OR (patient positioning[Title/Abstract])) OR (combined modality therapy[MeSH])) OR (combined modality therapy[Title/Abstract])) OR (complementary therapies[MeSH])) OR (complementary therapies[Title/Abstract])) OR (manipulation, orthopedic[MeSH])) OR (manipulation, orthopedic[Title/Abstract]) OR ((((((((((((((((((((((((((((((therapeutic[Title/Abstract]) OR (condition*[Title/Abstract])) OR (isometric[Title/Abstract])) OR (isotonic[Title/Abstract])) OR (isokinetic[Title/Abstract])) OR (plyometric[Title/Abstract])) OR (train*[Title/Abstract])) OR (warm up[Title/Abstract])) OR (warm-up[Title/Abstract])) OR (warming up[Title/Abstract])) OR (warming up[Title/Abstract])) OR (cool down[Title/Abstract])) OR (cool-down[Title/Abstract])) OR (cooling down[Title/Abstract])) OR (activit*[Title/Abstract])) OR (sport[Title/Abstract])) OR (pilate[Title/Abstract])) OR (yoga[Title/Abstract])) OR (yoga[Title/Abstract])) OR (pre-operative[Title/Abstract])) OR (post-operative[Title/Abstract])) OR (weight-lift*[Title/Abstract])) OR (weight lift*[Title/Abstract])) OR (program[Title/Abstract])) OR (weight bear*[Title/Abstract])) OR (weight-bear*[Title/Abstract])) OR (static[Title/Abstract])) OR (dynamic[Title/Abstract])) OR (ballistic[Title/Abstract])) OR (PNF[Title/Abstract])) OR (propriocep*[Title/Abstract]))) OR (zone therapy[Title/Abstract])) OR (therapies, zone[Title/Abstract])) OR (zone therapies[Title/Abstract])) OR (therapy, zone[Title/Abstract])) OR (massage therapy[Title/Abstract])) OR (massage therapies[Title/Abstract])) OR (therapies, massage[Title/Abstract])) OR (therapy, massage[Title/Abstract])) OR (conservative treatments[Title/Abstract])) OR (treatment, conservative[Title/Abstract])) OR (treatments, conservative[Title/Abstract])) OR (conservative management[Title/Abstract])) OR (conservative managements[Title/Abstract])) OR (management, conservative[Title/Abstract])) OR (managements, conservative[Title/Abstract])) OR (conservative therapy[Title/Abstract])) OR (conservative therapies[Title/Abstract])) OR (therapies, conservative[Title/Abstract])) OR (therapy, conservative[Title/Abstract])) OR (physical medicine[Title/Abstract])) OR (physiatrics[Title/Abstract])) OR (physiatry[Title/Abstract])) OR (physical medicine and rehabilitation[Title/Abstract])) OR (medicine, physical[Title/Abstract])) OR (conservative[Title/Abstract])) OR (nonoperative[Title/Abstract])) OR (strength[Title/Abstract])) OR (resistance[Title/Abstract])) OR (aerobic[Title/Abstract])) OR (isometric[Title/Abstract])) OR (isotonic[Title/Abstract])) OR (athletic therap*[Title/Abstract])) OR (massage therap*[Title/Abstract])) OR (concentric[Title/Abstract])) OR (eccentric[Title/Abstract])) OR (anaerobic[Title/Abstract])) OR (circuit[Title/Abstract])) OR (high intensity[Title/Abstract])) OR (low intensity[Title/Abstract])) OR (physician, osteopathic[Title/Abstract])) OR (physicians, osteopathic[Title/Abstract])) OR (osteopaths[Title/Abstract])) OR (osteopathic physician[Title/Abstract])) OR (doctor of osteopathy[Title/Abstract])) OR (osteopathy doctor[Title/Abstract])) OR (osteopathy doctors[Title/Abstract])) OR (osteopath[Title/Abstract])) OR (joint range of motion[Title/Abstract])) OR (joint flexibility[Title/Abstract])) OR (flexibility, joint[Title/Abstract])) OR (range of motion[Title/Abstract])) OR (passive range of motion[Title/Abstract])

Appendix 2.

Evidence summary table of author, year of publication, study design, treatment type, description of exercises and rationale.

Author, year	Study design	Treatment (exercise alone or combined with other modalities)	Description of exercises (type, sets/reps, duration)	Rationale for exercise
Abe et al. 1999	Narrative review	Exercise followed by orthopaedic bracing	Serratus anterior, levator scapulae, and erector spinae muscle isometric strengthening.	Isometric shoulder girdle exercises in positions of relief.
Aktas et al. 2019	Case report	Ultrasound-guided botulinum toxin injection to pectoralis minor	"Stretching exercises to the pectoral muscles were added to the rehabilitation program"	No rationale listed.
Aligne and Barral 1992	Narrative review	Physical therapy utilizing mobilizations and exercise therapy	Isometric sternocleidomastoid, serratus anterior and superior trap exercises. Physical therapy sessions: 3x week for 1st month, twice weekly for the 2nd month, 6-8 sessions as needed in the future.	Enlarge the costoclavicular passage to decrease the constraints of the neurovascular elements.
Balderman et al. 2019	Retrospective cohort study of prospectively collected data, 130 participants with nTOS undergoing physical therapy.	N/A	Scalene and pectoralis muscle stretching and relaxing exercises, with a focus on shoulder girdle and scapular mobility, mechanics, postural improvement, and diaphragmatic breathing, using caution with strengthening, weight training, and the use of resistance bands	No rationale listed.
Boezart et al. 2010	Narrative review + case report	No treatment administered, just opinion	Nerve gliding exercises, 4-6 months of conservative therapy for specific neck and shoulder exercises. Strength training, weightlifting, and neck traction	Nerve gliding relieves tension on nerves of brachial plexus during arm and neck movements. 4-6 months of conservative therapy recommended by Kenny et al. 1993.
Brown 1983	Narrative review	Physical therapy	Shoulder shrugs with 10lb weights in each hand. Bilateral arm abduction with pronated hands with weight in each hands. Wall push-ups	Restoration of normal postures.
Campbell 1996	Case series	Case 1: exercises, posture repositioning strategies, ice and heat, discontinuing upper extremity exercise, soft tissue mobilizations, strengthening exercises. Case 2: Noritriptyline was prescribed and referral to occupational therapy	Case 1: Cervical side bend stretches, and pelvic tilt exercises combined with deep breathing Prone middle and lower trapezius strengthening and latissimus strengthening of 5 repetitions each with 10s hold without weight. Told to increase repetitions to 10 after 3 days if tolerated without a return of symptoms. Progression involved a 1lb weight was added to this exercise and decreasing to 5 repetitions Case 2: physical therapy involved exercise program of middle trapezius, lower trapezius, latissimus dorsi, and rhomboid strengthening – 5 repetitions with 10 second hold. Told to increase this to 8 repetitions with 10 second holds within 7 days. Increased to a 2lb weight for 5 repetitions	No rationale listed.
Christo & McGreevy 2011	Narrative review	Behavioural/ergonomic modification, massage therapy.	Postural correction and shoulder girdle strengthening exercises, relaxation exercises, stretching, biofeedback exercises and nerve glides.	These interventions focus on decompressing the brachial plexus, restoring muscle balance in the neck, and providing neural mobility

N/A = not applicable; lb = pound; ROM = range of motion; B/L = bilaterally; NSAIDs = non-steroidal anti-inflammatory drugs; kg = kilogram; TENS = transcutaneous electrical nerve stimulation; SVS = Society for Vascular Surgery; TA = transverse abdominus

Author, year	Study design	Treatment (exercise alone or combined with other modalities)	Description of exercises (type, sets/reps, duration)	Rationale for exercise
Crawford 1980	Narrative review	Postural education	Exercises designed to strengthen the muscles of the shoulder girdle are outlined and begun as follows: 10 times, twice a day Shoulder shrug + scapular retraction then protraction (2lbs each hand, progressing to 5-10lbs). Lateral raises with weights with 2lbs progressing to 5-10lbs. Standing leaning wall push-up. Lateral cervical flexion ROM isotonic contractions. Prone-lying chin tucks. Supine-lying pectoral stretch with towel between shoulder blades.	No rationale listed.
Crosby et al. 2004	Narrative review	Authors suggest pain control with medication, therapeutic modalities, injections, edema control with massage therapy, patient education on posture and ergonomics, and relaxation techniques such as deep breathing, mild aerobic exercise, contract-relax exercise, and hot showers/heat packs.	Tendon and nerve gliding exercises. Cervical spine ROM exercises, chin tucks – 5 sets 5 seconds. Shoulder ROM exercises, pendulum exercise with 1 lb weight to 1-2mins, shoulder shrugs with 1-3lbs. Relax shoulder girdle via upper trapezius, scalene and pectoralis stretching. Strengthening cervical extensors, scapular adductors. and shoulder retractors.	Conservative treatment focuses on decreasing extrinsic pressure and reducing intrinsic irritation. By reducing inflammation in the thoracic outlet and shortening or lengthening the surrounding musculature for proper balance, pressure against the neurovascular bundle is decreased. Decreased intraneural pressure and minimize scarring (author noted not based on factual basis and on author preferences).
Dale and Lewis 1975	Retrospective study	Exercise program followed by surgery if exercise not relieving.	10 reps, two times per day. Shoulder shrugs with 2lb weights in each hand. Lateral raises starting at 90 degrees abduction to touching overhead with 2lbd weight in each hand. Pec stretch in corner of a wall. Neck lateral flexion B/L without shoulder shrugging. Prone thoracic spine extension with chin tucking, hold for three seconds then relax. Supine shoulder flexion above head with rolled up towel between shoulder blades.	No rationale listed.
Dobrusin 1989	Narrative review	Osteopathic treatment consisting of avoidance of aggravating factors, weight loss, manipulation, exercise, counselling, medication, trigger point therapy, physical therapy and surgery.	Peet protocol. 2lb per hand weighted shoulder shrugs and abduction manoeuvres. Prone thoracic and cervical spine extension exercises. Repetitions and weight increased as patient can tolerate	Increasing strength and flexibility of shoulder and scapula elevators. Increase strength and flexibility of thoracic and cervical musculature.
Fitzgerald 2012	Case report	Manual force to muscle, joint manipulation, home stretch, and home rehabilitation	Home stretch for pectoralis minor muscle – do not hyperabduct and trigger symptoms Home rehabilitation – stretching pectoralis minor and upper trapezius + strengthening serratus anterior, latissimus dorsi and rhomboid muscles	No rationale listed.
Hanif et al. 2007	Quasi-experimental trial, 50 participants with nTOS	Prescribed tablet paracetamol & NSAIDs (e.g., Ibuprofen) for pain relief during the study.	Active strengthening exercises of paraspinal, scapular and trapezius muscles and stretching exercises of sternocleidomastoid, scalene anterior and pectoralis major muscles. 1x/day for 4 days per week, 6 consecutive months.	No rationale listed.

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Author, year	Study design	Treatment (exercise alone or combined with other modalities)	Description of exercises (type, sets/reps, duration)	Rationale for exercise
Huang et al. 2004	Narrative review	Modification of behaviors by avoiding provocative activities and arm positions,	Individually tailored physical therapy programs that strengthen the muscles of the pectoral girdle and help to restore normal posture.	Postural restoration.
Karas 1990	Narrative review	No treatment administered, just opinion, and clinical experience	Trapezius, rhomboid, and levator scapulae muscles can be strengthened using elastic bands or free weights with arms elevated less than 90 degrees and with avoidance of bracing of scapulae. Some patients may start the exercise program with simple shoulder shrugs and progress to movements with increasing flexion in diagonal patterns.	Treatment of TOS should be guided by underlying pathogenesis and contributory factors. Cornerstone of conservative therapy is carefully regulated program of muscle strengthening and postural re-education exercises.
Smith 1979	Single cohort trial + case study	-Home program + -Posture work + -Orthopaedic Manual Therapy	Shoulder girdle circumduction exercise + specific shoulder girdle and upper trunk exercises on a case-by-case basis. 1-3 weeks for maximum of 8-14 treatments.	Exercises for specific shoulder girdle muscles and/or upper trunk are given only when there is evidence of musculoskeletal defect due to a postural fault, muscle weakness, or muscle tightness. Treatment objective is to: 1. Enhance overall mobility of shoulder girdle by restoring any loss of accessory joint movement with passive mobilization techniques 2. Improve muscle efficiency with active exercises and massage 3. change postural habits and body mechanics that exacerbate patient's signs and symptoms.
Kenny et al. 1993.	Prospective study	Physiotherapy	Graduates resisted shoulder elevation exercises for 3 weeks. Elevate shoulders and hold for a count of 5 then relax shoulders. Progress through 3 weeks increasing weight and reps every week. 15-20 repetitions, 5-6 times per day.	Decompress the brachial plexus with exercise.
Kuhn et al. 2015	Narrative review	N/A	Physical therapy involves stretching, ROM exercises, and tendon and nerve gliding techniques.	No rationale listed.
Laulan J. 2016	Narrative review	N/A	Initially, muscle relaxation and stretching exercises are performed to alleviate muscle tightening, followed by postural correction exercises for the cervical spine and shoulder girdle. In the last stage, an exercise program is used to strengthen the weak shoulder muscles.	The aim of rehabilitation is mainly to correct muscle imbalances in the cervicoscapular region.
Levine and Rigby 2018	Narrative review	No treatment administered, just opinion	1. resistance exercises with bands or dumbbells with a goal of achieving muscular endurance (low weight and high reps) using 2-3kg. 2. combination of strengthening, stretching, and postural adjustments must all be incorporated 3. Exercises start with shoulder movements ranging from 0-30degrees flexion and 40degrees horizontal abduction → 45-90degrees flexion and functional overhead tasks. 4. stretching of scalenes and pectoralis muscles while strengthening cervical spine muscles. 5. Exercises described in study: Scapular retraction, scapular depression, standing external rotation, straight arm extension, banded high rows, prone shoulder extension, abduction, horizontal abduction, frontal raise, lateral raise, serratus push, chin tuck	Important to initially target scapular muscles to stabilize the shoulder. Strengthening the serratus anterior is important but horizontal adduction should be minimized to prevent further injury. Emphasis on proper scapular function during upper-body movements, breathing techniques, and head and pelvis alignment during various tasks.

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Author, year	Study design	Treatment (exercise alone or combined with other modalities)	Description of exercises (type, sets/reps, duration)	Rationale for exercise
Lindgren 1997	Descriptive study	Exercise supervised by physiotherapists.	Shoulder girdle exercises consisted of movements where the patient brought the shoulders backward and up (left), flexed the upper thoracic spine, brought the shoulders forward and down (middle), and then straightened the back and brought the shoulders backward (right). These exercises were repeated 5 to 10 times. Chin tucks- The movement of the upper cervical spine can be effectively normalized by keeping the back and head firmly against a wall and then lowering the chin against the chest with the back of the head still touching the wall. The exercise can be made more effective by pressing the head down by hands. The exercise is repeated 5 to 10 times. Resisted scalene strengthening- Normal function of the first ribs and the upper aperture can be achieved by activation of the scalene muscles by the patient. The patient first activates the anterior scalene muscles by pressing the forehead against the palm, with the cervical spine being all the time in a neutral position (left). The middle scalene muscles are activated by pressing sidewards against the palm (middle), and the posterior scalene muscles by pressing the back of the head against the palm (right). The exercises are done five or six times for a duration of 5 seconds each and with about 15 seconds between the exercises. The exercises are done to both sides. Levator scapulae stretching- by grabbing a chair with the left hand and then bending the upper part of the body to the right. The head is then turned towards the ceiling. This position should be held for 5 to 10 seconds. The patient then relaxes and repeats the exercise five times. (B) An effective stretching exercise involving mainly the levator scapulae	Shoulder exercises to restore full shoulder movement and provide more space for neurovascular components
Lindgren et al. 1995	Case report	Physical therapy	Isometric scalene strengthening with force applied against hands. Hand placed at front, side and back of head and resists head movement.	Restore function of the upper thoracic aperture. Correct malfunctions of the first ribs.
Lindgren and Rytkonen 1997	Controlled trial	Therapy administered in rehab ward	Shoulder exercises followed by cervical spine exercises for anterior, middle, and posterior scalenes, stretching of muscles of shoulder girdle, trapezius, levator scapulae, sternocleidomastoid, and small pectoral muscles. Further stretching administered as needed. Exercises advised to be done 4-6 times a day for 5-10 repetitions. Instructed to do for a year (3,6,12month follow-up)	Restore movement of whole shoulder girdle. Scalene exercises shown to correct malfunction of upper thoracic aperture.
Masocatto et al. 2019	Narrative review	No treatment administered	Specific exercises aimed at strengthening and lengthening postural muscles of the back and shoulder.	Conservative management aims to alleviate neurovascular strain to reduce symptom severity and frequency through non-invasive means. Has shown to be effective in reducing pain.

