L'Association chiropratique canadienne

Canadian Chiropractic Association ™/MC

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Editorial Board

Inheriting the Journal

Kent Stuber, DC, MSc, Editor-in-Chief

Kent Stuber, DC, MSc,
Editor-in-Chief

Dr. Allan Gotlib was the fourth Editor-in-Chief of the Journal of the Canadian Chiropractic Association (JCCA). On June 30th Dr. Gotlib officially retired and on July 1st I began serving in this capacity. Until late last year when Dr. Gotlib approached me about taking over as the Journal's Editor-in-Chief upon his retirement, assuming this position had never occurred to me. It actually never occurred to me that Dr. Gotlib might retire. I think of Allan as indefatigable, not the retiring type. However, I am very happy for him and hope that he is able to reflect proudly upon a career of serving this profession that is second-to-none. Dr. Gotlib has likely done more for the profession than any other single person that I can think of in the past 30 years. I am very happy that he will now be able to enjoy his retirement and hopefully enjoy many long wonderful years watching grandchildren's hockey games and the like.

I am also very pleased that Dr. Gotlib has agreed to accept the position as the Journal's Editor Emeritus. When you change Editors for the first time in 30 years, there will likely be a few bumps in the road and I am sure that as time goes on that we will need to make some changes to the way that we conduct the Journal. However the core purpose of the JCCA will remain unchanged. Canada has always been at the forefront of research in chiropractic and the Journal has been one of the chief means of disseminating those research findings. The Editorial team that Dr. Gotlib has assembled is experienced and full of many of the best minds that our profession has to offer. It is my privilege to work with each of them.

However, it is intimidating to inherit the Editorship from Dr. Gotlib. There is tremendous weight and responsibility that comes with it. Dr. Gotlib is a Member of the Order of Canada and has deservedly received every honour that has been bestowed upon him during his career. I do a double take when I think about it; I have to follow a Member of the Order of Canada. That is a ridiculously tough act to follow. What Dr. Gotlib does for this profession and this Journal cannot be replaced. However it is incumbent upon those of us who are asked to succeed Dr. Gotlib to give the same blood, sweat, and tears that he has in order to continue the tremendous momentum that he has initiated.

One of the things that has always struck me is that Dr. Gotlib ran the Journal in a way that was extremely patient and encouraging to authors and researchers, particularly those early in their research careers. This kindness and humanity should be no surprise to anyone who has ever spent more than a minute with Dr. Gotlib. I am very proud to have served under and learned from him over the past decade or so in a variety of roles for the Journal: peer reviewer, Editorial Board member, Assistant Editor, Associate Editor, and of course author. As much as I can, I will try to continue to run and grow the Journal in the way that Dr. Gotlib did.

Looking at where the profession sits from a research standpoint in Canada today, it would have been unfathomable even ten years ago. The University Research Chair program across the country has allowed some of the brightest minds in the profession to advance themselves while researching and publishing extensively. These research chairs universally represent great success stories as the research chairs achieve higher ranks within their institutions and continue with their impressive output.

There are several of our colleagues who have either

just completed or will soon complete PhD and Master's degree programs and my hope is that they can find appointments at more universities across the country. The dream of a chiropractic researcher at every major university in Canada, along with strong research programs at CMCC and UQTR is not as far away as one might have thought a few short years ago.

CMCC has established their own research Chair in Dr. Sam Howarth, and that Chair along with the rest of the CMCC research department including the CMCC-UOIT collaboration headed by Dr. Pierre Côté (whom I am so pleased is one of the JCCA's Assistant Editors) are producing at an unbelievable rate. Similarly, UQTR's chiropractic and research faculty including Drs. Martin Descarreaux, André Bussières, and Mathieu Piché are publishing extensively and helping to train the next generation of both chiropractors and chiropractic researchers in the form of several PhD candidates and recently completed DC, PhDs such as Dr. Jean-Alexandre Boucher. This is very encouraging, but there is still a long way to go, the job isn't nearly finished. The people and the infrastructure are coming into place that will allow for continued success and progress. However, as a profession we must continue to support and work with these researchers.

My goals for the JCCA as Editor-in-Chief include expanding readership by Canadian and international chiropractors. The Journal also wants to increase readership by other health professionals and increase the number of contributions from multidisciplinary teams. Patient care for musculoskeletal conditions is becoming increasingly collaborative and multidisciplinary these days and the health care research environment is no different. The articles that we publish should reflect this. The staff and senior Editors will continue to try to find ways to get our articles in front of clinicians, researchers, and important third parties. I want the JCCA to continue to be one of the first journals that a chiropractic researcher thinks of submitting to when they are preparing a research manuscript.

Chiropractic is a profession that enjoys a reputation of being patient-centered. I feel that a future where chiropractors practice in a manner that is evidence-informed, collaborative, and patient-centered is paramount for the health of our patients and for the profession. The Journal holds an important place for our readers in that it helps provide that evidence that can help inform the actions that clinicians take for their patients.

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Chiropractors' characteristics associated with their number of workers' compensation patients

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Clermont E. Dionne, PhD[8,9]

Study design: *A cross-sectional survey.*

Objective: *The purpose of this study was to identify characteristics of Canadian doctors of chiropractic (DCs) associated with their number of workers' compensation patients.*

Summary of background data: *It has been previously hypothesized that DCs that treat a relatively high volume of workers' compensation cases may have different characteristics than the general chiropractic community.*

Methods: *Secondary data analyses were performed on data collected in the 2011 survey of the Canadian Chiropractic Resources Databank (CCRD). The CCRD survey included 81 questions concerning the practice and concerns of DCs. Of the 6,533 mailed*

Plan d'étude : *Une enquête transversale.*

Objectif : *Cette étude visait à déterminer les caractéristiques des chiropraticiens canadiens associées à leur nombre de patients traités pour accidents de travail.*

Introduction : *Selon des hypothèses émises précédemment, les chiropraticiens qui traitent un nombre relativement élevé de patients pour accidents de travail peuvent avoir des caractéristiques différentes de l'ensemble des chiropraticiens.*

Méthodologie : *Des analyses secondaires de données ont été effectuées sur des données recueillies dans l'enquête de 2011 de la banque de données de ressources chiropratiques canadiennes (CCRD). Cette enquête comportait 81 questions relatives à l'exercice et aux préoccupations des chiropraticiens. Sur les*

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questionnaires, 2,529 (38.7%) were returned. Of these, 652 respondents did not meet our inclusion criteria, and our final study sample included 1,877 respondents. Bivariate analyses were conducted between predetermined independent variables and the annual number of workers' compensation patients. A negative binomial multivariate regression was performed to identify significant factors associated with the number of workers' compensation patients.

Results: *On average, DCs received 10.3 (standard deviation (SD) = 17.6) workers' compensation cases and nearly one-third did not receive any such cases. The type of clinic (other than sole provider), practice area population (smaller than 500,000), practice province (other than Quebec), number of practice hours per week, number of treatments per week, main sector of activity (occupational/ industrial), care provided to patients (electrotherapy, soft-tissue therapy), percentage of patients with neuromusculoskeletal conditions, and percentage of patients referred by their employer or a physician were associated with a higher annual number of workers' compensation cases.*

Conclusion: *Canadian DCs who reported a higher volume of workers' compensation patients had practices oriented towards the treatment of injured workers, collaborated with other health care providers, and facilitated workers' access to care.*

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KEY WORDS: chiropractic, Workers' Compensation Board, occupational, work related, survey, care seeking

6 533 questionnaires envoyés, il y a eu 2 529 (38,7 %) réponses. Parmi celles-ci, 652 ne répondaient pas à nos critères d'inclusion. Donc, l'échantillon final utilisé pour notre étude comprenait 1 877 répondants. Des analyses bivariées ont été menées entre les variables indépendantes prédéterminées et le nombre annuel de patients traités pour accidents de travail. Une régression multivariée binomiale négative a été réalisée pour déterminer les facteurs importants associés avec le nombre de patients traités pour accidents de travail.

Résultats : *En moyenne, les chiropraticiens ont traité 10,3 (écart-type = 17,6) patients pour accidents de travail et près d'un tiers n'ont pas reçu de tels cas. Les facteurs suivants ont été associés à un nombre annuel plus élevé de patients traités pour accidents de travail : type de clinique (autre que fournisseur unique), population de la ville de la clinique (inférieure à 500 000), province de la clinique (autre que le Québec), nombre d'heures de cabinet par semaine, nombre de traitements par semaine, principal secteur d'activité (professionnelle / industrielle), soins prodigués aux patients (électrothérapie, thérapie des tissus mous), pourcentage de patients atteints de maladies neuro-musculo-squelettiques, et pourcentage de patients référés par leur employeur ou un médecin.*

Conclusion : *Les chiropraticiens canadiens qui ont déclaré un nombre plus élevé de patients traités pour accidents de travail avaient des pratiques axées sur le traitement des travailleurs blessés, ont collaboré avec d'autres fournisseurs de soins de santé, et ont facilité l'accès aux soins des travailleurs.*

(JCCA. 2015; 59(3):202-215)

MOTS CLÉS : chiropratique, commission des accidents du travail, lié au travail, enquête, recours aux soins

Introduction

"Work disability occurs when a worker is unable to stay at work or return to work because of an injury or disease"[1]. Work disability is associated with many consequences for the worker, employer, healthcare system and compensation system.[2] There is increasing evidence that health care providers may influence work disability, both positively and negatively.[3] The most prevalent components of clinical return-to-work interventions for musculoskeletal disorders are physical exercises, education and behavioral treatments.[4] These components are considered the core components of return-to-work interventions.[5-9] Unfortunately, early aggressive care may delay recovery[10-14] from whiplash injuries and not listening carefully to the patient

(particularly women) may delay return-to-work for occupational low back pain[15]. Unnecessary diagnostic imaging tests are also frequently ordered.[16-20]

It has been demonstrated that general practitioners are less likely to implement evidence-based management of back pain than occupational physicians and occupational therapists.[21,22] The latter health care providers experience fewer barriers to guideline implementation because their tasks focus on disability prognosis, yellow flag management, and return to activity parameters.[22] However, little is known about the impact of doctors of chiropractic (DCs) on work disability and their adherence to guidelines. Chiropractic and medical care appear to have similar cost-effectiveness during the treatment of occupational low back pain[23,24] and chiropractic adherence to radiological guidelines appears to be increasing[25-28]. The broad approaches described by DCs experienced in the treatment of occupational injuries are consistent with those proposed by evidence-based guidelines.[29] Barriers related to different provincial workers' compensation systems have previously been identified by Canadian DCs.[29] It has been hypothesized that DCs that treat a relatively high volume of workers' compensation cases may have different characteristics than the general chiropractic community.[29] In Quebec, the act regulating occupational injuries grants physicians the role of sole gatekeeper.[30] This is the only province where chiropractic care, to be reimbursed by the provincial workers' compensation board, must be prescribed by a medical doctor. It is thus reasonable to hypothesize that DCs from the province of Quebec treat fewer workers' compensation cases on average than DCs from other provinces.

Little is known about the characteristics of health care providers who tend to treat more workers' compensation cases. Identifying those characteristics is important for understanding the care seeking behaviours of injured workers. This research project aimed to perform a secondary data analysis from a nationwide survey to describe the characteristics of Canadian DCs who tend to treat more workers' compensation cases.

Specific objective

To identify DCs' characteristics that are associated with the number of workers' compensation patients they treat.

Methods

Study design

We performed a cross-sectional analysis using the 2011 survey of the Canadian Chiropractic Resources Databank (CCRD).[31] Members of the Canadian Chiropractic Association (CCA) were surveyed using a self-administered questionnaire (mail or online version). The University of Montreal Health Research Ethics Board approved this study (13-106-CERES-D).

Study Population

The study population included all Canadian DCs who were CCA members and had active practices in 2011. DCs practicing another profession (i.e., dentist, physician, nurse, occupational therapist, physiotherapist, psychologist or radiologist), or not in active practice (i.e., practicing less than 10 hours per week or 37 weeks yearly, retired and semi-retired) were excluded. During the 2011 iteration of the CCRD, 6,533 survey questionnaires were mailed to members of the CCA. The respondents were able to return the paper version of the questionnaire by mail or to complete the survey online. 1,889 questionnaires were returned by mail and 640 were completed online, resulting in a total of 2,529 completed questionnaires. The effective response rate was 38.7 percent. A total of 652 respondents were excluded because they were practicing another profession, not in active practice, or had missing answers for the main dependent variable. The current study included 1,877 respondents (Figure 1).

Source of data

The CCRD survey includes 81 questions detailing the practice and concerns of DCs and is used to inform the Canadian Chiropractic Association about services to provide to their membership.[31] For this project, we used information concerning professional activities, education, research and teaching activities, main sectors of activity, care provided to patients, chiropractic techniques used, type of conditions treated, and referral practices.

Description of study variables

Annual number of workers' compensation patients treated by a DC (dependent variable)

The annual number of workers' compensation pa-

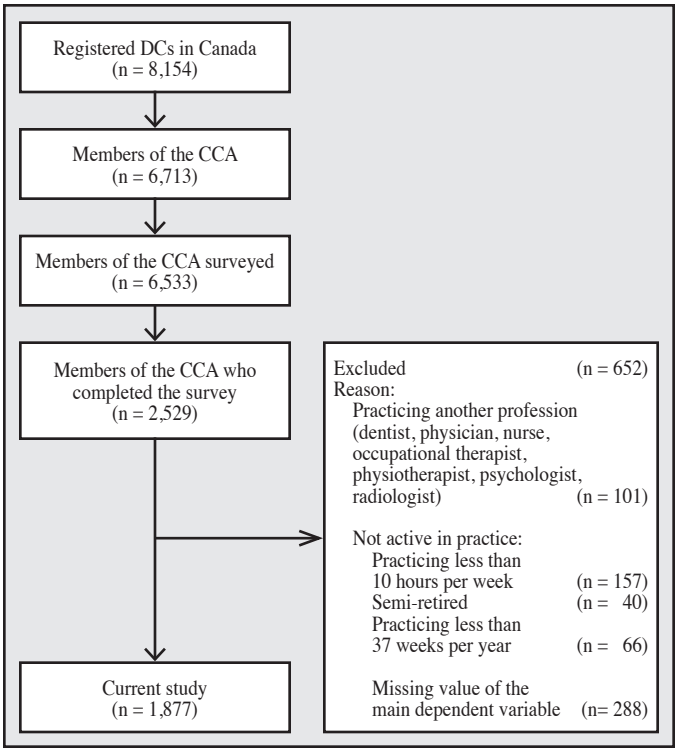

Figure 1.
Flow chart diagram showing the inclusion and exclusion of respondents through each stage of the study

tients treated by a DC was obtained by multiplying the respondent's answers to the following questions:

- The average number of new patients / week
- The average number of weeks practicing chiropractic per year
- The percentage of monthly income from the workers' compensation board.

DC characteristics (independent variables)

The survey administered by the CCRD includes multiple items that describe the practice of DCs. The questionnaire contained items classified into five category headings: background information (demographics), professional activity, education, training and affiliations, practice characteristics, finances and income[31]. Pertinent themes were selected a priori and our hypotheses of the association between selected variables and the number of workers' compensation cases are listed in Appendix 1.

Analyses

We generated frequencies (categorical variables) or means and standard deviations (continuous variables) for variables that we determined as relevant a priori. To investigate non-responses to the survey, we compared the analyzed sample to the complete CCA membership for all available characteristics (i.e., sex, college of graduation, years of practice and province of exercise) using Student's t-tests and Pearson's chi-square test. Bivariate analyses were conducted between all the predetermined independent variables and the annual number of patients referred by MDs using Student's t-tests and ANOVA for categorical variables and Pearson's correlation coefficients for continuous variables. When appropriate, the Games-Howell for unequal variances post-hoc test was applied.[32] All comparisons were 2-tailed and considered statistically significant at $p < 0.05$.

Because our data were highly skewed and over dispersed (i.e., the variance was greater than the mean), a multivariate negative binomial regression was performed to identify factors associated with the number of workers' compensation cases. We did not include the number of new patients per week and the number of weeks of practice per year in our model because they were used to construct the dependent variable. All other independent variables with a $P < 0.25$ in bivariate analyses were entered into the multivariate negative binomial regression model. The least significant variables were removed from the model individually until all remaining variables had a $P < 0.10$ to form the preliminary model. We then attempted to reintroduce all the excluded variables individually. The final model was created by reintroducing variables into the model if they had a $P < 0.10$ or if their introduction altered the other variables' coefficients by more than 10%. We reported the incidence rate ratios (IRR) and their 95% confidence intervals for each independent variable included in the final model. The IRR values were obtained from the regression coefficients on an exponential scale. IRR values greater than 1 represent an increase in the annual number of workers' compensation cases and values lower than 1 represent a decrease. For continuous variables, the IRR represents the average change in the predicted annual number of workers' compensation patients for a one-unit increase of the independent variable. For categorical variables, the IRR represents the factor of change in the predicted annual number of workers' compensation patients

Table 1.
Descriptive statistics of DC characteristics (n=1877)

General information			
Sex; n (%)	Male	1,313	(70.0%)
	Female	564	(30.0%)
Age (years); mean (SD)		43.7	(10.8)
Years of practice; mean (SD)		16.5	(10.9)
Type of practice; n (%)	Solo practitioner	646	(34.4%)
	Group of DCs	379	(20.2%)
	Multidisciplinary without MD	741	(39.5%)
	Multidisciplinary with MD	91	(4.8%)
	Missing	20	(1.1%)
Practice province; n (%)	British Columbia	303	(16.1%)
	Alberta	270	(14.4%)
	Saskatchewan	79	(4.2%)
	Manitoba	85	(4.5%)
	Ontario	793	(42.2%)
	Quebec	260	(13.9%)
	Atlantic provinces	87	(4.6%)
Primary practice community population; n (%)	Under 10,000	232	(12.4%)
	Between 10,000 and 49,999	367	(19.6%)
	Between 50,000 and 99,999	285	(15.2%)
	Between 100,000 and 499,999	488	(26.0%)
	Over 500,000	490	(26.1%)
	Missing	15	(0.8%)
Views on adequacy of supply of DCs in community; n (%)	Too few	100	(5.3%)
	Too many	717	(38.2%)
	The right number	763	(40.6%)
	I do not know	297	(15.8%)
Professional activities			
Number of hours of practice per week; mean (SD)		37.5	(10.1)
Number of weeks of practice per year; mean (SD)		48.8	(2.0)
Number of new patients per week; mean (SD)		3.4	(2.6)
Number of treatments per week; mean (SD)		105	(74)
Education, research and teaching			
Chiropractic college of graduation; n (%)	CMCC	1,111	(59.2%)
	UQTR	125	(6.7%)
	PCC-D	151	(8.0%)
	PCC-W	68	(3.6%)
	LoganU	41	(2.2%)
	WSU	83	(4.4%)
	NUHS	52	(2.8%)
	NSHSU	51	(2.7%)
	LCC-W	24	(1.3%)
	LU	23	(1.2%)
	Others	146	(7.8%)
	Missing	2	(0.1%)
Postgraduate education; n (%)		232	(12.4%)
Number of hours of continued education per year; mean (SD)		26.8	(39.2)
Involved in research; n (%)	Yes, currently	126	(6.7%)
	Not now, but in the last 3 years	193	(10.3%)
	No	1,542	(82.2%)
	Missing	15	(0.8%)
Involved in teaching; n (%)		116	(6.2%)
Practice management seminar in the last 3 years; n (%)		561	(29.9%)
Client of chiropractic practice management service; n (%)		143	(7.6%)

Main sectors of activity		
Consulting/ specialized assessment; n (%)	246	(13.1%)
Geriatrics; n (%)	224	(11.9%)
Maintenance/ wellness; n (%)	1,111	(59.2%)
Nutrition; n (%)	154	(8.2%)
Occupational/ Industrial; n (%)	60	(3.2%)
Pediatrics; n (%)	243	(12.9%)
Pregnancy; n (%)	137	(7.3%)
Rehabilitation; n (%)	306	(16.3%)
Sports Injuries; n (%)	539	(28.7%)
Care provided to patients		
DC takes his/her own radiographs; n (%)	435	(23.2%)
Percentage of patients radiographed; mean (SD)	34.8	(31.9)
Acupuncture; n (%)	386	(20.6%)
Cryotherapy; n (%)	908	(48.4%)
Diathermy; n (%)	56	(3.0%)
Electrotherapy; n (%)	792	(42.2%)
Exercises; n (%)	1,595	(85.0%)
Heat Packs; n (%)	552	(29.4%)
Laser; n (%)	469	(25.0%)
Low volt therapy; n (%)	192	(10.2)
Patient education; n (%)	1,530	(81.5%)
Soft-tissue therapy; n (%)	1,537	(81.9%)
Traction, flexion/distraction; n (%)	746	(49.7%)
Ultrasounds; n (%)	683	(36.4%)
Adjustment practice; n (%) Full spine only	114	(6.1%)
Full spine and extremities	1,728	(92.8%)
Cervical spine only	12	(0.6%)
Other	20	(1.1%)
Missing	3	(0.2%)
Chiropractic technique used		
Diversified; n (%)	1,746	(93.0%)
Sacral Occipital technique; n (%)	222	(11.8%)
Hole In One; n (%)	54	(2.9%)
Gonstead; n (%)	199	(10.6%)
Thompson; n (%)	519	(27.7%)
Activator; n (%)	988	(52.6%)
Cranio-sacral technique; n (%)	154	(8.2%)
Type of condition treated		
Percentage of patients with neuromusculoskeletal conditions; mean (SD)	91.0	(14.0)
Percentage of patients with somatovisceral conditions; mean (SD)	7.0	(11.1)
Percentage of patients with vascular related conditions; mean (SD)	1.2	(5.4)
Referral practice		
Percentage of patients referred to other health care providers; mean (SD)	14.9	(15.7)
Percentage of patients referred by their employer; mean (SD)	1.7	(5.4)
Percentage of patients referred by a physician; mean (SD)	8.1	(13.0)

Missing value were always less than 4%

CMCC = Canadian Memorial Chiropractic College
UQTR = Université du Québec à Trois-Rivières
PCC-D = Palmer College of Chiropractic, Davenport
PCC-W = Palmer College of Chiropractic, West
LoganU = Logan University
WSU = Western States University
NUHS = National University of Health Sciences
NWHSU = Northwestern Health Sciences University
LCC-W = Life Chiropractic College, West
LU = Life University

Table 2.
Comparison on the analyzed sample population with all Canadian Chiropractic Association (CCA) members

Variables		Analyzed Sample (n = 1,877)	CCA Members (n = 6,713)	p-value
Sex; n (%)	Male	1,313 (70.0%)	4,273 (67.1%)	0.021
	Female	564 (30.0%)	2,093 (32.9%)	
	Missing (n)	0	347	
Years of practice; mean (SD)		16.5 (10.9)	14.7 (11.1)	<0.001
	Missing (n)	5	856	
Practice province; n (%)				
	British Columbia	303 (16.1%)	914 (14.5%)	<0.001
	Alberta	270 (14.4%)	904 (14.3%)	
	Saskatchewan	79 (4.2%)	177 (2.8%)	
	Manitoba	85 (4.5%)	222 (3.5%)	
	Ontario	793 (42.2%)	3,026 (47.9%)	
	Quebec	260 (13.9%)	829 (13.1%)	
	Atlantic provinces	87 (4.6%)	247 (3.9%)	
	Missing (n)	0	394	
Chiropractic College of graduation; n (%)				
	CMCC	1,111 (59.3%)	3,718 (58.4%)	0.495
	UQTR	125 (6.7%)	395 (6.2%)	
	PCC-D	151 (8.1%)	515 (8.1%)	
	PCC-W	68 (3.6%)	192 (3.0%)	
	LoganU	41 (2.2%)	140 (2.2%)	
	WSU	83 (4.4%)	307 (4.8%)	
	NUHS	52 (2.8%)	214 (3.4%)	
	NSHSU	51 (2.7%)	155 (2.4%)	
	LCC-W	24 (1.3%)	62 (1.0%)	
	LU	23 (1.2%)	85 (1.3%)	
	Others	146 (7.8%)	583 (9.2%)	
	Missing (n)	2	347	

CMCC = Canadian Memorial Chiropractic College
UQTR = Université du Québec à Trois-Rivières
PCC-D = Palmer College of Chiropractic, Davenport
PCC-W = Palmer College of Chiropractic, West
LoganU = Logan University
WSU = Western States University
NUHS = National University of Health Sciences
NWHSU = Northwestern Health Sciences University
LCC-W = Life Chiropractic College, West
LU = Life University

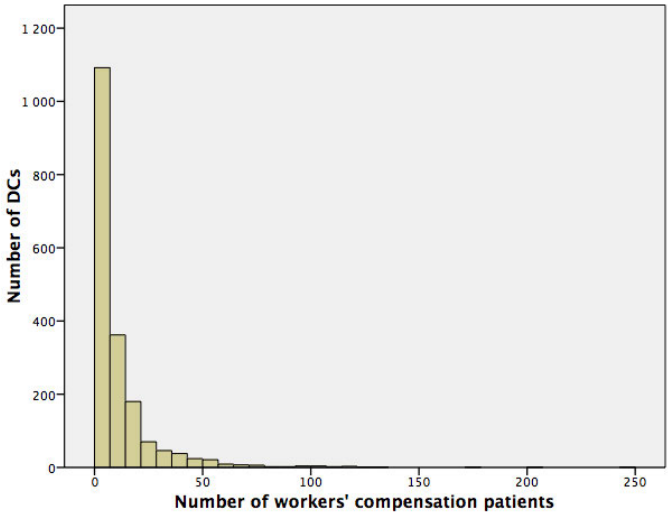

Figure 2.
Distribution of the annual number of workers' compensation patients

attributable a given category of the independent variable under examination compared to the reference category. All analyses were performed using SPSS for Mac (version 21.0, IBM corporation, Armonk, NY, USA).

Results

On average, DCs received 10.3 (standard deviation (SD) = 17.6) workers' compensation cases per year. This finding represents 6.2% of all new patients treated by DCs on average in a year. The distribution of the workers' compensation cases was heavily skewed to the right (Figure 2), with 29.9% of DCs receiving no such cases and 5% receiving more than 40 per year. The results of the bivariate analyses examining the associations between DC characteristics and the number of workers' compensation cases are presented in Table 3. In this table, the numbers in the second column represent the average number of workers' compensation patient seen each year and SD for categorical variables and the Pearson's correlation coefficients for continuous variables.

Representativeness of the current study

The characteristics of the analyzed sample are presented in Table 1. When compared with the complete 2011 membership of the Canadian Chiropractic Association, the analyzed sample had similar distributions in terms of college of graduation, but the analyzed sample included slightly more males (2.9%), included slightly more experienced DCs (1.8 years) and had a significantly different provincial distribution (Table 2).

Table 3.

DC characteristics associated with the number of workers' compensation patients seen per year in bivariate analyses

Variables		Association with the annual number of workers' compensation patients; mean (SD)	p-value
General information			
Sex	Male	11.5 (19.4)	<0.001
	Female	7.5 (12.3)	
Age (years)[P]		r = –0.018	0.442
Years of practice[P]		r = –0.021	0.370
Type of practice	Sole practitioner	9 (18)	0.030*
	Group of DCs	11 (19)	
	Multidisciplinary without MD	11 (15)	
	Multidisciplinary with MD	14 (29)	
Practice province	British Columbia	8 (12)	<0.001[a]
	Alberta	9 (17)	
	Saskatchewan	28 (28)	
	Manitoba	19 (19)	
	Ontario	9 (17)	
	Quebec	5 (10)	
	Atlantic provinces	22 (30)	
Practice area population	Under 10,000	11 (18)	0.003[b]
	Between 10,000 and 49,999	12 (18)	
	Between 50,000 and 99,999	10 (14)	
	Between 100,000 and 499,999	12 (21)	
	Over 500,000	8 (15)	
Number of DCs in relation to the demand	Too few	12 (23)	0.001[c]
	Too many	9 (17)	
	The right number	12 (19)	
	I do not know	8 (12)	
Professional activities			
Number of hours of practice per week[P]		r = 0.158	<0.001
Number of weeks of practice per year[P]		r = 0.030	0.192
Number of new patients per week[P]		r = 0.485	<0.001
Number of treatments per week[P]		r = 0.212	<0.001
Education, research and teaching			
College of graduation	CMCC	11 (18)	0.004[d]
	UQTR	5 (12)	
	PCC-D	9 (18)	
	PCC-W	7 (8)	
	LoganU	16 (22)	
	WSU	13 (20)	
	NUHS	12 (20)	
	NSHSU	14 (18)	
	LCC-W	13 (20)	
	LU	7 (9)	
	Others	9 (13)	
Post graduate studies	Yes	9 (14)	0.224
	No	11 (18)	
Number of hours of continued education[P]		r = –0.019	0.416
Involved in research	Yes, currently	13 (30)	0.112
	Not now, but in the last 3 years	10 (16)	
	No	10 (17)	
Involved in teaching	Yes	12 (27)	0.330
	No	10 (17)	
Management training in the last 3 years	Yes	9 (18)	0.191
	No	11 (18)	
Client of chiropractic practice management service	Yes	8 (16)	0.164
	No	10 (18)	
Main sectors of activity			
Consulting/ specialized assessment	Yes	10 (18)	0.900
	No	10 (18)	
Geriatrics	Yes	10 (15)	0.921
	No	10 (18)	
Maintenance/ wellness	Yes	9 (16)	0.011
	No	12 (19)	
Nutrition	Yes	10 (18)	0.932
	No	10 (17)	
Occupational/ Industrial	Yes	18 (21)	0.009
	No	10 (17)	
Pediatrics	Yes	8 (15)	0.037
	No	11 (18)	
Pregnancy	Yes	9 (16)	0.345
	No	10 (18)	
Rehabilitation	Yes	13 (19)	0.002
	No	10 (17)	
Sports Injuries	Yes	12 (20)	0.005
	No	10 (17)	
Care provided to patients			
Do you take your own radiographs	Yes	8 (14)	<0.001
	No	11 (19)	
Percentage of patients radiographed[P]		r = –0.073	0.002
Acupuncture	Yes	14 (25)	0.001
	No	9 (15)	
Cryotherapy	Yes	12 (17)	0.001
	No	9 (18)	
Diathermy	Yes	16 (17)	0.016
	No	10 (18)	
Electrotherapy	Yes	13 (19)	<0.001
	No	9 (16)	
Exercises	Yes	11 (18)	0.003
	No	8 (14)	
Heat Packs	Yes	13 (21)	<0.001
	No	9 (16)	
Laser	Yes	12 (17)	0.062
	No	10 (18)	
Low volt therapy	Yes	14 (22)	0.013
	No	10 (17)	
Patient education	Yes	11 (18)	0.042
	No	9 (16)	
Soft-tissue therapy	Yes	11 (18)	0.037
	No	8 (16)	
Traction, flexion/distraction	Yes	12 (19)	0.001
	No	9 (17)	
Ultrasounds	Yes	13 (18)	<0.001
	No	9 (17)	
Adjustment practice	Full spine only	11 (16)	0.522
	Full spine and extremities	10 (18)	
	Cervical spine only	4 (8)	
	Other	7 (9)	
Chiropractic technique used			
Diversified	Yes	11 (18)	0.034
	No	7 (20)	
Sacral Occipital technique	Yes	8 (14)	0.093
	No	11 (18)	
Hole In One	Yes	6 (9)	0.002
	No	10 (18)	
Gonstead	Yes	12 (20)	0.166
	No	10 (17)	
Thompson	Yes	11 (18)	0.207
	No	10 (18)	
Activator	Yes	10 (17)	0.826
	No	10 (19)	
Cranio-sacral technique	Yes	9 (15)	0.197
	No	10 (18)	
Types of conditions treated			
Percentage of patients with neuromusculoskeletal condition[P]		r = 0.068	0.003
Percentage of patients with somatovisceral conditions[P]		r = –0.058	0.012
Percentage of patients with vascular related conditions[P]		r = –0.014	0.560
Referral practice			
Percentage of patients referred to other health care providers[P]		r = 0.025	0.283
Percentage of patients referred by their employer[P]		r = 0.080	0.001
Percentage of patients referred by a physician[P]		r = 0.218	<0.001

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[P] Pearson correlation coefficient

[a] Saskatchewan, Manitoba and the Atlantic provinces are significantly higher than the other provinces. British Columbia, Alberta and Ontario are significantly lower than Saskatchewan, Manitoba and the Atlantic provinces, but significantly higher than Quebec.