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Author, year	Study design	Treatment (exercise alone or combined with other modalities)	Description of exercises (type, sets/reps, duration)	Rationale for exercise
McGough et al. 1979	Narrative review	Physical therapy	Shoulder girdle strengthening and postural correction. Shoulder shrugs 5-10 times per day, 7-15 repetitions held for 3-4 seconds per repetition. Weight placed into plastic buckets and were lifted using shoulder girdle elevator muscles (plane of motion not indicated) 2-3 times per day	Basis of elevated and slightly abducted shoulder girdle decreases compressive forces on the neurovascular bundle
Nichols 2009	Narrative review	Physical therapy	Gentle rehabilitation exercises.	No rationale listed.
Novak 2003	Narrative review	Patient education on postural awareness and activity modification to minimize provocative positions. Physical modalities (heat, ultrasound, TENS).	Cervical retraction exercises, McKenzie method. Stretching pectoralis muscles. Strengthening/resistance exercises beginning gravity-assisted positions with an emphasis on motor re-education as to not over-recruit scapular elevators and to focus on lower scapular stabilizers. Diaphragmatic breathing. Aerobic conditioning program such as walking.	Postural correction exercises to address elongated and weak lower scapular stabilizers and overuse of scapular elevators. Janda's hypothesis of tight muscles; sternocleidomastoid, levator scapulae, upper trapezius, pectoral muscles, and weak muscles; deep neck flexors and lower scapular stabilizers. Treatment should be directed toward the restoration of normal muscle length and then toward increasing strength. The primary goal of therapy should be to correct postural abnormalities and muscle imbalance.
Novak et al. 1996	Retrospective Study	Night splinting and exercises including ROM, stretching, strengthening and aerobic conditioning.	Upper trapezius, levator scapulae, scalene, and sternocleidomastoid stretching. Chin retraction. Strengthening middle/lower trapezius, serratus anterior, lower rhomboids. Diaphragmatic and lateral costal breathing. Progressive walking.	Correcting poor posture to relieve pressure on neurovascular components and reversing obesity in patients.
Novak et al. 1995	Retrospective study	Physical therapy including exercise program	Gradual stretching of trapezius, sternocleidomastoid, levator scapulae, scalenes, suboccipitals and pectorals. Strengthening of middle and lower traps and serratus anterior. Diaphragmatic breathing and aerobic conditioning (walking).	Stretching and strengthening of shortened muscles.
Nichols and Seiger 2013	Case report	Physical therapy consisting of exercises, manual therapy, and orthoses.	Shoulder and scapular resistance and stabilization training. Simulated boxing on the Nintendo Wii and shadow boxing. Exercise program consisting of: Cervical stabilization supine, shoulder banded ROM exercises in all planes, unilateral supermans, middle rows on yoga ball, body blade exercises, standing: arm by side, in front and behind held for 30 seconds B/L. Isometric contraction of levator scapulae, sternocleidomastoid and cervical extensor musculature. Wall push ups and arm bike: 5 minutes at 2.5 resistance level.	Stabilize sternoclavicular joints and improve upper extremity muscle performance.
Patetta et al. 2020	Narrative review	No treatment, just opinion	Physical therapy focused on scalene stretching	No rationale listed
Pesser et al. 2021	Prospective cohort study	1. physiotherapy 2. physiotherapy + thoracic outlet decompression	Posture evaluation and improvement, shoulder girdle therapy, scapular mobility therapy for 6-12 weeks (at least 1/week) physiotherapy and daily unsupervised training.	Treatment pathway based on North American SVS published in 2016.

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Author, year	Study design	Treatment (exercise alone or combined with other modalities)	Description of exercises (type, sets/reps, duration)	Rationale for exercise
Press and Young 1994	Narrative Review	No treatment, just opinion	Physical therapy should address pectoral and scalene muscle stretching, scapular mobilization, and scapulothoracic mobility. Side-bending and cervical retraction exercises Thoracic extension and brachial plexus stretching Advancement to cervicothoracic stabilization exercises	"opening up" the thoracic outlet by correcting abnormal structure and posture side-bending and cervical retraction exercises – can correct forward-head posture by stretching the soft tissues of the lateral cervical spine.
Richardson 1999	Case series and review	Physiotherapy	Postural correction exercises.	Avoidance of swimming postures that contribute to TOS, increased thoracic kyphosis and lumbar lordosis
Robey and Boyle 2009	Case report	Shoulder strengthening and stretching + postural restoration institute (2 different treatments)	Intervention 1 - Shoulder strengthening and stretching: 2 times a day, 7 days a week: 3 times 30s of self stretching for bilateral neck, shoulder and chest muscles (scalenes, upper trapezius, pectoralis major muscles) + strengthening with tubing for the rotator cuff (internal + external rotators), deltoid, pectoralis major, latissimus dorsi, supraspinatus, biceps, and upper trapezius muscles for 3 by 15reps twice a day every day for 4 weeks. Intervention 2 – Postural Restoration Institute protocol. 1. 90/90 hip shift with hemibridge and balloon to activate hamstring, TA, internal and external intercostals, and abdominals) 2. sternal positional swiss ball release for 5 breaths done twice daily Intervention 3 – Postural Restoration Institute – seated resisted serratus punch with left hamstring muscles, standing resisted bilateral serratus press through, standing serratus squat, paraspinals release with left hamstrings, two-point stance on left and right sides, all 4 belly lift reach, long sitting press downs and latissimus dorsi hang with low trap activation. Done twice in one day. Done 5x each.	Intervention 1 – improve posture via stretching and strengthening of shoulder girdle muscles. Intervention 2 – exercises beneficial for those with faulty posture, faulty respiration, and over-developed musculature. Exercises done to put pelvis in posterior tilt that causes ribs to depress → discourages paraspinal and neck muscles from firing. Goal is to reduce overactivation of paraspinal muscles and encourage rib depression and abdominal muscles to work in a shortened position.
Sadat et al. 2008.	Narrative review	Physical therapy (moist heat and massage) and exercise program	Pectoral stretching, levator scapulae strengthening and postural correction exercises.	Increase space between first rib and clavicle. Improve posture and muscular stability.
Sanders and Annest 2017	Narrative review	No treatment, just opinion	Pectoral minor stretching – 3 times a day for 15-20 seconds, rest for the same length of time and do 3 times at each session.	No rationale listed.
Sheon et al. 1997	Commentary	No treatment administered (just opinion stated)	Exercises to strengthen shoulder elevator and neck-extensor muscles.	No rationale listed.
Strukel et al. 1978	Case series	Case 1: wrist curl + stretching exercise + oral steroids → after 1 year revisited and did rehabilitation of the shoulder Case 2: strengthening exercises Case 3: rehabilitation program Case 4: rehabilitation program	Special exercises to strengthen the upper, mid, and lower trapezius, along with serratus anterior and erector spinae muscles, coupled with attention to correcting the drooping shoulder Case 1: strengthening suspensory musculature of the shoulder Case 2: strengthening program of the shoulder suspensory muscles Case 3: rehabilitation program (no specifics) + discouraged from neck strengthening exercises Case 4: rehabilitation program (no specifics)	Based off of Britt's recommendations (Britt LP 1967) and that this protocol 'has brought good results in our patients' Case 1: see reference 26 of this paper Case 2: no rationale Case 3: no rationale Case 4: no rationale

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Author, year	Study design	Treatment (exercise alone or combined with other modalities)	Description of exercises (type, sets/reps, duration)	Rationale for exercise
Sucher 1990	Narrative review	Analgesic or anti-inflammatory medication. Muscle relaxants. Heat, ultrasound, electrical muscle stimulation. Osteopathic manipulative myofascial release to restricted or contracted muscles. Postural awareness and correction.	Vigorous progressive stretching 5-10 times per day, holding for 10-30 seconds. Stretching of anterior/middle scalene, pectorals	Re-energizing of tissues and reprogramming of central engram for the particular muscle length.
Sucher and Heath. 1993.	Narrative review	Osteopathic treatment including myofascial release	Strengthening of parascapular muscles. High repetition, light weight exercises with bands.	Decrease shortening of muscles and prevent recurrence of trigger points causing pain in patient
Thevenon et al. 2020	Retrospective single-centered hospital based study of 63 patients for 3 weeks (15 sessions, 3-5 times a week)	A daily physiotherapy session, a pool exercise session, and an occupational therapy session and optional psychological support. passive mobilization of the cervical spine and the scapula, and relaxation of the neck and shoulder muscles via massage, stretching, and hold-relax exercises	Diaphragmatic breathing. Strength training focusing on shoulder girdle elevators consisting of supine-lying shoulder elevation, single-arm scapular protraction, and isometric contractions of neck extensors. Pectoral stretching	No rationale listed.
Vanti et al. 2007	Literature review of 8 open non-controlled studies, 1 retrospective non-controlled study, and 1 prospective clinical trial ranging from 8 to 119 participants.	Studies had a combination of patient education, manual therapy including joint mobilizations, soft tissue and massage treatment, heat, ultrasound, adhesive bandages, and/or strapping device.	Peet's exercises (strengthening posterior spine muscles, isometric exercises for serratus anterior and pectoralis minor, exercises aimed at targeting muscles that depress the first rib) at home, daily with weights up to 1kg each hand. Graduated resisted shoulder elevation for count of 5 (weights ranged from 0-5lbs) for 3 weeks, 5 times daily. Britt's method; shoulder girdle exercises involving strapping device to elevate shoulders. Graduated stretching program for shoulder girdle elevators, chin retraction exercises, strengthening lower scapular stabilizers, and aerobic conditioning program. Exercises targeting anterior, middle and posterior scalenes, strengthening of shoulder girdle elevators and small pectoral muscles, scapular stabilizers for 5-10 times a day. Shoulder resisted adduction and extension, cervical isometric and stabilization.	Restore muscle balance; strengthening muscles that open the thoracic outlet by raising the shoulder girdle (e.g – trapezius, sternocleidomastoid), stretching muscles that close the thoracic outlet (e.g. – lower trapezius, scalene muscles). Postural correction.
Walsh. 1994.	Narrative review	Home exercise program. Conditioning and strengthening of muscles necessary to maintain postural correction.	Peet protocol for exercises. Scalene stretching, cervical protraction and retraction, diaphragmatic breathing, pec stretching, shoulder circle exercises.	Improve the flexibility of the entire thoracic outlet area.

N/A = not applicable; lb = pound; ROM = range of motion; B/L = bilaterally; NSAIDs = non-steroidal anti-inflammatory drugs; kg = kilogram; TENS = transcutaneous electrical nerve stimulation; SVS = Society for Vascular Surgery; TA = transverse abdominus

Author, year	Study design	Treatment (exercise alone or combined with other modalities)	Description of exercises (type, sets/reps, duration)	Rationale for exercise
Watson et al. 2010	Narrative review	Authors recommend 'axillary sling' or taping to create scapular elevation and upward rotation during exercises if exercises are too provocative in symptoms.	Scapular control phase: upward rotation shrug in 20-30 degrees of abduction in standing, progressing functional movement patterns (abduction in external rotation) and breaking isolated movements down if necessary. 20 reps 3x/day in which patient can maintain control. Progressed starting with 0.5kg in hand increased until 2kg to 20 repetitions. Load phase: resisted upper trapezius (upward rotation shrugs), external rotation (usually side-lying), posterior deltoid (extension standing), subscapularis (supine internal rotation) and anterior deltoid (supine flexion), Prone horizontal extension drills are also very good drills for developing posterior deltoid, supraspinatus, infraspinatus and teres minor. Resisted exercises: once per day 2kg for women, 3kg for men, endurance repetition range. Hypertrophy phase: >3kg, 6-8 repetitions, 4 sets, once per day.	Exercises are focused on addressing "drooping shoulder" (shoulder girdle depression) as it leads to altered scapular kinematics and possible traction stress on the neurovascular bundle of the thoracic outlet. The rehabilitative approach is to elevate the shoulder girdle to "decompress" the thoracic outlet and restore scapular control. Focus on establishing normal scapular muscle recruitment and control in resting position. Once this is achieved then the program is progressed to maintaining scapula control while both motion and load are applied. The programme begins in lower ranges of abduction and is gradually progressed further up into abduction and flexion range until muscles are being re-trained in functional movement patterns at higher ranges of elevation. Emphasis is on facilitating and encouraging sufficient firing in any muscles that may be weak, inhibited or slow to switch on in the normal movement strategies.
Wehbe and Schlegel. 2004.	Narrative review	Nerve gliding exercises	Diagrams of upper and lower plexus nerve gliding, median nerve at elbow and wrist nerve gliding, ulnar nerve at elbow, dorsal wrist and plantar wrist and radial nerve at spiral groove, elbow and wrist nerve gliding.	Nerve gliding to help accommodate joint motion to prevent injury.

N/A = not applicable; lb = pound; ROM = range of motion; B/L = bilaterally; NSAIDs = non-steroidal anti-inflammatory drugs; kg = kilogram; TENS = transcutaneous electrical nerve stimulation; SVS = Society for Vascular Surgery; TA = transverse abdominus

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Factors associated with recording the exercise vital sign (EVS) in the electronic health records of patients in chiropractic teaching clinics

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Objective: *We set out to identify factors associated with recording of exercise minutes per week in electronic patient files at chiropractic teaching clinics to better understand whether this important health determinant – exercise vital sign (EVS) – is captured or not.*

Methods: *Patient files (4018) from 23 clinicians eligible for inclusion underwent multilevel logistic regression modeling to explore the association between a recorded EVS and the following: patients' age, sex, comorbidities and interns nested within clinicians.*

Results: *EVS discussion was documented in 81.2% of patient files, whereas 44.9% had exercise minutes recorded numerically. Clinicians and interns explained 1.7% and 25.5% of the variance in the EVS outcome.*

Facteurs associés à l'enregistrement du signe vital d'exercice (SVE) dans les dossiers médicaux électroniques des patients dans les cliniques d'enseignement chiropratique.

Objectif : *nous avons entrepris d'identifier les facteurs associés à l'enregistrement des minutes d'exercice par semaine dans les dossiers électroniques des patients dans les cliniques d'enseignement chiropratique afin de mieux comprendre si cet important déterminant de la santé, signe vital d'exercice (SVE), est capturé ou non.*

Méthodologie : *les dossiers des patients (4018) de 23 cliniciens admissibles à l'inclusion ont fait l'objet d'un modèle de régression logistique à plusieurs niveaux pour explorer l'association entre un SVE enregistré et les éléments suivants : l'âge des patients, le sexe, les comorbidités et les résidents travaillant avec les cliniciens.*

Résultats : *la discussion du SVE était documentée dans 81,2 % des dossiers des patients, tandis que les minutes d'exercice pour 44,9 % avaient été enregistrées numériquement. Les cliniciens et les résidents ont expliqué le 1,7 % et le 25,5 % de la variance du résultat du SVE.*

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Conclusion: *To enhance EVS recording, clinic directors and clinicians should better educate the interns on the importance of exercise is medicine and appropriate record keeping, as they explained the largest portion of variability in recording exercise in minutes per week.*

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KEY WORDS: chiropractic, education, exercise, physical activity, vital signs

Conclusion : *pour améliorer l'enregistrement du SVE, les directeurs de clinique et les cliniciens devraient mieux éduquer les résidents sur l'importance de l'exercice dans la médecine et la tenue de dossiers appropriés, car ils ont expliqué la plus grande partie de la variabilité dans l'enregistrement de l'exercice en minutes par semaine.*

(JCCA. 2022;66(1):61-73)

MOTS CLÉS : chiropratique, éducation, exercice, activité physique, signes vitaux

Introduction

Participation in physical activity has well-established relationships with a variety of health outcomes such as mortality, morbidity, and well-being.[1-3] For instance, from a 2008 systematic review with meta-analysis synthesizing findings from 33 studies, people with high levels of physical activity, compared to people who are least active, have risk reduction for cardiovascular mortality of 35% (95%CI 30-40%) and risk reduction for all cause mortality of 33% (95%CI 28-37%).[2] Women participating in strength training have reduced mortality from any cause with reported improvements in strength, mental health, and fitness.[4] In the elderly and youth, improvement in self-esteem and quality of life have also been linked to physical activity.[5-7]

Despite these benefits of enhanced strength, fitness, and well-being with associated reductions in all-cause mortality, one in two Canadian adults do not meet Canadian Physical Activity Guidelines (CPAG) recommendations of 150 minutes of moderate-to-vigorous physical activity per week.[8] Researchers and clinicians alike have acknowledged the importance of addressing exercise and physical activity in the clinical encounter.[9-11] Addressing 'exercise as medicine' has origins in ancient times within health care contexts and offers broad benefits in relation to preventive and reactionary medicine.[9-16] For instance, Kaiser Permanente has shown that incorporating 'exercise as medicine' principles with exercise as a vital sign (EVS) increases exercise adherence and shows significant health benefits within their patient population.[12-14]

Given discrepancies between physical activity recommendations and patient behaviours, there has been increasing promotion of exercise as a vital sign in primary care.[8-22] In this context, exercise is synonymous with physical activity. Vital signs are measurements used to assess the general physical health of a person, aimed at giving insight into potential disease states or showing progress towards recovery. The traditional vital signs used clinically are pulse rate, respiratory rate, body temperature and blood pressure. There is growing momentum to incorporate exercise as a fifth vital sign by recording minutes per week of physical activity in patient records.[12,18-22] For example, Ross *et al*.[23] highlighted that an individuals' fitness level is a better predictor of death than established risk factors, such as high blood pressure. This demonstrates that exercise minutes per week can offer a meaningful measure of someone's potential health status. Capturing EVS in clinical records has also shown a variety of benefits related to improved patient outcomes, such as greater weight loss for overweight patients and a decline in HbA1c for diabetic patients.[18-19] It also is a low-cost strategy with minimal time demands.[10-11] EVS documentation has also shown benefits related to more frequent exercise documentation, appropriately directed referrals and physician exercise counselling in line with exercise guidelines.[10-14,24-27] The growing evidence for the utility of EVS has led to a call to action for its implementation in primary care clinical settings and implementation into health system frameworks.[13,28,29]

Chiropractors often manage musculoskeletal conditions and adding EVS to the chiropractic encounter offers an opportunity to improve documentation of exer-

cise, provide counselling on exercise, and target exercise recommendations based on patient need. Currently, the Canadian Memorial Chiropractic College (CMCC) uses an electronic medical record (EMR) within its clinic system which includes a dedicated field to record an exercise vital sign as minutes per week of physical activity. This offers the opportunity for clinicians and interns to record EVS, to regularly observe this measure and implement it into the standard care of patients. The use of the EVS field within the CMCC EMR has been the focus of ongoing investigation.[9] A pilot study investigated whether interns under the supervision of two CMCC clinicians were appropriately recording EVS in the patient charts and found that a discussion of exercise was documented in 86.4% of patient files with a numeric EVS recorded in 75.8% of those files.[9] A preliminary review of a new, more extensive dataset covering patient files of 23 CMCC clinicians found that exercise was discussed and documented in 81.2% of patient files, yet only 44.9% had a numerical value in the form of minutes per week.[30]

Given the importance of physical activity for a variety of health outcomes and the utility of EVS to promote physical activity, understanding the factors associated with the recording of EVS is paramount.[1,2,10-14,24] The purpose of the current study is to investigate factors associated with the recording of exercise minutes per week as an EVS in patient EMRs at clinics affiliated to a chiropractic college. The current study used the terms "physical activity" and "exercise" synonymously. Specifically, associated factors related to the patient (age, sex, comorbidities), the interns and the clinicians were explored to inform the enhanced recording of EVS.

Methods

Study design, population, inclusion and exclusion criteria

This study is a secondary analysis of data from a retrospective case series of consecutive new patient files with chart abstraction from electronic medical records.[30] Consecutive new patients were identified for inclusion between January 2016 and September 2017, under care of one of 23 clinicians across five teaching clinics of a chiropractic college. The targeted sample size was 200 new patient files per clinician, anticipating 80% of patients had given consent for their clinical data to be used for research purposes yielding approximately 160 patient files per clinician. The clinic management team provided file numbers to a research assistant who assigned a unique study identifier to each patient file for inclusion in the analytic dataset. These did not include patient files of students, staff, or faculty of the college to maintain privacy and confidentiality. Linkage between the patient file number and the study ID was maintained in a separate password-protected spreadsheet. The study protocol was reviewed and approved by the research ethics board at the college (REB# 2005X07).

Data extraction

For each patient file number provided by the clinic management team, the research assistant first checked to ensure the patient had provided consent for their clinical data to be used for research purposes. If this consent form was not located in the chart, then no further information was extracted for that patient file. If consent was provided, the following information was extracted from each file: patient age, sex, blood pressure recorded (Y/N), history of cancer documented (Y/N), history of cardiovascular disease documented (Y/N), history of diabetes documented (Y/N), documentation of discussion of exercise (Y/N), whether EVS minutes were recorded (Y/N) and finally the EVS minutes recorded. The co-morbidities captured are common non-communicable chronic diseases linked to physical inactivity.[2,8]

Within the EMR, EVS can be entered into the physical examination input screen by chiropractic interns. This examination page within the EMR includes vital signs, systems review and lifestyle review. The EVS field appears under the lifestyle review section in the clinical record on the physical examination page after the history, in close proximity to the blood pressure recording entry. Blood pressure was captured as a comparator given it is a traditional vital sign. Blood pressure, smoking, drinking habits and EVS entries are automatically populated into the EMR encounter homepage for each patient file which allows for easy reference for chiropractic interns and clinicians.

In addition, the extracted data was indexed by separate IDs for clinic, clinician, and intern. Clinician specialty designations were included in the data and classified as clinical sciences, orthopedics, rehabilitation, sports, or none. At this college, interns are fourth year chiropractic students seeing patients under the supervision of a clin-

ician. Patient age was further grouped into three broad categories (5–17, 18–64, 65+ years of age), consistent with the CPAG guideline age groups.[1] The extracted data were stored on encrypted flash drives which were kept in a locked filing cabinet between sessions of data extraction. After data extraction was complete, the de-identified analytic dataset was moved to the chiropractic college internal server for analysis.

During data extraction, periodic random samples of patient files were drawn for double extraction and compared to assess reliability of data extraction. This was repeated three times. The first round involved 202 randomly sampled patient files from the first 1000 patient files extracted. The second round involved 203 randomly sampled patient files from the second 1000 patient files extracted. The final round involved 303 patient files from the next 1000 patient files extracted. Each data field double entered was compared and discrepancies represented as % disagreement at field / variable level. This allowed for an appropriate determination if raw data collection was extracted precisely.

Measures and analysis

The primary outcome analyzed was a dichotomous measure (yes or no) whether exercise minutes (EVS) was recorded in the patient file. The main explanatory variables were clinic location, clinician (nested within clinics) and clinician specialty, interns nested within clinicians and patient file characteristics (patient age, sex, recording of blood pressure as a vital sign, documented presence of comorbidities). The relationship between the outcome and the explanatory factors was investigated one at a time using cross-tabulations and chi-square tests. Rao-Scott chi-square tests stipulating clinician as the primary sampling unit were used to correct for clustering of patient files within clinicians.[31-32] Multilevel logistic regression models were used to model the primary outcome as a function of patient file and clinician characteristics.[33-35] The multilevel multiple logistic regression models included three levels: patient files (level 1), interns (level 2) and clinicians (level 3) with each level nested within the next. The models included random intercepts for interns nested within clinician and random intercepts for clinicians. The hypotheses of zero variance in outcome due to clinicians and due to interns nested within clinicians were tested and intraclass correlation coefficients (ICCs) were derived from covariance parameter estimates for the models to quantify variance in outcome explained by interns and by clinicians. Some interns appeared in the data nested under more than one clinician, due to rotations in supervision during the timeframe of the study files. For these cases, the models maintain the nesting of interns under clinicians (e.g., the same intern appears nested under two or more clinicians. The analysis for this study was generated using SAS software v9.4. (Copyright © 2012-2018, SAS Institute Inc., Cary, NC, USA. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA.)

Adequacy of sample size

This study is a secondary analysis of the data collected from DeGraauw *et al*.[30] There were 4018 patient files usable for analysis with EVS recorded for 1802 (45%). General principles for single level (not multi-level) logistic regression suggest 10 to 20 limiting sample size per parameter to be estimated.[36] Limiting sample size is the smaller of the two outcome categories, in this case 1802, which under the general principles accommodates estimation of 90 parameters. In a fully specified model, including patient file characteristics (age, sex, BP recorded, three comorbidities) and specialty of clinician (five categories), there are 12 parameters to estimate, so limiting sample size based on 20 per parameter yields 240 sample sizes for each level of the outcome (yes and no), and the available sample size is sufficient. However, we also note that with clustering of patient files within interns and clustering of interns within clinicians, there is additional correlation within the data which may drive sample size requirements higher, but how much higher depends on how much variability in the outcome is driven by intern level and clinician level.

Results

Reliability analysis

Three stages of reliability analysis were performed based on review of random samples of 202, 204, and 303 patient files extracted a second time covering 4,242, 4,284 and 6,363 fields, respectively. Discrepancies between data values from the two extractions were for 1.4%, 1.5% and 0.3% of fields at each stage, respectively. These were all considered satisfactory error rates. By the final round of reliability analysis, the error rate of 0.3% was low enough that no further reliability assessments were performed.

From January 2016 to September 2017, 4998 files were identified (Figure 1) and provided to the research team by the clinic management team; 958 (19%) of these files were excluded due to missing research consent forms, one was excluded due to lack of a medical history, one was excluded due to lack of patient sex specification, and one was excluded due to the clinician having a single patient file at one clinic with all other patient files at a different clinic. Another 19 files were excluded due to missing intern numbers leaving 4018 files eligible for data analysis.

Patient files came from five clinic locations with 23 clinicians nested within these locations. Table 1 displays the nesting structure of patient files under interns, under clinicians, and under clinics. There were 597 unique interns in the data with 491 nested under a single clinician, 103 nested under two clinicians and 3 nested under three clinicians due to clinical rotations occurring during the time-period for data collection. The models included parameters for 706 interns (491 + 103x2 + 3x3) to maintain nesting of interns within clinicians. Patient files per clinic ranged from 119 to 2152. There were on average 5.7 patient files per intern (Table 2) with a minimum of 1 and maximum of 20, an average of 30.7 interns per clinician ranging from a minimum of 17 to a maximum of 37, and an average of 174.7 patient files per clinician with a minimum of 82 and maximum of 365.

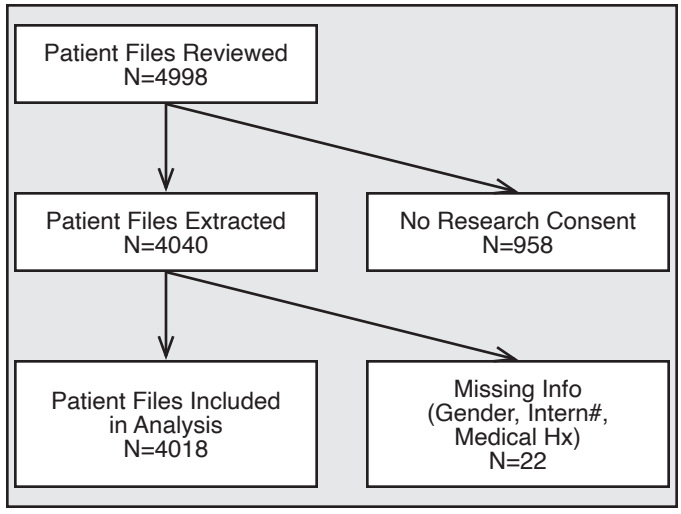

Figure 1.
Flow of patient files from identification through to inclusion in analytic dataset

Descriptive statistics for patient file level data are displayed in Table 3. The majority (80.7%) of patients

Table 1.
Levels of data included in the study and nesting.

Level	Overall #	Clinic 1	Clinic 2	Clinic 3	Clinic 4	Clinic 5
Clinicians (#)	23	2	13	7	1	2
Interns (#)	706	61	420	197	19	58
Patient Files (#)	4018	623	2152	857	119	267

Table 2.
Structure of nested data in terms of patient files per intern, per clinician and interns per clinician.

	Mean	SD	Minimum	Maximum
# Patient Files per Intern	5.7	3.3	1	20
# Patient Files per Clinician	174.7	55.2	82	365
# Intern per Clinician	30.7	5.4	17	37

Table 3.
Description of patient file level variables for the N=4018 files included for analysis.

Patient Variables	Level	N	(%)
Age group	<18	102	2.5
	18-64	3244	80.7
	≥65	672	16.7
Sex	Male	2013	50.1
	Female	2005	49.9
Blood Pressure Recorded	Yes	2530	63.0
	No	1488	37.0
Cancer documented	Yes	126	3.1
	No	3892	96.9
Cardiovascular Disease documented	Yes	522	13.0
	No	3496	87.0
Diabetes documented	Yes	197	4.9
	No	3821	95.1
EVS Discussed	Yes	3261	81.2
	No	755	18.8
EVS Recorded	Yes	1802	44.9
	No	2216	55.2

fell between 18 and 64 years of age. Patients were evenly split between male and female (50.1% male). Blood pressure was recorded in 63% of the files. The patients' comorbidities (cancer, diabetes, cardiovascular) were undocumented in the majority of patient files. Although there was a documented discussion of EVS in 81.2% of patient files, only 44.9% had a formal recording of EVS in minutes.

Tables 4a and 4b display bivariate relationships between patient and clinician characteristics and the main study outcome of EVS recording. Chi-square tests were conducted to test whether EVS recordings were independent of these characteristics or not. The Rao-Scott chi-square test was used for all comparisons except for one as it accounts for the clustering of patient files within clinicians. The one exception was when the relationship

Table 4a.

Bivariate comparisons between whether EVS recorded and other study variables using Rao-Scott corrected chi-square test (corrected for clustering of patient files within clinicians).

		Exercise Recorded		Rao-Scott Corrected Chi-Square Test
		Yes N (%)	No N (%)	
Age group	< 18	40 (39.2)	62 (60.8)	$\chi^2 = 8.2$
	18 – 64	1495 (46.1)	1749 (53.9)	df=2, p=0.017
	≥ 65	267 (39.7)	405 (60.3)	
Sex	Male	921 (45.8)	1092 (54.3)	$\chi^2 = 1.8$
	Female	881 (43.9)	1124 (56.1)	df=1, p=0.2
Blood Pressure Recorded	Yes	1246 (49.3)	1284 (50.8)	$\chi^2 = 53.8$
	No	556 (37.4)	932 (62.6)	df=1, p<.0001
Cancer Documented	Yes	58 (46.0)	68 (54.0)	$\chi^2 = 0.07$
	No	2148 (55.2)	1744 (44.8)	df=1, p=0.8
Cardiovascular Disease Documented	Yes	227 (43.5)	295 (56.5)	$\chi^2 = 0.36$
	No	1575 (45.1)	1921 (55.0)	df=1, p=0.6
Diabetes Documented	Yes	1708 (44.7)	2113 (55.3)	$\chi^2 = 1.0$
	No	94 (47.7)	103 (52.3)	df=1, p=0.3
Clinic	1	245 (39.3)	378 (60.7)	$\chi^2 = 14.8$
	2	958 (44.5)	1194 (55.5)	df=4, p=0.005
	3	421 (49.1)	436 (50.9)	
	4	73 (61.3)	46 (38.7)	
	5	105 (39.3)	162 (60.7)	
Clinician Specialty	Clinical	236 (43.22)	310 (56.78)	$\chi^2 = 5.9$
	Orthopaedics	274 (50.18)	272 (49.82)	df=5, p=0.3
	Rehabilitation	64 (35.16)	118 (64.84)	
	Sports & Rehabilitation	153 (52.9)	136 (47.1)	
	Sports	670 (43.3)	879 (56.8)	
	None	405 (44.7)	501 (44.7)	

between EVS recording and clinician was examined, in which case the Rao-Scott chi-square test cannot be computed. Among patient characteristics displayed in Table 4a, there was a significant relationship between age group and EVS outcome, and between blood pressure recording and EVS outcome. EVS was more likely to be recorded in the 18-64-year-old age group than the other two age groups and when blood pressure was recorded. Among clinic characteristics, whether EVS was recorded or not varied significantly depending on clinic location (Table 4b). The recording of EVS at different clinics ranged from 38.7% to 60.7%. The variance in whether EVS was recorded is dependent on the clinician, which ranged from 35.2% to 66.8% and this result is statistically significant. The clinicians' specialty is not significantly related to whether EVS was recorded within patient files.