[b] "Over 500,000" is significantly lower than "Between 10,000 – 49,999" and "Between 100,000 – 499,999"

[c] "The right number of DCs" is significantly higher than "Too many DCs" and "I do not know"

[d] CMCC is significantly higher than UQTR and PCC-W

* No significant differences after the post hoc testing.

Association with the number of workers' compensation cases

Bivariate results

General information

Male DCs and DCs who perceived that there was an appropriate number of DCs in their area received significantly more workers' compensation cases. DCs from Saskatchewan, Manitoba and the Atlantic provinces received significantly more workers' compensation cases than DCs from the other provinces. DCs from British Columbia, Alberta and Ontario received significantly fewer workers' compensation cases than DCs from Saskatchewan, Manitoba and the Atlantic provinces, but significantly more cases than DCs from Quebec. DCs practicing in areas of more than 500,000 inhabitants received significantly less workers' compensation cases than those practicing in areas with populations between 10,000 and 49,999 inhabitants or between 100,000 and 499,999 inhabitants. Age and years of practice were not significantly associated with the number of workers' compensation cases. Post hoc specific comparisons did not reveal significant differences between the types of practice.

Professional activities

The number of hours of practice per week, the number of new patients per week and the number of treatments performed per week were all significantly, positively correlated with the number of workers' compensation cases. The number of weeks of practice per year was not significantly correlated with the number of workers' compensation cases.

Education, research and teaching

DCs who had graduated from the Canadian Memorial Chiropractic College (CMCC) received significantly more workers' compensation cases than those who had graduated from the Université du Québec à Trois-Rivières (UQTR) and Palmer West (PCC-W). The amount of postgraduate education, continuing education, teaching, management training, practice management services, and research activities were not significantly associated with the number of workers' compensation cases.

Main sectors of activity

DCs reporting occupational/industrial practice, rehabilitation practice, or sports injury management as a main sector of activity received significantly more workers' compensation cases. DCs reporting maintenance/wellness activities or pediatric care as a main sector of activity received significantly fewer workers' compensation cases. Reporting that consulting/specialized assessment activities, geriatric care, nutritional activities, or pregnancy care was a main sector of activity was not significantly associated with the number of workers' compensation cases.

Care provided to patients

DCs that performed their own radiographs received significantly fewer workers' compensation cases than those who referred their patients to radiology clinics. The percentage of patients who were radiographed was significantly negatively correlated with the number of workers' compensation cases. Providing acupuncture, cryotherapy, diathermy, electrotherapy, exercises, heat packs, low volt, soft-tissue therapy, traction, flexion/distraction, ultrasound or patient education was associated with a significantly greater number of workers' compensation cases. The adjustment practice and providing laser therapy were not significantly associated with the number of workers' compensation cases.

Chiropractic techniques used

DCs reporting the use of the Diversified technique received significantly more workers' compensation cases. DCs reporting the use of the Hole-In-One technique received significantly fewer workers' compensation cases. The uses of the Thompson, Sacro-occipital, Gonstead, Activator or Cranio-Sacral techniques were not associated with the number of workers' compensation cases.

Types of conditions treated

The reported percentage of patients with neuromusculoskeletal conditions was significantly positively correlated with the number of workers' compensation cases. The reported percentage of patients with somatovisceral conditions was significantly negatively correlated with the number of workers' compensation cases. The reported percentage of patients with vascular conditions was not significantly associated with the number of workers' compensation cases.

Table 4.
Variables associated with the annual number of workers' compensation patients in the multivariate negative binomial regression model (n=1,733)

	IRR	Wald's 95% confidence interval of the IRR	p–value
(Constant)	0.60	(0.30 to 1.19)	0.143
General information			
Type of clinic			
Sole practitioner	Reference	–	–
Group of DCs	1.23	(1.04 to 1.54)	0.018
Multidisciplinary without MD	1.19	(1.01 to 1.40)	0.039
Multidisciplinary with MD	1.35	(0.96 to 1.89)	0.082
Population of practice area			
Under 10,000	1.19	(0.94 to 1.51)	0.157
Between 10,000 and 49,999	1.37	(1.10 to 1.69)	0.004
Between 50,000 and 99,999	1.19	(0.96 to 1.48)	0.122
Between 100,000 and 499,999	1.36	(1.11 to 1.67)	0.003
Over 500,000	Reference	–	–
Practice province			
Quebec	Reference	–	–
British-Columbia	1.63	(1.23 to 2.15)	0.001
Alberta	1.52	(1.13 to 2.05)	0.005
Saskatchewan	4.34	(2.89 to 6.52)	<0.001
Manitoba	2.67	(1.81 to 3.90)	<0.001
Ontario	1.23	(0.96 to 1.58)	0.106
Atlantic provinces	3.04	(2.07 to 4.46)	<0.001
Professional activity			
Number of hours of practice per week	1.02	(1.01 to 1.03)	<0.001
Number of treatments per week	1.01	(1.00 to 1.01)	<0.001
Education, research and teaching			
Post graduate studies	0.78	(0.63 to 0.96)	0.017
Management training in the last 3 years	0.76	(0.65 to 0.89)	<0.001
Main sectors of activity			
Occupational/ Industrial	1.59	(1.09 to 2.32)	0.017
Care provided to patients			
DC performs his own radiographs	0.85	(0.70 to 1.03)	0.098
Electrotherapy	1.30	(1.12 to 1.52)	0.001
Soft-tissue therapy	1.21	(1.01 to 1.47)	0.044
Chiropractic techniques used			
Sacral Occipital technique	0.78	(0.62 to 0.98)	0.030
Thompson	1.21	(1.04 to 1.42)	0.017
Cranio-sacral technique	0.79	(0.60 to 1.02)	0.073
Types of conditions treated			
Percentage of patients with neuromusculoskeletal conditions	1.01	(1.00 to 1.01)	0.009
Referral practice			
Percentage of patients referred by their employer	1.02	(1.01 to 1.04)	0.003
Percentage of patients referred by a physician	1.02	(1.01 to 1.03)	<0.001

IRR = incidence rate ratio
Pearson's chi-square = 2,264
Pearson's chi-square/degree of freedom = 1.329

Referral practice

The reported percentages of patients referred by their employer or by a physician were significantly positively correlated with the number of workers' compensation cases. The reported percentage of patients referred to other health care providers was not significantly correlated with the number of workers' compensation cases.

Multivariate results

Our final multivariate model (Table 4) included the following: type of clinic; population of practice area; province of practice; number of hours of practice per week; number of treatments per week; post graduate studies; management training; main sector of activity (occupational/ industrial); providing radiographic examination at the clinic; care provided to patients (electrotherapy, soft-tissue therapy); chiropractic technique used (Sacro Occipital technique, Thompson, Cranio-sacral technique); percentage of patients with neuromusculoskeletal conditions; and the percentage of patients referred by their employer or a physician. All the independent variables of the final model influenced the dependent variable in the same direction as in the bivariate analyses; however, slight changes in their statistical significance were observed. Quebec DCs received significantly fewer workers' compensation cases than DCs of the other provinces, but the difference from Ontarians was not significant when controlling for all other variables. Sole practitioners received significantly less workers' compensation cases than DCs practicing with a group of DCs or in a multidisciplinary clinic (without an MD) when controlling for all other variables. Postgraduate studies, management training, and some chiropractic techniques (Sacro Occipital, Thompson and Cranio-sacral techniques) were not significant in the bivariate analyses but became significant in the multivariate model. Providing radiographic examination at the clinic was significantly associated with the number of workers' compensation cases in the bivariate analyses, but not in the multivariate model.

Discussion

Several of our intuitive a priori hypotheses were not confirmed: age, years of practice, number of DCs in relation to demand, post graduate studies, continued education, adjustment practice, involvement in research and teaching activities were not associated with the reported number of workers' compensation cases treated per year.

CMCC graduates reported more workers' compensation cases than graduates from UQTR in the bivariate analysis, but the college of graduation was not statistically significant in the multivariate analysis. The difference observed in the bivariate analysis was most likely attributable to provincial differences because nearly all UQTR graduates are practicing in Quebec.

The results of our analysis indicate that three broad categories of factors may influence the number of workers' compensation cases that a DC reports, including the DC's interactions with other health care providers, a practice oriented toward the treatment of injured workers, and potential access to care.

Interactions with other health care providers

In both our bivariate and multivariate analyses, receiving more physician referrals was associated with a greater number of reported workers' compensation cases. This is consistent with the results of a previous American study that concluded that physicians were involved in the treatment of the majority of workers receiving care for occupational low back pain.[33] Sending the patient to another clinic for radiologic investigation was associated with a greater number of reported workers' compensation cases. This association may also indicate better physician-DC collaboration. Working in a multidisciplinary clinic without a physician was also associated with a greater number of reported workers' compensation cases when controlling for the amount of physician referrals. This result suggests that collaboration with other health care providers is also important during the care of injured workers. This result is supported by the literature, which views inter-professional collaboration as a cornerstone of successful return-to-work.[34-37] Surprisingly, referring more patients to other health care providers was not associated with the number of reported workers' compensation cases. This result is may be because in the context of occupational injuries, DCs may receive referral patients that are primarily within their scope of practice. DCs reporting maintenance and wellness care as a main sector of activity reported significantly fewer workers' compensation cases in all our analyses. This is potentially because they may be perceived as providers of excessive care by other health care providers[38,39] or by patients who want to rapidly return to work. DCs attending management training reported significantly fewer workers' compensation cases only when controlling for other variables in the final model. Their marketing strategy may be perceived to be aggressive, which can have a negative impact on physician referrals.[39] DCs interested in developing an occupational practice should develop good inter-professional relationships with physicians and other health care providers.

Practices oriented on the treatment of injured workers

It is not surprising that DCs with occupational/industrial and rehabilitation as main sectors of activity report more workers' compensation cases. Although sports injuries can be similar to occupational injuries, a pediatric-oriented practice is obviously different from an occupational practice. An explanation for the significantly lower number of reported workers' compensation cases associated with the completion of post graduate studies may be that these DCs specialize in a different field than occupational injury DCs. It is also not surprising that DCs that treat a higher percentage of patients with neuromusculoskeletal conditions report more injured workers because occupational injuries generally lie within their scope of practice. Occupational diseases are not within the scope of chiropractic practice and require medical care.

DCs that treat more injured workers also appear to provide care that respects radiographic guidelines, with less radiographic use associated with an increased number of reported workers' compensation cases.[27,28,40-42] Common components of clinical return-to-work interventions for musculoskeletal disorders[4], such as physical exercise and patient education, were also associated with higher numbers of reported workers' compensation cases. In fact, every additional treatment modality (with the exception of laser therapy) had a significant positive impact on the number of reported workers' compensation cases in the bivariate analyses. Electrotherapy and soft-tissue therapy met the inclusion criteria for the multivariate model. DCs that offer multimodal care may be perceived as having added value over those that provide only spinal manipulations. Although these results are interesting, clinician DCs should consider the best interests of their patients and remember that spinal traction, laser therapy, electrotherapy and ultrasound are not recommended by the National Institute for Health and Care Excellence (NICE) guidelines for the early management of persistent, non-specific low back pain.[43]

In our bivariate analyses, the Diversified technique had a significant positive impact on the number of reported workers' compensation cases while the Hole In One technique had a significant negative impact. In our multivariate analysis, the Thompson technique had a significant positive impact on the number of workers' compensation cases reported while Sacral Occipital Technique had a significant negative impact when controlling for all other variables. The Hole in One technique is a spinal manipulative technique specializing in the upper cervical area. Because cervical injury is only one type of occupational injury, this may explain why DCs using this technique report fewer workers' compensation cases. Additionally, DCs using the Thompson and Sacral Occipital techniques may provide different care to workers' compensation patients or patients may differently seek care from DCs that use these techniques. Further investigations will be necessary to understand the impact of chiropractic techniques on care seeking behaviors.

DCs that report more workers' compensation cases also report more employer referrals. This observation is interesting because an American study revealed that employers selected the majority of providers for workers who receive care.[33] Employers were more likely to choose physicians, while workers were more likely than employers to select DCs[33].

Our results suggest that DCs that consider occupational/industrial care as a primary sector of activity, stimulate employer referrals and offer care adapted to the needs of injured workers (multimodal care, avoiding excessive radiographic imaging); therefore, these DCs tend to report more workers' compensation cases.

Potential access to care

In both our bivariate and multivariate analyses, the practice area population, practice province and number of practicing hours per week were significantly associated with the reported number of workers' compensation cases. The number of practicing hours per week as well as practicing in a group of DCs (compared with solo practice) increases the number of hours when injured workers are able to seek care. Our results indicate that DCs in larger cities (more than 500,000 inhabitants) report less workers' compensation cases. Usually, Canadians in rural areas experience more difficulty when seeking immediate care.[44] A possible explanation for these results may be that injured workers in smaller towns have access to a limited number of providers and seek more care from their local DCs, while the opposite situation is present in metropolitan centers. When DCs perceive that there is an appropriate number of DCs in their area, they report significantly more workers' compensation cases than when they perceive that there are too many DCs, which also supports the previous hypothesis. As expected, Quebecers report significantly fewer workers' compensation cases than DCs from the other provinces in all our analyses. Physicians, the sole gatekeepers to the Quebec worker's compensation system[30], are acting as a barrier to chiropractic care. In general, the residents of eastern Canadian provinces are more likely to report difficulty accessing routine and immediate care than residents of western provinces[44]. This may explain why DCs in the Atlantic provinces receive the highest number of workers' compensation cases. Our results suggest that DCs offering more office hours and practicing in areas with limited access to other health care resources report more workers' compensation cases.

Strengths and Limitations

The main strength of this study is the large sample size, which provides sufficient statistical power for modeling all the investigated DC characteristics. The use of an appropriate regression model (negative binomial) also enabled us to deal with the highly skewed distribution of the annual number of workers' compensation cases.

Our results obtained from the secondary analysis of the CCRD cross-sectional survey should be interpreted with caution. As with every cross-sectional study, the temporality of the exposure-outcome relationship cannot be firmly established. A prospective study would provide better evidence regarding the temporality of the observed associations between the different independent variables and the amount of workers' compensation board cases. The low response rate, 38.7%, has important implications. It is possible that non-responders may have systematically differed from responders and that our results may have limited the generalizability to DCs outside of the analyzed group. Additionally, the proportion of respondents differed between the provinces. The DCs in our analysis had an average 1.8 years more practice experience and were 2.9% more often males than the complete CCA membership. Although these differences are relatively small, they are significant and may have biased the magnitude of the

observed associations. It is also possible that DCs that chose to be CCA members have different profiles than non-members. However, in order to reverse the direction of the observed associations, the non-respondents would need to show an inverse relationship between the dependent and the independents variables. The CCRD survey was not designed for the purpose of this study and the metric properties of the questionnaire are unknown. Our composite dependent variable might not reflect the exact number of workers' compensation case seen by DCs. Furthermore, our model only included data available in the CCRD and it is possible that other variables, such as the incidence of occupational injuries in the area of practice, may be of interest.

Nonetheless, we believe our results provide valuable information regarding DC characteristics associated with the amount of workers' compensation cases. Additional qualitative research would be useful to better identify the relevant factors that influence the type of care sought by injured workers and to understand the mechanism underlying the choice of healthcare provider.

Conclusion

The reported number of workers' compensation cases substantially varies among Canadian DCs, with nearly one-third of DCs' receiving no cases and a few DCs receiving many cases. Canadian DCs with practices oriented toward the treatment of injured workers that collaborate with other health care providers and facilitate workers' access to care reported more workers' compensation patients.

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Appendix 1
List of a priori hypotheses regarding the association between relevant CCRD variables and the number of workers' compensation patients seen per year

Variable	Hypothesis
General information	
Sex	Women see less workers' compensation patients since they were under represented in a previous study[29].
Age, years of practice	Older DCs receive fewer workers' compensation patients because they adhere less to new guidelines[21].
Type of practice	DCs in multidisciplinary clinics receive more workers' compensation patients
Practice province	Quebecers receive fewer workers compensation patients because they require prior medical referral.
Practice area population	DCs in smaller towns receive more workers' compensation patients.
Number of DCs in relation to demand	DCs that practice in areas with a high concentration of DCs are expected to receive fewer workers' compensation patients
Professional activities	
Number of hours of practice/week	No association is expected
Number of weeks of practice / year	No association is expected
Number of treatments / week	DCs who receive a high volume of patients are expected to receive fewer workers compensation patients Or DCs treating more patients are more successful at attracting workers' compensation patients
Education, research and teaching	
College of graduation	DCs graduating from a "straight" college receive fewer workers' compensation patients.
Post graduate studies	DCs with post graduate qualifications receive more workers' compensation patients
Number of hours of continued education	DCs that are more up-to-date receive more workers' compensation patients
Management training in the last 3 years	DCs who receive a high volume of patients are expected to receive fewer workers' compensation patients Or DCs treating more patients are more successful at attracting workers' compensation patients
Research involvement	DCs implicated in research receive more workers' compensation patients
Involvement in teaching activities	DCs implicated in teaching activities receive more workers' compensation patients
Main sectors of activity	
Type of practice	DCs who provide more specialized care receive more workers' compensation patients
Care provided to patients	
Radiographs	DCs who prescribe radiographs out of their clinic receive more workers' compensation patients. DCs who perform a higher percentage of radiographs receive less workers' compensation patients.
Type of care provided	DCs who provide complimentary therapies and soft tissue mobilization receive more workers' compensation patients. DCs who prescribe more therapeutic exercise receive more workers' compensation patients.
Adjustment practice	DCs who only treat the cervical spine receive less workers' compensation patients.
Types of conditions treated	
Condition treated	DCs treating more viscerosomatic conditions receive less workers' compensation patients.
Referral Practice	
Percentage of patients referred	DCs receiving more referrals from physicians and employers receive more workers' compensation patients. DCs who refer more patients receive more workers' compensation patients.

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Collaborative care for a patient with complex low back pain and long-term tobacco use: a case report

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Few examples of interprofessional collaboration by chiropractors and other healthcare professionals are available. This case report describes an older adult with complex low back pain and longstanding tobacco use who received collaborative healthcare while enrolled in a clinical trial. This 65 year-old female retired office worker presented with chronic back pain. Imaging findings included disc extrusion and spinal stenosis. Multiple co-morbidities and the complex nature of this case substantiated the need for multidisciplinary collaboration. A doctor of chiropractic and a doctor

Il y a peu d'exemples de collaboration interprofessionnelle entre les chiropraticiens et d'autres professionnels de la santé. Cette étude de cas décrit une personne âgée souffrant d'une lombalgie complexe et de tabagisme de longue date qui a reçu des soins de santé en collaboration pendant qu'elle participait à un essai clinique. Cette employée de bureau à la retraite âgée de 65 ans souffrait d'une lombalgie chronique. Les examens d'imagerie ont révélé des extrusions discales et une sténose rachidienne. Des comorbidités multiples et la nature complexe de ce cas ont justifié la nécessité d'une collaboration multidisciplinaire. Un chiropraticien et un ostéopathe ont fourni des soins en collaboration selon

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of osteopathy provided collaborative care based on patient goal setting and supported by structured interdisciplinary communication, including record sharing and telephone consultations. Chiropractic and medical interventions included spinal manipulation, exercise, tobacco reduction counseling, analgesic use, nicotine replacement, dietary and ergonomic recommendations, and stress reduction strategies. Collaborative care facilitated active involvement of the patient and resulted in decreased radicular symptoms, improvements in activities of daily living, and tobacco use reduction.

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KEY WORDS: chiropractic, integrative medicine, interdisciplinary communication, low back pain, patient-centered care, radiculopathy, spinal manipulation, tobacco use cessation

les objectifs établis pour la patiente et soutenus par une communication interdisciplinaire structurée, y compris le partage du dossier et des consultations téléphoniques. Les interventions chiropratiques et médicales étaient notamment axées sur la manipulation vertébrale, l'exercice, des conseils sur la réduction de l'usage du tabac, l'utilisation d'analgésiques, le remplacement de la nicotine, des recommandations diététiques et ergonomiques, et des stratégies de réduction du stress. Les soins en collaboration ont facilité la participation active de la patiente et ont entraîné une diminution des symptômes radiculaires, des améliorations dans les activités de la vie quotidienne, et la réduction de l'usage du tabac.

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MOTS CLÉS : chiropratique, médecine intégrative, communication interdisciplinaire, lombalgie, soins centrés sur le patient, radiculopathie, manipulation vertébrale, cessation du tabagisme

Introduction

Older adults with low back pain (LBP) often represent a complex clinical picture due to the inherent challenges of treating LBP especially when combined with multiple co-morbidities.[1-4] Given the potential for such complexity, it is important for clinicians and patients to consider these elements as management plans are designed and implemented.[2,5] Multidisciplinary collaborative care including care coordination among providers is one possible approach to the management of complex LBP.[1,2,6,7]

Boon and colleagues defined collaborative care as "an interprofessional process for communication and decision making that enables the separate and shared knowledge and skills of health providers to synergistically influence patient care."[8,9] Successful collaboration requires patient interest and involvement[10-12], mutual respect[9,10,12], maintenance of professional autonomy[8,13,14], understanding each team members' practice scope[9,13,15-17], goal setting[9,10,13], and an openness to discussion and consensus building processes[13]. Communication models that may support interprofessional collaboration include telephone consultations[10,18-20] or face-to-face meetings[10,16,18,21], job shadowing experiences[9,16,20], use of electronic medical records[9,14,18], and confirming understanding among team members[12,19,21].

This case presentation describes a collaborative effort between healthcare providers and a patient enrolled in a clinical trial on interdisciplinary co-management of older adults with LBP.[20,22] The trial randomly allocated eligible participants to receive 12-weeks of LBP care under 1 of 3 professional practice models: medical care; concurrent medical and chiropractic care; or collaborative care involving the patient and a medical and chiropractic co-management team. The co-management team collaborated through scheduled phone consultations and a secure, web-based, electronic communication system to share health records between the different health systems involved.[20] The interprofessional practice model emphasized patient goal setting; provider discussions of diagnoses, complicating factors and challenges to treatment; a cooperative treatment approach; monitoring patient status and care challenges; and ongoing support of the patient's treatment goals.[20] The co-managing practitioners in this case were a doctor of chiropractic (DC) working at a

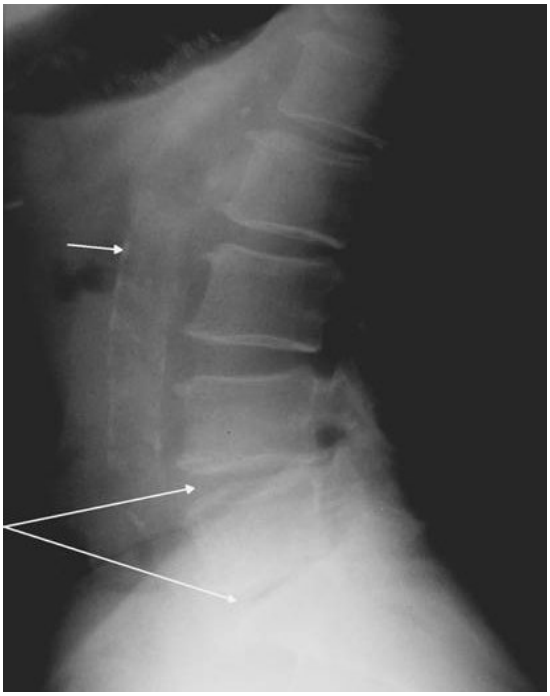

Figure 1.
Lateral lumbar spine x-ray: showing arteriosclerotic calcification of the abdominal aorta (short arrow), osteophytes throughout the lumbar spine, and advanced disc degeneration at L4-5, L5-S1 (long arrows).

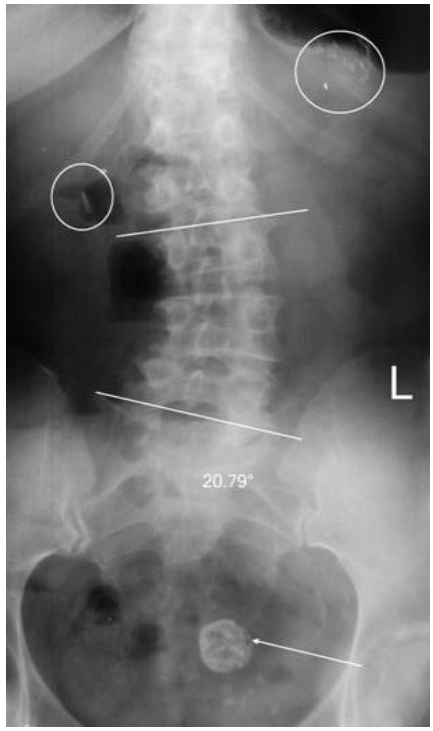

Figure 2.
A-P lumbar x-ray: showing a 21° lumbar curvature, surgical clips (circled) and a 2.6 cm diameter density consistent with uterine fibroid (arrow).

chiropractic research center and a doctor of osteopathy (DO) completing a residency in family medicine. This case report discusses the collaboration process of a DC, DO, and patient engaged in the management of complex LBP in an older adult.

Case presentation

Clinical history

A 65 year-old female retired office worker presented with LBP and constant radiation to the left gluteal and posterior thigh regions with occasional radiation to the great toe. The LBP first occurred 30 years prior when the patient acquired a flexed and twisted trunk position causing immediate and severe pain. Daily activities became progressively affected, albeit gradually over 30 years.

This patient's healthcare seeking for her LBP depicted a common fragmented patient care history of being 'in the system.'[23] This fragmented care included multiple primary care evaluations, specialist referrals, repeated imaging studies, minimal attention to co-morbid conditions potentially complicating her LBP, consultations with complementary and alternative providers, and an overall lack of care coordination.

Thirty-four months prior to examination in our clinic, the patient underwent a lumbar magnetic resonance imaging (MRI) scan and an orthopaedic evaluation, which included lumbar radiographs. She then received corticosteroid injections that relieved the pain extending below the knee. Subsequently, the patient received chiropractic care with another provider 6 months prior to our examination. Care from medical and chiropractic providers resulted in partial, temporary improvement. At our initial evaluation, symptoms were severe enough to cause sleep interruption and interfere substantially with activities of daily living (ADL).

Table 1.
Clinical history and concurrent conditions

Diagnosis	Health History and Current Status
Spinal conditions	• Lumbar disc degeneration (Figure 1) • Lumbar central canal stenosis • L4-S1 bilateral neural foraminal stenosis • 21^0 left lumbar curvature (Figure 2)
Activities of daily living impairments	• Reduced ability to stand and walk with limitations reported in ability to shop, cook, clean and garden • Timed get up go test averaged 11.63 seconds (independent mobility); patient had shooting pain into left thigh with test • Exercise avoidance due to pain reported with movement • Positional sleep interruption resulting in fatigue • Increased bed rest for pain relief
Tobacco dependence	• Current cigarette smoker reporting 1.5-2 packs/day • 60-90 pack-year history over 45 years • Self-reported use of tobacco as coping mechanism for back pain
Obesity	• History of bariatric surgery (Figure 2) • Body Mass index = 33.1 (Height 164.08 centimeters, Weight 88.90 kilograms)
Mental health conditions	• Self-reported history of anxiety, depression and post-traumatic stress disorder • Self-reported current life and family stressors • Previously treated with supportive therapy and medication • Currently not receiving any mental health care
Benign positional vertigo	• Self-reported fall 3 years ago due to vertigo symptoms • Symptoms recurrent but milder than at onset
Cardiovascular conditions	• Hypertension medically managed with angiotensin converting enzyme inhibitor/diuretic • Blood pressure 132/75 • Abdominal aortic calcification (Figure 1)

Examination

The patient reported her LBP at a level of 6 of 10 on the 0-10 numeric rating scale for pain. Examination findings included limited lumbar extension, radiating pain to the left posterior thigh with Valsalva's maneuver and during a brief walking test[24], and a positive straight leg raise test with radiation to the posterior thigh.