Table 4b.
Bivariate comparison of whether EVS recorded across clinician using chi-square test.

		Exercise Recorded		Chi-Square Test
		Yes N (%)	**No N (%)**	
Clinician	1	97 (37.6)	161 (62.4)	$\chi^2 = 119.9$
	2	72 (40.7)	105 (59.3)	df=22, p<.0001
	3	45 (37.2)	76 (62.8)	
	4	60 (41.1)	86 (58.9)	
	5	133 (66.8)	66 (33.2)	
	6	48 (35.3)	88 (64.7)	
	7	88 (54.3)	74 (45.7)	
	8	73 (61.3)	46 (38.7)	
	9	105 (60.0)	70 (40.0)	
	10	69 (40.6)	101 (59.4)	
	11	45 (44.1)	57 (55.9)	
	12	64 (35.2)	118 (64.8)	
	13	37 (45.1)	45 (54.9)	
	14	89 (45.9)	105 (54.1)	
	15	77 (42.1)	106 (57.9)	
	16	148 (40.6)	217 (59.5)	
	17	64 (37.4)	107 (62.6)	
	18	79 (43.7)	102 (56.4)	
	19	68 (35.2)	125 (64.8)	
	20	77 (44.3)	97 (55.8)	
	21	80 (47.1)	90 (52.9)	
	22	96 (54.2)	81 (45.8)	
	23	88 (48.6)	93 (51.4)	

Table 5.
Multilevel logistic regression level 1 (patient file) model coefficients, t-tests and odds ratios with 95%CI

		β	SE(β)	t-stat	p-value	OR	95%CI
Age Group	< 18	0.13	0.26	0.50	0.6175	1.14	(0.69, 1.89)
	18 – 64	0.29	0.11	2.71	0.0068	1.34	(1.08, 1.65)
	≥ 65	ref					
Sex	Male	ref					
	Female	-0.09	0.07	-1.23	0.2170	0.92	(0.79, 1.05)
Blood Pressure	Yes	0.48	0.08	5.71	<.0001	1.61	(1.37, 1.90)
	No	ref					
Cancer	Yes	ref					
	No	-0.29	0.21	-1.36	0.1729	0.75	(0.49, 1.14)
Cardiovascular Disease	Yes	ref					
	No	0.09	0.12	0.76	0.4453	1.09	(0.87, 1.38)
Diabetes	Yes	ref					
	No	-0.18	0.17	-1.01	0.3118	0.84	(0.60, 1.18)

Tables 5 and 6 display findings from the final multilevel model. Table 5 shows level 1 (patient file) factors while Table 6 shows level 2 and 3 (intern and clinician) factors. This model included patient file level factors; age group, sex, documentation of cancer, diabetes, and cardiovascular disease and whether blood pressure was recorded. It also included a random intercept for interns nested within clinician and a random intercept for clinician. Table 5 shows two significant patient file level factors for whether EVS was recorded or not, age group and whether blood pressure was recorded, aligning with results from the bivariate comparisons reported above. For the age group, the middle group (18-64-year-olds) was most likely to have EVS recorded with an odds ratio of 1.34 (95%CI 1.08-1.65) compared to the reference group of ≥65 years. When blood pressure was recorded, EVS was more likely to be recorded with odds ratio of 1.61 (95%CI 1.37-1.90). Table 6 shows that there is significant variance in the recording of EVS between both clinicians and interns (both tests of variance=0 significant with p-values of 0.0026 and <.0001 respectively). The ICC values indicate that 1.7% of the variance in patient EVS recording is explained by clinicians and 25.5% of the variance is explained by interns. When we considered other variables for the multi-level model, such as clinician specialty, there was no additional relationship explained. Variation across clinics was largely tied to clinician variability.

Table 6.
Multilevel logistic regression results, variance in outcome due to clinicians and interns nested within clinicians: test of variance = 0 and Intraclass Correlation Coefficient (ICC) expressing how much of the variance explained by that level of clustering

Hypothesis	DF	Chi-square	p-value	ICC
Clinician Variance = 0	1	7.81	0.0026	0.017
Intern Variance = 0	1	274.4	<0.0001	0.255

Discussion

This research assessed the factors related to whether EVS was recorded or not. This research highlights that chiropractic interns were the predominant source of variability for the recording of EVS and that those who record EVS also tended to record blood pressure, a standard vital sign, much more consistently. Blood pressure was chosen as the vital sign to compare EVS to, since it is commonly

monitored and recorded. It was felt that respiratory rate and pulse may be more highly utilized and recorded in a critical care setting. This research builds on the work of Howitt *et al*.[9] and DeGraauw *et al*.[30] which investigated the minutes of weekly physical activity recorded for patients at CMCC clinics. The results of this current study indicate that physical activity was discussed during the initial visit at CMCC for the majority (81.2%) of patients. However, the numeric EVS minutes of weekly physical activity was only recorded in 44.9% of files. Interns are trained to routinely evaluate exercise behaviour as a tool to capture patient health information, but their habits in recording it as a vital sign within the patient file is limited. This behaviour does not appear to be driven by lack of understanding of exercise efficacy as CMCC interns show positive perceptions toward the intervention.[37] Results also showed that interns appear to be the largest predictor of EVS recording (25.5%) compared to clinicians (1.7%). Based on this information, interns' behaviours related to appropriate recording of EVS minutes in the patient file needs greater attention and emphasis.

The results of this study showed that blood pressure recording was significantly associated with the recording of EVS. Blood pressure is already considered a vital sign measurement that appears quite proximal in the EMR where EVS can be recorded. As a result, there may be some concordance in the recording of vital signs or items located in similar locations within the EMR system. This may also simply be that chiropractic interns with better patient record keeping skills tend to record both metrics more frequently. This further highlights the importance of educating interns on appropriate record keeping behaviours for patient management.

The patient variable of age group was also significantly associated with a recorded EVS. Patients within the 18 to 64-year-old group were found to have EVS recorded more than the other two age groups (below 18 years old and 65 years old and older). There are numerous possible explanations for this, such as intern priority, as children and elderly patients may be seeking care for alternative reasons or have increasingly complex cases in which interns did not feel it necessary to ask about EVS. Additionally, a clinical assumption may be made by the intern and/or clinician that this (18 to 64) age group may be more receptive to the question and respond positively or be more willing to increase their physical activity. Perhaps interns also feel most comfortable to enter into a conversation regarding physical activity in this generally healthy group. Exercise for pediatrics and geriatrics is often more nuanced and may have concomitant conditions to consider. It was found that 45% of adults 65 years and older at CMCC clinics were not meeting the Canadian Physical Activity Guidelines (CPAG) recommendation of 150 minutes of moderate to vigorous exercise per week.[9] Although this is similar to the general population, it still offers an opportunity to improve.[8] Physical activity and exercise have been shown to reduce fall risk, improve quality of life and self-esteem, decrease risk of dementia, and improve cardiorespiratory fitness in the elderly.[5,38-39] In individuals younger than 18 years of age, physical activity has the unique benefit of showing improved self-rated health and specifically, improved mental health in previously inactive girls.[6] Regardless of age, reporting an EVS can be helpful to further promote physical activity. In the present study, age group (18 to 64 years old) and blood pressure recording were found to be statistically significant predictors(of EVS recording), but the odds ratios were small in magnitude and considered not important.

With respect to clinicians and clinic location, several interesting results were noted. Statistically clinicians were found to influence the recording of EVS, but clinician specialty did not play a role. A large range was also found for EVS recording by clinicians (35.2% to 66.8%). There was a similar result for Howitt *et al*.[9] and the current study (86.4% and 81%) for a documented EVS discussion. Although, there was also a noticeable discrepancy in the data between the previous study by Howitt *et al*.[9] given that 75.8% of patient files had a formal recording compared to 45% in the current study. While the importance of exercise appears well understood given the high percentage of files in which it is discussed, the previous work of Howitt *et al*.[9] may be reflective of the emphasis the two chiropractic clinicians placed on this measure with their interns given their clinical and research interests in 'exercise as medicine.' The results of this study and the study by Howitt *et al*.[9] demonstrate the variability in the recording of EVS and offers an opportunity to standardize practice among clinicians and clinic locations.

Chiropractors are typically viewed as health care providers for musculoskeletal problems, specializing in conservative management for conditions such as low back

pain. Given current musculoskeletal guidelines for low back pain promoting the use of exercise, chiropractors are afforded the opportunity to facilitate promotion of physical activity.[40] As the burden of physical inactivity is ranked the fourth largest contributor to overall morbidity and mortality, this has a multitude of benefits.[41-48] Physical activity has a variety of musculoskeletal and non-musculoskeletal benefits that are helpful for conditions such as osteoporosis, low back pain, type 2 diabetes, and coronary artery disease.[24,41,49] As we improve the consistency of obtaining EVS through regular patient interactions, there is an opportunity to utilize this exercise vital sign to realize the health impacts of physical activity.[50-51]

Clinical implications

Several avenues may be explored to improve the frequency of recording of EVS in the clinical record. To help bridge the gap between knowledge and implementation, clinical and educational directors could further educate interns and clinicians on the importance of recording EVS as a numerical entry in clinical encounters. Secondly, the EMR layout and interface may better position EVS within the vital signs' category to logically encourage interns to formally record the number. The clinical management staff may promote the clinical recording of the EVS measure through initiatives such as comprehensive file audits for specific vital signs. As clinicians dictate the final recording, it is pertinent to emphasize their role within appropriate recording of EVS. This would influence clinicians to better guide interns in EVS documentation. Finally, the authors also feel an important but significant change to the EMR should include changing exercise in minutes per week to, physical activity in minutes per week. This would better reflect the information we are currently striving to obtain from patients.

Research implications

Future research should seek to investigate ways to influence clinical behaviour for the recording of EVS in an academic chiropractic setting. The current significant variables driving EVS investigated in this study were found to be small in magnitude and do not explain a large degree of the variance. More comprehensive characteristics of interns who are more frequently recording EVS could be explored. Patient variables can be investigated in the context of various social determinants of health, such as income level, education, employment status and access to physical activity opportunities. A prospective study design may be beneficial to understand if implementation of an educational intervention changes behaviour for interns in a clinical setting for the recording of EVS. Additionally, as this research was performed in an academic chiropractic setting with a dedicated EHR field for EVS, further analysis of data and behaviours should be performed in community-based non-academic chiropractic settings and clinics without a dedicated EHR entry for EVS. Overall, given the importance of physical activity, future research should further investigate if including EVS in all patients' files influences increased physical activity levels over time.

Strengths and limitations

The study presented several strengths and limitations. The strengths of the study included a large sample size for data interpretation. Data from multiple clinicians and interns were also collected allowing for greater generalizability for results. Data was also collected from consecutive patient files. A quality control phase was done through a secondary data collection of a random sample of the files recorded, in which high rates of agreement were found. The electronic medical record system also had a dedicated area for the recording of exercise, allowing for more consistent data recording. Finally, the data collected offers a novel investigation of EVS in a chiropractic setting with pragmatic clinical utility to guide clinical and educational initiatives.

Regarding limitations, data collection excluded CMCC students, staff and faculty given anonymity concerns which may have skewed the results. The data analyzed was only from the patient intake information entered (exercise minutes per week) which disregards the potential discussion or recording of EVS at subsequent visits which may appear in a clinical SOAP note with more detail including exercise types, such as resistance training. Files between January 2016 and September 2017 were extracted, as such the data were collected prior to the new 24-hour physical activity guidelines. Due to this, the data may not represent current practice in 2022 and may underestimate PA levels which considered bouts of exercise of at least 10 minutes, previously. Two CMCC clinic locations were not included in the study due to their use of a different electronic medical record system. Therefore,

generalizability for all chiropractic clinics at CMCC is not entirely possible. Additionally, the original data collection did not include all vital sign measures and did not explain a large degree of the variance in EVS collection. As such, a thorough interpretation of vital sign recording in relation to exercise was not possible. Finally, clinician specialty was recorded but other potential education and training variables were not explored which could help explain the minor variance attributed to clinicians. For example, clinicians could have differed in their undergraduate education, chiropractic college attended, gender or years in practice. Similarly, the intern variable was not further explored and could have included looking at gender, grades, undergraduate training, etc. However, this was beyond the scope of the current research.

Conclusion

This study elaborates on several factors related to the recording of EVS. The main patient variables related to EVS recording were age group (18 to 64 years old) and if blood pressure was also recorded. Although clinicians and clinic locations were found to influence the recording of EVS, clinician specialty was not found to affect the recording of EVS. Interns accounted for the majority of variance compared to clinicians for the recording of EVS. Considering the significant role physical activity can play in one's health and its recommendation in various guidelines for musculoskeletal rehabilitation, educational institutions should understand what factors affect its recording, in order to have all files include this important health determinant.

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Nonoperative management of degenerative cervical radiculopathy: protocol of a systematic review

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Background: *Degenerative cervical radiculopathy (DCR) is a common condition which, due to the aging global population, is expected to worsen over time. For the majority of patients with DCR, surgical intervention is not required as nonoperative management is sufficient for symptom improvement. However, there are significant gaps within the literature as the majority of past systematic reviews assessing conservative interventions are outdated, or omit relevant studies due to strict inclusion/exclusion criteria. Therefore, an updated understanding of the effectiveness of noninvasive nonoperative management for DCR is required.*

Prise en charge non opératoire de la radiculopathie cervicale dégénérative : protocole d'un examen systématique.
Contexte : *la radiculopathie cervicale dégénérative (DCR) est une affection courante qui, en raison du vieillissement de la population mondiale, devrait s'aggraver avec le temps. Pour la majorité des patients atteints de DCR, une intervention chirurgicale n'est pas nécessaire, car la prise en charge non opératoire est suffisante pour l'amélioration des symptômes. Cependant, il existe des lacunes importantes dans les publications scientifiques, car la majorité des examens systématiques antérieurs évaluant les interventions conservatrices sont obsolètes ou omettent des études pertinentes en raison de critères d'inclusion et exclusion stricts. Par conséquent, une compréhension actualisée de l'efficacité de la prise en charge non invasive et non opératoire de la DCR est nécessaire.*

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Methods: *We will search MEDLINE, CENTRAL, Embase, PsycINFO, and CINAHL from inception, as well as hand-search reference lists of included studies and previous systematic reviews, to identify peer-reviewed randomized controlled trials on this topic.*

Discussion: *The results of this review will provide an understanding of the effectiveness of various nonoperative interventions. The quality of evidence will also be assessed using the GRADE approach.*

Systematic review registration: PROSPERO CRD42021249699

(JCCA. 2022;66(1):74-84)

KEY WORDS: cervical radiculopathy, cervical stenosis, nonoperative management, systematic review protocol, spine osteoarthritis

Méthodologie : *nous effectuerons des recherches dans MEDLINE, CENTRAL, Embase, PsycINFO et CINAHL depuis le début, et entreprendrons des recherches manuelles dans les listes de références des études incluses et des examens systématiques précédents, afin de déterminer les essais contrôlés randomisés et évalués par des pairs sur ce sujet.*

Discussion : *les résultats de cet examen permettront de comprendre l'efficacité de diverses interventions non opératoires. La qualité des preuves sera également évaluée à l'aide de l'approche GRADE.*

Enregistrement d'examen systématique : PROSPERO CRD42021249699

(JCCA. 2022;66(1):74-84)

MOTS CLÉS : radiculopathie cervicale, sténose cervicale, prise en charge non opératoire, protocole d'examen systématique, arthrose du rachis.