Imaging

Lumbar radiographs obtained from the prior orthopaedic evaluation demonstrated disc narrowing at L4-5 and L5-S1, endplate osteophytosis in the lower thoracic region and throughout the lumbar spine, a 21° left lumbar convexity, mild osteoporosis, arteriosclerotic calcification of the abdominal aorta, calcification within the pelvis consistent with a uterine fibroid, and evidence of abdominal surgery consistent with a history of bariatric surgery and cholecystectomy (Figures 1 and 2). Previous lumbar MRI demonstrated L5-S1 left para-central disc extrusion with slight displacement of the left S1 nerve root and severe bilateral neural foraminal stenosis. At L4-5 there was mild/moderate central canal stenosis, a small central disc protrusion and bilateral foraminal stenosis.

Diagnosis

DC evaluation revealed a diagnosis of non-compressive lumbar radiculopathy and neurogenic claudication.[25] The examining DO documented a diagnosis of chronic LBP due to a previous injury. Though a straight leg raise test produced symptoms in the posterior thigh, examination by both providers revealed no conclusive evidence for the clinical presentation of compressive radiculopathy despite MRI evidence of nerve root displacement and foraminal stenosis. Table 1 presents the patient's clinical history and concurrent conditions. Notably, there was a 45-year smoking history (1.5-2 packs of cigarettes/ day),

obesity, physical inactivity, and significant ADL impairment.

Case management

LBP management

Treatment goals were determined jointly at the first chiropractic visit by the DC and patient as: 1) reduction of LBP, 2) improved psychological management of chronic pain and 3) improved ability to perform ADLs. Specifically, the patient hoped to participate in gardening activities with less pain. Goal 1 was addressed by manual lumbar distraction, gentle high velocity manipulation at the left sacroiliac joint[26-29], and manual ischemic compression of associated hypertonic muscles[30,31]. Goal 2 was supported by the recommendation of a mindfulness meditation technique as a strategy to help manage stress and assist with pain reduction.[32] Goal 3 was supported by the in-office chiropractic treatments and home exercise recommendations consisting of gentle stretching exercises with trunk motions and brisk walking to tolerance.[33,34] The DC advised tobacco cessation, although this was not a high priority for the patient at first.

The DO initiated a similar goal-setting process, identifying short-term pain management as an objective. To achieve this goal, the DO recommended acetaminophen, emphasizing appropriate dosing and side effects. Weight reduction through physical activity was explored, but no acceptable options were identified as exercise increased the patient's LBP. The patient agreed to attempt weight reduction through diet modification. The DO also recommended continuation of chiropractic care.

Tobacco cessation

During the initial DO visit, the patient expressed that her addiction to tobacco was troubling because she was aware it worsened her LBP recovery prognosis. These concerns motivated her and the DO to initiate a trial of nicotine replacement therapy to facilitate smoking reduction. After a review of previous medication use for smoking cessation and prior side effects, a nicotine patch was prescribed.

During a subsequent visit, the DC recommended an additional supportive measure of a Personal Quit Plan (PQP), developed during a 30-minute consultation that included the association of smoking and chronic LBP.[35] The PQP was developed for use by DCs,[36] based on the American Cancer Society's *Guide to Quit Smoking*[37]. The written PQP included reasons for tobacco cessation, financial implications, a plan for support by family and friends, and a quit date. Additional suggestions included replacements for social cues of tobacco use, stress reduction through breathing and meditation techniques, and behavioral changes, such as removing cigarettes and ashtrays, increased engagement in enjoyable activities such as gardening and constructing puzzles, and drinking water. The patient's PQP was shared with the DO through the secure health record website. Collaborative communications between the patient and providers confirmed the smoking reduction goal and reinforced team member roles. A summary of interprofessional communications is provided in Table 2.

Outcomes

Figure 3 depicts the patient's LBP outcomes, smoking habits, and tobacco cessation efforts during the trial. The patient rated her LBP at 1-2 on the 0-10 numerical rating scale at the end of the 12-week intervention, down from 6/10 at baseline. She reported performing some gardening activity, yard-work, and housework with less pain and a reduced amount of pain medication. Both providers made final recommendations, which included continued walking and exercises to improve core stability, acetaminophen for pain relief, limited heavy lifting and twisting motions, and chiropractic and/or medical care as needed.

The patient ceased smoking for 6.5 consecutive days. She discontinued the nicotine patch and resumed tobacco use after experiencing increased psychological stress, LBP, and a side effect of skin irritation. At a subsequent visit to the DO, the patient expressed frustration that "her quitting efforts had been a failure." The DO congratulated the patient, stating "this was a victory and not a defeat." The patient considered further smoking cessation efforts, but expressed concern over dealing with life and family stressors without smoking as a coping mechanism. Both providers encouraged continued smoking cessation efforts following discharge.

Discussion

While best practices for chiropractic care recommend multidisciplinary management when appropriate[2], there are few examples available in the scientific literature of interprofessional collaboration that describe chiroprac-

Table 2.
Interprofessional communications during case co-management

Week	Communication Type	Patient Goals	Interprofessional Communication Summary
1	Treatment summary/DC	• Pain reduction for LBP • Improved psychological management of chronic pain • Improved ability to perform ADLs (gardening, walking)	• Low back pain diagnosis with description and rationale for recommended treatment • Lumbar distraction • Gentle high velocity manipulation at the left sacroiliac joint to improve joint function • Home exercise recommendations included trunk motions and brisk walking using a short stride with mild effort to tolerance • Tobacco cessation advised
3	Treatment summary/DO	• Short-term pain management • Tobacco use cessation due to the costs of smoking and expressed embarrassment from habit	• Low back pain and tobacco use diagnosis with treatment recommendations • Acetaminophen recommended for short term pain relief • Continue chiropractic care as scheduled • Weight reduction through diet (increased physical activity not recommended due to pain with movement) • Tobacco cessation with nicotine patch • Review of previous medications and side effects for smoking reduction
4	Phone call summary/DO Phone call summary/DC		• Tobacco use and excess weight as factors that worsen inflammation in patients with chronic low back pain • Pain reduction techniques, such as relaxation response
5	Health records/DC	• Tobacco use reduction or cessation	• Personal Quit Plan with behavioral measures along with nicotine patch to support tobacco reduction
6	Treatment summary/DC	• Tobacco use reduction or cessation	• Cessation length compared to previous history (current effort lasted 6.5 days; Previous cessation lasted 6 days during an inpatient hospitalization without access to cigarettes.) • Challenges related to life stresses (family stress, lack of sleep, and increased LBP combined to decrease ability to resist smoking) • Home exercise recommendations included thoracolumbar lateral flexion isometric exercises
12	Phone call summary/DO Phone call summary/DC		• Summary of gains with treatment • Decreased pain level • Improved ability to perform ADLs • Reduced pain medication Future recommendations • Acetaminophen as needed for pain • Walking regularly for exercise • Avoiding twisting and lifting while performing ADLs such as gardening • Continued smoking cessation efforts.
14	Treatment summary/DC	• Better understanding condition and self-management tools.	• Diagnosis • Summary of care • Treatment goals • Outcomes relating to decreased pain with ADLs • Result of tobacco cessation effort, and • Continued recommendations for tobacco reduction • Performing exercises more regularly • Chiropractic and/or medical care on an as needed basis

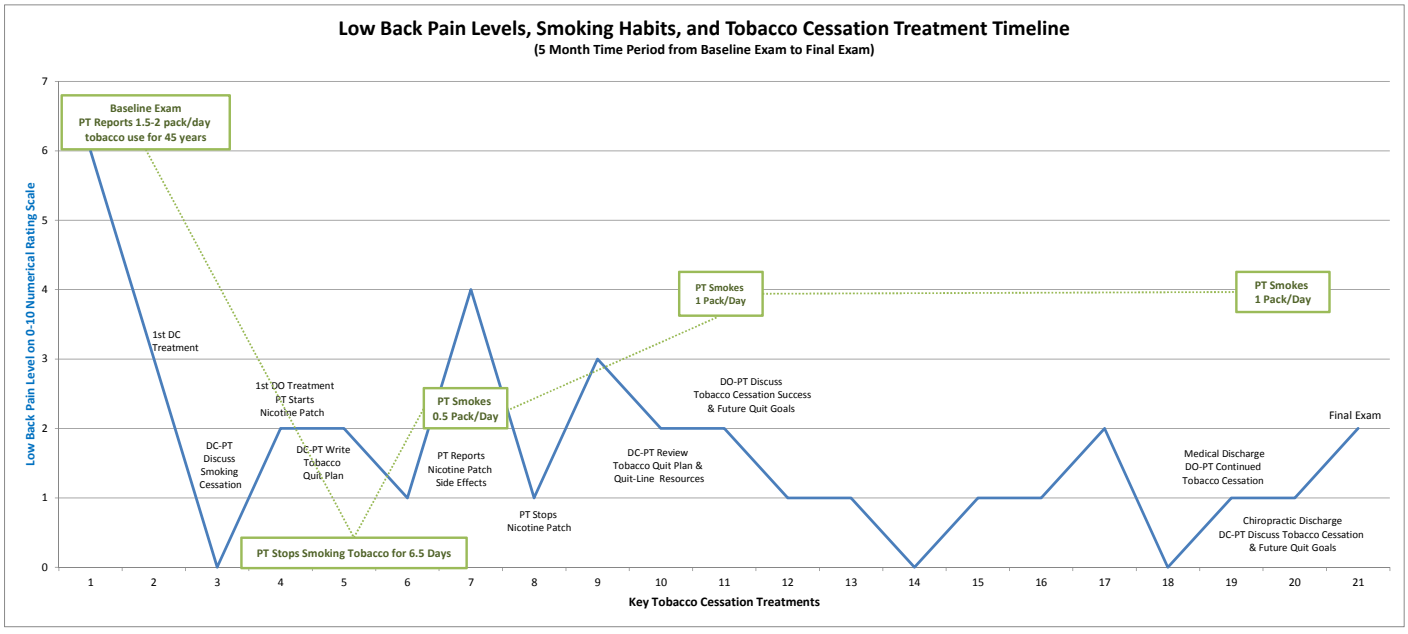

Figure 3.
Low Back Pain Levels, Smoking Habits, and Tobacco Cessation Treatment Timeline

tic patients of any age[7,9,17,38], much less for older adults with complex LBP[2,17,39]. This 65-year old female patient exhibited chronic LBP diagnosed as non-compressive lumbar radiculopathy and neurogenic claudication complicated by spinal curvature and degeneration, obesity, physical inactivity, impaired ADLs, life stresses, cardiovascular disease, and long standing tobacco use.

Some clinical guidelines support comprehensive multidisciplinary approaches for LBP management, with collaboration encouraged between practitioners[40], while others note the effectiveness of such treatments has not been compared to less intensive programs[41]. Although chiropractic may be delivered concurrently with medical services[42], care coordination or collaboration between patients and providers may not occur[13,19,43]. Co-management, referral, and health record sharing between medical doctors and DCs is often limited[7,42,44-48] and may result in care fragmentation[9]. Patients and providers may not discuss the concurrent use of conventional and complementary medicine[43], which precludes the opportunity for integrated care and may impact "efficiency, quality, and patient safety in health care delivery systems"[44]. Collaborative care can be essential in expediting timely referral for complicated geriatric conditions.[49,50]

In the case reported here, tobacco cessation was a main focus of care coordination. The Council on Chiropractic Education urges chiropractors to provide information and resources to every patient who smokes and indicates a willingness to attempt smoking cessation.[51] Both providers evaluated this patient's tobacco use history, reviewed the relationship between LBP and smoking, and encouraged tobacco cessation both as a pain management strategy and as beneficial for overall health.[35,37,52-55] The patient successfully refrained from cigarette smoking for 6.5 days, the longest reported cessation in her 45-year smoking history.

This case supports the concept of improving the effectiveness of health care for chronic LBP in older adults by information sharing and coordinated decision making between practitioners and by incorporating the patient as an active member of the treatment team.[10,11] A recent focus group study demonstrated older adults' interest in LBP co-management by chiropractors and medical physicians.[19] Indicators of successful co-management valued

by older adults in the study included "patient-centered communication, collegial interdisciplinary interactions between these providers, and health record sharing".[19] Another qualitative study on treatment coordination in primary care models reported that while continuity and information sharing is important, they are not adequate to provide care coordination for complex health conditions, and patient participation in decision-making must also be incorporated.[9-11,14]

Conclusion

This case report demonstrated interprofessional collaboration in the treatment of an older adult with complex low back pain and tobacco use by a DC and a DO. Collaboration may improve the treatment effectiveness of musculoskeletal disorders which are often multifactorial in causation. Effective collaboration encompassed interactions between diverse health practitioners and the patient's opinions and preferences. This healthcare team used a patient-centered approach that included the patient's participation in goal setting and attainment, health record sharing, structured interdisciplinary communications, and cooperative treatment plans. For successful implementation, a collaborative care model must be specifically selected and tailored for the practice settings involved.

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Leg length discrepancy and osteoarthritis in the knee, hip and lumbar spine

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Osteoarthritis (OA) is an extremely common condition that creates substantial personal and health care costs. An important recognised risk factor for OA is excessive or abnormal mechanical joint loading. Leg length discrepancy (LLD) is a common condition that results in uneven and excessive loading of not only knee joints but also hip joints and lumbar motion segments. Accurate imaging methods of LLD have made it possible to study the biomechanical effects of mild LLD (LLD of 20mm or less). This review examines the accuracy of these methods compared to clinical LLD measurements. It then examines the association between LLD and OA of the joints of the lower extremity. More importantly, it addresses the largely neglected association between LLD and degeneration of lumbar motion segments and the patterns of biomechanical changes that accompany LLD. We propose that mild LLD may be an important instigator or contributor to OA of the hip and lumbar

L'arthrose est une pathologie extrêmement fréquente qui engendre des frais personnels et des coûts de soins de santé importants. Un facteur important de risque reconnu pour l'arthrose est la charge mécanique excessive ou anormale sur les articulations. L'inégalité de longueur des membres inférieurs (ILMI) est une affection fréquente qui se traduit par une charge inégale et excessive non seulement sur les articulations du genou, mais aussi sur les articulations de la hanche et les segments mobiles lombaires. Des méthodes d'imagerie précises de l'ILMI ont permis d'étudier les effets biomécaniques d'une ILMI légère (ILMI de 20 mm ou moins). Cette étude examine l'exactitude de ces méthodes par rapport aux mesures cliniques de l'ILMI. Elle se penche ensuite sur l'association entre l'ILMI et l'arthrose des articulations des membres inférieurs. Mais surtout, elle examine l'association peu étudiée entre l'ILMI et la dégénérescence de segments mobiles lombaires et les tendances des changements biomécaniques qui accompagnent l'ILMI. Nous suggérons que l'ILMI légère peut être un instigateur important ou un facteur de l'arthrose de la hanche et de la colonne lombaire, et qu'elle mérite d'être étudiée

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spine, and that it deserves to be rigorously studied in order to decrease OA's burden of disease.

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KEY WORDS: chiropractic, leg length discrepancy, osteoarthritis, knee, hip, lumbar spine

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MOTS CLÉS : chiropratique, inégalité de longueur des membres inférieurs, arthrose, genou, hanche, colonne lombaire

Introduction

Musculoskeletal diseases, including osteoarthritis (OA), constitute a substantial economic burden to the community and are the most common causes of chronic pain and disability.[1] Chronic joint pain, such as degeneration of the knee, hip, and lumbar spine, affects an estimated 22% of the Australian population at any one point.[1] Similarly, the monthly prevalence of joint pain in the United States of America has been estimated at 30.7% in the general population.[2] Furthermore, musculoskeletal disease is the most common cause of chronic pain in Australia accounting for 26% of all reported chronic pain cases at any point in time.[1] Given that chronic joint pain is linked to aging, this problem is expected to become even more burdensome as the population of industrialised countries ages.[1] There is limitation of daily activities in a large proportion (43.3% – 57.9%) of people suffering from chronic joint pain.[2] In fact, low back pain, in particular, is the most common cause of long-term disability in industrialised countries.[3] In 2001 in Australia, the yearly direct and indirect costs of back pain were estimated at AUD 1.02 billion and AUD 8.15 billion respectively.[4] Similarly, in the United States in 2008, the combined total cost of all back pain cases was estimated at USD 624.8 billion.[5]

In terms of the spine, moderate to severe OA and degeneration of the intervertebral disc are commonly associated with chronic low back pain.[6,7] There is further evidence that significant disc degeneration, at least in the elderly, is associated with a twofold increase in chronic low back pain status.[6] However, the effects of OA on the spine are not confined to pain. For instance, Iguchi and co-workers, among others, have defined radiological criteria for segmental spinal instability as a result of advanced OA that would require surgical immobilization.[7]

A number of risk factors have been identified for OA including abnormal or excessive mechanical joint loading[8-14] as occurs with lower extremity joints or spinal discs in obesity[15,16], and with excessive occupational standing or lifting[17]. It is also widely believed that abnormal joint loading plays a major role in the development of adjacent segment degeneration following surgical fusion of a spinal motion segment.[18] Leg length discrepancy (LLD) is a very common condition that involves abnormal loading of the lower extremity and lumbar joints.[19] LLD, where one femoral head is lower than the contralateral side in the standing position, can be due to: anatomical differences in lengths of bones of the lower extremities (anatomical LLD); or functional differences in the tone of lower extremity muscles or abnormalities of joint function (functional LLD).[20] Approximately 59% of the population is affected by LLD of 5mm or more.[21] However, in 99.9% of cases LLD can be classified as mild since it falls below 20mm.[21]

Leg length discrepancy (LLD) affects up to 90% of the general population with a mean discrepancy of 5.2 mm[21,22] that involves abnormal patterns of weight bearing in the joints of the lower extremities and the spine. There is a range of studies demonstrating that LLD is associated with postural and functional changes in the lower limbs, the pelvis, and the spine. These studies document the role of LLD in: scoliosis[23]; OA of the lumbar spinal joints[10]; low back pain[20,24]; OA of the hip[8,25]; OA of the knee[2,12,13]; stress fractures in the metatarsals tibia and femur[26]; and gait disturbance[27,28]. However, the degree of LLD required to cause, or contribute to, a musculoskeletal disorder remains controversial. Some authors hold the view that LLD of less than 20 mm is clinically insignificant.[29,30] However, others suggest that LLD of less than this magnitude is of clinical significance.[13,22,31-33] It is possible that LLD can, over time, lead or contribute to the development

of OA in the lumbar spine. Understanding the contribution of abnormal joint weight bearing, as occurs in LLD, to the development of OA and disc degeneration could allow for more effective preventive strategies for OA, at least in this population of patients. This review explores the current evidence for an association between LLD, particularly mild LLD (LLD of ≤20mm), on one hand and OA of the joints of the lower extremity, the lumbar facet joints and intervertebral discs on the other. It also examines if LLD is associated with a predictable pattern of degenerative change in the joints of the lower limb and lumbar spine. Literature searches were conducted using the PubMed database as well as Scopus and Index to Chiropractic Literature. Care was taken to avoid a selection bias. However, studies that were deemed low quality, according to standard quality criteria, were excluded.

Definition of Leg Length Discrepancy (LLD)

Leg length discrepancy (LLD), also known as short leg syndrome, leg length deficiency, leg length insufficiency or anisomelia, is classified as either anatomical (also called structural) or functional.[20,34,35] Anatomical or structural LLD is caused by side-to-side differences in lower limb length, due to actual bony asymmetry existing between the level of the femur head and the calcaneus. Functional LLD is defined as LLD that is due to biomechanical abnormalities of joint function in the lower limbs.[28,36,37] For example, unilateral pronation may cause an apparent shortening of the leg. A third type is often described as an environmental LLD and is common in runners who run on a sloping or a slightly banked surface in one direction, and for long periods of time.[34] This will be considered as a type of functional LLD for the purposes of this review. Anatomical LLD can be congenital or acquired. Congenital causes include phocomelia and dysgenetic syndromes. Acquired aetiologies include: dysplasias, Ollier's disease, slipped epiphysis: poliomyelitis; neurofibromatosis; septic arthritis; osteomyelitis; fractures; pes planus; knee valgus/varus and dislocation; and also surgically induced.[38] In the case of an anatomical LLD, there may often be compensation by functional adaptation on the contralateral side, in an attempt to cause the shortening of the long leg. One example of this being pronation of the foot on the side of the long leg, which results in an anatomical LLD on one side and essentially a functional LLD on the other.[28]

LLD can exist from childhood or it can develop in adult life.[20,39] In addition, functional activities of the individual play a role in determining whether LLD becomes symptomatic. Athletes may suffer complications such as patella tracking disorder or trochanteric bursitis in cases of unilateral foot pronation with a much smaller degree of LLD than non-athletes. Subotnick[28] proposed that 18 mm of LLD in a non-athlete equates to 6 mm of LLD in an athlete since during running approximately three times the body weight is transmitted through the supporting limb compared to walking. Additionally, Friberg has demonstrated using his rigorous method of measuring LLD, a positive correlation between the degree of LLD and incidence of stress fractures in 547 Finish Army conscripts involved in very strenuous training.[26] In fact 89% of these fractures occurred in those with an LLD of greater than 3mm. Of the 130 stress fractures in this study, unilateral fractures occurred in the tibia, metatarsals and femur in 73% and 16% of cases in the longer or shorter leg respectively. Bilateral fractures occurred in subjects with equal leg length or LLD not exceeding 3mm. It is important to note that stress fractures in these army conscripts with LLD occurred predominantly on the side of the longer leg. From a clinical biomechanical perspective, this is consistent with the longer leg being under increased mechanical stress during strenuous physical activities associated with military training.

Measurement/Assessment of LLD

Clinical Methods of Assessment

Valid and reliable measurement of LLD has been an area of considerable controversy. There is a range of clinical methods of measuring LLD that suffer from inaccuracy and poor inter- and intra-examiner reliability.[40-45] These include the so called 'direct' and 'indirect' methods of clinical assessment. An example of the direct method uses a tape measure to determine the distance between the anterior superior iliac spine (ASIS) and the medial malleolus with the subject lying supine. The indirect method of assessment of LLD relies on palpating the levelness of the iliac crests to determine lateral pelvic inclination and then placing boards of known thickness under the perceived shorter leg until the iliac crests are thought to be level. Several variations of the direct method of measurement have been described and include measuring from

the anterior iliac spine to the lateral or medial malleolus, from the umbilicus to the medial malleolus, and from the xiphosternum to the medial malleolus.

Direct and indirect measurement of LLD relies on the palpation of bony landmarks, which is prone to error. For example, assessment may fail to detect iliac asymmetries that may mask or accentuate LLD. Furthermore, measurement may be affected by asymmetry in the position of the umbilicus, or affected by unilateral deviations of the long axis of the limb (e.g. genu valgus). These measurements also fail to include the floor to malleolus distance and therefore entirely ignore the significant effects of foot posture in upright stance. Indirect methods may be only slightly more reliable. Clark compared radiographic evaluation to clinical assessment using iliac palpation and found two examiners agreed to within 5 mm in only 16 out of 50 subjects.[45] Fisk and Baigent compared the iliac palpation and block correction method to radiographic measurement in 107 subjects.[42] They also found that the clinical assessments of the examiners were incorrect by greater than 5mm in 29% of subjects. In a clinical situation, palpation of pelvic landmarks with block correction has the strongest support[46,47], with tape measurement methods found to have the weakest reliability[46]. Chiropractors routinely assess LLD using visual analysis with the patient prone or supine and compare medial malleolus, sole-heel interface or bottom of the shoes for relative position. The finding may be used in determining the exact biomechanical treatment given. Often a post-treatment re-check is performed to reassess LLD and if leg lengths become even then it is assumed that any pelvic or spinal imbalances have been corrected. Otherwise an anatomical LLD is suspected. A thorough literature review on the research data available on this method of assessment is available.[37] The finding of that review was that questionable methodologies and statistical analyses used in these studies meant that there was no convincing evidence on the validity of the quick visual leg length assessment.

A number of small studies have reported a high degree of inter- and intra-examiner reliability in terms of detection of the side of the shorter leg by clinical assessments of LLD using an antigravity position (prone or supine) in primarily asymptomatic volunteers[48-52], while detection of the magnitude of LLD using these methods has been found to have lower levels of inter-examiner reliability[46,48,53]. Caveats with these small studies include methodological errors that seriously compromise these findings, the use of asymptomatic participants, utilization of methods that are not commonly practised in the clinical setting[49,50,54], and the lack of comparison to a radiographic assessment to demonstrate validity. Other authors have found clinical methods of measurement to be of low reliability.[40,45] Crude clinical methods of LLD detection have complicated the effort to define the clinical significance and biomechanical effects of LLD.

Imaging Methods of Assessment

Most studies, particularly in early years of LLD research, employed clinical methods of measurement. More rigorous studies have used imaging methods of measurement that enjoy higher levels of validity and reliability.[20] Four different imaging methods have been used for detection and quantification of LLD: teleroentgenography; computed tomography; slit scanography; and orthoroentgenography.[20,35] A teleroentgenogram is a single anterior – posterior exposure of the standing subject, imaging the entire lower limbs, that also includes a measuring instrument, such as a ruler. Limitations of teleroentgenography include hip and knee joint flexion contractures, and given the size of the image, magnification errors that can give a false reading.[55] Computed tomography has not been found to be any more accurate than plain radiography in detecting LLD unless the patient has hip or knee joint contractures[55], and increases radiation dose. Slit scanography, relies on a method which uses a lead diaphragm placed over the x-ray tube containing a slit, while the tube is moved along the long axis of the lower extremity during the exposure with the subject lying supine. However, as neither CT nor slit scenography are done under weight-bearing conditions, they do not amount to a postural analysis of LLD. Orthoroentgenography uses separate exposures of hips, knees and ankles in an attempt to avoid the magnification error in teleroentgenography. However, errors can still be generated due to patient movement and joint contractures. Friberg's[24,56] variation of orthoroentgenography uses a single anterior-posterior lumbo-pelvic exposure allowing for comparison of the heights of femoral heads. Friberg's method, has been found to be accurate, reproducible, and affords the advantage of lower patient radiation dose[24], and has since been widely used to study LLD. Standing antero-posterior (A-P) radiographs of the pelvis are con-

sidered an acceptably accurate and reliable method for assessing true LLD. In fact the reliability of Friberg's method has been reported to have a mean error of 0.6 mm and a range of 0 to 2.0 mm on repeated imaging.[40] Similarly, Clark and co-workers found plain radiography to be accurate, within 3 mm, for both functional and anatomical LLD.[45] Similarly, the radiographic method advocated by Giles and Taylor, involves placing the feet in line with the femoral heads in AP lumbo-pelvic X-rays which produces a mean error of only 1.12 mm.[31]

In a landmark study, Friberg and co-workers compared the inter- and intra-examiner reliability of LLD detection between radiographic methods and clinical methods using 21 subjects.[40] They demonstrated a wide variance in LLD measurements with 88% of clinical measurements being erroneous, and overestimations by as much as 20mm. In 12% of direct and 13.4% of indirect clinical measurements, the observers failed to detect the short leg even when the radiologically assessed measurement was as much as 25mm. Repeat measurements taken three months later, showed significant disagreement in 28% of cases. Similarly, Woerman and Binder-Macleod compared direct clinical methods for evaluating LLD with radiographic assessments.[46] Using a tape measure from: the ASIS to lateral malleolus had a mean error of 6.0 +/- 16mm; the umbilicus to medial malleolus had a mean error of 4.2+/-9.9mm; ASIS to medial malleolus had a mean error of 7.3+/-10.1mm; and from xiphosternum to medial malleolus had a mean error of 10.9+/-16.2 mm. Therefore, it is clear that clinical methods of measurement of LLD should be abandoned in LLD research in favour of the radiographic gold standard.

Recently, Krettek and colleagues have reported an ultrasound method for LLD measurement with error margins of less than 1mm when compared to the radiographic gold standard.[57] More recently, Rannisto and co-workers examined the accuracy of LASER-Ultrasound measurement of LLD as compared to the radiographic gold standard.[58] They reported almost perfect agreement between these methods, with interclass correlation co-efficient (ICC) for agreement of 0.97 (95% CI of 0.93-0.99). They also reported excellent levels of intra- and inter-examiner reliability for this method. These studies strongly suggest that LASER-Ultrasound may be a valid and reliable alternative to radiography in measurement of LLD, while also affording the advantage of being non-invasive. Thus, this method lends itself to a wide variety of study designs including large-scale population studies of mild LLD and its association with OA over time.

Clinically Significant LLD

The degree of LLD required to reach clinical significance has also remained controversial. However, clinical significance may be context-dependent. In the context of surgical treatment, most surgeons have advocated that LLD of less than 20 mm is clinically insignificant, as no surgery is indicated.[59] However, other authors investigating the functional effects of LLD of 3 to 20 mm have discovered clinical significance in the context of prevention of stress fractures, chondromalacia patellae, and osteoarthritis in the joints of the lower extremity. Subotnic suggests that LLD of just over 6 mm, which may be asymptomatic during walking, is sufficient to cause chronic repetitive overuse injuries such as chondromalacia patellae on the short leg side in runners.[28] LLD has been associated with many lower limb and lumbar biomechanical conditions including: foot pronation[28]; low back pain[60]; scoliosis[39] and osteoarthritis in the knee and hip joints[2,11,13,32].

A retrospective study of the radiographs of 106 chiropractic patients reported that more than half of those with LLD of 6 mm or more also had scoliosis or an abnormal degree of lumbar lordosis, indicating abnormal weight bearing in the joints of the lumbar spine.[61] However, this study did not compare this incidence of postural abnormalities with that of the general population, which compromises one's ability to link LLD and postural asymmetries. In addition, Giles and Taylor using 1,309 subjects with (and 50 volunteers without) chronic low back pain found that 18.3% of chronic low back pain sufferers had LLD of 10 mm or more compared to 8% of controls.[31] More importantly, a subsequent study by the same authors reported that subjects with LLD of greater than 9 mm had significantly altered lumbosacral facet joint angles compared to subjects with LLD of less than 3 mm.[10] This suggested that the joint loading abnormalities associated with LLD might affect the development of facet joints. Moreover, Cummings studied the effect of varying increases in leg length in healthy college women and noted that posterior innominate rotation occurs on the side of the lengthened limb and anterior innominate rotation occurs on the side of the shorter limb and a concomitant pelvic obliquity occurs in an almost linear relationship

from 6mm through to 22 mm.[62] Taken together these studies suggest that LLD is associated with abnormal or asymmetrical loading of lower extremity and spinal joints, which may well be significant in the context of OA.

However, there are studies suggesting that mild LLD is clinically insignificant. These include a 1975 study by Fisk and Baigent[42] that suggested that moderate LLD had little or no involvement in causation of back pain. Similarly, Hoikka radiographed 100 chronic low back pain subjects with a mean age of 40 and a mean LLD of 5 mm (+/-3 mm) and reported that while LLD correlated well with iliac crest tilt and lateral sacral tilt, its correlation with the degree and direction of scoliosis was poor.[63]

LLD and OA in the Lower Extremity and the Lumbar Spine

OA is characterised by degeneration of articular cartilage, hypertrophy of bone at the joint margins, and thickening of synovial membrane.[8] In advanced stages the surfaces of articulating bones, where cartilage has deteriorated, become significantly deformed. Osteoarthritis may be categorised as primary, often referred to as idiopathic, or secondary to other pathology.[8] Secondary OA follows a precipitating event such as fracture or dislocation, or disease such as Perthe's disease, or developmental abnormality such as scoliosis. Solomon questioned the existence of idiopathic OA after finding signs of trauma or other pathology in the hip joint in all of the 327 cases of OA of the hip that he examined.[8] On the basis of these findings, he proposed three pathogenic groups of secondary arthritis: abnormal or incongruous loads causing failure of essentially normal cartilage; cartilage breaking up under normal conditions of loading due to damage or defective cartilage, defective subchondral bone causing break-up of articular cartilage. However, the cause-effect relationships in the associations that Solomon observed remain unclear. Nevertheless, pelvic tilt or torsion resulting from LLD may place unequal stresses on the foot, ankle, knee, hip, sacro-iliac, and lumbar spinal joints in the upright posture. Tilting of the pelvis shifts the centre of gravity, resulting in compensatory muscle activity, which may increase the magnitude of internal joint load. Pelvic tilt may also reduce the contact area of articular cartilage within the joint due to a disruption of normal skeletal alignment. These two effects, of increased joint loading and reduced articulating joint surface area, may translate to increased pressure on the cartilage and the underlying bone thereby leading to the development of osteoarthritis.[64]

LLD and OA in the Knee and the Hip Joints

A large population study of 926 participants by Golightly and colleagues[12] found a positive association between LLD of greater than or equal to 20 mm and knee osteoarthritis, in an African American and Caucasian general population sample in North Carolina, USA. In adjusted models for covariates including gender, race, age, knee injury/surgery, hip pathology, BMI, and height, radiographic knee OA was 80% higher in participants with LLD. However, this study suffers from several limitations. For instance, whilst radiographic examination was used for OA of the knee, a tape measure was used to determine the presence and magnitude of LLD. In addition, the distance between the malleolus to the floor was not measured and a 20mm threshold was used for LLD. These factors may have distorted or underestimated a significant relationship between LLD and knee and hip OA.

In concert with this notion a recent large prospective study, by Harvey and colleagues[28] using radiographic LLD measurements in 3,026 subjects aged 50 to 79, found that LLD of 5 mm was associated with an increase in prevalent symptomatic and progressive osteoarthritis of the knee. This large cohort study involved a follow up of 30 months, and was the first prospective study to define mild LLD as a risk factor for knee osteoarthritis. Subotnick completed a survey over a six-year period of athlete patients attending his office, and found that approximately 40% of his 4,000 patients suffered from some form of LLD. He reported that in most of these cases of LLD, sufferers externally rotated the short leg, which caused excessive medial strain on the entire limb leading to: overuse knee injuries; chondromalacia patella; greater trochanteric bursitis; iliotibial band strain; flexor group shin splints or anterior tibial shin splints; medial ankle synovitis; posterior tibial tendonitis; and medial plantar fasciitis.[28] Of equal importance are reports suggesting that LLD or altered weight bearing of the hip joint[8,11,32] is a potential contributing factor to OA in the hip. For instance, a report of 100 consecutive patients immediately prior to hip arthroplasty found that in LLD, hip OA was 84% more common on the side of the longer limb.[32]

LLD and Degeneration of the Lumbar Intervertebral Disc

As an avascular structure, the intervertebral disc derives its nutrients by diffusion from the end plates.[65] Whether sustained or abnormal mechanical load interfered with this diffusion in vivo had remained unknown until recently. To answer this question, Arun and co-workers simulated the effects of upright posture on all five lumbar intervertebral discs in 8 volunteers in sitting and standing positions and employed contrast magnetic resonance imaging (MRI). The volunteers' spines were loaded in a sustained fashion with 50% of body weight in the supine position for 4.5 hours, and MRI scans were done at 1.5, 3 and 4-hour time points as well as 2 and 3.5 hours following the end of loading. The investigators found that this amount of sustained creep loading reduced the transport of small solutes into the centre of the human intervertebral disc. Furthermore, this study found that it took 3 hours for levels of diffusion of small solutes to reach pre-loading levels. These findings support the notion that sustained mechanical loading may predispose the intervertebral disc to degeneration by impairing the diffusion of nutrients entering the disc and metabolites exiting the disc. These findings also support earlier work by Buckwalter, showing that one of the main causes of disc degeneration is reduced nutrition of the disc, in particular the nucleus pulposis which becomes fibrotic and leads to a reduction in disc height and annulus fibrosis fragmentation especially posteriorly.[66] A degenerated disc displays properties of being solid, while healthy discs have more fluid properties.[67] It has also been shown by Adams and colleagues that age-related degeneration in the lumbar intervertebral discs compromises the weight-bearing capacity of the nucleus pulposis by 50%, and substantially increases the stress on the annulus fibrosis. They also found that the posterior aspect of the annulus was more affected than the anterior annulus, and that degeneration had a greater effect on intradiscal stresses than ageing.[68]

Similarly, Sato and colleagues measured intra-discal pressure in vertical and horizontal positions in 28 subjects with either ongoing lower back pain, sciatica or both, and 8 healthy controls using advanced pressure sensors placed into the L4-L5 disc.[69] They found that intra-discal pressure significantly changed in negative correlation with MRI-demonstrated disc degeneration. Additionally, Adams and Hutten examined the effect of sustained load on lumbar discs and facet joints using eighteen cadaveric lumbar spines.[70] They found that the discs took most of the compressive loads in all postures. However, after about three hours of compressive loading at a level equivalent to standing, the joints lost approximately 9% of their height, causing the apophyseal joints to bear approximately 16% of the compressive load compared to zero in the equivalent of an unsupported sitting position. Moreover, in four severely degenerated discs in this study, large proportions of the load were transferred to the apophyseal joints.

Furthermore, in a comprehensive and rigorous recent study, Rajasekaran and colleagues used contrast MRI for direct examination of the effects of dynamic and static weight bearing on diffusion of nutrients into 21 IVDs in 6 adolescent idiopathic scoliosis patients prior to surgery.[71] They also assessed cell viability in nucleus pulposis biopsy material taken from the convex and the concave regions of the disc, which corresponded to regions where the disc was stretched and compressed respectively. These findings were then correlated with histopathological and biochemical analyses. These investigators found that all discs and end plates were damaged by asymmetrical pressure, regardless of location or severity and showed affected diffusion patterns through the endplate. A subsequent study by the same group found that: end plate junction failure preceded disc herniation; the nucleus pulposis tended to migrate to the convex side of the curve; and compression as well as tension was damaging to the end plate as well the disc.[72] Taken together, these studies strongly support asymmetrical joint loading of the spinal motion segment as a mechanism for intervertebral disc (IVD) degeneration.

It is important to note that there is recent evidence suggesting that age-related degeneration, disc prolapse and OA may be inter-related but different entities. For instance, a recent study by Kanna suggests that patients with multi- or pan-lumbar degeneration are a different patient group to single-level disc prolapse and degeneration patients.[73] Disc prolapse and resultant degeneration has been shown to be accompanied by end plate avulsion and failure, particularly following injury involving combined flexion and torsion forces affecting the lumbar spine.[74] It is also becoming clear that disc degenerative disease (without herniation or prolapse) may be a result of end plate failure through sustained loading affecting diffusion of nutrients.[71,75]

LLD and OA in the Facet Joints

The function of the facet joints (also known as zygapophyseal or apophyseal joints) is to control and guide spinal movements prevent forward displacement of vertebrae and, in the lumbar region, inhibit sideways movement.[76] The human erect posture creates a lordosis in the lumbar spine that causes the lower lumbar joints to be subjected to a sheering force even in the relaxed upright posture. The sacral articular processes resist the sheering force that attempts to displace the L5 segment anteriorly.

In addition to the IVD, the facet joints of the spine can be loaded abnormally as a result of LLD. Giles and Taylor[10], showed that when the intervertebral disc degenerates, the zygapophyseal joints also frequently display degenerative changes. Biomechanical studies have shown that during combined compression and bending, zygapophyseal joints carry from 12% to 16% of the total load.[70] This load on the zygapophyseal joints is known to increase up to 70% when the intervertebral disc height is reduced.[70] At the L5-S1 level, there are also significant shear forces in correlation to the sagittal angle of L5 upon S1. Hicks and associates, in a study of OA-related chronic low back pain, reported minimal facet joint degeneration in the upper lumber region followed by a steep rise in the prevalence of facet joint OA at the lower levels with the greatest change at L5-S1.[6] They also found that facet joint degeneration typically appeared in the lumbo-sacral spine prior to the fourth decade of life and continued to increase until the age of 60+ when it became extremely prominent. Therefore, both increased or abnormal loads and ageing seem to increase the likelihood of OA in the facet joints. In this context, it is important to note that there is good evidence for a link between LLD and facet tropism at the L5/S1 level.[77]

It is also important to note that OA-related changes in zygapophysial joint hyaline articular cartilage may be different from age-related changes.[78] Unlike ageing, in OA the hyaline cartilage often develops areas of disintegration and erosion, even early in life. OA results in diffuse degradation and repair rather than general thinning as found in aging. In addition, in OA the water content of hyaline articular cartilage is normal or increased whereas in aging the water content is reduced.[78]

Patterns of skeletal asymmetry due to LLD

There is a general consensus that LLD has postural consequences. These include torsional changes in pelvic posture with posterior rotation of the ilium on the longer leg side and anterior rotation of the ilium on the short leg side, relative to the contralateral ilium, in both anatomical and artificially induced LLD.[62,79] Clearly, LLD also causes a lateral tilt of the pelvis, consequent to which a functional lumbar rotatory scoliosis can develop with the convexity usually found on the short leg side. Although one investigator described the curve as being convex toward the side of the long leg.[63] These effects are said to be common to both functional and anatomical LLD.[46] Whilst not universally accepted, some authors believe functional scoliosis may become structural over time.[24,28,77] These adaptations may be the cause of permanent spinal changes such as asymmetrical facet joint angles, disc degeneration, osteophytic spurs, facet joint OA, disc herniation, muscle imbalances and scoliosis.

There are reports of a strong association between asymmetrical disc degeneration and degenerative lumbar scoliosis.[80,81] However, in children with LLD-related functional scoliosis, a small LLD is often asymptomatic and hence may be ignored by clinicians.[23] Nevertheless, LLD may cause an increase of mechanical load on the foot on the side of the longer leg by up to 6% of body weight.[23] Importantly, using an internal shoe lift, these investigators reported that the functional scoliosis could be eliminated.[23] Even though Hoikka and colleagues have reported a poor correlation between scoliosis and mild LLD[63], many other authors have reported a significant correlation between the two[24,36,39,60,63,82].

Many investigators have examined the effects of artificial (experimentally-induced) LLD on pelvic torsion and scoliosis. Young and colleagues artificially increased the leg length on one side in 29 healthy young adults and reported that this produced a contralateral innominate rotation anteriorly and a posterior rotation on the ipsilateral innominate.[83] Also lateral flexion increased towards the side of the lift. This assessment was based on an abrupt induction of LLD that does not allow for postural compensations over time. Similarly, Betsch and colleagues assessed the effects of simulated LLD on spinal posture and pelvic position using dynamic rastersterographic analysis in 115 volunteers and found a significant correlation with pelvic tilt, torsion and scoliosis.[84] Similarly, Timgren and colleagues found that 87% of 150 consecutive neurologic patients presenting to a physiatrist had LLD with asym-

metry of the pelvis and spine.[85] They described two types of scoliosis in these patients; a) an S-shaped scoliosis associated with an elevation of the iliac crest and the ipsilateral scapula, and b) a c-shaped scoliosis associated with an elevation of the iliac crest and the contralateral scapula. These shapes represented approximately equal proportions of patients. The patients with the c-shaped scoliosis exhibited apparent leg lengthening on the side of the elevated crest, and the s-shaped patients showed a shortening of the leg on the side of the elevated crest. Taken as a whole, these studies demonstrate that the postural changes induced by LLD may be complex and may depend on the magnitude of LLD and the compensatory mechanisms operative in particular individuals. These compensatory mechanisms may include: asymmetrical foot pronation/supination, genu valgus, knee degeneration, alterations to spinal kinematics and gait disturbances.

Conclusion

Much of the LLD literature is compromised by the use of invalid and unreliable clinical methods of LLD quantification. This has largely been the cause of the controversy that still exists about the clinical significance of mild LLD. However, the literature that is based on the gold standard of radiographic assessment has allowed elucidation of the subtle postural effects of mild LLD and their consequences in terms of excessive and abnormal loading of lower extremity and at least lumbar spinal joints. Given that excessive weight bearing is a known predisposing factor in OA, this may well have implications in the development of OA in these joints. Clinically, standing radiographic assessment would be an indispensable tool in accurately assessing LLD, if it is clinically suspected. The introduction of accurate ultrasound methods of LLD detection also has promising clinical applications particularly in children and adolescents, in terms of early LLD management and OA prevention. In addition, there is a significant body of literature linking LLD and knee OA, and to a lesser extent hip OA. However, there is little research attention that has been paid to date to the relationship between mild LLD and OA of the lumbar facet joints or lumbar disc degeneration. This relationship needs to be more thoroughly investigated. This effort will ideally involve long-term population studies to properly establish and quantify the impact of mild LLD on OA in terms of a cause-effect relationship. It will also need to be rigorously studied in subpopulations such as athletes in an effort to improve sports performance and prevent injuries. Furthermore, this link needs to be interrogated in adolescent populations to possibly prevent the development of OA later in life. If this cause-effect relationship is established by further research, interventional studies using heel-lifts, shoe lifts or other orthoses could be carried out to assess the value of this relatively simple and inexpensive measure in reducing OA's burden of disease. This is a promising area of clinical research that may well have important public health implications.

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Conservative treatment of a rock climber with a SLAP lesion: a case report

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This case report describes the clinical presentation and conservative treatment of a patient who suffered from a superior labrum anteroposterior (SLAP) tear of the shoulder after a rock climbing session. The 26 year old man had injured his right shoulder while trying to reach a distant socket with his shoulder 90° abducted and in extreme external rotation. After initial treatment failure in chiropractic, the patient sought an orthopaedist and physiotherapy care. A contrast magnetic resonance examination revealed a SLAP lesion. Awaiting orthopaedic consultation and in the absence of clinical improvement the patient sought care from a second chiropractor. Clinical examination revealed a mild winging of the right scapula and the presence of trigger points in the rotator cuff muscles, biceps, rhomboids and serratus anterior. The chiropractic treatment then included soft tissue mobilization and the prescription of strengthening exercises of the serratus anterior and rotator cuff muscles. After 4 sessions, the patient

L'objectif de ce rapport de cas est de décrire la présentation clinique et le processus thérapeutique d'un patient ayant subi une déchirure de la partie supéro-antérieure du labrum (SLAP) de l'épaule droite suite à une séance d'escalade. L'homme de 26 ans s'est infligé cette blessure à l'épaule droite en tentant d'atteindre une prise éloignée en maintenant son épaule en position abduction à 90° avec rotation externe extrême. Après un premier échec thérapeutique en chiropratique, le patient a consulté un orthopédiste et un physiothérapeute. Un examen par résonance magnétique avec contraste a révélé une lésion de type SLAP du labrum. Dans l'attente d'une consultation orthopédique et en l'absence de progrès clinique le patient a de nouveau consulté en chiropratique. L'examen a révélé un léger décollement scapulaire droite et des points gâchettes dans les muscles de la coiffe des rotateurs ainsi que dans les muscles biceps, rhomboïdes et dentelé antérieur. Le patient a été traité au moyen de mobilisations des tissus mous et des exercices de renforcements du dentelé antérieur et de la coiffe des rotateurs ont été prescrit. Après 4 séances, le patient ne ressentait plus aucune

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did not feel any pain and gradually resumed all his recreational activities. Clinicians should be aware that SLAP lesions are difficult to identify clinically and that manual therapy might be an important component of conservative treatment of SLAP lesions.

(JCCA 2015; 59(3):238-244)

KEY WORDS: shoulder, chiropractic, SLAP, labrum tear, sports injuries, diagnostic imaging, radiology, rock climbing, conservative care

douleur et effectuait un retour à ses activités récréatives. Les cliniciens doivent être conscients que les lésions de type SLAP sont difficiles à identifier cliniquement et que les thérapies manuelles semblent être un élément important du traitement conservateur des lésions de type SLAP.

(JCCA 2015; 59(3):238-244)

MOTS CLÉS: épaule, chiropratique, slap, déchirure labrum, blessures sportives, imagerie diagnostique, radiologie, escalade, traitement conservateur

Introduction

The term SLAP (superior labrum anteroposterior) tear was originally introduced by Snyder et al. in 1990[1] but Andrews was the first to report this type of lesion in 1985[2]. SLAP lesions refer to a tear of the superior labrum (11-to-1 o'clock position), typically at the origin of the long head of the biceps tendon and might extend into the labrum anteriorly or posteriorly and into the adjacent structures.[3-5] The prevalence of SLAP lesions in people seeking orthopaedic care with shoulder pain varies between 6% and 11.8%.[6,7] Although it is difficult to assess the incidence in the population of this type of injury, the incidence of associated number of surgeries was 22.3 / 100,000 inhabitants in the state of New York in 2010.[8] This represents an increase of 464% compared to the year 2002.[8] In the military, the incidence of surgery rates can reach 2.13 cases per 1,000 person-years.[9] Male gender, age and being in the Marine Corps were all significant risk factors.[9] SLAP lesions are also frequently reported in young athletes with 'throw' movements sports (baseball, tennis, swimming, etc.).[10,11] The natural evolution of SLAP lesions and the effectiveness of conservative treatment is unknown since it has only been investigated in the context of a case series.[12] However, the results look promising with a significant decrease in pain, improved quality of life and rates of return to play similar to surgical patients.[12] Nevertheless, half of the patients who start conservative treatment ultimately choose surgery.[12] The latter option seems to produce good results in the general population, but the return to play of athletes (especially baseball) is unpredictable.[13] Treatment modalities used during the conservative care of SLAP lesions are poorly documented. This case report presents in detail the treatments used for a young recreational climber suffering from a SLAP lesion.

Case presentation

A 26 year-old recreational rock climber developed a dull pain in the right shoulder during a bouldering session (difficulty V2-V3). The patient reported that he felt a popping sensation when he tried to reach a distant socket with his shoulder abducted 90° and in extreme external rotation (ABER position). The patient initially sought chiropractic care at a rate of 1 to 2 treatments per week over a two month period. Although we did not have access to that clinical record, the patient reported that the treatments consisted of transverse friction at the insertion of the rotator cuff tendon; spinal manipulative therapy of the thoracic spine; and prescription of stretching exercise of the pectoralis minor. Since his condition did not improve, the patient then consulted an orthopaedic surgeon and received a prescription for a magnetic resonance arthrography (MRA) examination as well as a reference for physiotherapy. The patient visited the physical therapist only once. During this visit, his shoulder was taped and he received a prescription for stretching exercises of the pectoralis minor and major, as well as strengthening exercises of the internal and external rotators using an elastic band.

Not feeling any improvement after performing the exercises for two weeks, the patient obtained an appointment for the MRA examination in a private clinic. The MRA examination revealed an isolated posterosuperior

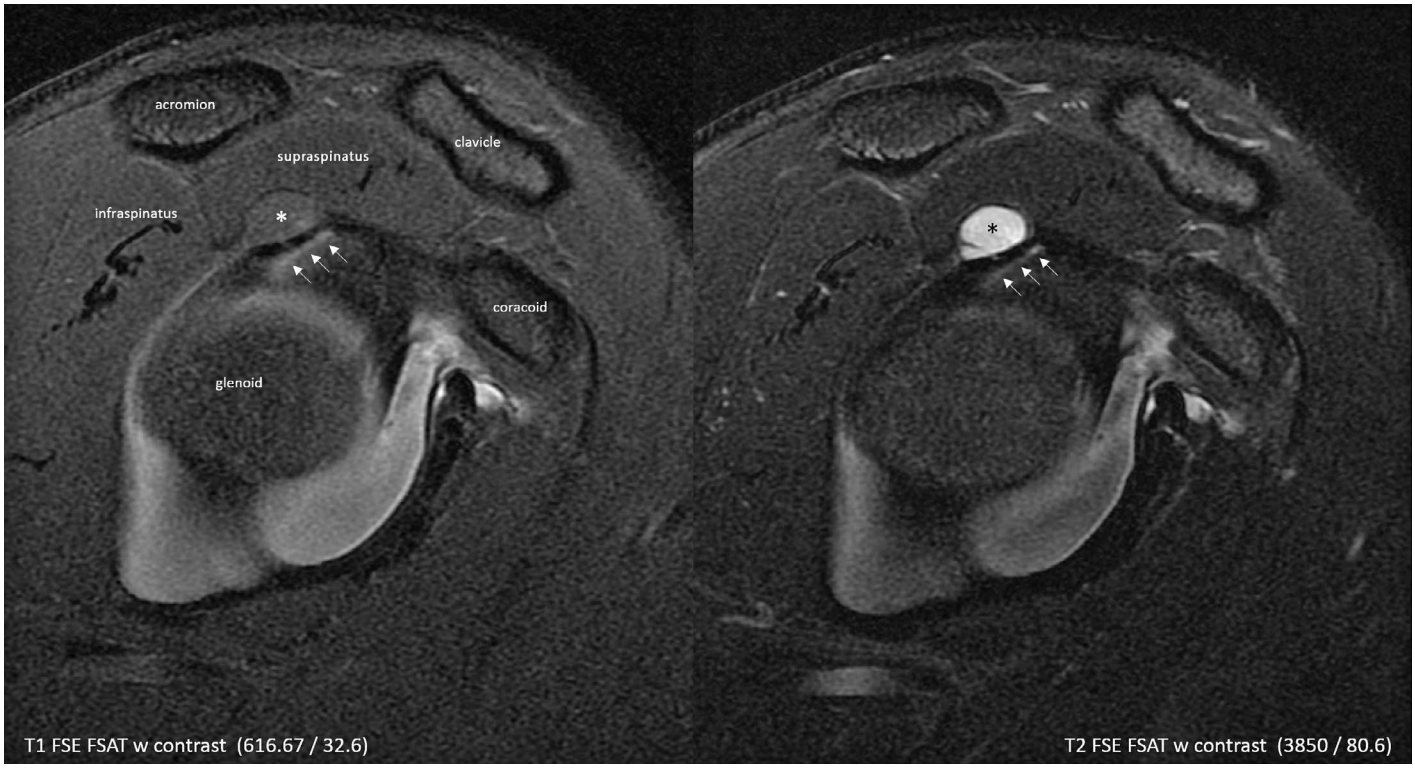

Figure 1.

MRA sagittal images demonstrating a paralabral cyst (*) and a tear (arrows) in the superior–posterior aspect of the glenoid labrum. The tear can be seen as a linear region of high signal intensity region. When one imagines the glenoid surface as a clock, the tear occupies the region between 10 to 12 o'clock. The cyst measured approximately 1 cm in diameter and is slightly septated, as seen on the T2 FS image. The different signal intensity between the T1 FS and T2 fat saturated images indicates that the cyst (*) does not fill with contrast.

glenoid labral tear associated with a paralabral cyst without injury to the tendon of the long head of the biceps. All other structures including the rotator cuff tendons and bursae appeared normal (Figure 1 and 2).

Consequently, the patient consulted an orthopaedic surgeon to evaluate surgical options. Awaiting the preoperative consultation, the patient decided to consult another chiropractor for a second opinion 5 months after his initial injury because the pain was still intense (5/10) during exercise. During this clinical examination all the orthopedic tests of the shoulder (Neer, Jobe, Sulcus sign, Hawkins, Speed, Apprehension manoeuvre) were inconclusive and the ranges of motion (active, passive and resisted) were normal. Trigger point pains were identified in the following muscles: supraspinatus, subscapularis, infraspinatus, teres minor, biceps (long head), rhomboids and serratus anterior. In addition, postural analysis showed a slight winging of the right scapula. Conservative care consisted of soft tissue mobilization of muscles, tendons, ligaments and joint capsule using Active Release Techniques® and Graston Technique®. Strengthening exercises of the external shoulder rotator (with an elastic band) and the serratus anterior (scapular "push-up") were also prescribed. After four treatments, the patient cancelled his appointment with the orthopaedic surgeon because he was pain free. He then gradually returned to his sport, performing today at a more advanced level than before (bouldering V4-V5).

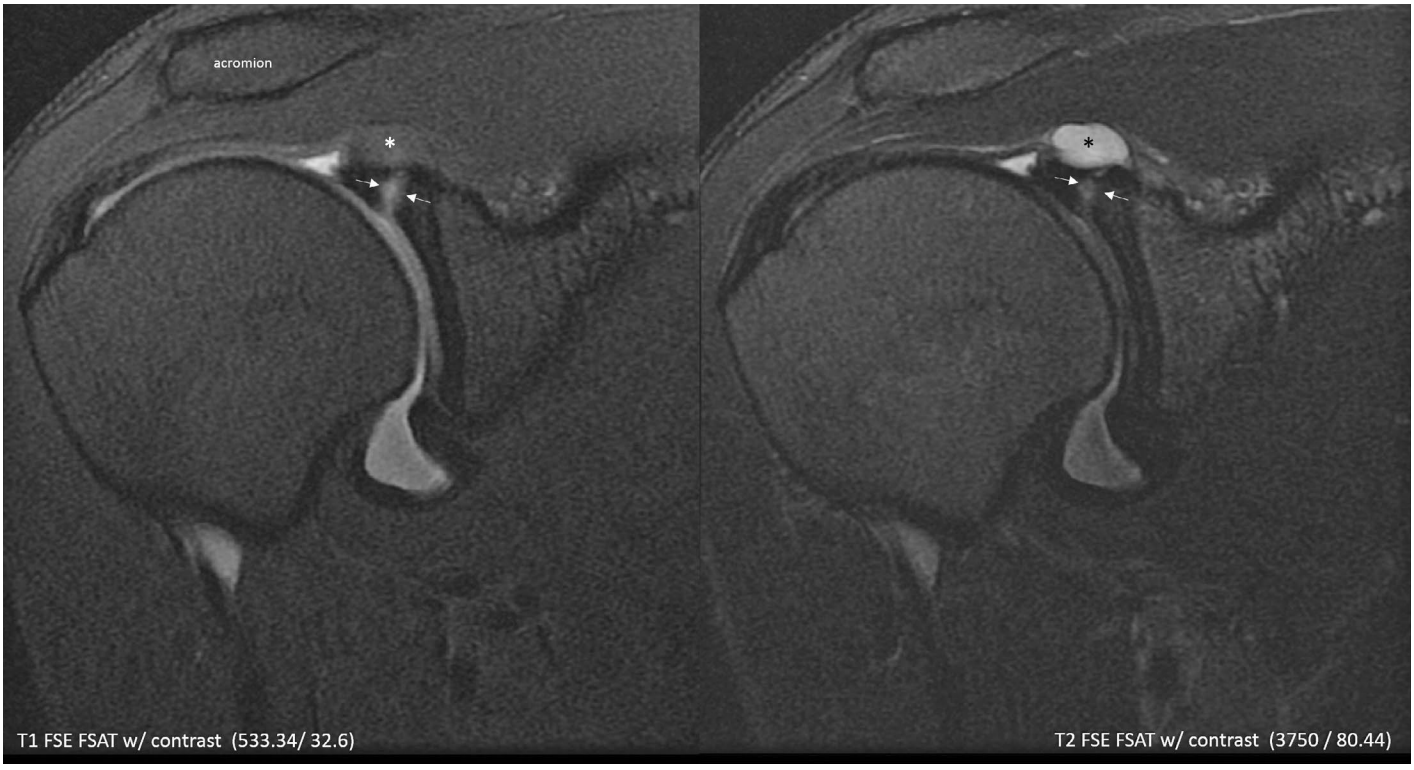

Figure 2.
MRA coronal (oblique) images demonstrating a paralabral cyst (*) and a tear (arrows) in the glenoid labrum. The tear can be seen as a linear region of high signal intensity (contrast-filled) region on both images, as the gadolinium-based contrast media mixed with articular fluid demonstrates a high signal intensity on both sequences. The cyst (*) does not fill with contrast.

Discussion

This case report is a good example of positive outcomes following the conservative treatment of a SLAP lesion. Having tried several conservative approaches, it is likely that using manual therapies (Active Release®, Graston Technique®) was a key component of the treatment of this patient, along with the inclusion of scapular stabilization exercises. The diagnosis of SLAP requires a high level of clinical suspicion to wisely prescribe imaging. There is little literature on the natural history of this condition and the effectiveness of conservative care. We will now discuss the anatomy, clinical presentation, imaging and treatment of SLAP lesions.