Background

Cervical radiculopathy from degenerative disorders, termed degenerative cervical radiculopathy (DCR), is defined as "pain in a radicular pattern in one or both upper extremities related to compression and/or irritation of one or more cervical nerve roots".[1,2] This condition can result from degenerative changes to the intervertebral disc and uncovertebral and facet joints, leading to disc herniations and bone hyperplasia, which can cause nerve root compression.[2-5] Despite the generally favourable natural history of DCR, with significant improvements within four to six months, patient symptoms can include severe pain, paresthesia and motor weakness, which can lead to significant morbidity and disability, resulting in poorer quality of life (QOL).[2,6-8] Current epidemiological data suggests that DCR has an incidence between 0.83 to 1.79 per 1000 person-years and a point prevalence of 1.21 to 5.8 per 1000.[9-12] These numbers are expected to increase as a result of the aging population and a rise in degenerative spinal conditions.[13,14]

Conservative management is considered the first-line treatment for DCR, with surgery reserved for non-responsive cases or significant neurological decline.[2,15] The majority of past systematic reviews have focussed on the effectiveness of single unimodal conservative interventions. Zhu *et al*.[16] identified three trials that demonstrated a significant short-term improvement in pain with cervical manipulation compared to computer traction. Romeo *et al*.[17] and Colombo *et al*.[18] found that the effectiveness of cervical traction for cervical radiculopathy has mixed results, demonstrating statistically but not clinically significant improvements.[17,18] Liang *et al*.[19] assessed exercise in patients with cervical radiculopathy, finding low quality evidence that exercise significantly improves pain and disability scores.

Despite the range of nonoperative interventions assessed in individual systematic reviews, significant gaps still exist. One reason for this includes the date of completion for some reviews. Systematic reviews assessing exercise and cervical traction have search strategies ending between 2018 to early 2020, but Zhu *et al*.[16] completed the most recent systematic review assessing the literature on cervical spine manipulation for DCR with a search ending in 2014.[16-19] In addition, the most recent systematic review to assess multiple conservative interventions searched until 2011, and this review found only low to very low quality evidence for any single intervention.[20] Furthermore, clinical practice guidelines with the

most recent search ending in 2016 have cited limited literature, providing varying levels of evidence to support their recommendations.[21-23] Another reason for these gaps in knowledge involves the exclusion of relevant comparative groups required to assess and understand the clinical effectiveness of each treatment. For example, Colombo *et al*.[18] excluded studies assessing cervical traction compared to other passive/active interventions and Liang *et al*.[19] excluded studies that included exercise in both the treatment and control group. As a result of the above limitations of past systematic reviews on this topic, a significant number of studies have not been assessed and included.[24-34] Therefore, an updated comprehensive review examining the effectiveness and quality of evidence for conservative interventions of DCR is urgently needed.

Our objective is to conduct a systematic review to identify, appraise and synthesize the evidence on the effectiveness and safety of noninvasive nonoperative treatments for the management of adults with DCR.

Methods

Protocol

This systematic review protocol development was guided using the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P).[35] The subsequent systematic review will be reported based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.[36] The systematic review protocol has been registered through the International Prospective Register of Systematic Reviews (PROSPERO) database (CRD42021249699).

Eligibility criteria

PICO question

Are noninvasive nonoperative interventions associated with short-term and long-term improvements in pain, associated symptoms such as numbness and weakness, disability, functional status, and quality of life compared to other interventions, placebo/sham interventions, or no intervention for the management of adults with DCR?

Population

Our systematic review will include studies examining adults aged 18 years or older with DCR of any duration (i.e. acute/recent, chronic/persistent) secondary to degenerative disorders, which are the most common causes of cervical radiculopathy. As it is clinically difficult to identify the pathoanatomical cause for an individual's cervical radiculopathy, included studies will involve participants with disc herniations and bone hyperplasia in isolation or in combination.[7] Studies will be excluded if major structural or serious pathology is present such as fractures, tumor, infection, major trauma, neurodegenerative disease or inflammatory arthritides. Furthermore, post-surgical studies will be excluded.

The diagnostic criteria used for participant inclusion in conservative intervention studies is heterogenous, with a history based diagnosis such as radiating arm pain being the most common.[37] Concurrent diagnostic modalities including a neurological examination (sensory, motor and/or reflex deficits), physical examination tests (i.e., Spurling's and/or upper limb nerve tension tests) and/or imaging are used less frequently.[8,37,38] In particular, imaging is recommended for interventional and/or surgical procedures, and as a result may be utilized less in patient populations receiving conservative care.[1,37] Since this systematic review will be assessing nonoperative interventions, a diagnosis based on clinical findings and/or diagnostic findings would be appropriate.

For this systematic review, diagnostic imaging reported in any included study will be used as supplemental information. If imaging is present and an isolated etiology of radiculopathy can be ascertained, study results will be stratified according to the etiology. This will provide the opportunity to assess the effectiveness of nonoperative interventions depending on the cause of symptoms, which has been demonstrated to be important in other degenerative cervical spine disorders.[39]

Intervention

Studies that assess at least one treatment arm of noninvasive nonoperative management will be included. Examples of treatment can include physical therapy, medications (e.g. NSAIDs, muscle relaxants, gabapentin/pregabalin), collars, cervical manipulation/mobilization, acupuncture, cervical traction, and multimodal care.[16,19,20] Nonoperative treatments will be categorized based on the Ontario Protocol for Traffic Injury Management (OPTIMa) Collaboration which includes manual therapy (e.g. manipulation, mobilization, traction), soft tissue ther-

apy, exercise, patient education, acupuncture and passive physical modalities.[22,40] In addition, a category of pharmacological interventions will be used in this review as interventions such as medications will be included.

Comparators

Studies may include no treatment/observation, operative treatment, nonoperative treatment and/or placebo/sham treatment. These are similar to comparators other systematic reviews have utilized when assessing the effects of nonoperative treatment for degenerative spinal conditions.[41,42]

Outcomes

The following outcomes for DCR will be targeted: (1) Disability scores (e.g., neck disability index (NDI)[43,44]), (2) pain intensity (e.g., neck and arm pain[44]), (3) functional status (e.g., patient specific functional scale[44,45]), (4) quality of life (e.g., SF-36, EuroQol[46]), (5) psychological impact (e.g., Fear-Avoidance Beliefs Questionnaire (FABQ)[47]), and (6) global success of treatment (e.g., global perceived effect scale[46], global rating of change[1]). When available, adverse events and/or complications will be recorded. Clinical outcomes unrelated to the conservative treatment of DCR will be excluded, such as qualitative studies describing patient experiences, surgical outcomes (e.g., blood loss), health care utilization, and cost-effectiveness outcomes.

Time

Following similar protocols utilized when evaluating the nonoperative management of lumbar spinal stenosis[42], treatment outcomes will be analyzed according to: immediate (up to one week following the intervention), short-term (between one week and three months), intermediate (between three months and one year) and long-term (one year or longer) post-treatment. This will help inform the effect of nonoperative treatments on DCR with regards to short-term compared to long-term symptom relief.

Study designs/characteristics

Eligible studies targeting the population, intervention and outcomes listed above must meet the following criteria: 1) English language; 2) randomized controlled trial; 3) at least one treatment arm is nonoperative and noninvasive; 4) mixed population studies must report DCR subjects separately; 5) included studies must have participants diagnosed with symptomatic DCR confirmed through positive clinical examination tests and/or diagnostic tests; and 6) at least one of the outcomes listed above has to be measured. The following will be excluded: 1) case reports, case series, cohort studies, and case-control studies; 2) cadaveric or animal studies; 3) studies assessing degenerative cervical myelopathy; 4) DCR caused by major structural or serious pathology such as fractures, tumor, infection, neurodegenerative disease or inflammatory arthritides; 5) post-surgical studies; and 6) qualitative studies.

Information sources and search strategy

MEDLINE (Ovid), Cochrane Controlled Register of Trials (CENTRAL), CINAHL (EBSCO), Embase (Ovid), PsycINFO (Ovid) will be searched from database inception to April 30, 2021. The search strategy will be developed with the assistance of a Health Sciences Librarian, with a second librarian peer reviewing the final search strategy using the Peer Review of Electronic Search Strategies (PRESS) Checklist.[48] The search strategy will be constructed in Ovid MEDLINE (Appendix 1) and adapted to the other databases listed. Search terms will include subject headings (e.g. MeSH in MEDLINE) and free text words to capture key concept DCR, and retrieve randomized controlled trials. EndNote X9 will be used as an electronic reference manager to identify duplicate references across databases, and record the number of duplicates identified. In addition, reference lists of included studies and previous systematic reviews on this topic will be hand searched to ensure all relevant studies are identified.

Data collection and analysis

Study selection

Screening for eligible studies will occur using pairs of independent reviewers over a two-phase process. In phase 1, title and abstracts will be screened by pairs of independent reviewers to determine study eligibility by denoting studies as possibly relevant or irrelevant. Studies where disagreements arise will automatically move to phase 2.[49] In phase 2, possibly relevant articles will be screened by pairs of independent reviewers to determine

eligibility and studies will be categorized as relevant or irrelevant, with reasons provided for excluding studies. After independent review is completed, reviewers will meet to discuss disagreements and reach consensus for study eligibility. During phase 2, a third reviewer will be consulted if consensus cannot be reached. Missing information will be sought by contacting study authors for information pertinent to screening, risk of bias assessment, and data extraction.

Data items and data collection process

Pairs of independent reviewers will extract the relevant study data. One reviewer will build evidence tables through data extraction from eligible studies. A second reviewer will independently extract study results (e.g. means and 95% confidence interval) to ensure accuracy, with any disagreements discussed to reach consensus. In addition, a second reviewer will assess the remaining extracted evidence table fields to verify and ensure accuracy and completeness. Disagreements will be discussed to reach consensus, with an independent third reviewer used if needed. Data will be extracted from each study on:

1) **study characteristics** (e.g., author, publication year, number of patients, mean age of participants, country and years of trial conduction, number of trial centres, institution of first author, country where trial was conducted, funding sources, randomization method, blinding method, the use of cross-overs, dropouts and withdrawals, study follow-up, reported prior conservative treatment, study participant demographics, duration of condition, inclusion and exclusion criteria, etiology of cervical radiculopathy, utilization of imaging, co-morbidities);
2) **symptoms** (e.g., neck pain, arm/hand pain, arm/hand symptoms including weakness and sensory deficits);
3) **outcome measures** such as pain scores, disability scores, global success of treatment, well-being (e.g., quality of life measures), participation restriction (e.g., ability to work, mental status), activities of daily living, medication consumption, and adverse events);
4) **interventions and comparisons** (e.g. number of patients, type, intensity, dosage, frequency and duration);
5) **study results** organized based on immediate (up to one week following the intervention), short-term (between one week and three months), intermediate (between three months and one year) and long-term (one year or longer) post-treatment; and
6) **statistical analysis** (e.g. effect size, confidence intervals, power calculation, intention-to-treat analysis and statistical tests such as ANOVA).

Authors will be contacted if there is missing information in studies and if no response is received, study results will be described based on availability. The data extraction form will be pilot tested on five randomly selected studies with amendments made accordingly.[49]

Methodological quality and risk of bias appraisal

Pairs of independent reviewers will critically appraise eligible studies for bias using the Cochrane Risk of Bias for Randomized Trials (ROB 2). Established on empirical evidence, bias will be assessed based on five domains; bias arising from the randomization process, bias due to deviations from intended interventions, bias due to missing outcome data, bias in measurement of the outcome, and bias in selection of the reported results.[50] Signalling questions within the ROB 2 tool are utilized by reviewers within an algorithm in order to identify a judgement on the risk of bias.[50] The risk-of-bias judgement within each domain will be assigned to one of the three categories: low risk of bias, some concerns or high risk of bias.[50] If a consensus cannot be reached, a third independent reviewer will be used to assist with any disagreement.

Data synthesis and strength of the evidence

The Grades of Recommendations, Assessment, Development, and Evaluation (GRADE) will be used to assess the overall study quality. GRADE assessments are based on five domains: limitations in design and implementation (risk of bias), inconsistency (heterogeneity), indirectness (inability to generalize), imprecision (insufficient or imprecise data), and publication bias (selective reporting).[49]

Inconsistency refers to the heterogeneity of the results measured by I^2. While downgrading based on I^2 thresh-

olds have been proposed in the literature (<40% is low, 30-60% is moderate, 50-90% is substantial, and 75-100% is considerable[50,51]), for this review significant heterogeneity will be defined as an $I^2 \geq 50\%$.[52] When pooling of studies is not possible, consistency will be defined as ≥ 75% of studies in the same direction (i.e. benefit versus no benefit).[49]

Indirectness refers to the representative nature of the population, intervention or outcomes compared to the review's inclusion criteria, with downgrading occurring if deviations from the inclusion criteria occur.[49,53]

Imprecision refers to the number of participants, events, and width of confidence intervals.[49] Sufficient sample size and narrow confidence intervals will be required for a classification of precise.[54] Sufficient sample size will be defined as 400 or more.[54]

Publication bias refers to the selective publication of trials and selective reporting of outcomes.[49] Selective reporting will be defined as pre-planned outcomes that are not provided in the results section.[49] When at least 10 studies are included in the meta-analysis, a funnel plot will be produced to assess for asymmetry.[49]

For the GRADE approach, RCTs begin as high-quality evidence and are downgraded for each domain not met.[49,55] Evidence for outcomes provided from a single small trial will be considered imprecise and inconsistent and therefore downgraded by at least two levels (Table 1).

Table 1.
GRADE quality of evidence and description.

Evidence Quality	Description
High quality	Further research is very unlikely to change our confidence in the estimate of effect
Moderate quality	Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate
Low quality	Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate
Very low quality	Any estimate of effect is very uncertain

Treatment effects for outcomes will be assessed based off statistically significant and clinically important differences. Dichotomous outcomes will be expressed as relative risk and continuous outcomes as mean differences or standard mean differences with 95% CI will be calculated. Clinically important differences between treatment groups will be measured according to published minimal clinically important differences (MCID) in a similar patient population. For outcomes where an MCID is not published, a between group absolute difference of 30% will be used in its place. When using MCIDs, it is important to understand their limitations. For example, MCIDs are sample dependent and therefore different MCIDs may alter the results, such as utilizing patient populations who have undergone conservative versus surgical interventions.[56-59] Despite these limitations, recognizing if between group differences appear to be clinically significant, in addition to statistically significant is important when assessing clinical effectiveness.

When possible, results will be stratified by the type of DCR (i.e., disc herniation; bone hypertrophy), and duration of symptoms (immediate, short-term, intermediate, and long-term post-treatment). If two or more studies are sufficiently homogenous, a random-effects model meta-analysis will be performed. The Cochrane Back and Neck Group recommends using a random-effects model rather than a fixed-effects model as a result of the clinical heterogeneity in the back and neck pain literature.[49] To assess the potential effects of heterogeneity, the following sensitivity analyses will be conducted: 1) methodological quality (risk of bias) impact on study results will be assessed by completing the meta-analysis with all studies (low, some concerns, and high risk of bias), as well as each category separated, 2) DCR etiology, and 3) small sample size bias through a fixed-effect model meta-analysis. If statistical pooling is not possible, the results will be qualitatively described. Results will be interpreted to determine if an intervention is superior, equal or inferior to a comparison group.

Discussion

The results of this review will provide an updated understanding of the quality of evidence for noninvasive nonoperative treatments for DCR. As mentioned above, there are significant limitations of the previously published DCR systematic reviews, resulting in an incom-

plete understanding of the effectiveness of nonoperative interventions for this condition. With the burden of disability associated with cervical radiculopathy expected to increase, an updated, comprehensive, in-depth understanding of conservative interventions is needed in order to inform clinical practice, and identify research gaps. The results of this review will be relevant to patients, clinicians, and researchers to ensure the best available care is provided to DCR patients and the current state of the literature is understood.