Anatomy

The labrum is a ring of fibrocartilage based on the glenoid cavity. It increases the shoulder's depth, stability and shock absorption capacity.[4] The labrum is also a site of attachment of the joint capsule, the glenohumeral ligaments, and the long head of the biceps tendon.[4] Approximately 50% of the biceps tendon fibers attach to the superior labrum and the other 50% on the supra-glenoid tubercle.[14] The superior and anterior region of the labrum has the poorest blood supply, and it is hypothesized that contributes to a slower healing process.[14] The 11-to-3-o'clock position is a common site of anatomic variants of the labrum and glenohumeral ligament (sublabral recess, sublabral foramen, Buford complex and mobile glenoid

labrum).[4] These normal variants are associated with a higher incidence of SLAP lesions.[15-17] Ten distinct types of SLAP lesion, based on the extent of the labral tear and involvement adjacent structures, have been reported in the literature. Type II SLAP lesion (superior labral tear and biceps tendon stripping) is the most common type. 90% of type II SLAP lesions have associated shoulders abnormalities like: rotator cuff tendinosis and/or tear, acromioclavicular and/or glenohumeral arthritis, adhesive capsulitis.[18]

Clinical Presentation

It is difficult to clinically diagnose SLAP lesions, because it does not have a specific presentation and associated conditions are frequent. During the initial interview, the patient may report non-specific anterior shoulder pain aggravated by overhead activity.[3] Clicking, popping, stiffness and glenohumeral instability might also be present.[3,19] Clinicians should also investigate the plausibility of the following potential mechanisms of injury[3]:

- sudden traction on the arm and forceful contraction of the biceps muscle which can peel back the labrum from the glenoid[20] during activity that involves overhead motion with the arm in the abducted and externally rotated (ABER) position (ex: baseball, tennis, swimming);
- the superior migration of the humeral head resulting from a rotator cuff tear, might also cause a lifting of the superior labrum and biceps tendon from the glenoid;[21]
- a fall on an outstretched hand (FOOSH) or a direct blow to the shoulder;
- an internal impingement syndrome that results from the impingement of the soft tissues of the rotator cuff and joint capsule on the glenoid or between the glenoid and the humerus.[22]

The physical examination should begin by a careful evaluation of the glenohumeral and scapulothoracic ranges of motion.[5,10] The glenohumeral ranges of motion are better assessed in the supine position with the shoulder positioned at 90° of abduction and the elbow in flexion. This position stabilises the scapula and it is easier to detect side-to-side difference in internal and external glenohumeral rotation. SLAP lesions could be associated with an increase of external rotation and a decrease of internal rotation, particularly in the throwing athlete.[10] This glenohumeral internal rotation deficit (GIRD), is characterize by a decrease of 20° when compared with the opposite side.[23] The evaluation of scapular kinematics is also an important component of the physical examination. Alteration of the scapular position or motion might produce greater stress to the glenohumeral joint[10,24] as in the present case report. Clinicians should also keep in mind that atrophy of the periscapular muscles might be secondary to a cervical pathology.[5,10] Despite the initial enthusiasm regarding particular orthopaedic shoulder tests (Biceps load II test and Active-Compression test (O'Brien's test)), a recent meta-analysis demonstrated that none of the studied tests had sufficient psychometric propriety (sensibility, specificity, positive and negative predictive value) to provide the clinician with useful information.[25] Test combinations represent a promising area of research, but none of the studied combinations were actually satisfactory.[25]

Imaging

Given the limitations of the clinical evaluation, imaging remains the key to diagnosing SLAP lesions. Plain radiographs of the shoulder are typically normal unless there are associated co-existing conditions such as glenohumeral subluxation, acromioclavicular deformation and/or outlet impingement.[5,10] Bankart lesions (anterior inferior fracture of the glenoid) and Hills-Sachs defect (posterior superior fracture of the humeral head) might also be signs of previous shoulder trauma and potential instability.[10] MRA is an examination where intra-articular Gadolinium is administered with a 18- to 25- Gauge needle into the shoulder joint under fluoroscopic or ultrasound guidance followed by magnetic resonance imaging (MRI). It is more sensitive than non-arthrographic MRI and ultrasound scans as Gadolinium distends the joint space allowing for improved visualization of the labral and joint capsular structures.[26,27] Unfortunately, false positives are frequent when compared to arthroscopy.[27] Since computed tomography arthrography demonstrated similar psychometric properties to MRA, it might be used in the context of limited access to MRA.[28] Clinicians might consider prescribing advanced imaging after failure of a course of conservative care if the mechanism of injury is consistent with a SLAP lesion.

Treatment

The evidence regarding the conservative treatment of SLAP lesions is very limited and the treatment recommendations are based on a case series and expert opinions.[5,10,12] Treatment recommendations include: rest from painful activities, nonsteroidal anti-inflammatory drugs and rehabilitation.[5,10,12] Rehabilitation care is oriented towards stabilizing muscles of the shoulder and shoulder girdle in order to regain normal muscle strength, neuromuscular activation and adequate proprioception.[10,12] In the presence of a GIRD, stretching exercises of the posterior capsule might also be prescribed.[10] The present case report suggests that manual therapy (Active Release®, Graston Technique®) might also play an important role in the treatment of SLAP lesions. In the case series reported by Edwards, 49% of patients treated conservatively avoided the surgery.[12] Conservative care significantly improved pain, function and quality of life of patients in 49% of cases.[12] The return to play rate at the pre-injury level of activity was 71% (66% in the overhead athletes).[12] The rate of return to play of conservative care was also comparable to surgical treatment.[12] Edwards recommended that patients should be referred for surgical interventions if significant pain and functional limitations were still present after 3 months of conservative care.[12] Orthopaedic surgeons will consider: the type of SLAP lesions (ie: the extent of the labral tear and the involvement of adjacent structures), the age, and the level of functionality of the patient before recommending surgical options.[5,10,13,29] Since surgical procedures vary widely (debridement, repair, fixation, partial or total resection of the tendon, etc.), it is difficult to assess the prognosis of SLAP lesion repairs.[5,13] A recent systematic review concluded that type II SLAP repairs produced excellent results for patients not involved in overhead throwing sports.[13] Baseball players had less predictable results with return to sport rates (at a similar level) ranging from 22% to 64%.[13]

Conclusion

This case report demonstrates that it is difficult to diagnose SLAP lesions without high clinical suspicion. It also illustrated that conservative treatment might provide an optimal recovery with a return to sport activities at the previous level (or higher). Manual therapies seemed to play an important role in the treatment of this patient. Future research should help to better understand the natural history of SLAP lesions and identify effective modalities of conservative care.

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Whole body vibration and cerebral palsy: a systematic review

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Purpose: *The goal of this review is to evaluate the effects of whole body vibration on outcomes in patients with cerebral palsy. The findings in this review may help clinicians make evidence informed decisions on the use of whole body vibration for cerebral palsy.*

Methods: *A systematic search was conducted on April 29, 2014.The following search terms were used to search of several databases: (whole body vibration OR whole-body vibration OR whole body-vibration OR WBV) AND (cerebral palsy). Articles that met the inclusion criteria were assessed using the Scottish intercollegiate guidelines network (SIGN) rating system to assess the methodology and bias of the articles for randomized control trials.*

Results: *The search produced 25 articles, of which 12 duplicates were identified and removed. Another seven articles were not considered since they did not fit the inclusion criteria, leaving a total of five studies for*

Objectif : *L'objectif de cette étude est d'évaluer les effets de la vibration du corps entier sur les résultats chez les patients atteints de paralysie cérébrale. Les conclusions de cette étude peuvent aider les cliniciens à prendre des décisions éclairées par des données probantes sur le recours à des vibrations du corps entier pour la paralysie cérébrale.*

Méthodologie : *Une recherche systématique a été effectuée le 29 avril 2014. Les termes de recherche suivants ont été utilisés pour la recherche de plusieurs bases de données : (whole body vibration OR whole-body vibration OR whole body-vibration OR WBV) AND (cerebral palsy) [(vibration du corps entier) ET (paralysie cérébrale)]. Les articles qui répondaient aux critères d'inclusion ont été évalués à l'aide du système de notation SIGN (Scottish intercollegiate guidelines network) pour évaluer la méthodologie et la partialité des articles pour des essais cliniques randomisés.*

Résultats : *La recherche a permis de recenser 25 articles, dont 12 qui étaient doubles ont été éliminés. Sept autres articles n'ont pas été retenus, car ils ne répondaient pas aux critères d'inclusion, laissant au*

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review. Four of the articles analyzed the effects of WBV in children while the other study focused on adults with cerebral palsy. There was one low quality article, four acceptable quality articles and one high quality article when assessed using the SIGN criteria.

Conclusions: *It appears that whole body vibration has the potential to provide symptomatic relief for patients with cerebral palsy. Whole body vibration may improve spasticity, muscle strength and coordination. There is a lack of research to conclusively determine whether it does alter bone mineral density.*

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KEY WORDS: cerebral palsy, whole body vibration, chiropractic

total cinq articles pour l'étude. Quatre des articles analysaient les effets de la vibration du corps entier chez les enfants tandis que l'autre étude portait sur des adultes atteints de paralysie cérébrale. L'évaluation de la qualité des articles selon les critères SIGN a révélé un article de qualité médiocre, quatre articles de qualité acceptable et un article de bonne qualité.

Conclusions : *Il semble que le traitement par vibrations du corps entier a le potentiel de fournir un soulagement symptomatique chez les patients atteints de paralysie cérébrale. La vibration du corps entier peut améliorer la spasticité, la force musculaire et la coordination. Les recherches ne sont pas suffisantes pour permettre de déterminer de façon concluante si elle modifie la densité minérale osseuse.*

(JCCA. 2015;59(3):245-252)

MOTS CLÉS : paralysie cérébrale, vibration du corps entier, chiropratique

Introduction

Dynamic mechanical loading of the skeleton is an arduous task and troublesome to induce in children who suffer from severe cerebral palsy (CP). Most of this difficulty results from the fact that these children are unable to achieve and maintain an upright position. The lack of dynamic weight bearing in this population predisposes them to reduced bone mineral density (BMD) and pre-mature osteoporosis.[1-3] These children are also more prone to muscle weakness, which contributes to pain, deformity and functional loss.[4,5]

Cerebral palsy is a disease that has a prevalence of two cases per 1,000 live born neonates.[6] The first signs tend to appear around 19 months however mild cases can present as late as five years old.[7] The symptoms can include motor problems, cognitive impairment or seizures.[7] CP can be grouped based on the motor effects it has on the individual, these can include pyramidal/spastic CP or extrapyramidal/non-spastic CP.[7,8] Pyramidal or spastic CP is the most common type and is associated with tight or contracted muscles.[6,8] These motor changes are caused by damage to the brain tissue, which can result from various possible mechanisms.[7]

Recently, whole body vibration (WBV) has become more popular in a rehabilitation setting. There are three components to vibration: frequency, amplitude and direction. Frequency is the number of complete cycles per second measured in Hertz (Hz). Amplitude is the amount of displacement measured in mm. WBV plates vibrate in one of two directions; either a vertical displacement or a side-to-side alternating vertical sinusoidal vibration. The vertical vibration creates a uniform amplitude throughout the vibration plate, whereas the sinusoidal vibration creates increased amplitude the further from the pivoting fulcrum at the centre of the vibration plate. Typical vibration sessions consists of the user standing on the platform statically, or while performing dynamic movements for a fixed duration of time.[9] Intensity is controlled through the frequency and amplitude components.[9]

Although vibration therapy has gained such popularity, exact action of the therapy is yet to be determined.[10] Many authors hypothesize that muscle spindles and alpha motor neurons are stimulated by the vibrations, which initiates a muscle contraction.[11] Short-term effects of vibration therapy include increased oxygen consumption, muscle temperature, skin blood flow, muscle power, and circulat-

ing levels of insulin.[12-14] It has been suggested that activation of the musculoskeletal (MSK) system via WBV appears to be a promising approach to increase BMD and to improve gross motor function in patients with CP.[15,16] Locally administered vibration has been used to decrease spasticity in children with CP.[17,18]

In a recent study, WBV has been utilized to assist in strength training in the legs.[19] Several studies have shown the influence of muscle strength on improved walking ability in children with CP.[20,21] Activation of the musculoskeletal system seems to be a promising approach to increase BMD, muscle volume, strength, walking ability and improve gross motor function in these children.[4,15] Similar results have been reported following strength training or exercise training interventions.[22,23]

The purpose of this review is to evaluate the effects of whole body vibration on outcomes in patients with cerebral palsy. The findings in this review may help clinicians make evidence informed decisions on the use of whole body vibration for cerebral palsy.[24]

Methods

Studies were identified by searching the following electronic databases: CINAHL (Cumulative Index to Nursing and Allied Health Literature), AMED (The Allied and Complementary Medicine Database), MEDLINE, SPORTDiscus, and Rehabilitation and Sports Medicine Source. The results were limited to studies published in 2002 to April 2014.

A systematic search was conducted on April 29, 2014. The following search terms were used: (whole body vibration OR whole-body vibration OR whole body-vibration OR WBV) AND (cerebral palsy). The articles were then selected based on the following inclusion criteria: 1) Randomized controlled trial; 2) Human participants with CP; 3) Intervention specifically described as whole body vibration; 4) Written in English; 5) Published in a peer-review journal; 6) Outcome measures include increasing muscle strength, motor function, balance, postural control, ambulation, mobility and bone mineral density.

Two reviewers independently reviewed the results to identify any articles that fit the inclusion criteria. If disagreement between the two reviewers occurred, a third independent reviewer would have the final decision to determine if the article met the inclusion criteria. The selected articles were then assessed with the Scottish intercollegiate guidelines network (SIGN) rating system to assess the methodology and bias of the articles for randomized control trials.[25] The articles were assessed by two reviewers with a third reviewer available to settle any discrepancies. Finally the data was extracted and placed into Table 1.

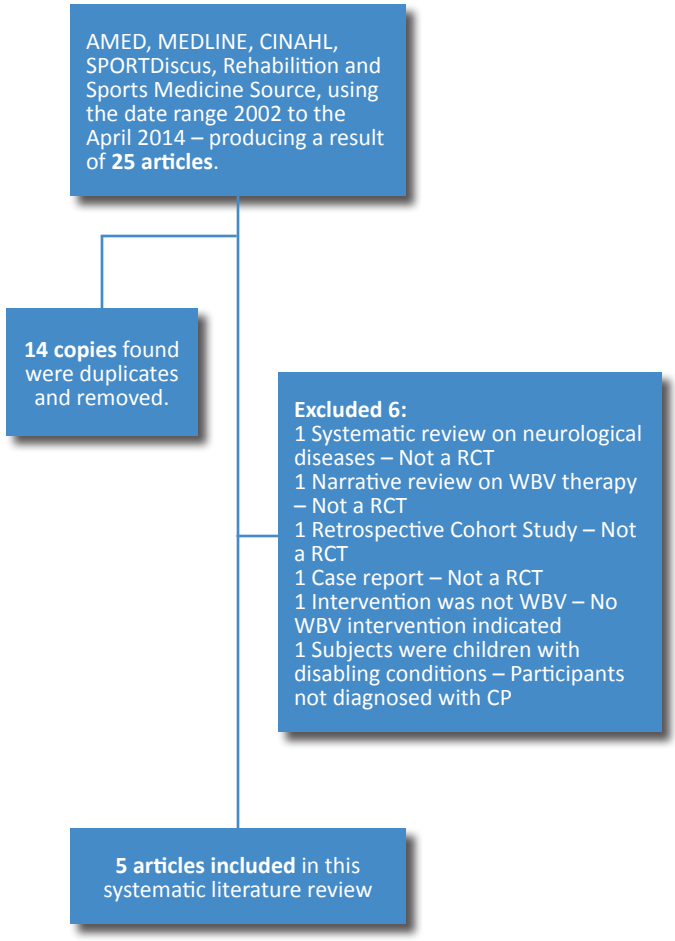

Figure 1.
Flowchart of article selection

Results

The search came up with a total of 25 articles. There were a total of 14 duplicates that were removed (see Figure 1). Another six articles were removed as they did not fit the inclusion criteria, leaving a total of five study studies.

Table 1.
Summary of reviewed articles

Author, year of index publication	Participants	Intervention	Control	Outcome Measures	Results
Lee, 2012	30 participants with either spastic diplegia or quadriplegia CP – Mean age 10.0 – 15 male and 15 female	Conventional PT training + WBV – WBV one hour per day, three days per week – 5 to 25 Hz and the amplitude ranged from 1 to 9 mm – Protocol 10 min Warm-up (1) 3 min of 5–8 Hz (2) 3 min of 10–15 Hz (3) 3 min of 15–20 Hz (4) 3 min of 20–25 Hz (5) 3 min of 15–20 Hz (6) 3 min of 10–15 Hz. 10 min cool-down – Side-to-side alternating vertical sinusoidal vibration	Conventional PT training consisting of gentle massage, muscle stretching, and balance training for 30 minutes	1: Three-dimensional gait analyses 2: Ultrasonographic imaging of the leg muscles	– significant improvements in gait speed ($p< 0.05$) stride length ($p< 0.05$) cycle time ($p<0.05$) – significant improvement in ankle angle ($p<0.05$) No significance in the hip angle ($p=0.321$) and knee angle ($p=0.102$) – significant increase in muscle thicknesses of the tibialis anterior ($p<0.05$) and soleus ($p<0.05$) – No significant change gastrocnemius thickness muscle ($p = 0.645$)
Ahlborg, 2006	14 people with spastic diplegia – 8 male and 6 female – 21-41 years	– WBV group exercised 3 times weekly during 8 weeks. – Protocol: 5 minutes warm-up 6 minutes of WBV training (rest included) Ending with a short program of muscle stretching – WBV training was performed in a static standing position with hips and knees in 50° of flexion – Frequency of 25-40 Hz – Utilized NEMES-LS vibration machine, o mention of amplitude or direction utilized	– Resistance Training 3 times weekly for 8 weeks – leg press device: 3 sets of 10-15 reps with 2 minute rest	1: Muscle spasticity (modified Ashworth scale) 2: Muscle strength (isokinetic dynamometry) 3: Walking ability: 6 MWT 4: Balance: TUG 5: GMFM	– Significant reduction of spasticity in the knee extensors of the stronger leg ($p<0.05$) – No other significant changes in spasticity – -Angle speed 30°/s: no significant change – At angle speed 90°/s: Increase of concentric ($p<0.05$) and eccentric ($p<0.05$) work and eccentric peak torque ($p<0.05$) in the WBV group's weaker leg – Values for 6MWT did not change significantly – Values for TUG did not change significantly after training – Spasticity: dimensions D and E increased in the WBV group ($p<0.05$)
Ruck, 2010,	– 20 children with CP – Ages 6.2 to 12.3 years – 14 male and 6 female	Regular PT program + WBV – one WBV session a day, 5 days per week – Frequency of the vibrations can be selected by the user – Protocol 3 mins of WBV 3 mins of rest 3 mins of WBV 3 mins of rest 3 mins of WBV – 12 Hz increasing to 18 Hz as intervention progressed – Side-to-side alternating vertical sinusoidal vibration	Conventional PT: the program was individualized according to the needs of each child 1-2 times per week	1: Walking speed: 10 m walk test 2: Areal BMD of lumbar spine and femur diaphysis 3: D and E domains of the 88 item GMFM	– No significant group differences were found for the changes in GMFM – increased the average walking speed by a median of 0.18 m/s ($p<0.05$) – No significant differences in areal BMD at the lumbar spine – distal femur, areal BMD in femur metaphysis tended to decrease in controls and to increase in the WBV groups – Femur diaphysis: a significant reduction of BMD in the WBV group.
El-Shamy, 2014,	– 30 children who were diagnosed with spastic diplegic CP – Ages 8-12 – 23 male and 7 female	WBV training – Traditional PT training + WBV – Protocol 3 mins of WBV 3 mins of rest 3 mins of WBV 3 mins of rest 3 mins of WBV – 12 Hz increasing to 18 Hz as intervention progressed – Side-to-side alternating vertical sinusoidal vibration	Traditional PT = neurodevelopmental techniques, muscle stretching, strengthening exercises, proprioceptive training, and balance training, for 3 mos (1 hr per day, 5 days per week	1: Knee extension peak torque to measure strength 2: stability index to measure balance.	– Significant increase in knee extensor peak torque ($p<0.05$) – significant difference between the baseline and posttreatment: overall stability index, anteroposterior stability index, and mediolateral stability index ($p<0.05$) – Greater improvements were seen in the stability index of the intervention group than control ($p<0.05$)
Unger, 2013,	– 27 spastic-type CP children – Ages 6-13 years – 17 male and 10 female	– Selective trunk-targeted exercise programme using the WBV – Protocol: 45s x35Hz Warm-up 3x 30s x 35–40Hz Various sit-up exercises: crunches, cycling, hand behind head and table top 30s x 35–40Hz Hip and lumbar extension exercise 2x 30s x 35–40Hz Side lying crunches 30s x 35–40Hz Plank – No mention of the direction or amplitude parameters	– pre–post crossover study design with random assignment – 0-4 weeks one group with intervention, one group with no invention – 4-8 weeks groups switch	1: 1 minute walk test 2: Sit-ups in 1 minute 3: 2D posturo-photography 4: ultrasound imaging	– significant increase in gait-speed ($p<0.05$), however was not sustained when treatment was withdrawn – Sitting: +/-5degree decrease in forward sway and an increase of 2.7cm in shoulder-to-seat height – All four muscles were significantly thicker post-intervention: TrA ($p<0.05$); OI ($p<0.05$); OE ($p<0.05$); RA ($p<0.05$)

Legend of Terms:

CP	– Cerebral Palsy	6MWT	– Six-Minute Walk Test	TrA	– Transverse Abdominus
WBV	– Whole Body Vibration	DEXA	– dual-energy x-ray absorption	OI	– Internal Oblique
PT	– Physiotherapy	BMD	– Bone Mineral Density	OE	– External Oblique
GMFM	– Gross Motor Function Measure	Min	– Minute	RA	– Rectus Abdominus
TUG	– Timed Up and Go test	Hz	– Hertz	mm	– Millimeter

Four of the articles analyzed the effects of WBV in children[19,26-28] while the other study focused on adults with CP.[29] These studies had interventions ranging from the immediate acute effects of WBV up to six month after intervention. The type of CP was heterogeneous across the studies and included children and adults with spastic diplegic, hemiplegic, and quadriplegia forms of CP. There were four acceptable quality and one high quality article when assessed using the SIGN criteria.

Lee and Chon used a WBV protocol that was unique from the other studies.[19] WBV was performed three times a week for eight weeks. The protocol involved six three-minute vibration sessions while squatting with frequencies varying in Hz (5-25) and received three-minute breaks. The experimental group had an increase in gait speed, stride length, cycle time and ankle angle as well as hypertrophy of the tibialis anterior and the soleus compared to the control group. The control group consisted of general physiotherapy, stretching and balance training. This was rated as a high quality randomized control trial (RCT).

Ahlborg et al., utilized WBV three times a week for eight weeks compared to a resistance training control group.[29] The experimental protocol consisted of six minutes of WBV including rest; the frequency was 25–40Hz. The protocol included a five minute warm-up and ended with static stretching. Spasticity, walking, balance and gross motor function were measured pre and post intervention. It was found that there was no significant difference between the groups in any of the measured variables. However, for time to complete each intervention, the WBV training intervention required less time than the resistance training to complete the protocol. This article was rated as an acceptable RCT.

Ruck et al. studied the effects of WBV on walking speed and BMD in a younger CP population (5-12.9).[26] The experimental group underwent their regular physiotherapy treatments plus five vibration sessions per week for six months, whereas the control group only underwent the regular physical therapy. The WBV sessions consisted of three minute periods with three minutes of rest in between. The frequency depended upon the child's tolerability to the vibration. There was a significant difference in the 10m walk times with the experimental group decreasing their time by a median of 18m/s, while the control group showed no change. The differences in BMD after the intervention period, however, were unexpected. The distal femur metaphysis tended to increase in the WBV group, whereas there was a reduction in BMD in the femoral diaphysis.[26] This article was rated as an acceptable RCT.

El-Shamy looked at the of WBV on both muscle strength and balance.[28] The experimental protocol consisted of WBV with conventional physiotherapy compared to a control group who only received conventional physiotherapy. The WBV intervention consisted of a nine minute intermittent WBV with the frequency controlled by the user. The author evaluated knee extension peak torque to measure strength and a stability index to measure balance. After the intervention, there was a significant increase in the knee extensor torque ($p<0.05$) as well as improved anteroposterior stability and mediolateral stability index ($p<0.05$). The stability improvements were found in both the control and intervention groups, however the control group had a significantly larger increase ($p<0.05$). This article was rated as an acceptable RCT.

Finally, Unger et al. looked at the effectiveness of a trunk strengthening program using WBV.[27] This experimental intervention consisted of the patients performing different selective trunk-targeted exercises while using WBV. The protocol consisted of a 45 second(s) warm-up at 35Hz, followed by three 30 second exercises (crunches, cycling, hand behind head and table top) at 35–40Hz, then 30 seconds of hip and lumbar extension exercise at 35–40Hz, then finished with two 30 second side lying crunches and a 30 second plank. Gait and core improvements were tested using the 1-Minute Walk Test, 2D-posturography, ultrasound imaging and sit-ups in one minute. The authors found that there was a significant increase in distance walked ($p<0.05$), more upright posture, an increase in sit-ups executed ($p<0.05$) and an increase in resting thicknesses of all the four abdominal muscles was recorded: transversus abdominis ($p<0.05$) obliquus internus ($p<0.05$), obliquus externus ($p<0.05$) and the rectus abdominis ($p<0.05$). It was also noted that the strength and posture gains were maintained at four weeks post-intervention. This article was rated as an acceptable RCT.

Strength and Motor Function

Four studies found that WBV resulted in a statistically significant increase in muscle strength and force (Ruck, Unger, El-shamy, Ahlborg).[26-29] The comparison study of

physiotherapy versus WBV found increased thickness of tibialis anterior (31%) and soleus muscles (40%).[19] The comparison study of exercise versus WBV found no significant differences in isokinetic quadriceps muscle strength between groups.[29] However, El-Shamy found that there was an increase in the significant increase in the knee extensor torque.[28] Additionally, Unger et al. found that there was increase in the abdominal musculature thickness with a core targeting WBV intervention.[27] This was accompanied by the number of sit-ups a participant could perform in one minute.[27] Alhborg, and Ruck all used the Gross Motor Function Measure (GMFM) to assess motor function and found improvements in the sitting and crawling sections.[26,29]

Spasticity

One study (Ahlborg) found that there was a significant decrease in knee extensor spasticity using the modified Ashworth scale in the WBV group. Additionally, there was a decrease side effects of muscle stiffness and soreness noted in the WBV compared to the exercise group.[29]

Bone Density

One study (Ruck) found a paradoxical change in BMD within participants' femurs.[26] This change consisted of an increase within the distal femur metaphysis in the intervention group compared to the control group. However it was also noted that there was significant decrease in BMD in the femoral diaphysis. Finally it was noted that there was no changes to the BMD of the lumbar spine. The authors suggested that one possible explanation for this finding is the difficulty in performing densitometry for the distal femur with CP patients. This is due to positioning and movement artifacts.

Walking speed

Four studies found that WBV resulted in improved walking speed (Lee, Ruck, Unger, Ahlborg).[19,26,27,29] One study used Kinematic data obtained by three-dimensional analysis to evaluate gait speed which showed that WBV improved gait speed by 0.110m/s.[19] Lee and Chon found there was improvement in walking and mobility, specifically gait speed, stride length, cycle time and ankle angle.[19] Unger found that with the improved core strength that there was an improvement in the 1-minute walk test.[27] WBV intervention demonstrated a 38% improvement in walking speed above baseline in a 10-meter walk.[26] The WBV group had an increase in their average walking speed of 0.180m/s while the control group had no change.

Vibration Parameters

A summary of the frequency, amplitude and time on vibration plate utilized within the interventions showed significant heterogeneity within the protocols. The following are the ranges: frequency 5–40 Hz, 1- 9 millimeters (mm) and 30 seconds – 6 minutes. The majority of studies utilized the Galieo system for the vibration intervention, this machine involves a side-to-side alternating vertical sinusoidal vibration. To control for the differences in displacement due to the teetering action, the authors would have marked distances from the centre for foot placement. As the participants' feet moved further from the fulcrum; the amplitude of the vibration increases. With this concern, there was variable reporting of the amplitude utilized within the studies. Finally the exercises utilized on the machine included squats, core exercises, standing and lunges.

Discussion

Whole body vibration as a treatment option for CP is a relatively new subject with limited high quality research. The results of most of the included articles appear promising in terms of WBV as an intervention in CP patients, in regards to building strength, decreasing spasticity, increasing functionality in the short term (up to six months); however, positive effects on bone mineral density are questionable.

Throughout the five studies investigated there was a large amount of heterogeneity in almost all aspects: WBV protocols, vibrating platforms, setups and type of CP. CP is an umbrella term and the types of CP included in the studies were heterogeneous making it difficult to extrapolate the findings to all patients with CP.[30,31] Future research into the effects of WBV on CP, need to better address the type of CP they are investigating. With the heterogeneity of CP, it could be possible that WBV may be effective for one group while less effective or ineffective for another group.

WBV seems to be a promising adjunct to the regular therapies that CP patients participate in. Based on the studies appraised by these authors, WBV appears to be a safe and time efficient therapy that may help to improve

walking ability and increase walking speeds, overall mobility, muscle mass and force production, and decreasing spasticity. However, there should be further investigation into the effects of WBV on BMD, due to the paradoxical decreased bone mineral density seen in the WBV group by Ruck et al.[26] Based on all the studies, the most commonly utilized time intervals for the vibration was three minutes maximum per interval. Further research into this subject must include determining the optimal protocol to achieve therapeutic result. Other possible areas of investigation could include determining if individualized treatment protocols are more effective than a standardized programs, including investigations into the optimal time, direction of vibration, amplitude, and frequency to gain clinically relevant changes, as well as studies looking at the long-term follow-ups to determine whether these results from WBV are retained. Future research should include additional reporting of the vibration parameters utilized within the study to allow better implementation by clinician wishing to use vibration as a treatment modality.

One area for concern with investigating WBV is the difficulty in blinding participants and investigators. The nature of the intervention of WBV makes patient blinding difficult. One of the previous blinding method utilized included using a physiotherapist who was blinded to the type of intervention the patients received to perform outcome measure testing.[19] This change would limit the potential for measurement bias and further strengthen the research protocols.

Although all studies used WBV as the primary intervention, the studies did not administer identical interventions in terms of the frequency, duration, or interval times. Not only were the interventions not heterogeneous, but the types and forms of CP were not heterogeneous between the populations either. Due to the small sample size, it can be argued that the results are unable to be generalized to other CP patients and populations. Further research needs to be completed with larger sample sizes and homogenous CP populations, with consistently administered treatment frequencies, durations and intervals over a set period of time.

Conclusion

In conclusion, it appears that WBV has the potential to improve symptoms in those patients with cerebral palsy. It has been shown to help improve spasticity, muscle strength and coordination. There is a lack of research to conclusively state whether it does in fact alter bone mineral density. The aim of this systematic review was to compile the recent literature on vibration therapy in patients with CP in order to guide future clinical decisions when treating these patients. The authors hope that this systematic review stimulates further research in regards to WBV and its effects on the CP population.

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A rare case of unilateral variations of forearm arteries: anatomy, embryology and clinical implications

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This study documents the existence and topographic anatomy of a rare case of variant forearm arteries found in the left upper limb of a 68-year-old male cadaver. The arteries of the arm followed typical courses, but both the radial and ulnar arteries in the forearm followed a superficial course. The common interosseous artery and recurrent ulnar arteries branched from the radial, not the ulnar, artery. The radial artery was larger than the ulnar artery and was the major source of blood supply to the forearm. Clinical implications for single superficial forearm arteries are reviewed. A person with both superficial radial and superficial ulnar arteries would be at a substantially increased risk of injury or iatrogenic effects that could compromise blood supply to the hand. This study will enhance clinician's awareness of potential arterial variations, so they can provide

Cette étude documente l'existence et l'anatomie topographique d'un rare cas de variante d'artères de l'avant-bras observé dans le membre supérieur gauche du cadavre d'un homme de 68 ans. Les artères du bras ont suivi des trajets typiques, mais les artères radiale et cubitale de l'avant-bras ont suivi un trajet superficiel. L'artère interosseuse commune et les artères cubitales récurrentes se sont ramifiées à partir de l'artère radiale, pas l'artère cubitale. L'artère radiale était plus grande que l'artère cubitale et elle était la principale source d'approvisionnement en sang à l'avant-bras. Les effets cliniques d'artères simples superficielles de l'avant-bras sont examinés. Une personne dont les deux artères radiale et cubitale sont superficielles serait à un risque considérablement accru de blessures ou d'affection iatrogène qui pourraient diminuer l'approvisionnement en sang à la main. Cette étude permettra de sensibiliser davantage les cliniciens aux variations artérielles potentielles, de sorte qu'ils puissent offrir une

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adequate assessment, diagnosis and treatment of upper limb lesions.

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KEY WORDS: radial artery, ulnar artery, arterial variations, arterial development, ultrasonography, diagnosis, chiropractic

évaluation, un diagnostic et des traitements adéquats des lésions des membres supérieurs.

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MOTS CLÉS : artère radiale, artère cubitale, artère ulnaire, variations artérielles, développement artériel, échographie, diagnostic, chiropratique

Introduction

Variations in upper limb arteries are a source of great interest since they provide insight into individual development and can affect both diagnosis and treatment.[1,2] Reviewing the literature, we found the variations in the arterial pattern of the upper limb are common and have long received attention from anatomists and clinicians.[3-14]

It is important that surgeons, chiropractors, and other medical professionals are aware of variations in the course of the forearm arteries that can affect both symptoms and diagnoses. These variations can affect the interpretation of morphological and functional findings, or lead to difficulty interpreting angiographic images.[15-20] They can directly affect the success, and complication rates of procedures, such as cannulation, radial forearm flap surgery, arterial grafting, fasciotomy for compartment syndrome, cardiac catheterization, angioplasty, and orthopaedic surgery.[6,7,10,12,16,17,19-31]

It is especially important to understand these variations in order to avoid misdiagnosing forearm pathology, as described by McWilliams et al[27], when a variant superficial ulnar artery was clinically mistaken for phlebitis. Also of note is the increased vulnerability of superficial arteries to injury and laceration.[14,20,32]

The purpose of the presented study is to document the existence and topographic anatomy of a case of variant forearm arteries. We hope our study helps to enhance clinician's awareness of potential arterial variations, so they can then provide adequate assessment, diagnosis and treatment of upper limb lesions.

Materials and Methods

During a routine dissection of the upper limbs of a 68-year-old male cadaver, atypical courses and branching pattern of the left forearm arteries were encountered. These variant arteries were followed and their features documented and photographed.

Results

Both variant forearm arteries in the left upper limb arose from a typical brachial artery. As is usual, the brachial artery was at first medial to the humerus, and then gradually spiralled anterior to it, reaching the midpoint of the cubital fossa, lateral to the median nerve. Within the cubital fossa the brachial artery was located centrally and divided near the neck of the radius into its terminal branches, the radial and ulnar arteries. We observed a variant course for the ulnar artery, and a variant course and unusual branching pattern for the radial artery (Figure 1A).

Ulnar artery

The ulnar artery, as one of the two terminal branches of the brachial artery, was smaller than is commonly seen. In typical cases, the ulnar artery is the larger terminal branch of the brachial artery.[4,14] The variant ulnar artery descended through the entire forearm superficially, covered only by the skin, subcutaneous tissue and the antebrachial fascia. For this reason, we classified it as a superficial ulnar artery (SUA).

The course of the SUA with respect to the median nerve was also of note. Distal to the elbow, the SUA followed the usual course lateral to the median nerve, then crossed superficial to the median nerve, but was separated from it by the humeral head of the pronator teres muscle (Figure 1B). In the typical course, the ulnar artery crosses deep to the median nerve and is separated from it by the ulnar head of the pronator teres muscle.[4,14] On its course from the cubital fossa to the medial side of the forearm midway between the elbow and wrist, the SUA descended superficial to the pronator teres, flexor digitor-

Figure 1.
Topography of the variant radial and ulnar arteries.

LEGEND
1 – brachial artery
2 – median nerve
3 – pronator teres muscle: humeral head
4 – ulnar artery
5 – radial artery
6 – brachioradialis muscle
7 – flexor digitorum superficialis muscle
8 – flexor carpi radialis muscle
9 – common interosseous artery

Figure 1A. Illustration of the superficial course of the variant ulnar and radial arteries in the anterior forearm region. The variant ulnar artery (4) is the smaller terminal branch of the brachial artery (1) and descends superficial to the forearm flexors. The variant radial artery (5) is the larger terminal branch of the brachial artery and runs superficial along its course in the forearm.

Figure 1B.
The variant ulnar artery (4) crosses superficial to the median nerve (2), but is separated from it by the humeral head of the pronator teres muscle (3). The common interosseous artery (9) in this case, is the branch of the radial artery (5).

um superficialis and flexor carpi radialis muscles (Figure 1A). In typical cases, the ulnar artery passes deep to these muscles.[4,14]

The distal half of the SUA, from the level of the mid-forearm to wrist, follows a typical course for the ulnar artery: at the wrist it was accompanied medially by the ulnar nerve and the tendon of the flexor carpi ulnaris, then traversed the superficial part of the flexor retinaculum, and continued across the palm as the superficial palmar arterial arch. The comparison of the courses of the variant SUA and the typical ulnar artery is provided in Table 1.

Table 1.
Comparison of the courses of the variant superficial ulnar artery (SUA) and the typical ulnar artery.

Course & features	Typical ulnar artery[4,14]	Variant SUA
Origin	Larger terminal branch of the brachial artery.	Smaller terminal branch of the brachial artery.
Forearm's proximal half	Passes deep to the pronator teres, flexor digitorum superficialis, and flexor carpi radialis muscles.	Passes superficial to the pronator teres, flexor digitorum superficialis, and flexor carpi radialis muscles. It is covered by the skin, subcutaneous tissue and antebrachial fascia.
Relationship to median nerve	Lateral to the median nerve, and then it crosses deep to the median nerve, but is separated from it by the ulnar head of the pronator teres.	Lateral to the median nerve, and then it crosses superficial to the median nerve, but is separated from it by the humeral head of the pronator teres muscle.
Forearm's distal half, wrist and hand	Covered by the skin, subcutaneous tissue and antebrachial fascia. Lateral to the flexor carpi ulnaris tendon and ulnar nerve. Traverses the superficial layer of the flexor retinaculum and continues across the palm as the superficial palmar arterial arch.	Follows the typical course.

Radial artery

Contrary to what is typically seen, the radial artery in this case was the main branch of the brachial artery, and was therefore larger than usual. The course of a typical radial artery in the proximal forearm is deep to the belly of the brachioradialis muscle, and in the distal forearm it is more superficial, covered only by skin and antebrachial fascia.[4,14] In our subject the radial artery was covered only by skin and antebrachial fascia along its course in the forearm and did not run deep to the brachioradialis (Figure 1A). For this reason, we classified it as a superficial radial artery (SRA). Unlike most of the reported superficial radial arteries,[4,6,14,18,33-35] the superficial radial artery in our subject followed a typical course in the wrist by running deep to the extensor tendons at the level of the anatomical snuff box.

We also found an atypical branching pattern of the radial artery. The common interosseous artery, which usually arises from the ulnar artery, in this case emerged as a short branch of the radial artery distal to the radial tuberosity (Figure 1B). While passing toward the interosseous membrane, the common interosseous artery was separated from the median and anterior interosseous nerves by the ulnar head of the pronator teres muscle (Figure 2). The common interosseous artery gave off the anterior interosseous artery and the anterior and posterior ulnar recurrent arteries before continuing across the interosseous membrane as the posterior interosseous artery. All of these branches followed typical courses and supplied the major part of the posterior and anterior muscular compartments of the forearm region.[4,14]

Discussion

Since the presence of both a superficial ulnar and a superficial radial artery in one arm is extremely rare, we will first discuss the incidence of the better documented singly occurring superficial forearm arteries. We will then discuss the two studies in which both forearm arteries were superficial, and the clinical implications of this type of variation.

Superficial ulnar arteries are relatively rare, 0.7% to 9.4%.[6,14,30] However, they usually branch much higher, either from the axillary artery or the brachial artery as it courses in the arm, and are classified as superficial brachioulnar arteries.[6] The superficial ulnar artery in our subject originated in the cubital fossa, so would not meet the definition of a brachioulnar artery.

Superficial radial arteries are even more rare, at an

Figure 2.
The relationship of the common interosseous artery with the median and anterior interosseous nerves and with the ulnar head of the pronator teres muscle.

The common interosseous artery (7), branch of the radial artery (6), divides into the anterior (9) and posterior interosseous arteries. The ulnar head of the pronator teres muscle (2) separates the common interosseous artery (7) from the median (3) and anterior interosseous (10) nerves. The anterior (8) and posterior ulnar recurrent arteries are the branches of the common interosseous artery.

LEGEND
1 – pronator teres muscle: humeral head
2 – pronator teres muscle: ulnar head
3 – median nerve
4 – brachial artery
5 – ulnar artery
6 – radial artery
7 – common interosseous artery
8 – anterior ulnar recurrent artery
9 – anterior interosseous artery
10 – anterior interosseous nerve

incidence rate of ~0.5%, although this varies by population.[6,36,37] They most often occur at the level of the anatomical snuff box, with the artery passing superficial to the tendons that form the borders of the snuff box, rather than deep to them.[4,6,14,33] The superficial radial artery in our subject differed from this pattern since it originated in the cubital fossa, was superficial along the forearm, and followed a typical course deep to the tendons that border the anatomical snuff box.

Rodriguez-Niedenfuhr et al.[6], described a superficial brachioulnoradial artery as a superficial brachial artery branching at the elbow into radial and ulnar arteries and coexisting with a typical brachial artery that continues as the common interosseous trunk. This is a different variation than in our study where the brachial artery followed a typical course with just the radial and ulnar arteries following a superficial course.

The incidence of a combined superficial radial artery and superficial ulnar artery is far less than the incidence singly. We have only found two case reports where both a superficial radial and a superficial ulnar artery occurred in the forearm, and only one of these subjects had an abnormal branching pattern of the radial artery.[32,38] In both of these studies the subjects had a superficial brachial artery with many branches, but did not have a typical brachial artery. In these cases the superficial radial and superficial ulnar

artery arose from the bifurcation of a superficial brachial artery in the cubital fossa. This was different than in our study, where the SRA and SUA arose from a typical brachial artery. Similar to our study, the superficial radial and superficial ulnar arteries rejoined their "common textbook" position in the distal forearm. In one subject the common interosseous artery arose from the radial artery, but this subject also had a median artery originating from the common interosseous artery. In both of these studies there were variant arteries along most of the upper limb, both in the arm and forearm. Our study demonstrates that it is possible to have variant forearm arteries occurring with typical arm arteries. Despite this being a rare variant, the risk of injury and iatrogenic consequences that could impact blood supply to the hand are substantially higher than the risks associated with the more frequently reported single superficial forearm arteries. The clinical implications relating to a single SUA or SRA will be combined to discuss the clinical implications of the variants described in this study.

An awareness of these variations is essential in order to prevent difficulty in performing physical exams, or interpreting physical findings. McWilliams et al.[27], presented a case in which a superficial ulnar artery was misdiagnosed as phlebitis. Chin et al.[15], described the difficulty even trained anaesthesiologists have in differentiating between an artery and vein in a case when a superficial ulnar artery is present. In the current study this difficulty would be compounded by the difference in size of the radial and ulnar arteries, with the radial being larger than usual, and therefore having a relatively stronger pulse.

Clinical difficulties associated with superficial brachioulnar arteries and superficial radial arteries have been separately reported. These include inadvertent cannulation and difficulty interpreting angiographic images.[2,9,19,30] Due to its position close to the cephalic vein, a superficial radial artery is at greater risk of being accidentally cannulated than a superficial ulnar artery.[15] Surgery for radial forearm flaps, coronary bypass and compartment syndrome could lead to accidental division of the artery, which could jeopardize blood flow to the hand.[1,6,15,16,18,23-29,30,35] On the contrary, if the superficial brachioulnar artery is identified, it could actually be of benefit for plastic surgeons performing reconstructive surgery with skin flaps, since it potentially has lower complication rates and better cosmetic outcome than radial forearm flaps.[6,30]

The frequent use of the radial artery in coronary and forearm flap procedures makes preoperative identification of the arterial path by Doppler ultrasound or angiography important.[9,17,18,20,22,27,31] With the variant arteries described in this study this would be even more vital, since the radial artery was the main source of blood supply to the hand.

The clinical implications that were discussed above with regard to superficial brachioulnar and superficial radial arteries would also apply to our subject. The argument could be made that since both forearm arteries are superficial, a person with these variations is at much greater risk for an injury that could compromise blood supply to the hand.

Different theories about arterial development in the upper limb have been a source of controversy for many years.[39] When we combine the information from studies that analysed embryonic development using 3D reconstructive imaging[40] with information from molecular and genetic studies[41], a more comprehensive picture of arterial development emerges.

Vasculogenesis occurs when signalling pathways cause hemangioblasts and endothelial cells to assemble into primitive tubular networks. The cells involved further differentiate into arterial and venous endothelial cells, creating the primary capillary plexus. This primary capillary plexus is transformed into a complex network by a remodelling and sprouting process called angiogenesis. A delicate balance between activators and inhibitors in the signalling pathways controls vessel formation during angiogenesis. The capillary plexus develops in a proximal to distal pattern and is present in the entire upper limb by the 28th day of human embryonic development.

At this point the capillary plexus begins a maturation process involving the proximal to distal differentiation of selected parts. Some of the capillary plexus is maintained, some enlarged, and some is pruned in response to the demands of specific tissues and organs. Oxygenation and nutrient availability may play a role in the expression of the genetic pathways controlling this process. The axillary and brachial arteries are present by the 41st day, and the branches of the forearm arteries are present, except the distal radial artery, by the 44th day of human embryonic development. The variant arteries found in our subject indicate that a disruption occurred during the process of

vessel formation sometime between the 41st and 44th days of human embryonic development.

Conclusions

We present an unusual case of superficial radial and ulnar arteries. Typically variations in forearm arteries are associated with early branching from the brachial artery, or, in the case of the radial artery, a superficial course distally in the forearm and wrist. In the presented case the brachial artery bifurcates as usual in the cubital fossa, but both radial and ulnar arteries are superficial for the length of the forearm, then they resume typical paths as they cross the wrist. Also of note in this case, the common interosseous artery emerged as a branch of the radial artery, not the ulnar. To our knowledge, this combination of variations has not previously been reported. A person with these variations is at much greater risk of injury affecting blood supply to their hands, and of iatrogenic complications if invasive procedures are undertaken without identifying the variations beforehand.

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Intra- and inter-observer reliability of the Cobb measurement by chiropractic interns using digital evaluation methods

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Introduction: *It is important to create a body of evidence surrounding the reliability of certain diagnostic criteria. While the reliability of the Cobb measurement is well established with various licensed health care professionals, this study aims to determine the inter- and intra-observer reliability of the Cobb Measurement among chiropractic interns.*

Methods: *Fourteen chiropractic interns analyzed 10 pre-selected digital spinal radiographs on a Picture Archiving and Communication System (PACS) in two separate rounds of observation. The participants indicated their choice of end vertebra and Cobb Measurement in each round of observation. Agreement on vertebral levels selected was estimated using percentage agreement. Intra-observer reliability was estimated using the Pearson r correlation coefficient, and inter-observer correlation was estimated using the Inter-Class Coefficient (ICC).*

Results: *The range of percentage agreement on vertebral level selection was 0.36 – 0.79. The Pearson r*

Introduction : *Il est important de créer un ensemble de preuves sur la fiabilité de certains critères de diagnostic. Bien que la fiabilité de la mesure Cobb soit bien établie chez divers professionnels de la santé, cette étude vise à déterminer la fiabilité des observations individuelles et entre ces observations de la mesure Cobb parmi des stagiaires en chiropratique.*

Méthodologie : *Quatorze stagiaires en chiropratique ont analysé 10 radiographies numériques de la colonne vertébrale sur un système d'archivage et de transmission d'image (PACS) en deux séances distinctes d'observation. Les participants ont indiqué leur choix de vertèbre limite et de mesure Cobb dans chaque observation. Un consensus sur les niveaux vertébraux sélectionnés a été établi en fonction du pourcentage de concordance. La fiabilité des observations individuelles a été estimée à l'aide du coefficient de corrélation de Pearson r, et la corrélation entre les observations des stagiaires a été estimée à l'aide du coefficient interclasse (ICC).*

Résultats : *La fourchette de pourcentage de concordance sur la sélection de niveau vertébral était*

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correlation coefficient for round 1 and round 2 was 0.79. The ICC (3,1) was 0.79 (round 1), and 0.70 (round 2).

Conclusion: *Less than optimal agreement on end vertebrae selection was found between observers. Intra- and inter-observer reliability of the Cobb Measurement was 'excellent' (round 1) and 'good' (round 2).*

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KEY WORDS: chiropractic, Cobb measurement, scoliosis, reliability

de 0,36 à 0,79. Le coefficient de corrélation de Pearson r pour la première séance et la deuxième séance d'observations était de 0,79. Le coefficient interclasse (3,1) était de 0,79 (séance 1), et de 0,70 (séance 2).

Conclusion : *Le consensus sur la sélection des vertèbres limites a été moins qu'optimal entre les observateurs. La fiabilité des observations individuelles et entre ces observations de la mesure Cobb a été « excellente » (séance 1) et « bonne » (séance 2).*

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MOTS CLÉS : chiropratique, mesure Cobb, scoliose, fiabilité

Introduction

Accurate initial and subsequent Cobb measurements are important in scoliosis management protocols. Such protocols are determined by the degree of scoliosis curvature, and the progression of these curves.[1] It has been established in the current literature, that ±5 degrees or more of change on successive radiographs is clinically significant.[2] Oda et al. emphasized that patient management is based on curve progression as observed on serial radiographs.[3] This is significant because in teaching facilities, many different observers may interpret these radiographs over the course of the management period. As such, decisions may be made or altered based on progressive changes as interpreted by different observers. Because radiographs significantly influence management decisions, it is essential to understand the limits of measurement accuracy as well as limits of the measurement techniques used.[3]

While the reliability of the Cobb Measurement by many licensed health care professionals is well established, to our knowledge, reliability of the measurement by chiropractic interns has never been published. The purpose of this study is to evaluate the intra- and inter-observer reliability of Cobb angle measurement on digital radiographs by chiropractic interns.

Methods

The convenience sample used in this study consisted of 15 volunteer observers. Of the 15 original volunteers, one volunteer withdrew from the study before beginning while the remaining 14 completed the study in its entirety. All volunteers were chiropractic interns studying at the same chiropractic program in the United States. This study was granted full approval by the Institutional Review Board of D'Youville College on August 20, 2013.

The study took place over a 22-day period. Of the 14 observers, 13 completed their second round of measurement 14 days after their initial round. One observer could not complete their final round of measurement for an additional 8 days, resulting in a 22 day rather than a 14 day interval between readings. This convenience sample represented more than 75% of the chiropractic interns enrolled in the institution of study.

Interns were instructed to view on PACS ten pre-selected anonymous digital radiographs, previously determined by the researchers to have scoliosis. All images were DICOM format and were displayed and measured on an AMD Catella™ PACS system with high resolution 2K monitors. Representative cases were selected from an archive database of anonymous chiropractic patients by two experienced chiropractic radiologists and the primary researcher. Inclusion criteria included a) adequate image quality; b) obvious scoliosis above a minimum of 10 degrees; and c) conspicuity of both end vertebrae. Participants were instructed to perform a Cobb Measurement on a PACS digital display program. Each participant measured the Cobb Angle on a frontal thoracic, lumbar or full spine radiograph. They identified the cephalic and caudal end vertebra defined

Table 1.
Percentage Agreement on Vertebra Selection between Observers

		Agreement of Vertebrae Selection Between Observers									
		Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case10
Cephalic End											
Vertebra	Round 1	0.57	0.43	0.50	0.50	0.50	0.50	0.64	0.43	0.50	0.57
	Round 2	0.57	0.57	0.71	0.50	0.79	0.50	0.64	0.57	0.64	0.57
Caudal End											
Vertebra	Round 1	0.64	0.50	0.36	0.64	0.57	0.71	0.64	0.43	0.43	0.36
	Round 2	0.43	0.71	0.57	0.71	0.43	0.64	0.50	0.43	0.50	0.36

Observer agreement on vertebral levels (Round 1): 52%
Observer agreement on vertebral levels (Round 2): 57%
Combined observer agreement on vertebral levels (Round 1 and Round 2): 54%

as those vertebral segments at the superior and inferior end of the curvature respectively that would result in the maximum angle. A transverse line was constructed along the superior endplate of the cephalic end vertebral body, and another transverse line was constructed along the inferior endplate of the caudal end vertebral body. The angle between the two endplate lines was then automatically calculated by the Cobb angle application on the PACS program. These Cobb angles were then recorded by the primary researcher. The researcher recorded the resultant angle, and the cephalic and caudal end vertebrae selected by each observer. These values were recorded in a spreadsheet for later analysis. The interns participated in two separate sessions, measuring the same ten radiographs once in each session. Participants were blinded to the identity of the cases, and the original findings were not disclosed during the second session.

Data were analyzed using the ICC (3,1) to determine inter-observer reliability of the Cobb Measurement. For the purposes of this study, it was necessary to utilize the form of ICC that was best for the analysis of single measurements between observers, rather than that which best evaluates the mean of several observer measurements.[4] Gstoettner et al.[5] suggest a grading scale using ICC results in regard to Cobb Measurement reliability, such that scores below 0.40 are regarded as poor; scores of 0.40-0.59 are considered fair; scores from 0.60-0.74 are good; and scores from 0.75-1.00 are excellent. These evaluative guidelines were used in the analysis of the results following the observations. The confidence intervals for the ICC are reflective of the sample size and are included to assist the reader in understanding the precision of the estimate. If the variance in the sample stayed constant, increasing the sample size would reduce the confidence intervals. Please see the limitations section.

The Pearson *r* correlation coefficient was used to determine the intra-observer correlation of the Cobb Measurement. The Pearson *r* is most appropriate for continuous variables within the same class.[4]

Finally, cephalic and caudal end vertebrae selection was evaluated using the percentage of agreement between observers. In addition, the standard error (SE) for each case was calculated with both the 95% confidence interval and 99% confidence interval. Once the pool of data were collected from all participants, it was transferred to a master spreadsheet. All data were then analyzed with the psych package for the statistical software R (R Core Team (2013)) in preparation for ICC calculation, and coefficient correlation.[6]

Results

The sample included 11 males, and 3 females. Five observers were between 20-25 years of age, 8 observers were between 26-30 years of age, and one observer was over 30 years of age.

Inter-observer percentage agreement of cephalic end vertebra ranged from 36-71%, and caudal end vertebra ranged from 36-79% (Table 1). With regard to vertebral

levels most commonly selected, 10 of the 14 observers agreed with each other on the same cephalic vertebra in only 2 cases, and the caudal end vertebra in 2 cases. There was no instance where at least 10 observers agreed on the same cephalic and caudal end vertebra in the same case. Inter-observer agreement was 100% on the caudal and cephalic vertebra 0/10 times in round 1, and 0/10 times in round 2. Inter-observer agreement on vertebral levels occurred in 52% of cases in the first round, and 57% in the second round. Overall, when combining the first and second round, inter-observer agreement on vertebral levels occurred in 54% of cases.

Cephalic vertebra selection: In round 1, the highest level of inter-observer agreement on cephalic vertebra selection in a single case ranged from 0.43 (cases 2 and 8) to 0.64 (Case 6). In round 2, the highest level of inter-observer agreement on cephalic vertebra selection in a single case ranged from 0.50 (case 4) to 0.79 (case 5).

Caudal vertebra selection: In both rounds 1 and 2, the highest level of inter-observer agreement on caudal vertebrae selection in a single case was 0.71 (case 6 in round 1 and cases 2 and 4 in round 2). Also, in both rounds 1 and 2, the lowest level of inter-observer agreement on caudal vertebrae selection in a single case was 0.36 (cases 2 and 10 in round 1, and case 10 in round 2).

Intra-observer reliability: The combined round 1 and round 2 intra-observer average correlation as estimated with Pearson *r* was 0.79 (excellent).

Inter-observer reliability (Table 2): Inter-observer results of round 1 were 0.79 (excellent) (95% confidence interval between 0.62 – 0.93). Inter-observer results of round 2 were .70 (good) (95% confidence interval between 0.50 – 0.89).

Standard deviation (SD) (Table 3): The average SD, calculated for each case between observers, was 6.3 degrees. The largest SD was case 6 (10.15 degrees) and the lowest was case 4 (2.21 degrees).

Range of Cobb Measurements (Table 4): The range between the largest and smallest Cobb Measurements recorded for case 1 in round 1 was 12.56 degrees, and in round 2 it was 29.81 degrees (a difference of 17.25 degrees). The smallest range recorded (8.79 degrees) was for case 4, in round 1 and this was the only case in either round where the range was less than 10 degrees.

Standard Error (SE) (Table 3): SE was calculated for all cases within 95% and 99% confidence intervals. In round 1, the 95% confidence interval ranged from ±1.16 degrees to ±5.31 degrees. The SE within a 95% confidence interval in round 2 ranged from ±1.86 degrees to ±5.25 degrees. The 99% confidence interval in round 1 ranged from ±1.52 degrees to ±6.98 degrees and in round 2 between ±2.45 degrees and ±6.90 degrees.

Table 2.
Intra- and Inter-Observer Reliability

Cobb Angle Correlation Statistics		
		Pearson r Correlation Coefficient
Intra-observer Reliability	Round 1 & Round 2	0.79
		Inter-observer ICC (3,1)
Inter-observer Reliability	Round 1	0.79 (95% CI: 0.62 – 0.93)
	Round 2	0.70 (95% CI: 0.50 – 0.89)

Table 3.
Standard Error (SE) and Standard Deviation of Observer Cobb Angles

		Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10
Round 1 SE	95% CI	±2.37°	±3.27°	±3.68°	±1.16°	±2.90°	±5.31°	±3.55°	±3.92°	±3.37°	±3.48°
	99% CI	±3.12°	±4.30°	±4.84°	±1.52°	±3.81°	±6.98°	±4.66°	±5.15°	±4.43°	±4.58°
Round 2 SE	95% CI	±4.37°	±2.94°	±4.00°	±3.84°	±3.29°	±5.25°	±1.86°	±4.33°	±2.08°	±2.33°
	99% CI	±5.74°	±3.86°	±5.25°	±5.05°	±4.33°	±6.90°	±2.45°	±5.69°	±2.73°	±3.06°
Standard Deviation	*Average*	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10
	6.30	4.54	6.23	7.02	2.21	5.52	10.15	6.77	7.48	6.43	6.68

Table 4.
Range of Observer Cobb Measurements

		Range of Observer Cobb Measurements									
		Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10
Round 1	Greatest Angle	39.16°	48.22°	46.48°	22.92°	26.28°	53.56°	31.48°	53.21°	43.75°	44.83°
	Lowest Angle	26.60°	29.94°	28.39°	14.13°	7.57°	18.09°	6.02°	23.58°	23.85°	19.86°
	Range	*12.56°*	*18.28°*	*18.09°*	*8.79°*	*18.71°*	*35.47°*	*25.46°*	*29.63°*	*19.90°*	*24.97°*
Round 2	Greatest Angle	41.14°	51.31°	49.60°	32.56°	36.75°	57.32°	32.83°	54.34°	43.10°	43.37°
	Lowest Angle	11.33°	30.60°	24.98°	7.71°	14.94°	29.12°	20.09°	28.93°	30.01°	28.01°
	Range	*29.81°*	*20.71°*	*24.62°*	*24.85°*	*21.81°*	*28.20°*	*12.74°*	*25.41°*	*13.09°*	*15.36°*

Discussion

In a 2003 survey, 66.9% of chiropractors reported that they had diagnosed a structural scoliosis and 66.0% reported that they had diagnosed a functional scoliosis in their previous year of practice.[7] The Scoliosis Research Society has established the Cobb method as the standard of measurement to evaluate scoliotic curves and their progression, because it is both simple to perform, and accurate when evaluating repeated measurements.[3] A large body of literature addressing the issues of Cobb Measurement variability and measurement reliability both on an intra- and inter-observer level has been published. This literature offers insight into the Cobb Measurement, variables that affect the proficiency and accuracy of the measurement, and the variability between measurements (inter- and intra-observer reliability).