This review is not without limitations. First, there are no standardized diagnostic criteria for DCR. Therefore, to ensure appropriate conservative management studies are included, this review will utilize a diagnosis based on clinical and/or diagnostic findings. As diagnostic imaging is used infrequently in conservative management studies, there is the possibility of including participants in studies that do not have DCR due to the lack of imaging confirmed findings. Therefore, to mitigate this, studies that include participants based on a clinical diagnosis will be required to include at least one objective finding, as diagnostic studies have demonstrated acceptable psychometric properties for clinical tests such as orthopedic and neurological examination, and it is suggested that only relying on patient reported symptoms can lead to a false positive diagnosis and the inclusion of symptomatically similar conditions.[38,60,61] Second, even though it has been suggested that the etiology of DCR plays a role in prognosis and clinical course, studies do not consistently differentiate the cause of radiculopathy in their included sample. In this review, study results will be stratified according to the cause of symptoms when possible, potentially leading to a better understanding of the impact of etiology on clinical outcomes. Third, following the search, only studies published in English will be included, which will result in any study published in a different language being omitted from the review. Even though it has been demonstrated that limiting included studies to the English language does not result in systematic bias[62], citations for studies that were potentially relevant but in a different language will be provided in the manuscript.

The results of this review will be used in conjunction with current on-going work to develop an evidence-based, patient centered program of care for DCR patients through the use of intervention mapping. Intervention mapping incorporates the best available evidence, along with the application of theories, as well as program implementers and key stakeholders to ensure relevant needs are met.[63] This review will be utilized as one component of the intervention mapping process, as these findings will be vital to inform the current literature of nonoperative DCR interventions.

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Appendix 1.
Ovid MEDLINE search strategy

1. Radiculopathy/	40. exp Clinical Trials as Topic/
2. Polyradiculopathy/	41. Double-Blind Method/
3. radiculopath*.mp.	42. Single-Blind Method/
4. radiating*.mp.	43. exp Placebos/
5. radicular*.mp.	44. random*.mp.
6. radiculit*.mp.	45. clinical trial*.mp.
7. polyradiculopathy*.mp.	46. double* adj2 blind*.mp.
8. poly-radiculopath*.mp.	47. single* adj2 blind*.mp.
9. neuropath*.mp.	48. placebo*.mp.
10. NAD grad*.mp.	49. randomized controlled trial*.pt.
11. grade III NAD.mp.	50. controlled clinical trial*.pt.
12. pain grade III.mp.	51. clinical trial.pt.
13. 1-12/OR	52. 35-51/ OR
14. exp Cervical Vertebrae/	53. 34 AND 52
15. exp Cervical Plexus/	54. Limit 53 NOT (comment or clinical conference or congress or consensus development conference or editorial or letter or guideline or practice guideline or case reports).pt.
16. Brachial Plexus/	55. 54 NOT (Animals/ NOT Humans/)
17. cervical*.mp.	
18. neck*.mp.	
19. c-1*.mp.	
20. c-2*.mp.	
21. c-3*.mp.	
22. c-4*.mp.	
23. c-5*.mp.	
24. c-6*.mp.	
25. c-7*.mp.	
26. cervico-gen*.mp.	
27. cervicogen*.mp.	
28. c-spine*.mp.	
29. “c spine”.mp.	
30. brachial* adj2 plexus*.mp.	
31. cervicobrachial*.mp.	
32. cervico-brachial*.mp.	
33. 14-32/ OR	
34. 13 AND 33	
35. exp Randomized Controlled Trial/	
36. exp Randomized Controlled Trials as Topic/	
37. Controlled Clinical Trial/	
38. exp Controlled Clinical Trials as Topic/	
39. exp Clinical Trial/	

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Provider-patient communication: an illustrative case report of how provider language can influence patient prognosis

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Patient-provider communication can lead to unhelpful ideas and beliefs about a patient's condition, negatively impacting their clinical outcome. A 34-year-old male Veteran presented for an evaluation of high impact chronic low back pain. Previous interactions with various healthcare providers resulted in the Veteran viewing his condition as ominous and in need of intervention, however clinical findings did not support these beliefs. Our Veteran underwent six visits in the chiropractic clinic with treatment consisting of pain education, utilization of cognitive behavioral principles, active home care exercises and spinal manipulation, resulting in improvements in functional and objective outcome measures. This case report highlights the impact of misalignment between an early contact healthcare provider and patient misunderstanding of

La communication entre le fournisseur de soins de santé et le patient : un rapport de cas illustrant l'influence du langage du fournisseur sur le pronostic du patient.
La communication entre le fournisseur de soins de santé et le patient peut conduire à des idées et à des croyances inutiles sur l'état du patient, ce qui a un impact négatif sur son résultat clinique. Un vétéran de 34 ans s'est présenté pour une évaluation d'une lombalgie chronique à fort impact. Des interactions antérieures avec divers fournisseurs de soins de santé ont amené le vétéran à considérer son état comme inquiétant et nécessitant une intervention, mais les résultats cliniques n'ont pas appuyé ces croyances. Notre ancien combattant a effectué six visites à la clinique chiropratique subissant chaque fois un traitement consistant en une éducation à la douleur, l'utilisation de principes cognitivo-comportementaux, des exercices de soins actifs à domicile et des manipulations vertébrales, ce

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their condition on long term outcomes. It serves as an example of how physicians utilizing pathoanatomic explanations to describe a patient's chronic low back pain diagnosis can alter the patient's beliefs about their condition.

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qui a entraîné des améliorations dans les mesures de résultats fonctionnels et objectifs. Ce rapport de cas met en évidence l'impact d'un mauvais alignement entre un fournisseur de soins de santé de premier contact et l'incompréhension du patient de son état sur les résultats à long terme. Il sert d'exemple de la façon dont les médecins utilisant des explications d'anatomie pathologique pour décrire le diagnostic de lombalgie chronique d'un patient peuvent modifier l'idée que se fait le patient de son état.

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MOTS CLÉS : rapport de cas, chiropratique, lombalgie, communication avec le patient, langage du fournisseur, vétéran

Background

Chronic low back pain (CLBP) is multifactorial, and often perpetuated by poor self-efficacy, fear avoidance or catastrophizing behavior.[1] Low back pain is also the leading cause of disability worldwide, with the years lived with disability increasing by 54% between 1990 and 2015.[2] Peak prevalence of low back pain ranges from 28%-42% in adults ages 40-69 years old[3], and disproportionately affects Veterans as they are more likely to report having pain in the past three months with the rate of severe pain being 50% higher than civilians[4].

Most episodes of low back pain resolve quickly, and are self-limiting[2]; however, recent evidence suggests that up to 32% of patients transition from acute to chronic low back pain[5]. No longer an acute biomechanical response, CLBP is characterized by a range of psychological, biophysical, and social contributors that can affect quality of life.[2] Clinical practice guidelines support the assessment of unhelpful beliefs and other psychosocial risk factors, or yellow flags, in order to guide treatment and further predict prognosis in cases of CLBP.[7] Yellow flags include unhelpful beliefs about pain, such as perceiving a condition as likely to worsen, avoidance of activity due to pain, or treatment preferences that do not fit with best practices, such as preference for passive modalities.[6,8] There is a strong correlation between a patient's thoughts, ideas or beliefs of their pain experience, their disability, and its chronicity.[9] These beliefs are modifiable factors and can be influenced either positively or negatively by healthcare providers.[10] Strategies to address these risk factors include pain education, and cognitive behavioral principles. The effectiveness of interventions targeting unhelpful beliefs and additional yellow flags is limited, however evidence does report consistently positive results when compared to interventions that do not address these risk factors.[6]

With evidence supporting the positive influence healthcare providers can have on psychosocial risk factors that affect the chronicity of low back pain[6], healthcare providers can also negatively influence prognosis and the development of unhelpful beliefs due to the iatrogenic potential of their words[11]. Although many factors influence beliefs about low back pain, communication between healthcare providers and their patients may be the most important.[12] Communication and the language used to discuss a patient's symptoms and/or diagnosis can positively or negatively affect their attitudes, beliefs and overall prognosis.[12,13] Misalignment between the patient's interpretation of the provider's language and their intended message can also influence outcomes.[12,13]

The purpose of this case report is to present one example of recognizing and addressing misalignment between previous healthcare provider interactions and psychosocial risk factors to improve prognosis. This re-

port aims to further support the influence provider language has on patient outcomes and calls on providers to be diligent in screening for and addressing yellow flags.

Case presentation

A 34-year-old Caucasian male, Veteran of the United States Army, presented to a Veterans Administration (VA) Community Based Outpatient Chiropractic Clinic for evaluation of chronic low back pain with intermittent, bilateral, non-dermatomal anterior thigh paresthesia of insidious onset over 13 years prior. The presenting complaint was chronically high impact – affecting work, social and self-care activities. No pertinent medical or family history was identified. Despite a gradual and localized initial onset, the Veteran recounted his understanding of his condition being ominous as he recalled the interaction with his initial healthcare provider. He described a "collapsed lower lumbar" that he reported, according to this initial contact provider, would require surgery and, should he decline, he would be wheelchair-bound. Chart review indicated this was a primary care provider in 2008 who had taken plain film lumbar radiographs revealing multilevel Schmorl's type nodes with a plan for referral to physical therapy. Chart review also indicated documentation stating a surgical consult was not appropriate for his axial back pain at that time, which was not consistent with this Veteran's current understanding of the same interaction. Years later, he recounted a community chiropractic provider "would not touch [him] because [his] back was so bad", further contributing to his thoughts, beliefs and ideas of an ominous condition in need of surgery.

The Veteran was able to self-manage periodic exacerbations until a pain episode following an extended drive home from work prompted an Urgent Care visit in 2021. His pain presentation was similar to prior episodes, consisting of axial low back pain with intermittent, bilateral, non-dermatomal anterior thigh paresthesia without lower extremity weakness or cramping. He underwent lumbar computed tomography imaging, revealing right central disc extrusion at L5/S1. Despite the palliative effects of intramuscular ketorolac tromethamine during this urgent care visit, fear surrounding his condition was heightened secondary to a provider sharing a story of their relative undergoing surgery for a similar imaging finding. As a result, the Veteran presented to his VA primary care provider requesting a neurosurgical consult. Chart review indicated an electronic consult (E-consult) was placed to neurosurgery who suggested obtaining lumbar magnetic resonance imaging (MRI) and nerve conduction studies prior to face-to-face consultation.

The Veteran's 2021 lumbar spine MRI was significant for mild disc bulge at L4/L5, and moderate left and mild right L5/S1 foraminal narrowing secondary to central and right paracentral disc herniation. Electromyography and nerve conduction velocity studies were significant for chronic right L5 radiculopathy. Subjective complaints did not correlate with L5 radiculopathy, while clinical examination findings did support chronic, mild nerve tension without progressive neurological deficits on the right. Based on this, the neurosurgeon recommended conservative care for pain management.

Pertinent physical examination findings included mild/moderate limitations in active lumbar range of motion complicated by mild kinesiophobia. Neurologic examination was significant for an absent patellar reflex on the right and hypoesthesia to pinprick about the right proximal anterior thigh, and right L5 and S1 dermatomal regions, corroborating with known chronic right L5 radiculopathy on electrodiagnostic testing. Orthopedic examination provoked generalized lumbosacral pain with nerve tension described in the right lower extremity when challenged with neurodynamic testing. Repeated movement in prone lumbar extension improved active range of motion and axial back pain without peripheralization.

The working diagnosis provided by our chiropractic clinic was chronic, non-specific low back pain with EMG evidence of chronic, right L5 radiculopathy without correlating subjective radicular symptoms. The prognosis was deemed poor, secondary to complicating factors such as the chronicity of the chief complaint and the Veteran's subjective report of how various providers communicated with him concerning his diagnoses and invasive treatment needs.

Initial chiropractic treatment included reassurance and education concerning etiology of the Veteran's CLBP. All imaging was reviewed and the Veteran's questions were answered. The initial treatment also consisted of active patient initiated repeated end range loading exercises. Follow-up care included spinal manipulative therapy as well as utilization of cognitive behavioral principles and pain education surrounding pacing, graded activity, sleep hygiene and hurt versus harm concepts, addressing kin-

esiophobia and increasing exercise tolerance (see Table 1). The patient denied any adverse events following care.

This trial of care included six visits at one-week intervals. The Veteran's progress was assessed by subjective report and outcome measures including Visual Analog Scale (VAS) and Patient-Reported Outcomes Measurement Information System (PROMIS) Pain Interference short form 6b. Functional improvements included increased ability to hunt for recreation without being limited by back pain, ability to don or doff socks, performing side jobs such as installing docks, and performing his job as a mechanic with manageable pain. He did not experience any episodes of lower extremity symptoms during the trial of care. A 42% improvement in VAS occurred over the trial of care (see Table 1). The Veteran also demonstrated a 10.3-point improvement in PROMIS Pain Interference with 3.5-5.5 points being clinically significant.[14]

Table 1.
Case management over six chiropractic visits at one-week intervals.

Visit	**Manual Therapy**	**Patient Education/ Home Care Advice**	**VAS (out of 100mm)**	**PROMIS Pain Interference 6b T-score**	**Functional Improvements**
Initial Evaluation	—	Reviewed past imaging findings and educated patient on unlikely correlation between these findings and his symptoms Provided reassurance surrounding the absence of red flags or progressive neurological deficits Educated patient on the nature of chronic low back pain Prescribed repeated end range loading exercises	57mm	66.4	
2nd visit	Spinal manipulation – due to limited response to home care	Reviewed hurt versus harm concepts Education surrounding pacing activity	—	—	Increased tolerance to installing docks and performing work duties
3rd visit	Spinal manipulation	Advice to stay active	—	—	Increased tolerance to installing docks and performing work duties
4th visit	Spinal Manipulation	Education surrounding graded activity	34mm	65.5	Increased tolerance to hunting and performing work duties
5th visit	Spinal Manipulation	Patient presented wearing a lumbar support brace recently given by physiatrist, we advised limiting its use	—	—	Successfully used pacing methods during his weekend activities
6th visit	Spinal Manipulation	Education on sleep hygiene practices	15mm	56.1	Required assistance donning socks only 1 day of the week Felt he did not need the lumbar brace between visits

VAS = Visual analog scale, PROMIS= Patient Reported Outcomes Measurement Information System

Discussion

It was the authors' interpretation of the Veteran's subjective history that his "collapsed lower lumbar" in need of surgical intervention may have been a case of misalignment from the incidentally found Schmorl's nodes on initial imaging. Although Schmorl's nodes can be a potential pain generator, most are asymptomatic, with a high prevalence of 19% in the asymptomatic population [15] and do not require additional intervention[16]. Therefore, it is reasonable to discern that describing them as a pathoanatomic process that violates the integrity of the vertebral body may have had an iatrogenic effect on the patient's beliefs about their condition. Additional context, including the high prevalence of Schmorl's nodes on imaging studies and lack of clinical significance in most cases, may have prevented the development of unhelpful ideas and beliefs in this scenario. Additionally, disc pathology was reported in this case after the Veteran underwent lumbar MRI; however, it is widely recognized that the prevalence of asymptomatic disc protrusions is high, reported at 29% at 20 years-old and increasing to 43% at 80 years of age, and findings on advanced imaging need to clinically correlate with the patient's symptoms in order to be determined to be clinically significant.[17] Therefore, this is the most likely explanation for this case and was concluded after conducting a thorough patient intake and physical examination, but was also supported by the neurosurgery consultation, confirming the lack of necessity for additional intervention. When comparing clinical predictions for the vertebral level of lumbar radiculopathy and MRI findings, a majority of patients do not have matching signs or symptoms, further supporting the disconnect between this case presentation and diagnostic findings.[18] In cases where clinical examination does not correlate with diagnostic imaging results, provider-patient communication holds even more importance, as providers need to proactively educate the patient about the unlikely relationship between their symptoms and imaging findings. It is unclear whether these conversations were had during previous provider-patient interactions in this case. Still, it can be inferred from the Veteran's subjective report that if they had in fact been discussed, the Veteran did not interpret the information as intended. This disconnect likely contributed to the development of harmful ideas and beliefs about his spinal pain as well.