An accurate Cobb Measurement is important because of the implications that the Cobb Measurement may have in management protocol, which is determined by the degree of curve progression between radiographs.[1] Because digital radiography is rapidly replacing conventional radiography in clinical practice, we used digital radiography to examine the reliability of the Cobb Measurement by chiropractic interns. All areas of investigation included cephalic end vertebrae selection, caudal end vertebrae selection, as well as and intra- and inter-observer reliability analysis of actual Cobb angles.

Oda et al.[3] identified variation in measurement attributed to the selection of end vertebra, measurement accuracy, and variability in measurement technique. The results of the study point to true error of measurement between radiographs on repeated readings to be ± 9 degrees, attributing the wider range of variability to end vertebra selection by the observer.[3] In this study, intra-observer and inter-observer error was 12.61 degrees, and 7.57 degrees respectively.

In situations where the selection of end vertebra was left to be determined by the observer, it was found that 4.2% of Cobb Measurements had more than 5 degrees of variation.[2] In a study of intra-observer and inter-observer variation of scoliosis by Carman et al., participants included four orthopedic surgeons and one physical therapist who observed 8 scoliosis images.[1] The participants measured each radiograph randomly in two sessions with a two-week interval between sessions.[1] While the degree of variability in this study resembled the Oda et al.[3] findings, variations were not quite as high. Carman et al.[1] determined the mean SD to be 2.97 degrees, compared to Oda et al.[3], which was 4.49 degrees.

In one reliability study, Gsteottner et al.[5] evaluated and compared the Cobb Measurement and end vertebra selection on conventional radiographs and digital radiographs. The Gstoettner study found that Cobb Measurement coefficient variance (CV) was dependent on which medium the measurement was obtained and that measurement reliability varied depending on whether the measurements were performed on conventional or digital radiographs.[5] Of special relevance to this study, Gstoettner et al.[5] found that intra-observer selection of end vertebra on conventional radiographs was 'excellent', while it was only 'good' digitally. Inter-observer reliability was found to be 'good' on conventional radiographs and 'excellent' when measured on digital radiographs.[5]

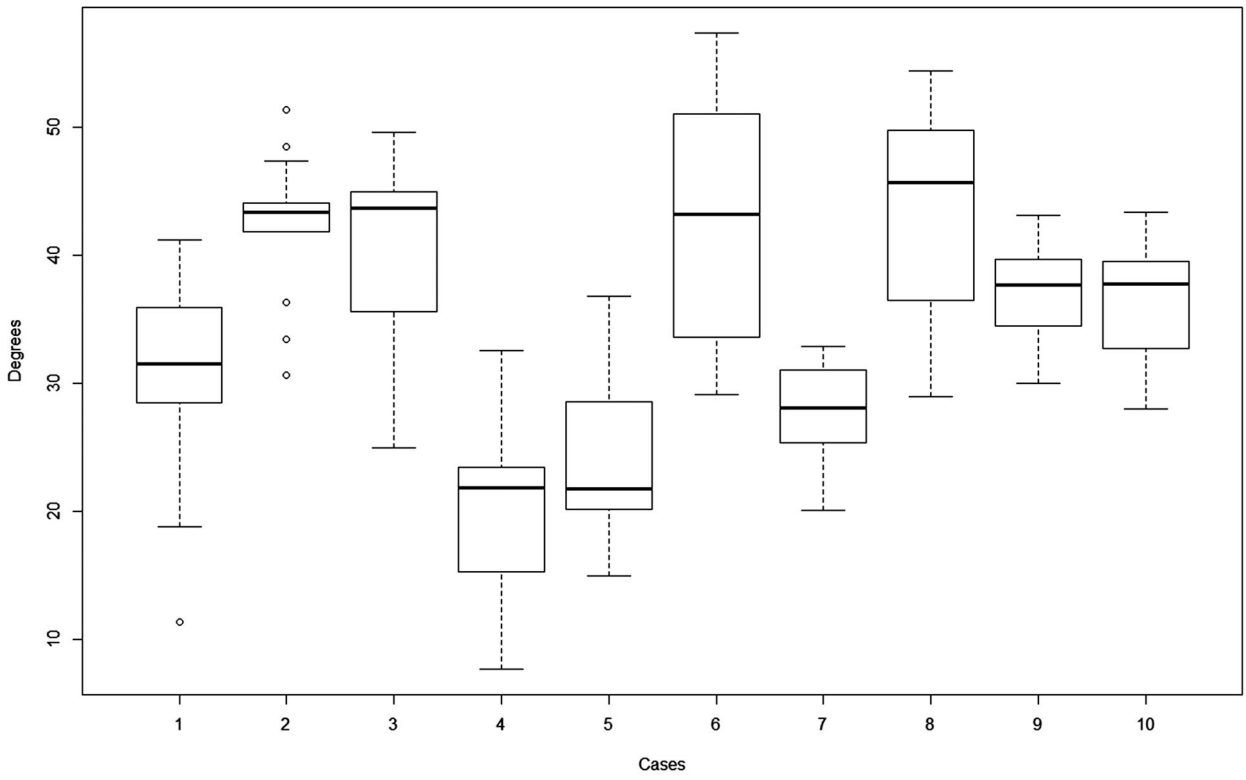

Figure 1.
Boxplot with Whisker Plots of Cobb Measurements

Figure 1. Demonstrates the Cobb Measurements with boxplot and whisker plots. For each box, the lower border is the 25th percentile and the top border is the 75th percentile. The dark line in the middle of the box is the 50th percentile (the median). The whiskers extend to the furthest data point which is within 1.5 times the interquartile range (from the 25th to the 75th). Data points beyond the whiskers are considered outliers and indicated as circles.

Beekman and Hall[8] assessed variability in scoliosis measurement by two physicians, using ten radiographs. Carman et al. tested four orthopedic surgeons and one physical therapist, measuring eight separate scoliosis images.[1] Gstoettner et al. tested inter- and intra-observer reliability of six orthopedic surgeons.[5] Despite the fact that Cobb Measurement reliability has been studied extensively in many licensed health care professionals, it has yet to be examined in interns in training who are still making important contributions to patient management decisions. Carmen et al. examined the clinical importance of observer error in an effort to determine acceptable limits of measurement and subsequent application of changes in patient management.[1] It was proposed that when five degrees or less of measurement difference between radiographs is used to identify curve progression, approximately 30% of patients will meet this criterion because of observer error alone.

The review by Malfair et al.[9] found that the major sources of error leading to variability are a product of radiographic quality, technique, and measurement error. The use of PACS to measure digital radiographs is purported to be equivalent in proficiency to manual measurements on analog conventional radiographs.[9] In an error analysis of scoliosis measurement, it was established that Cobb Measurement error is also not a result of curve magnitude.[10] In this study, Case 6 showed the largest interquartile range (Figure 1) and also the largest Cobb Measurements recorded which

indicates it was it was the curve with the largest magnitude. Case 4 however, recorded far lower Cobb Measurements but also had a large interquartile range. These findings are consistent with the above assertion that error in measurement is not a result of curve magnitude.

Selection of the incorrect end vertebrae has been identified by Gstoettner et al.[5], Morrissy et al.[2], Shea et al.[11], and others as the most significant variable contributing to measurement error. There remains some debate about whether to include selection of end vertebrae in such reliability studies. Some researchers such as De Carvalho et al.[12], Morrissy et al.[2], and Shea et al.[11] elected to eliminate the selection of end vertebrae by the observers by having the researchers pre-select the end vertebrae prior to measuring. For the purpose of this study, we elected to not pre-select the end vertebrae. As such, the observers in our study (interns) were instructed to select the end vertebrae that they believed was most appropriate. While this added another potentially significant variable, we reasoned that this approach is more realistic and that it more accurately reflects the demands of real-life practice.

Intra-observer scores of six orthopedic surgeons using the digital mode of assessment as reported by Gstoettner et al.[5] found that the mean ICC for proximal end vertebra to be 'good' (0.79), for the distal end vertebra to be 'good' (0.80), and the Cobb Measurement ICC to be 'excellent' (0.96). Inter-observer scores using the digital mode of assessment by Gstoettner et al. found that the mean ICC for proximal end vertebra to be 'good' (0.75), for the distal end vertebra to be 'poor' (0.73), and the Cobb Measurement ICC to be 'excellent' (0.93).[5] These findings offer insight into the reliability findings when examining the same variables as proposed by this study. The main difference represented by the fact that all six Gstoettner et al.[5] observer participants were experienced orthopedic surgeons proficient in Cobb Measurement (as opposed to inexperienced chiropractic interns).

There was little inter-observer agreement on cephalic and caudal end vertebra selection. Inter-observer agreement was only 52% in round 1, and 57% round 2. The combined percentage agreement of round 1 and round 2 was 54%. There was no case in round 1 or round 2 where inter-observer agreement was 100% on either or both of the same end vertebrae (cephalic and caudal) in the same case. There was also no case in round 1 or round 2 where inter-observer agreement was 100% on either the cephalic or caudal vertebra in the same case. The combined range of inter-observer agreement in round 1 and round 2 on the cephalic end vertebra is 0.36 – 0.71, and 0.36 – 0.79 on the caudal end vertebra. As a result, it was concluded that inter-observer agreement on end vertebra is not strong. There is not a scale reported in the literature to report this, however the wide range of vertebral level selection and the low percentage agreement in most cases suggest that the observers' ability to identify the correct end vertebra was not strong.

Intra-observer reliability of the Cobb Measurement was estimated using the Pearson *r* correlation coefficient (see Table 2). The average intra-observer reliability was 0.79 (excellent) following round 1 and round 2 evaluations. These values imply that there is 'excellent' reliability of the assessment of the Cobb Measurement on an intra-observer level. Consequently, it may be concluded that chiropractic interns were effective and proficient in Cobb Measurements when each intern performs multiple Cobb Measurements on the same subject.

Many patients choose a chiropractic clinic for management of problems related to the spine. As a result, there is a need for chiropractors to become especially proficient in radiologic spinal measurement and assessments such as the Cobb Measurement. Therefore, there is a need to place further emphasis on the Cobb angle measurement as well as to assign more practice opportunities for chiropractic students and interns during the course of their education. This will better develop their proficiency and thereby better prepare interns for the challenges of treating patients professionally.

Limitations

This study was limited in that it only includes chiropractic interns enrolled at the same chiropractic college in the Northeastern United States. There were 17 total interns at the time of this study attending this chiropractic college, and 14 completed the study. The study could have been improved by increasing the sample sizes of images and of students. The study does, however, meet and at time exceed previous studies.

Conclusion

It was concluded that inter-observer reliability of the Cobb Measurement between chiropractic interns was 'good' to 'excellent'. If the premise is accepted that a 95%

confidence interval is acceptable in regard to the Cobb Measurement reliability, then the observers in this study were accurate and thus are unlikely to make incorrect management decisions based on poor radiographic analysis. However, it is likely that larger degrees of error will occur in chiropractic interns than in other more experienced health care professionals described in the literature such as orthopaedic surgeons.

There is a need for further research on the reliability of the Cobb Measurement in both chiropractic interns, and graduate chiropractors. This study was specific to chiropractic interns who attended the same chiropractic school, and have received the same chiropractic and radiologic education. It is suggested that this study be expanded to include a wider range of chiropractic interns with a broader representation of chiropractic schools. Such a study will provide a better understanding of the larger population of chiropractic interns and their proficiency in the Cobb Measurement.

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Chiropractic management of a patient with breast cancer metastases to the brain and spine: a case report

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Cancers of the breast, kidney, lungs, prostate and thyroid metastasize to the musculoskeletal system in the majority of patients with malignancy. This report chronicles the case of a 65-year-old female with a known history of breast cancer who presented to a chiropractic clinic. Once metastasis was ruled out as the cause of her complaint, the patient was treated with manual therapies and exercises. As the patient's treatments progressed and her pain improved, she presented with a new complaint of 'pressure' in her head. Advanced imaging revealed metastasis to the brain and subsequently to the spine. The aim of this case is to heighten awareness of the presentation of metastasis to the brain and the spine in a chiropractic patient, and to demonstrate the benefit of chiropractic care in the management of such patients.

(JCCA. 2015;59(3):269-278)

KEY WORDS: breast cancer, spinal metastases, brain metastases, chiropractic care, chiropractic

Les cancers du sein, du rein, des poumons, de la prostate et de la thyroïde métastasent dans l'appareil locomoteur pour la majorité des patients atteints de tumeurs malignes. Cette étude décrit le cas d'une femme de 65 ans ayant des antécédents connus de cancer du sein et qui s'est présentée à une clinique de chiropratique. Une fois la métastase écartée comme cause de sa plainte, la patiente a été traitée par des thérapies manuelles et des exercices. Alors que les traitements de la patiente avançaient et sa douleur s'atténuait, elle a commencé à se plaindre d'une « pression » dans la tête. Une imagerie avancée a révélé des métastases au cerveau et plus tard à la colonne vertébrale. Le but de cette étude est d'accroître la sensibilisation à la manifestation des métastases au cerveau et à la colonne vertébrale chez un patient chiropratique, et de démontrer les bienfaits des soins chiropratiques dans la gestion de ces patients.

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MOTS CLÉS : cancer du sein, métastases vertébrales, métastases cérébrales, soins chiropratiques, chiropratique

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Consent: Written consent was obtained from the patient to include information and images from her file for this case report.

Introduction

Tumours of the breast, lung, kidney, prostate and thyroid metastasize to the skeletal system in approximately 70% of cancer patients.[1] With newer developments in cancer treatments, incidence of metastases to the spine and other organs such as lungs, liver and brain is increasing along with survival.[2] Patients with a history of cancer often present to chiropractic clinics with neuromusculoskeletal symptoms. A survey of patients with early stage breast cancer found that 28.1% of patients seek alternative medicine along with their standard therapy, including acupuncture, chiropractic and massage therapy.[3] Twelve to twenty percent of patients present with back pain or headaches, often as the initial presentation of symptomatic spinal metastasis.[2,4]

This case report describes the chiropractic management of a patient with a known history of breast cancer, which metastasized. The patient presented to the clinic with pain in the neck and low back, and with a history of breast cancer with metastasis to the lungs. As the patient's cancer progressed she then developed metastasis to the liver, brain and spine. This case report highlights metastases to the spine, and describes their clinical presentation and concurrent chiropractic management; and metastasis to the central nervous system, which may manifest as headaches, a symptom commonly presented at chiropractic practices.

Case

A 65-year-old female was referred by her family physician to a chiropractic clinic for acute low back pain (LBP), but presented to the chiropractor with a chief complaint of neck and mid-back pain. The pain in her cervicothoracic (C/T) region started insidiously two days prior, when she noticed a sharp pain in her neck and numbness and tingling in both hands. The patient also complained of LBP that she had experienced for the last 25 years; the recent acute episode, caused by coughing and pulling a suitcase, which had triggered the referral had resolved within days since the referral was initiated.

She rated the intensity of her neck pain as 9 out of 10 (0 representing no pain at all and 10 representing the worst pain ever felt). The patient scored 44% on the Oswestry Disability Index, indicating severe disability, and 18 out of 50 on the Neck Disability Index, indicating moderate disability. Movement and recumbency were aggravating factors for her C/T pain, but no relieving factors were identified. Advil and swimming attenuated her LBP. Inquiry about current red flags revealed that she experienced no night sweats, fever or chills, headaches, dizziness, dysphagia, or significant change in weight. However, she did experience unrelenting C/T pain that woke her up at night, and had a previous history of cancer.

Her family history was significant for multiple myeloma and Parkinson's disease in her mother, lung cancer in her father and pancreatic cancer in an aunt. Her medical history was significant for osteoporosis since 2008, irritable bowel syndrome, benign paroxysmal positional vertigo, and breast cancer, for which she had received and

Table 1.
Chronology

Year	Event
1987	Lumpectomy for right lobular carcinoma in situ (LCIS) Patient prescribed Tamoxifen for 5 years
June 2010	Ultrasound showed highly suspicious area in right upper quadrant Biopsy confirmed invasive ductal carcinoma in situ (DCIS)
February 2011	Patient started radiation therapy
August 2011	In assessing exertional dyspnea, chest x-ray reveals recurrence of right breast cancer, metastasis to lung with malignant pleural effusion CT scan shows pulmonary metastasis and right axillary lymphadenopathy Patient started on chemotherapy
October 2011	Recurrence of chronic LBP, radiates to right groin and proximal thigh; negative neurological assessment X-rays reveal lumbar spinal OA, severe OA of right hip Patient receives physiotherapy
November 2011	Patient resumes chemotherapy
January 2012	Full body CT scan shows no further metastasis
February 2012	Referred to chiropractic clinic re: acute LBP, but patient complains of neck pain and dorsalgia
March 2012	Spinal x-rays taken Cervicothoracic symptoms resolved; patient advised to consider chiropractic SMT over prednisone for recurring LBP
April 2012	Patient has difficulty balancing & abnormal gait Presents to the chiropractic clinic with "pressure" in her head, aggravated by forward bending MRI reveals Stage 4 cancer with metastasis to brain, liver and lungs Neurological symptoms improve after 2 sessions of radiation therapy and taking steroid medication
May 2012	Pathological compression fractures of T9 & L1 vertebral body Kyphoplasty at T9 & L1
June 2012	Referred for palliative radiation therapy Chest x-ray reveals progressive metastatic disease Patient admitted to hospice

Figure 1A

Figure 1B

Figure 1.

Lateral (A) and lower AP (B) cervical radiographs reveal moderate disc space narrowing at C5-C6 and C6-C7 with uncovertebral arthrosis. Mild facet arthrosis visualized from C2 – C4.

was again receiving chemotherapy. The timeline related to her past medical history is outlined in Table 1.

Examination revealed a frail woman in moderate distress. Active, passive and resisted ranges of motion of the cervical spine were moderately restricted and painful in flexion, lateral flexion and rotation. Extension of the cervical spine was markedly limited due to elicitation of severe C/T pain. Cervical Kemp's (compression, extension and rotation), Jackson's (cervical rotation plus compression), Spurling's (cervical lateral flexion and compression) and thoracic outlet tests created some local pain but did not elicit upper extremity symptoms. Valsalva maneuver caused some increased pain in her cervicothoracic region. Spinous percussion was unremarkable. The Soto-Hall test (passive head and neck flexion with stabilization of the sternum of the supine patient) exacerbated her neck pain.

Palpation revealed tenderness in the rhomboid, trapezius and C/T paraspinal musculature, bilaterally. Joint mobility restrictions were also found on palpation at C4-C5, C7-T1 and T3-T4 levels. Sensory examination revealed intact light touch in the upper extremities. Motor testing revealed generalized weakness graded 4/5 that could be attributed to previous and ongoing chemotherapy.[5] Deep tendon reflexes (biceps, brachioradialis and triceps) were 1+ bilaterally, and Hoffman's sign was absent.

In patients with a history of cancer and new onset of pain, a diagnosis of metastasis should be considered until ruled out. In order to rule out more serious pathologies such metastasis to the spine and compression fracture, the patient was referred for full spine radiographs. The radiographs revealed moderate disc space narrowing from C5 – C7 and L4 – S1, mild disc space narrowing from L2 – L4 and minimal facet joint sclerosis at C2 – C3 (Figures 1A and 1B). There were old endplate compression

Figure 2A

Figure 2B

Figure 2C

Figure 2.

AP thoracic (A) radiograph reveals the old compression fracture at T6. Lateral (B) and AP (C) lumbar radiographs demonstrate the old compression fracture at L1 (arrows). Mild (L2-L3), moderate (L4-L5) and marked (L5-S1) disc degeneration is evident.

fractures noted at T6 and L1 (Figures 2A-C). The patient was also sent for a bone scan by her family doctor, which showed no metastasis to the spine.

The patient was diagnosed with and treated for cervicothoracic and lumbopelvic strains. Since clinical examination could not reproduce the paresthesias in the hands, this symptom was considered to possibly arise from chemotherapy or an undetected thoracic outlet syndrome. Chemotherapy-induced peripheral neuropathy is present in up to 40% of patients receiving chemotherapy, commonly presenting as paresthesia and dysesthesia in the fingers and toes.[5]

The patient was treated nine times over the span of a month. Her treatments included soft tissue therapy, mobilization, cryotherapy, heat and rehabilitative exercises. Rehabilitative exercises included neck range of motion, stretches and isometric exercises; low back and hip stretches, "bird dog" and plank exercises were prescribed for her low back (hold 10 seconds, repeat five times). As there was no metastasis to the spine, confirmed with radiographs and the bone scan, the patient was also offered spinal manipulation for her neck pain and mobilization for her lumbar spine. In providing informed consent for treatment, the patient stated that she might consider spinal manipulation in the future, if the soft tissue therapy and mobilization were ineffective. Acknowledging the patient's preference and apprehension in receiving spinal manipulation, the practitioner employed a patient-centred approach and abstained from manipulation. Within a few treatments the patient's C/T pain resolved, while her LBP persisted. (At the third visit, the patient reported that since resuming chemotherapy in November 2011, she had con-

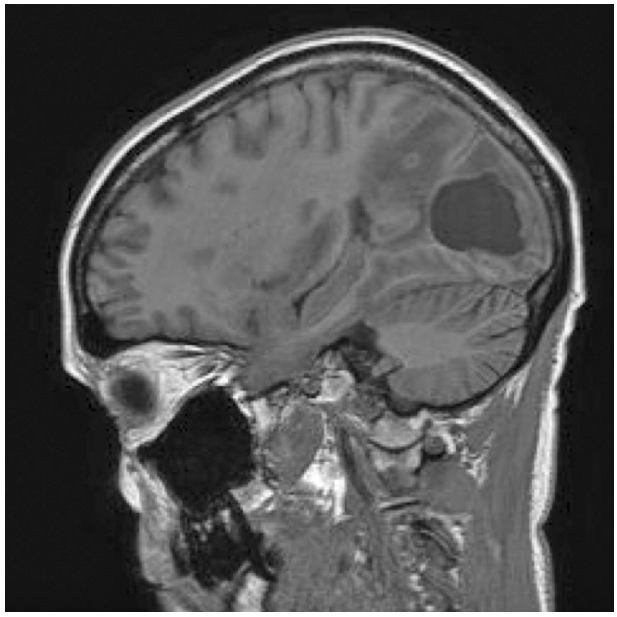
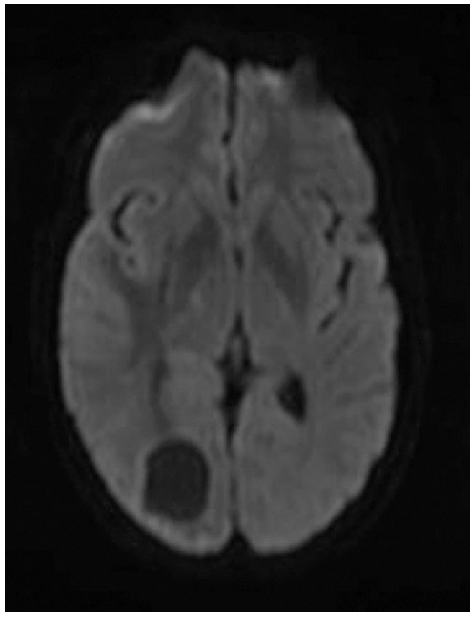
Figure 3A   Figure 3B

Figure 3.
Sagittal (A) and axial (B) T1-weighted images following intravenous injection with gadolinium demonstrate a large intra-axial mass located in the right occipital lobe.

stant paresthesiae in toes 1 – 4 bilaterally. The symptom was reproduced then with Tinel's test at the tarsal tunnel, bilaterally.)

On a scheduled visit for her LBP (for which she was considering receiving spinal manipulation, having had this option recommended by her family physician over taking prednisone) a month after her initial visit, the patient presented with a complaint of significant "pressure" in her head. She had also been experiencing difficulty balancing, and was observed to have an abnormal gait. During treatment she had difficulty maintaining a prone position, feeling increased pressure in her head with forward flexion. A letter documenting the unusual increase in severity of her headache, abnormal gait and difficulty tolerating the prone position was sent to her family physician, who noted she also had difficulty with reading, and had developed urinary urgency.

The patient was subsequently referred for magnetic resonance imaging (MRI) that revealed that the Stage 4 breast cancer had further metastasized to her lungs, liver and brain (Figures 3A and 3B). The patient commenced a course of whole brain radiotherapy and decided to temporarily refrain from chiropractic treatment.

A few weeks later the patient experienced a significant increase in her LBP. She was referred for radiographs by her family physician, which revealed new pathologic compression fracture of the T9 vertebral body and old osteoporotic compression fractures at T6 and L1 (Figures 4 and 5). The patient was referred to an orthopedic surgeon and underwent kyphoplasties at the levels of T9 and L1, after which she experienced significant reduction in the intensity of her back pain.

In June 2012, chest x-rays revealed progressive metastatic disease. The patient became anorexic. Follow-up of the patient a few months later revealed she had moved to a hospice for palliative care.

Discussion

Breast cancer is the most common malignancy afflicting women in North America and is one of the leading causes of cancer-related death in women.[6,7] Risk factors for breast cancer include a positive family history, older age,

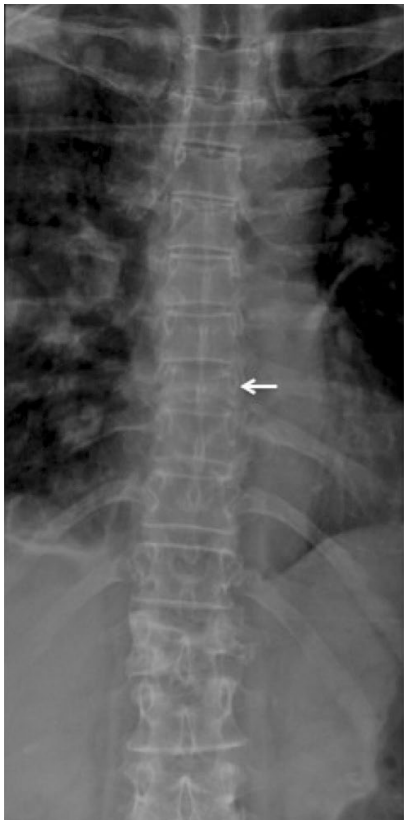


Figure 4.
AP thoracic radiograph reveals a new compression fracture at T9 (arrow).

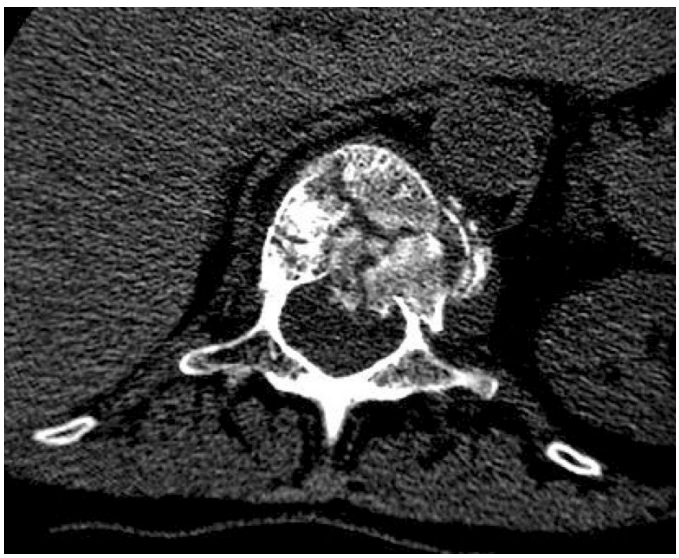


Figure 5.
Axial computed tomography (CT) reveals a burst component to the compression fracture with projection into the spinal canal.

younger age at menarche and older age at menopause.[6,7] The incidence increases until the age of 50 and in individuals with a family history of breast cancer (particularly in first-degree relatives).[6] Childbearing increases the risk of cancer soon after birth, but the risk then diminishes such that childbirth confers protection.[7] Other risk factors are oral contraceptive use and hormonal therapy for menopause.[7]

The patient in our case presented to the chiropractic clinic with a new onset of neck pain, chronic LBP and a known history of breast cancer. Therefore, the priority for our patient was ruling out metastasis to the spine. The patient was sent for radiographs and a bone scan, which ruled out skeletal metastasis. A few weeks into her treatment plan, the patient's neck pain had subsided, but she still had complained of chronic LBP.