We provided care based on our working diagnosis of chronic non-specific low back pain derived from our clinical examination.[19] The treatment plan was based on best practice guidelines and included active interventions such as exercise, activity advice, and education alongside manual spinal manipulation.[19] Our clinical examination revealed signs of psychosocial risk factors, which were addressed throughout the trial of care using cognitive behavioral principles such as graded activity, pacing, sleep hygiene and hurt versus harm concepts.[20] Graded activity concepts were taught in the setting that the patient should steadily expose himself to specific activities that he was fearful of, as they have been painful in the past. In this case, it was the patient's gradual return to hunting without provocation of debilitating lower back pain. Pacing concepts work in tandem with graded activity, as the patient was encouraged to take intentional breaks during this new activity, to ensure he did not "burn and bust," doing too much too soon and feeling discouraged by his progress. Lastly, the provider informed the patient that it was normal and safe to experience mild discomfort (hurt) while re-engaging in meaningful activities, without fear of causing additional damage (harm) to his lower back. Active approaches to pain management (return to work, lumbar extension exercises, etc.) were always emphasized over passive interventions, such as rest or the need for additional manual therapy. Throughout the trial of care the Veteran demonstrated functional improvements as well as changes in his knowledge about CLBP (Table 1), including ways to modify his activities by pacing instead of discontinuing activities he enjoys. The authors suspect that his prognosis would have improved if these communication strategies had been utilized during his early interactions with healthcare providers.

Still, there remains the possibility that fear-inducing language was not used and the Veteran mis-interpreted the information, which makes a case for tools or strategies to evaluate the effectiveness of provider-patient interactions. The teach-back method has been proposed by Ha Dinh *et al*.[21] as a simple tool used for this purpose, and has produced positive results in educating patients about disease-specific knowledge, adherence and self-care skills[21,22]. While we did not use this specific tool in our case, it may be a useful method in healthcare settings to limit potential iatrogenic effects of provider language. In this case, the authors felt that it was important to implement various principles of cognitive behavioral therapies

to educate the patient about their condition at the time of their diagnosis. Healthcare providers should encourage and support movement early in their treatment plans so patients do not develop these maladaptive behaviors and beliefs.

Further information should be gathered surrounding patients' interpretation of common provider education with regards to low back pain. The specific language a provider chooses to use may directly influence patients' beliefs about their condition.[13] For example, it has been reported that providing examples of activities that a patient should avoid leads to them interpreting their back as vulnerable and something that could be easily damaged.[13] Even if health care providers do not explicitly state these ideas or beliefs, their communication with the patient may result in these beliefs and checks should be in place, such as teach-back, to ensure the intended message is received. Patients' own biases can also contribute to their interpretation of low back pain and its prognosis. Surveys conducted surrounding people's attitudes and beliefs about low back pain revealed people believe they need to protect their back and that it is easy to injure.[23,24] These negative beliefs, which may contribute to the development of fear avoidance behaviors as well as low recovery expectations, are risk factors for the development of CLBP.[25] Thus, beliefs about low back pain associated with psychosocial risk factors can develop from patients' own thoughts as well as provider-patient interactions. It is our role as healthcare providers to screen for unhelpful thoughts, ideas or beliefs and develop effective communication skills to avoid contributing to the chronicity of low back pain.

Summary

This case is an example of prolonged disability due to the Veteran's unhelpful ideas and beliefs about their condition. It is the authors' interpretation of the Veteran's subjective history that such beliefs were shaped by previous interactions with early healthcare providers. Healthcare providers should be cognizant about the language that they utilize to describe a patient's CLBP diagnosis, limiting pathoanatomic explanations for pain, and implement tools, such as teach-back method, to assess patients' understanding of their condition. This case also gives one example of a treatment approach for a patient who exhibited unhelpful ideas or beliefs about their condition. Although this is a single case report where conclusions cannot be drawn regarding the effectiveness of these treatment methods, it serves to demonstrate the potential impact providers can have to either positively or negatively influence beliefs surrounding CLBP.

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Conservative management of pediatric temporomandibular disc displacement presenting as juvenile idiopathic arthritis: a case report

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There is limited research regarding management of temporomandibular disorders (TMD) in adolescents with imaging signs of juvenile idiopathic arthritis (JIA). An 11-year-old girl presented to a hospital-based chiropractor for evaluation of a 1.5-year history of unilateral temporomandibular joint (TMJ) pain and trismus. Previously, pediatric rheumatologists diagnosed JIA after contrast-enhanced magnetic resonance imaging revealed edema, effusion, and bilateral anterior disc displacement, and recommended methotrexate, corticosteroid injection, and arthrocentesis. The chiropractor questioned the JIA diagnosis, instead relating symptoms to a mechanical TMD/disc origin.

Prise en charge conservatrice, en pédiatrie, du déplacement du disque temporo-mandibulaire se présentant comme une arthrite juvénile idiopathique : à propos d'un cas.

Il existe peu de recherches sur la prise en charge des troubles temporo-mandibulaires (TTM) chez les adolescents présentant des signes d'imagerie de l'arthrite juvénile idiopathique (AJI). Une fillette de 11 ans s'est présentée chez un chiropraticien en milieu hospitalier pour l'évaluation d'un antécédent d'un an et demi de douleur unilatérale à l'articulation temporo-mandibulaire (ATM) et de trismus. Auparavant, les rhumatologues pédiatriques diagnostiquaient l'AJI une fois que l'imagerie par résonance magnétique avec contraste aurait révélé un œdème, un épanchement

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Authors' contributions – RT, DV, and JD conceived of the case report. CT interpreted imaging findings. All authors provided intellectual content, drafted, critically revised, and approved of the final manuscript to be published.

Manual therapy, TMJ exercises, and acupuncture improved TMJ pain and opening. Invasive medical JIA interventions were avoided without long-term recurrence, further questioning the preceding JIA diagnosis. The success of this case suggests that stepped care, beginning with conservative treatment, has value for adolescents with TMD suspect for JIA. Integration of chiropractors and acupuncturists into healthcare institutions may facilitate this care model by affording nonpharmacologic interventions earlier in patient care.

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KEY WORDS: acupuncture, chiropractic, differential diagnosis, juvenile arthritis, misdiagnosis, musculoskeletal manipulations, overtreatment, pediatrics, temporomandibular joint

et un déplacement bilatéral du disque antérieur, et recommandaient le méthotrexate, l'injection de corticostéroïdes et l'arthrocentèse. Le chiropraticien a remis en question le diagnostic d'AJI, associant plutôt les symptômes à une origine mécanique du TTM/disque. La thérapie manuelle, les exercices de l'ATM et l'acupuncture ont amélioré la douleur et l'ouverture de l'ATM. Les interventions médicales invasives d'AJI ont été évitées sans récidive à long terme, remettant davantage en question le diagnostic d'AJI précédent. Le succès de ce cas suggère que les soins par étapes, en commençant par un traitement conservateur, ont de la valeur pour les adolescents atteints de TTM supposés d'AJI. L'intégration des chiropraticiens et des acupuncteurs dans les établissements de santé peut faciliter ce modèle de soins en permettant des interventions non pharmacologiques plus tôt dans les soins aux patients.

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MOTS CLÉS : acupuncture, chiropratique, diagnostic différentiel, arthrite juvénile, diagnostic erroné, manipulations musculosquelettiques, surtraitement, pédiatrie, articulation temporo-mandibulaire

Introduction

Temporomandibular disorders (TMD) are those affecting the masticatory system, which includes the temporomandibular joint (TMJ), masticatory muscles, and associated tissues.[1] The prevalence of TMD is relatively high in adolescents, ranging between 7 and 30%.[2] The etiology of adolescent TMD includes a broad differential diagnosis with the most common causes being myofascial pain and disc displacement[2], and less common including trauma-associated synovitis[3], fracture, juvenile idiopathic arthritis (JIA), and idiopathic condylar resorption[4].

There is limited research and testing available to help distinguish between TMJ disc disorders and JIA in adolescents. While limited maximal incisal opening or deviation on jaw opening are predictive of TMJ synovitis in those with a known history of JIA[5], these findings are also often seen in more common disorders such as TMJ disc displacement[6,7]. In addition, the diagnostic accuracy of contrast-enhanced magnetic resonance imaging (MRI) for diagnosing JIA of the TMJ has been questioned, as many children without JIA have contrast-enhancing joint fluid.[8] One study comparing the contrast-enhanced MRI features of adolescents with TMJ disc displacement and those having JIA found that both groups had similar rates of joint enhancement, joint effusion, and synovial thickening.[4]

There is also limited evidence to guide the management of pediatric TMD.[2] In adolescents without JIA, there is some evidence that a stabilizing occlusal appliance is superior to advice or relaxation therapy.[2] In adolescents with JIA there is no consensus on TMD treatment, although methotrexate and intra-articular corticosteroid injections are often utilized.[9] In the absence of a standardized management algorithm for adolescent TMD, alternative care models could have value, such as stepped care, which begin with the least invasive treatments.[10]

In adults, occlusal splints are an evidence-based and routinely-used non-invasive treatment for TMD.[1,11] A recent systematic review supported the efficacy of occlusal splints for TMD, which were found to have a positive effect on mandibular movement in several studies.[11] In addition, occlusal splints were found to benefit mouth opening, and TMJ pain, locking, and clicking.[11]

While there is evidence to support less invasive treatments such as manual therapy and acupuncture for TMD, most supporting studies have been conducted with an adult population.[12–14] One systematic review found evidence that manual therapy is effective for medium-term TMD outcomes, and the addition of therapeutic exercises helped maintain these outcomes in the long-term.[12] Another systematic review found that manual therapy or therapeutic exercise were beneficial for patients with TMJ disc displacement without reduction, with limited evidence to suggest that exercises can improve mouth opening.[13] There is limited, lower quality evidence that acupuncture is superior to placebo and equivalent to occlusal splints in treating TMD.[14]

Disorders of the TMJ often co-occur with abnormalities of spinal posture and/or cervical spine dysfunction. Systematic reviews including mostly an adult population have identified moderate evidence of an association between TMD and cervical postural misalignment (i.e. forward head posture)[15], abnormal global posture[16], reduced cervical spine range of motion[17], lower deep cervical extensor muscle endurance[18], upper and global cervical spine hypomobility[18], and strong evidence of an association between TMD and self-reported neck disability[18]. There is some evidence that spinal manipulative therapy (SMT) for the cervical spine is beneficial for TMD[19], while there is less evidence supporting the use of thoracic spine SMT for TMD[20].

The goal of this case report is to present an adolescent with TMD suspected for JIA that was successfully treated with conservative therapies without recurrence. Our literature search of the Index to Chiropractic Literature, PubMed, and Google Scholar revealed one other pediatric case of TMJ disc displacement that received chiropractic care and was co-managed with arthrocentesis.[21] Otherwise, few cases of chiropractic management of pediatric TMD have been reported.

Case presentation

Patient information

An otherwise healthy 11-year-old female soccer player presented to an integrative hospital-based chiropractic office with an insidious-onset 1.5-year history of left TMJ pain, limited mouth opening, locking, and clicking, and intermittent left temporal headache. Pain was rated 3-5/10 on a numeric rating scale. She had difficulty eating meat and occasionally had difficulty sleeping due to the symptoms. While she had been experiencing TMJ symptoms for over a year, symptoms worsened two months preceding her chiropractic evaluation, when she was hit in the face with a soccer ball that had been kicked towards her, however the exact mechanism of this incident (i.e. direction and location of the hit) was not ascertained. She had prior sports injuries including a left ankle sprain and left forearm fracture but no other significant medical history such as arthralgia or uveitis, and did not have dental braces. She was taking indomethicin 50 mg bid as prescribed by a pediatric rheumatologist. The patient's mother had undergone evaluations and laboratory testing for joint pain via orthopedic and internal medicine specialists, which were not supportive of an inflammatory arthritis, resulting in diagnoses of generalized hypermobility and peripheral joint osteoarthritis. The patient's father had asthma. There was no other significant family history.

Two months prior the patient saw a pediatric otolaryngologist. This provider ordered TMJ radiographs and computed tomography, the findings of which were normal. Based on the patient's symptoms and limited mouth opening on examination this provider considered JIA as the main differential diagnosis, followed by Ehlers-Danlos syndrome, and referred the patient to a pediatric rheumatologist.

The pediatric rheumatologist ordered laboratory tests which were significant for a positive HLA-B27, however the other tests were normal including: erythrocyte sedimentation rate (4 mm/hr), c-reactive protein (0.058 mg/dL), antinuclear antibodies, rheumatoid factor, anti–cyclic citrullinated peptide antibodies, complete blood count with differential, tissue transglutaminase antibodies, Gliadin peptide IgA, Varicella Zoster IgG, tuberculosis (TB) spot, reticulin antibody IgA, endomysial IgA <1:10, Westergren ESR 4 mm/hr, CRP 0.058 mg/dL, comprehensive metabolic panel, gamma glutamyl trans-

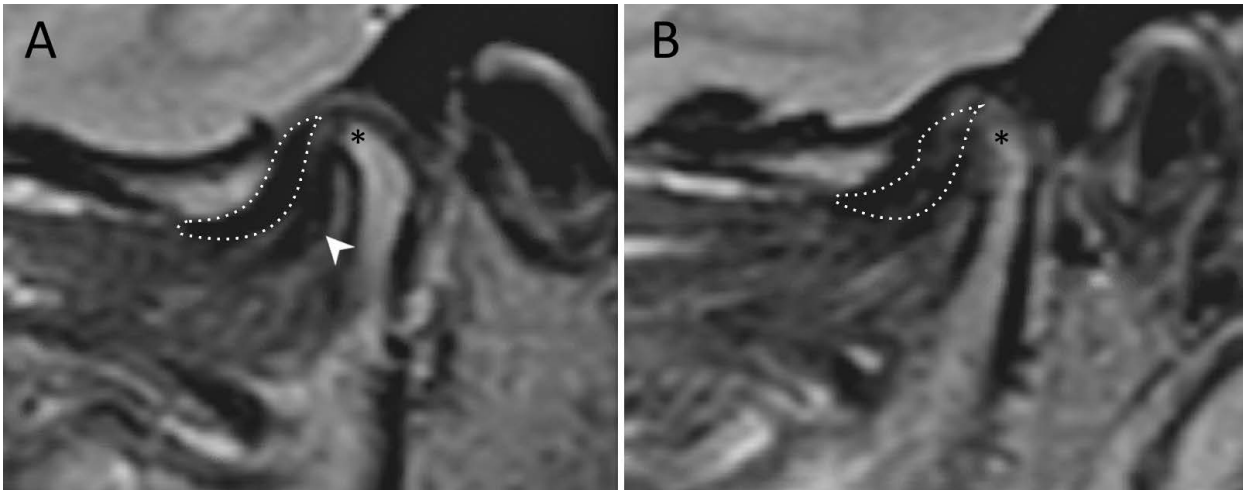

Figure 1.
Oblique sagittal T2-weighted MRIs of the left (A) and right (B) TMJ with the mouth closed. The articular disc (dotted line) is displaced anteriorly from its normal position near the top of the mandibular condyle (*). Thickening of the lateral pterygoid muscle tendon (arrowhead) is seen parallel and subjacent to the disc, more clearly seen in image A, producing the "double disc" sign.

ferase, phosphorus, lactate dehydrogenase, and uric acid. Diclofenac 50 mg bid was prescribed.

The pediatric rheumatologist also ordered a gadolinium-enhanced MRI of the TMJ (Figures 1 and 2) which identified bilateral anterior disc displacement, and additional findings in the left TMJ of synovial enhancement, marrow edema, and enhancement of the mandibular condyle without discrete erosion. The radiologist noted that the findings were "concerning for early inflammatory arthritis in the proper clinical setting."

The pediatric rheumatologist considered the patient to have JIA and for the purpose of treating this suspected arthritis changed the patient's medication to nabumetone 1000 mg, followed by indomethacin 50 mg bid. Because none of these therapies alleviated the patient's symptoms, the specialist then prescribed oral methotrexate 20 mg weekly (15 mg/m^2), along with a folic acid supplement (1 mg/day), with the goal of eventually transitioning to adalimumab (Humira®). The patient and her family sought a second opinion from a pediatric rheumatologist at another health care organization, who concurred with the JIA diagnosis, and in addition, recommended an intra-articular corticosteroid injection.

The family then sought the opinion of two maxillofacial surgeons. One surgeon recommended arthrocentesis and

Figure 2.
Coronal fat-saturated T1-weighted MRI with contrast, at the left mid-mandibular condyle shows synovial enhancement (arrows), focal condylar marrow enhancement (arrowhead).

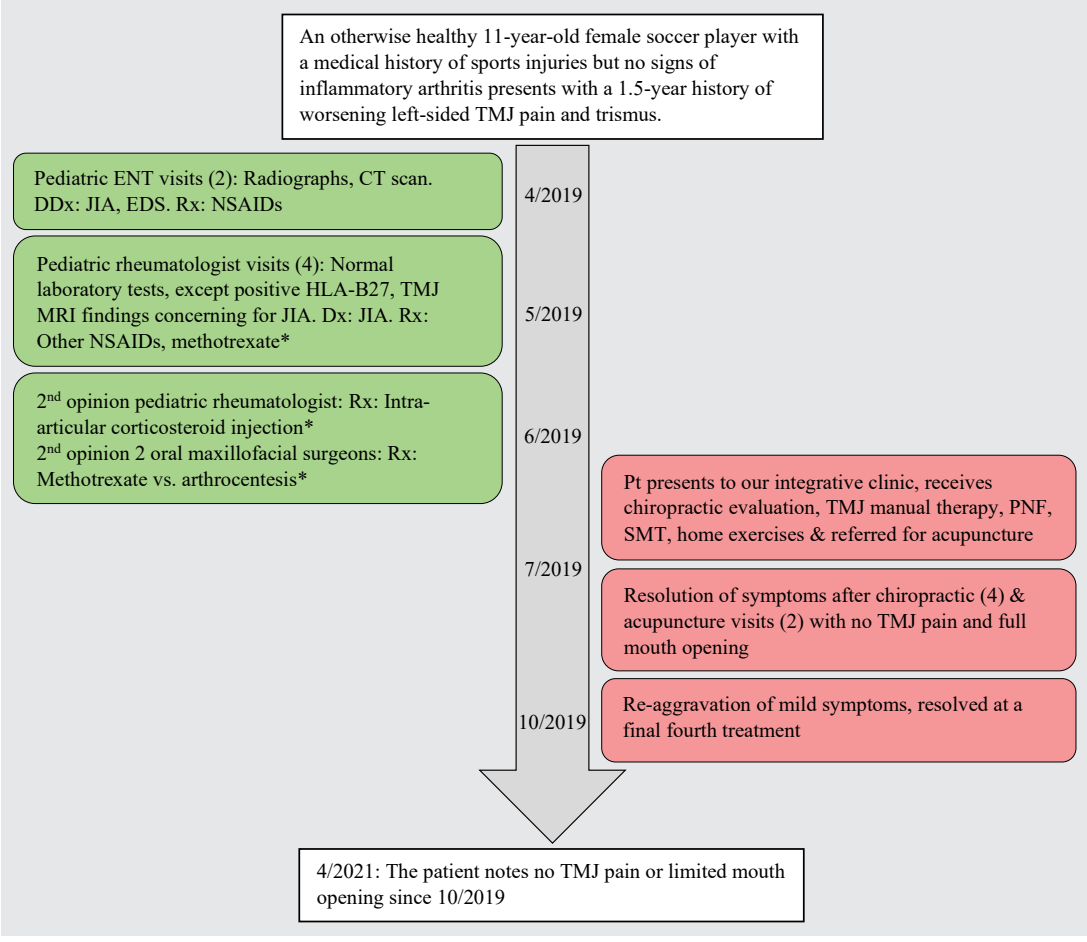

Figure 3.

Timeline of events. Otolaryngologist (ENT), computed tomography (CT), juvenile idiopathic arthritis (JIA), prescription (Rx), non-steroidal anti-inflammatories (NSAIDs), magnetic resonance imaging (MRI). The green boxes on the left side show the patient's management prior to presenting to our clinic for chiropractic care (red boxes on right). Treatments with an asterisk (*) were not utilized by the patient. Timeline created according to Scientific Writing in Health and Medicine (SWIHM) and CARE guidelines.

discussed the possibility of eventual arthroplasty. The other concurred with the use of methotrexate. This surgeon also stacked tongue depressors between the front teeth to maximally stretch the TMJ, and recommended the patient incrementally add tongue depressors each day. The family deferred medical treatment and sought chiropractic care based on recommendations from family and colleagues (see Figure 3 for the case timeline).

Clinical findings

Physical examination of the patient revealed a thin, athletic adolescent of 1.52 meters and 38.6 kg, with a forward head posture and slight thoracic hyperkyphosis. The patient had significant tenderness to palpation of the left TMJ and a limited mouth opening of 20 millimeters (mm) with slight deviation of the mandible to the left during opening (measurements obtained using a TheraBite Range of Motion Scale®). The patient was unable to open the TMJ without moderate to severe pain. The cranial nerve examination was normal, there were no neurological deficits noted in the upper extremities, gait was normal and spinal range of motion was full. There were no abnormalities de-

tected in the lumbopelvic region with regards to posture or palpation findings.

Diagnostic assessment

The chiropractor considered the patient to have a mechanical issue of the TMJ rather than a primary diagnosis of JIA, in view of her getting hit in the face with a soccer ball, displacement of the TMJ discs seen on MRI, and the absence of typical clinical, symptomatic, and laboratory features of JIA. A trial of manual therapy, home exercises, and acupuncture was recommended.

Therapeutic intervention

Chiropractic treatment included gentle extra-oral myofascial release of the TMJ muscles including the masseter, temporalis, and pterygoids bilaterally. Intra-oral therapy was not performed as the patient could not open her mouth sufficiently and was in significant pain. Proprioceptive neuromuscular facilitation (PNF) was performed for TMJ opening, closing, and lateral deviation using light to moderate resistance and three to five repetitions for each movement, to patient tolerance.

Jaw opening was resisted isometrically using external pressure at the inferior aspect of the chin (Figure 4). After each five-second contraction of resisted opening, the patient was asked to relax while the chiropractor performed a gentle passive stretch to open the TMJ for an additional five seconds, using inferiorly-directed pressure at the mentolabial sulcus. The goal of this exercise was to reciprocally inhibit the hypertonic jaw-closing muscles (e.g. masseter, temporalis) and facilitate a greater stretch to improve TMJ opening range of motion.

Jaw closing was resisted isometrically using external pressure at the mentolabial sulcus, for three to five seconds, followed by relaxation, and a passive stretch at end-range was not performed (Figure 5). For lateral deviation, gentle isotonic resistance was applied against the left side of the mandible to prevent aberrant ipsilateral deviation during mouth opening, and counteract hyperactivity of the contralateral (right) lateral pterygoid. A passive stretch was not applied after this maneuver.

Chiropractic spinal manipulation was performed using high-velocity, low-amplitude manipulations of restrictions at the cervical spine (C0, C1, C5 and C6) and thoracic spine (T2, T3, T4 and T7). Ischemic compression was performed at the cervical and thoracic paraspinal muscles, upper trapezius, levator scapulae, and suboccipital muscles.

The patient was given a home "jaw opener" exercise in which the patient slowly and actively opened the jaw, as

Figure 4.
Demonstration of resisted jaw opening.

Figure 5.
Demonstration of resisted jaw closing

far as possible without provoking moderate or severe pain. This was performed for multiple repetitions at least once per day for about a minute. The patient was instructed in-office on how to perform this exercise while looking into a mirror to ensure that the mandible was tracking properly, without lateral deviation.

The patient was also given postural home exercises. A stretch to improve thoracic extension and target the pectoralis muscles was to be performed for two to three minutes lying supine, with a pillow in the mid-thoracic region, arms abducted to 90°, and elbows slightly flexed. Chin tucks were to be performed at least once daily for 10 repetitions by retracting the head and neck with a brief hold at end-range.

The chiropractor also referred the patient to an in-office Licensed Acupuncturist. The patient attended sessions which took place later in the same day of the first and third chiropractic visits. At these appointments, 0.14x30 mm monofilament needles were utilized to stimulate the Stomach 7, Stomach 36, and Large Intestine 11 acupoints bilaterally. This treatment was well-tolerated.

Follow-up and outcome

The patient noted immediate relief with each treatment and a similar treatment protocol was performed at each visit for a total of four chiropractic and two acupuncture sessions. The first three chiropractic and two acupuncture visits were over the span of one month. At the third chiropractic visit, the patient presented with full mouth opening without pain of over 40 mm, and no locking or crepitus. Intermittent mild TMJ pain 1-2/10 NRS returned two months later which prompted the fourth and final chiropractic visit three months later which led to full symptom resolution.

Follow-up 18 months later revealed that the patient had no TMJ pain, locking, or crepitus, or difficulty eating since the final treatment, and had no other significant health issues aside from a gluteal muscle injury that developed when slipping while running. She never filled her methotrexate prescription, was not prescribed adalimumab, and did not have steroid injections, arthrocentesis or other medical procedures for the TMJ. As the patient was a minor, informed consent for treatment was obtained from the patient's parent. In addition, the parent provided written informed consent for this case report to be published.

Discussion

The clinical picture in this case was suggestive but not diagnostic of JIA. Although an insidious onset of chronic TMJ pain in an adolescent female can be consistent with JIA, and some cases of JIA present with TMD as the first sign[22], the imaging findings of joint effusion and bone marrow edema could also be explained by disc displacement[4]. While the laboratory testing was not suggestive of JIA, it also could not rule it out, as these tests may be normal in oligoarticular JIA.[23] However, one test result actually reduced the likelihood of JIA, as HLA-B27 positivity is associated with a reduced risk of TMJ involvement in JIA.[24]

Given that the clinical features in the current case were equivocal, a trial of conservative manual therapy and acupuncture was the deciding factor in distinguishing the etiology of the patient's TMD. Because the patient's response was rapid and sustained without utilization of anti-rheumatic or anti-inflammatory medications, a diagnosis of JIA no longer fit. In addition, the patient had no joint symptoms over 18 months' follow-up, without taking medications. Such improvement would be rare if the patient truly had JIA, as only 7% of patients will achieve remission without medications during this time frame.[25]

The medical treatments recommended in the current case did not match the patient and her family's preference and have certain risks. Methotrexate, the most commonly used disease-modifying anti-rheumatic drug used in JIA, is associated with adverse effects in nearly half of patients.[26] Most adverse effects are non-serious, for example nausea, vomiting, abdominal pain, restlessness, and anxiety[26], and may be mitigated by folic acid[23]. Intra-articular steroids also have adverse effects, as repeated injections can inhibit mandibular growth[27] and promote heterotopic bone formation[28].

In the absence of a clear management algorithm, the stepped care model, which begins with less-invasive treatments[10], could be an option for patients inconclusive for JIA affecting the TMJ. In this model, patients progress to more complex interventions if they do not respond to care.[10] Other models such as matched care (individualized interventions) or stratified care (categorization and treatment according to risk factors) may not be as optimal for adolescent TMJ, as diagnostic testing can be inconclusive.

Prior research has discussed the value of early identification and treatment of TMD in JIA in preventing on-

going damage to the orofacial structures.[4,24] While we do not contradict the value of this strategy, in the current case it appears a sense of urgency to recommend medical treatments for JIA led to conservative measures being overlooked. Because the diagnosis of JIA was not certain, it could have been more appropriate to begin treatment with a brief trial of conservative care including manual therapies, as in the stepped care model. This would provide the patient, family, and medical team with greater clinical insight regarding the patient response to care, and inform the strategy to recommend more complex interventions as needed.

In the current case report, the patient and her family only sought out conservative care after being recommended but deferring more invasive medical interventions. If the model of stepped care had been applied to this case, then the order of these treatments would have been different such that the manual therapy and/or acupuncture would have been recommended before the methotrexate, corticosteroid injection, and arthrocentesis.

Manual therapy in the current case targeted both the TMJ and the spine. Although these are separate regions, they are interdependent and may have been equally important in helping resolve the patient's TMD. Treatment of the TMJ may have inhibited hypertonic musculature, facilitated repositioning of the articular discs, and restored normal TMJ mobility. Spinal manipulative therapy may have been beneficial in addressing forward head posture, which is associated with hyperlordosis of the cervical spine, hyperextension at the occipital-cervical junction, retrusion of the mandible, alteration in masticatory muscle activity[29], and reduced masticatory muscle pressure pain thresholds[30]. We suspect that treating the cervico-thoracic spine in tandem with the TMJ was beneficial in improving static posture and reducing compensatory TMJ dysfunction.

There may have been a synergistic effect of adding acupuncture to the patient's care. Acupuncture may provide benefits to overall health quality[31], yet in addition, address local myofascial sources of TMJ pain[14,31]. Stomach 7 is one of the most common acupoints used in treatment of TMD, and due to its alignment with the masseter muscle, may help relax this muscle when stimulated.[31] The remaining acupoints were used as part of an overall acupuncture diagnosis and treatment, despite having no direct anatomical link to the TMJ. Stomach 36 was used to facilitate the effects of Stomach 6, being in the same meridian, while Large Intestine 11 was used for clearing heat (TMJ-related inflammation).

The model of stepped care including conservative treatment for equivocal TMD in JIA may function particularly well in a health care organization offering chiropractic, acupuncture, and other integrative therapies. In this type of healthcare setting chiropractors work alongside medical specialists and have access to the same electronic medical records and laboratory and imaging results. In the current case, the chiropractor was employed by the same health care organization and was able to review the medical specialists' assessments and prior imaging, which informed the treatment approach.

We propose that the success of this case is partially related to the structural integration of chiropractic services, along with the manual therapies these providers utilize, across University Hospitals. Integrative medical interventions (e.g. chiropractic care, manual therapies, acupuncture, massage therapy, integrative medicine consultations) within health care organizations can facilitate a coordinated care model in which less invasive, but therapeutic, treatments are provided earlier in a patients' care pathway.[32]

Limitations

As this is a case report, results may not be generalizable to a larger population. The exact relationship between the soccer ball hit and etiology of the patient's TMD was unclear. The patient had a history of less severe TMJ pain and limited opening leading up to this event, yet there was no prior TMJ examination or imaging to compare to. It is plausible but inconclusive that the soccer ball incident was responsible for acutely restricting the patient's mouth opening, triggering TMJ disc displacement, and causing TMJ edema as seen on MRI. Repeat imaging could have determined if the TMJ disc was successfully recaptured with conservative care, and if inflammatory signs were reduced. Repeat imaging was unnecessary as the patient had no further symptoms, and gadolinium contrast has risks. A TMJ-specific outcome assessment questionnaire was not utilized in this case which could have helped track the patient's progress over time. As a range of treatments were used (acupuncture, manual therapies, home exercise), it is inconclusive which treatment helped the most or if the patient's improvement was due to a combination

of these therapies. In addition, it is possible the patient's TMJ disorder could have self-resolved regardless of the interventions used.

Summary

This case highlights the lack of a standardized treatment algorithm and the shortcomings of diagnostic imaging for adolescent TMD. The combination of these factors can allow for possible misdiagnosis and escalation of treatment, such as in the current case when advanced imaging findings suggestive of JIA prompted recommendations for methotrexate, corticosteroid injection, and arthrocentesis. However, the success of chiropractor-led management in this case highlights the potential utility of a stepped care model in which early conservative therapies are provided as both a diagnostic and therapeutic trial for those with TMD and an uncertain diagnosis of JIA. We suggest that this care pathway can inform the clinical decision-making prior to the use of higher levels of care such as disease-modifying antirheumatic drugs and/or injections. Chiropractors, acupuncturists, and medical specialists have an opportunity to collaborate within integrative settings to optimize the treatment for adolescents with TMD.

Patient perspective

I felt that during all my doctor appointments I was not part of the decision of what was going to happen to me. I felt like the doctors did not think it mattered what I thought, but when I met [the chiropractor], he told me exactly what he was going to do before he did it and asked me how I was feeling the whole time. I felt like I was actually part of the conversation with [the chiropractor]. Before I saw [the chiropractor] we had been looking for about a year for someone who could tell me what was wrong with my jaw, and what we could do to fix it. Lots of doctors told me to go on Humira, but at the age of 12 my mom and I did not think that would be a smart choice. We then found [the chiropractor] who realized that my jaw was out of place and none of the other doctors had been able to see that. We had three appointments with [the chiropractor] that consisted of massaging my jaw and readjusting it. Now two years later my jaw feels normal again, all because of the acupressure and the help of [the chiropractor].

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