On a routine subsequent visit, she complained of a "pressure" in her head. She also had trouble balancing and found her gait altered. She was sent for a brain MRI that revealed metastasis to the brain, which occurs in 10-16% of patients with stage IV breast cancer, arising within the parenchyma or the leptomeninges.[8] The latency between diagnosis of breast cancer and metastasis to the central nervous system (CNS) is two to three years. In the majority of cases, metastasis to the CNS occurs after spread to the liver, lung and bones, generally in the late stage of breast cancer.[8]

The most common presenting symptom of a parenchymal metastasis, headache (which our patient developed), occurs in up to 48% of patients. Headaches associated with intracranial masses may be described as a dull ache, pressure or throbbing.[9] The headaches do not occur daily, vary from moderate to severe intensity, and are frequently accompanied by nausea, papilledema, blurred vision and neurological deficits.[9,10] Only a small percentage of patients present with more ominous headache characteristics such as morning or nocturnal incidence, worsening pain with Valsalva maneuver, and change in presentation of pre-existing headaches.[9,10] Patients also frequently present with altered mental status, cognitive disturbances, motor deficits, seizures, ataxia, nausea and vomiting.[8,11] Magnetic resonance imaging with gadolinium is the most sensitive test to diagnose metastasis to the CNS.[8]

Metastasis to the CNS generally occurs in the late stage of breast cancer. The prognosis for patients with CNS metastasis is poor, with the mean survival time varying from

two to 16 months. The one-year survival rate of these patients is 20%.[8,11] Treatments for patients with CNS metastasis include corticosteroids to decrease cerebral edema, whole brain radiotherapy, surgery and chemotherapy.[8]

The patient in our case developed spinal metastasis after metastasis to the CNS. Tumours metastasize to the spine via the arterial system, Batson's venous plexus, or cerebrospinal fluid, or by direct extension from a paraspinal tumour.[12] Bone is a preferred site for metastasis as it is highly vascularized and rich in growth factors.[13] Spinal metastasis most commonly occurs in patients aged 40 – 65 years. Though the lumbar spine is the most commonly involved region of the spine, metastasis is most symptomatic when it occurs in the thoracic spine.[12] Metastasis to the spine can cause significant morbidity, pain, restricted motion, pathological fractures, compression of the spinal cord and hypercalcemia.[14]

Bone pain is one of the earliest symptoms, occurring in 90% of patients with spinal metastasis.[4,12] It is poorly localized, insidious in onset and progressive in nature.[4,14] The pain is characterized as a deep boring pain that awakens the patient at night or in the early morning, and which may improve with activity during the day. The pain can be caused as a result of release of inflammatory mediators, stretching the periosteum of the vertebral body, reactive muscle spasm and microfractures.[4,14–16] In contrast to patients with typical mechanical pain, cancer related pain is not aggravated by activity and may occur at rest.[4] Patients may also present with paraspinal muscle spasms and altered biomechanics.[14,17]

Metastasis results in a reduction in load-bearing capabilities by causing pathological trabecular microfractures and loss of structural integrity.[14] The most common fractures in these patients are vertebral compression fractures and rib fractures.[14] Neurological compression most commonly occurs in the thoracic spine and arises as a result of cord compression from the tumour, retropulsion from pathological vertebral body fracture fragments, or intradural metastasis.[4]

When patients present to a chiropractor, a thorough history and physical examination help discern whether the symptoms are of pathological or mechanical origin.[12] During the patient's history, practitioners should aim to rule out "red flags" that often suggest a more serious underlying pathology. Patients who present with constant progressive pain, past medical history of malignancy, unexplained weight loss, or nocturnal symptoms should raise suspicion of malignancy.[18] During the physical examination, practitioners should look for midline tenderness at affected levels during spinous percussion and palpation, and neurological deficits including numbness, weakness and pathological reflexes.[12]

Diagnostic imaging is required to confirm the diagnosis of skeletal metastasis. On plain radiographs, metastatic lesions are classified as osteolytic, osteoblastic or combined osteolytic and osteoblastic.[4] At least 50% destruction of bone is required before the lesion is visible on a plain radiograph, which makes it hard to detect metastasis radiographically early in the course of the disease.[4] Destruction of the pedicle, displacement of paraspinal shadows, and compression fracture are common radiographic findings.[12]

Bone scans, capable of detecting lesions with 3% – 5% of bone loss, are more sensitive in detecting metastases, up to 18 months before radiographs.[2,15,17] They are also advantageous as they are able to scan the entire body at the same time in search of metastases throughout the axial and appendicular skeleton. Bone scans are not specific in differentiating lesions from compression fractures, infections or degenerative changes, requiring supplementation with other imaging.

Magnetic resonance imaging is the most sensitive and specific imaging modality in detecting metastasis and is considered the gold standard.[2,15] Magnetic resonance imaging is important to differentiate osteoporotic compression fractures from pathological fractures; both commonly occur in cancer patients[15], in whom skeletal metastasis can cause significant morbidity and mortality[14]. The prognosis for patients with skeletal metastasis is poor, with only 20% of patients surviving five years after diagnosis.[13]

Patients with cancer may present with tumour-related pain and with various musculoskeletal dysfunctions.[15] Cancer patients may receive radiation therapy, which can cause fibrosis of normal tissue, resulting in restricted and painful ranges of motion.[19] Patients may also present with pain related to joint dysfunction due to long periods of immobilization in the hospital and during recovery. Furthermore, pathologic compression fractures result in severe pain causing patients to alter the way they sleep; e.g., patients with a kyphotic deformity may sleep upright for many weeks until the pain subsides, as lying supine

may aggravate their pain.[15] Unfortunately, pathology does not exempt patients from quotidian musculoskeletal dysfunction.

Medical treatment of patients with cancer has traditionally been focused on treating the disease and its immediate sequelae. The treatment options available for spinal metastases include chemotherapy, bisphosphonates, radiation therapy, surgery and kyphoplasty.[14,15] Treatment for these patients is palliative and aimed at reducing disability.[2] Recently, there has been acknowledgment of the need to improve patients' quality of life; e.g., multi-disciplinary treatments, including complementary and alternative therapies, to aid in pain management.[19]

This patient was treated with chiropractic care including myofascial massage (soft tissue therapy), mobilization, education and exercises. She responded well to chiropractic care and obtained unique relief from chiropractic treatment that she was unable to achieve from analgesic medication. She did not receive spinal manipulation as part of her treatment plan, though it was not considered absolutely contraindicated in our case. Cervical manipulation was considered in the plan of management because of the anticipation of more effective treatment of joint dysfunction.[20]

Manipulation of pathologically-affected motion segments is absolutely contraindicated, as there is potential for fractures due to compromised bone quality and, possibly, consequent spinal cord compromise. However, malignancy *per se* should be considered a relative contraindication to manipulation or other manual therapies in cancer patients, and practitioners should formulate treatment plans tailored to each patient's unique presentation and needs.[19] In patients with malignancy who do not have compromised bone quality, spinal manipulation could be considered in the treatment plan, as it can offer symptomatic relief and improved function for the patient.[19] Patients with compromised bone strength may be treated with low force techniques and achieve good clinical outcomes. However, practitioners should remain vigilant for signs and symptoms of metastasis, since rates of metastasis are increasing as newer and more effective cancer treatments are increasing survival.[2]

Aside from the improvement in symptomatology, function and quality of life obtained from the chiropractic therapy, this patient's case reveals less obvious advantages she derived from her chiropractic management. It is unusual for a patient to present with a significant problem, especially actual or suspected malignancy, without concomitant confusion, fear, anxiety, depression or anger.[21] Patient-centred health care based on the biopsychosocial model of illness requires providers to address the psychological and emotional facets of a patient's presentation as much as the physical ones, yet few primary care practitioners find the time to do so adequately. Although chiropractors have traditionally succeeded at establishing good rapport with their patients[22], they may feel unqualified to address complex concomitants of patients' somatic presentations, even when scheduling could be accommodative. At best, patients whose needs have at least been identified may be referred for concurrent care by another appropriate health care provider, though in financially overburdened health care systems, the referral may not be effected for weeks or months.

In this case, the patient, often accompanied by her husband, typically brought lists of questions about her condition, therapy, alternatives, progress, etc. to her chiropractic appointments, requiring scheduling of lengthier treatment sessions to address her needs more comprehensively. She often volunteered that she valued the psychological relief she felt from knowing she had this resource available to her and the reassurance she derived from knowing that everything possible was being done to assess, treat and monitor her entire health status by each of the providers of her health care team. She also related the profound relief she felt from the opportunity afforded to her by the regular chiropractic treatment schedule to vent the intense emotions affecting her to an empathic practitioner.

The nature of administration of many complementary therapies requires the patient to attend more frequently than, for example, for medical management. Therein lies the inherent potential benefit of quicker detection of new or worsening symptoms or signs. This was another benefit the patient in this case derived from her chiropractic management, as the detection of new symptoms and signs, which may have remained unexplored for a significant time if she were only attending for medical follow-ups, prompted the chiropractic referral to the family physician, which led rapidly to detection of further metastasis. Although this did not ultimately effect cure in this case, avoiding delay in effective treatment based on definitive diagnosis is critical for cure when it can be attained.[23] Thus, the patient's confidence and trust in her chiropractic

management, which included ongoing collaboration with her medical physician, was justified.

Summary

Patients may often present to chiropractic clinics with a known history of cancer, with musculoskeletal pain as the first manifestation of undiagnosed cancer, and with benign musculoskeletal dysfunction. Practitioners should complete a thorough history and physical examination in order to rule out serious underlying pathology prior to initiating treatment. Practitioners should be cognizant that in patients presenting with cancer, metastasis to the CNS may occur earlier than to the skeletal system. Patients with headaches and a known history of cancer should be evaluated for the presence of intracranial space occupying lesions. In any patient with new onset of spinal pain and a known history of cancer, a diagnosis of metastasis should be considered until ruled out.

Once malignancy has been diagnosed, chiropractors can still have a role to play in the interdisciplinary management of patients, offering effective treatments for relief of dysfunction and symptoms.[19] Patients with malignancy can still be treated with chiropractic care including spinal manipulation, mobilization, soft tissue treatments, education and rehabilitative exercises. The patient in our case underwent a thorough history and physical examination with appropriate diagnostic imaging, and received patient-centred treatment and chiropractic care.

Cancer patients, like the one described in this case report, often respond well to chiropractic care, achieving outcomes that are unattainable by medication or other therapies, or that reduce the patient's requirement for analgesic or narcotic medication. For cancer patients who are often on multiple pharmaceutical regimens for years, reduction of the need for any medication is in itself a desirable outcome. As illustrated by this case, patients can also benefit from chiropractic treatment, with its typical requirement for attending in person for the physical administration of treatment more frequently than attending the family physician or medical specialists, by being assessed more frequently and having any new developments in status recognized and managed appropriately, including communicating with other involved members of the health care team. Patient-centred treatment provided by any health care practitioner must involve establishment of good rapport with the patient in order to discover and address all facets of their illness.

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Diagnostic and treatment methods used by chiropractors: A random sample survey of Canada's English-speaking provinces

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Objective: *It is important to understand how chiropractors practice beyond their formal education. The objective of this analysis was to assess the diagnostic and treatment methods used by chiropractors in English-speaking Canadian provinces.*

Methods: *A questionnaire was created that examined practice patterns amongst chiropractors. This was sent by mail to 749 chiropractors, randomly selected and stratified proportionally across the nine English-speaking Canadian provinces. Participation was voluntary and anonymous. Data were entered into an Excel spreadsheet, and descriptive statistics were calculated.*

Results: *The response rate was 68.0%. Almost all (95.1%) of respondents reported performing differential diagnosis procedures with their new patients; most commonly orthopaedic testing, palpation, history taking, range of motion testing and neurological examination. Palpation and painful joint findings were the most commonly used methods to determine the appropriate*

Objectif : *Il est important de comprendre la pratique des chiropraticiens qui dépasse le cadre de leur éducation formelle. L'objectif de cette analyse était d'évaluer les méthodes de diagnostic et de traitement utilisées par les chiropraticiens dans les provinces canadiennes anglophones.*

Méthodologie : *Un questionnaire a été créé pour examiner les habitudes de pratique des chiropraticiens et a été envoyé par la poste à 749 d'entre eux, choisis au hasard et stratifiés proportionnellement entre les neuf provinces anglophones. La participation était volontaire et anonyme. Les données ont été saisies dans un tableur Excel, et les statistiques descriptives ont été calculées.*

Résultats : *Le taux de participation a été de 68,0 %. Presque tous (95,1 %) les répondants ont déclaré effectuer des diagnostics différentiels de leurs nouveaux patients; plus couramment des tests orthopédiques, la palpation, l'anamnèse, des tests d'amplitude de mouvement et l'examen neurologique. La palpation et la détection d'articulations douloureuses étaient les méthodes les plus couramment utilisées pour déterminer*

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joint to apply manipulation. The most common treatment methods were manual joint manipulation/mobilization, stretching and exercise, posture/ergonomic advice and soft-tissue therapies.

Conclusions: *Differential diagnosis is a standard part of the assessment of new chiropractic patients in English-speaking Canadian provinces and the most common methods used to determine the site to apply manipulation are consistent with current scientific literature. Patients are treated with a combination of manual and/or manipulative interventions directed towards the joints and/or soft-tissues, as well as exercise instruction and postural/ergonomic advice.*

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KEY WORDS: chiropractic, survey, differential diagnosis, diagnostic testing, treatment methods

l'articulation appropriée à manipuler. Les méthodes de traitement les plus fréquentes étaient la manipulation ou la mobilisation manuelle des articulations, les étirements et les exercices, les conseils posturaux ou ergonomiques et la thérapie des tissus mous.

Conclusions : *Le diagnostic différentiel fait partie de la norme d'évaluation de nouveaux patients chiropratiques dans les provinces anglophones canadiennes, et les méthodes les plus couramment utilisées pour déterminer les points à manipuler concordent avec les publications scientifiques actuelles. Les patients sont traités par une combinaison d'interventions manuelles ou de manipulation axées sur les articulations ou tissus mous, ainsi que par des instructions d'exercice et des conseils posturaux et ergonomiques.*

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MOTS CLÉS : chiropratique, enquête, diagnostic différentiel, tests de diagnostic, méthodes de traitement

Introduction

Doctors of Chiropractic (DC) focus on the evaluation and management of disorders of the musculoskeletal system[1] and there is a movement towards adopting a role as primary spine care providers[2,3]. The appropriate management of a patient requires the DC to diagnose the complaint, determine the best course of treatment and finally, provide that treatment, or refer to another healthcare provider for appropriate care. DCs are taught numerous diagnostic and therapeutic procedures during their undergraduate education and clinical internships and perhaps just as important, they are also able to obtain certifications through seminars and continuing education courses to employ a diversity of assessment and treatment techniques that may not be introduced within the context of their formal educational settings. It is imperative that we understand how Canadian DCs diagnose and treat their patients in order to guide research, guide the undergraduate, post-graduate and continuing educational chiropractic curricula, as well as to inform all stakeholders, including the public, insurance companies and government agencies about chiropractic practice. While previous studies have investigated similar topics among Canadian DCs[4-7], those previous examinations are limited by the age of the analysis[4], limited sampling[5-7], or poor response rates[6,7], resulting in poor reliability and generalizability. Moreover, no previous study has specifically investigated what methods Canadian DCs are using in clinical practice to decide where to apply joint manipulation, which is the most notable treatment method used by chiropractors.[8] The objectives of this descriptive analysis of DCs in English-speaking Canadian provinces were to 1) determine if DCs are performing differential diagnosis procedures and describe the methods used for this purpose; 2) describe the tests/procedures used to determine the site of joint manipulation and the frequency of their use; and 3) describe the treatment methods used and the frequency of their use.

Methods

Survey development and administration have been detailed in previous works.[9,10] In short, a 16 item survey instrument was developed by the authors that included topics ranging from practice techniques to practice philosophy. This paper reports on the data from three questions (Figures 1-3), which specifically addressed approaches to diagno-

A) When a **new patient** presents to you, do you perform a **differential diagnosis**? ❑ Yes ❑ No

B) If yes, which of the following do you usually use to help make a **differential diagnosis**? Mark all that apply.

❑ Blood pressure	❑ Leg length measurement	❑ Posture analysis
❑ Gait analysis	❑ Motion/static palpation	❑ Surface EMG
❑ Gross ROM analysis	❑ Muscle testing	❑ Thermography
❑ History (Complete health)	❑ Neurological exam	❑ X-ray
❑ History (Focused)	❑ Orthopaedic testing	❑ Other _____

Figure 1.
Survey item for assessing the differential diagnostic tests/procedures used by Canadian DCs.

On approximately what percentage of patients do you use the following methods to **decide where to adjust?**

0 = never **1** = 1-25% (rarely) **2** = 26-50% (often) **3** = 51-75% (usually) **4** = 76-100% (almost always)

____ Gross ROM analysis	____ Nerve conduction study	____ Surface EMG
____ Leg length analysis	____ Orthopaedic testing	____ Thermography
____ Motion/static palpation	____ Painful joint findings	____ X-ray measurements
____ Muscle testing	____ Posture analysis	____ Other_____

Figure 2.
Survey item for assessing the clinical tests/procedures used by Canadian DCs to determine the most appropriate site to apply joint manipulation.

On approximately what percentage of your patients do you use the following **methods of treatment**?

0 = never **1** = 1-25% (rarely) **2** = 26-50% (often) **3** = 51-75% (usually) **4** = 76-100% (almost always)

____ Adjustments/Mobilization (manual)	____ Nutritional supplements
____ Adjustments (instrumented)	____ Orthotics
____ Acupuncture	____ Postural/ergonomic advice
____ Cold laser	____ Soft tissue therapy (e.g., thumper, ART, Graston)
____ Dietary advice	____ Stretches/Exercise (in clinic or prescribed)
____ Electrotherapy (e.g., TENS, IFC)	____ Traction/distraction (manual/mechanical)
____ Homeopathic remedies	____ Ultrasound
____ Hot/Ice packs	____ Other_____

Figure 3.
Survey item for assessing the treatment methods used by Canadian DCs.

sis and treatment. The survey instrument was tested by ten DCs and revisions were made to the survey instrument after interviewing the test subjects to identify any problems. A list of all currently licensed DCs for each of the nine English-speaking Canadian provinces was developed from the online directories of the provincial chiropractic licensing bodies. A random sample was selected from each provincial list using a computerized random number generator; the final sample included 749 DCs (12% of eligible DCs), stratified proportionally across the English-speaking Canadian provinces. The survey was administered by mail from August 2010 to December 2010 and used postage-paid, return addressed envelopes and two follow-up mailings to maximize response rates.[11] Surveys were mailed with a personalized letter briefly explaining the purpose of the study, guaranteeing anonymity and providing a means of avoiding future mailings if they did not wish to participate; informed consent was implied by participation. The CMCC Research Ethics Board approved the study protocol (REB Approval # 1006X02) and the CMCC Research Division provided all funding.

In order to determine the use of various diagnostic procedures by DCs for the purposes of differential diagnosis, subjects were asked to document, from alphabetized lists of tests/procedures, which procedures they commonly used (Figure 1). With regard to determining where to apply joint manipulation, subjects were asked to document, from an alphabetized list of diagnostic procedures, which tests/procedures they used and also to indicate the percentage of patients on whom they used each procedure (Figure 2). To determine which treatment methods are being employed, participants were asked to document, from an alphabetized list, which treatment modalities they used and the frequency with which they are used (Figure 3).

All survey data were entered into an electronic spreadsheet by two authors using the double data entry method to control for errors. Descriptive statistics were used to report the data.

Results

Of 740 deliverable surveys, 503 were returned, a response rate of 68.0%; seven respondents returned the cover page only, indicating they did not wish to participate; nine surveys were undeliverable. The majority of respondents were male (68.4%); had attained a Bachelor's degree prior to attending chiropractic college (76.2%); and had attended chiropractic college at CMCC (62.6%). The average number of years in practice was 14.9 (standard deviation ±11.0). Table 1 contains the response rates and demographic information of respondents by province.

Table 1.
Response rates and respondent demographics by province.

Province	Surveys mailed / [a] Licensed DCs	Response rate; % (N)	Male responder; % (N)	Years in practice; Ave (SD)	[b] Bachelor degree; % (N)
BC	103/851	71.3 (72)	76.4 (55)	16.3 (10.5)	63.9 (46)
AB	117/971	68.1 (79)	78.5 (62)	14.4 (9.9)	63.3 (50)
SK	21/170	76.2 (16)	62.5 (10)	15.8 (11.7)	75.0 (12)
MB	33/271	68.8 (22)	81.8 (18)	19.8 (15.9)	77.3 (17)
ON	444/3,700	66.2 (292)	63.9 (186)	14.3 (10.8)	81.9 (236)
NB	8/59	87.5 (7)	85.7 (6)	17.7 (14.7)	71.4 (5)
NS	14/112	71.4 (10)	30.0 (3)	13.2 (13.0)	90.0 (9)
PEI[c]	2/15	—	—	—	—
NFLD	7/55	85.7 (6)	66.7 (4)	12.7 (2.8)	100 (6)
TOTAL	749/6,204	68.0 (503)	68.4 (344)	14.9 (11.0)	76.2 (381)

[a] Total number of DCs listed in the online directories of the provincial chiropractic licensing body in 2010.
[b] Earned a Bachelor's degree prior to attending chiropractic college
[c] All mailed surveys were undeliverable

Table 2.
Diagnostic tests/procedures used for the purpose of differential diagnosis. N=474.

Diagnostic method	% Canadian chiropractors commonly using method (N)
Orthopaedic tests	88.8 (421)
Motion/static palpation	88.0 (417)
History (focused)	83.5 (396)
History (complete)	82.9 (393)
Range of Motion	80.0 (379)
Neurological exam	79.5 (377)
Posture analysis	71.5 (339)
Muscle testing	53.8 (255)
Gait analysis	48.1 (228)
Leg length	46.4 (220)
X-ray	45.1 (214)
Blood pressure	28.5 (135)
Surface Electromyography	11.2 (53)
Thermography	10.5 (50)
Other	4.6 (22)

The vast majority (470/494; 95.1%) of respondents reported performing differential diagnosis procedures when a new patient presents to them for the first time. The prevalence of use of common diagnostic tests/procedures for the purpose of differential diagnosis is detailed in Table 2. The most commonly used diagnostic tests/procedures were orthopaedic testing (88.8%), palpation (88.0%), history taking (83.5%), range of motion (80.0%) and neurological examination (79.9%); each of which were used by at least 80% of respondents. With regard to determining where to apply joint manipulation procedures, the prevalence of use of common diagnostic tests/procedures and the proportion of patients on which they are used is detailed in Table 3. The most commonly used tests/procedures for determining where to apply spine manipulation were palpation (98.4%) and painful joint findings (89.8%); both used by at least 90% of respondents and used on the majority of their patients. Also commonly used was analysis of posture, range of motion and leg length, as well as orthopaedic testing (each used by at least 80% of respondents).

Table 3.
Clinical tests/procedures used for the purpose of determining where to apply joint manipulation and frequency of use. N = 488.

Diagnostic method	Percentage of patients on which diagnostic technique is used (N)				
	76-100% (always)	51-75% (usually)	26-50% (often)	1-25% (rarely)	0% (never)
Motion/static palpation	79.9 (390)	10.9 (53)	5.7 (28)	1.8 (9)	1.6 (8)
Painful joint findings	52.3 (255)	20.9 (102)	12.9 (63)	3.7 (18)	10.2 (50)
Posture analysis	29.9 (146)	20.7 (101)	18.9 (92)	14.3 (70)	16.2 (79)
Range of motion	42.6 (208)	18.4 (90)	11.9 (58)	10.7 (52)	16.4 (80)
Leg length analysis	31.1 (152)	13.3 (65)	18.4 (90)	20.1 (98)	17.0 (83)
Orthopaedic testing	35.9 (175)	22.1 (108)	13.7 (67)	10.9 (53)	17.4 (85)
Muscle testing	13.7 (67)	13.7 (67)	17.8 (87)	21.3 (104)	33.4 (163)
X-ray measurements	9.4 (46)	6.1 (30)	8.4 (41)	15.6 (76)	60.2 (294)
Nerve conduction	1.2 (6)	0.8 (4)	2.7 (13)	12.1 (59)	83.2 (406)
Surface EMG	5.3 (26)	1.4 (7)	1.8 (9)	5.1 (25)	86.3 (421)
Thermography	4.9 (24)	0.8 (4)	1.8 (9)	4.9 (24)	87.3 (426)
Other	3.3 (16)	0.8 (4)	0.8 (4)	0.4 (2)	94.9 (463)

The prevalence of use of specific treatment methods by respondents is detailed in Table 4. The most commonly used methods of treatment were manual joint manipulation and/or mobilization (99.0%), stretching and/or exercises (96.0%), posture and/or ergonomic advice (90.8%) and soft-tissue therapies (85.4%). These were each used by greater than 85% of respondents and used on the majority of their patients. Also used by a significant majority (>80%) of respondents, but used on only small proportion of their patients, were orthotics and dietary advice.

Discussion

While at least 65% of chiropractic patients have been shown to present for back pain[12], several medical conditions, such as cancer, infections, and visceral disease, are known to mimic non-specific, low back pain conditions[13-15]. As such, appropriate and skilled examinations are imperative for the delivery of optimal patient care. Indeed, the Canadian Chiropractic Association suggests that the chiropractic profession adheres to a patient-centred, biopsychosocial approach to health care that encompasses examination, diagnosis and treatment[16] and clinical practice guidelines suggest that the accurate diagnosis of patient conditions is key to effective management and treatment[17]. DCs are taught numerous diagnostic procedures during their undergraduate education and clinical internships and analyses conducted by the National Board of Chiropractic Examiners in the United States (US) have suggested that US DCs develop differential diagnoses on a daily basis.[18] However, to our knowledge only one recent investigation has assessed the use of diagnostic tests/procedures by Canadian DCs.[7] While the aforementioned study attempted a more specific assessment of the individual diagnostic tests and therapeutic procedures used by Canadian DCs than our current study, it had a number of limitations, including a very low response rate and

Table 4.
Treatment methods used by Canadian chiropractors and frequency of use. N=500.

Treatment method	Percentage of patients on which therapy is used				
	76-100% (always)	**51-75% (usually)**	**26-50% (often)**	**1-25% (rarely)**	**0% (never)**
Manual joint mobilization/manipulation	78.8 (394)	13.0 (65)	4.0 (20)	3.2 (16)	1.0 (5)
[a] Stretching/Exercise	53.8 (269)	27.0 (135)	11.6 (58)	3.6 (18)	4.0 (20)
Posture/ergonomic advice	34.4 (172)	28.2 (141)	18.6 (93)	9.6 (48)	9.2 (46)
Soft-tissue therapy (e.g., Thumper, ART, Graston)	49.6 (248)	18.6 (93)	9.6 (48)	7.6 (38)	14.6 (73)
Orthotics	1.2 (6)	6.4 (32)	30.6 (153)	45.8 (229)	16.0 (80)
Dietary advice	6.6 (33)	14.6 (73)	30.2 (151)	31.6 (158)	17.0 (85)
Traction/distraction	12.2 (61)	20.8 (104)	26.6 (133)	19.2 (96)	21.2 (106)
Heat/Cold therapy	15.6 (78)	17.0 (85)	21.6 (108)	21.2 (106)	24.6 (123)
Instrument-assisted joint manipulation	17.8 (89)	9.2 (46)	18.8 (94)	25.2 (126)	29.0 (145)
Nutritional supplements	3.4 (17)	10.6 (53)	20.2 (101)	31.0 (155)	34.8 (174)
Electrotherapies (e.g., TENS, IFC)	8.8 (44)	13.0 (65)	13.4 (67)	16.6 (83)	48.2 (241)
Ultrasound	2.4 (12)	7.8 (39)	13.0 (65)	18.8 (94)	58.0 (290)
Acupuncture	1.6 (8)	6.4 (32)	10.8 (54)	7.8 (39)	73.4 (367)
Low-level laser therapy	1.4 (7)	3.4 (17)	10.0 (50)	9.4 (47)	75.8 (379)
Homeopathic remedies	0.6 (3)	2.2 (11)	4.4 (22)	15.2 (76)	77.6 (388)
Other	1.4 (7)	0.8 (4)	1.2 (6)	1.2 (6)	95.4 (477)

[a] Could include in-office, or prescribed stretches/exercises.
ART=Active Release Therapies

a pseudo-randomized sampling method, which reduces both the reliability and generalizability of the findings. The present study suggests that nearly all (95%) DCs in English-speaking provinces are performing some form of differential diagnosis procedures with their new patients. The vast majority of respondents indicated using diagnostic methods consistent with standard assessment of musculoskeletal conditions[19]; that is, history taking, orthopedic testing, palpation, range of motion testing and neurological exams.

Notable is the fact that only a minority (28.5%) of DCs surveyed indicated using blood-pressure assessment as a common diagnostic test with new patients. Blood-pressure measurement can aid in the identification of cardiovascular, or pulmonary problems that might affect prognosis and intervention, or require referral to another practitioner. Indeed, it has been argued that blood-pressure measurements can prove to be an appropriate objective test for assessment prior to manual therapy interventions and provide direction for risk assessment and/or the management of patients.[20] That only a minority of respondents indicated assessing new patient's blood-pressure makes us question whether they are aware of the relevance of hypertension to the clinical reasoning necessary for the optimal management of musculoskeletal patient populations.

In addition to the standard tests involved with the diagnosis of a musculoskeletal complaint, DCs and other professionals who use joint manipulation will often perform supplementary physical examinations to determine whether dysfunctional joints are present that may be contributing to a patient's condition. If dysfunctional joints are present and no contraindications are found, manipulative procedures are often applied with the intent of improving joint biomechanics and function, which in turn may explain the efficacy of manipulative therapy for improving mobility and reducing pain. However, numerous reviews examining the validity and reliability of common examination methods intended to identify dysfunctional spinal joint segments have, to date, suggested that many tests are relatively unreliable and/or invalid.[21-26] Scientific investigation seems most supportive of direct, mechanical methods of assessing and identifying the site of care, such as maneuvers that replicate the patient's familiar pain.[26] There is also some evidence suggesting that palpation and leg-length analysis may be useful for some applications and orthopedic maneuvers may help narrow the region where treatment may be applied. On the other hand, the evidence is not supportive of less direct methods such as manual muscle testing for non-pathological states, radiographic measurements, thermography and surface electromyography.[26]

The present study thus suggests that DCs in English-speaking Canadian provinces are practicing consistently with the current scientific literature, as "palpation" and "painful joint findings" were the most commonly used methods for identifying spinal segments that could benefit from joint manipulation, used by nearly every respondent, on nearly every patient. Moreover, methods that are currently not supported by the scientific literature, such as radiographic measurements, thermography and surface electromyography, were the least-commonly used procedures. Nevertheless, it is a concern that there is a notable minority of DCs that reported regularly using methods not shown to be valid or reliable. Our data also suggests that DCs in Canada's English-speaking provinces use a combination of examination findings to identify spinal segments that could benefit from joint manipulation. While many clinical tests are of questionable diagnostic value, it has been suggested in the literature that improved diagnostic accuracy can be achieved by using combinations of clinical examination findings, as compared with individual physical examination tests.[27] As such, the use of examination methods with only low to moderate reliability and validity may add some clinical value when used in conjunction with pain provocation; to our knowledge, no analysis has examined the use of combination tests for identifying levels of segmental dysfunction in the spine.

In addition to the joint manipulation procedures commonly associated with care from a DC, nutritional and postural advice, lifestyle counselling and prescription of exercises have long been associated with chiropractic practice and are often considered as important hallmarks of the profession. In 1997, the Canadian Chiropractic Research Databank reported that the treatment techniques used by greater than 80% of chiropractors were joint manipulation, patient education and exercise.[4] Although our current data suggests that similar treatment modalities are still being used by most DCs, there was a notable increase in the use of soft-tissue therapies. In 1997, only 71.9% of Canadian DCs reported using soft-tissue therapies, whereas this survey saw 85.4% of respondents indicating

the use of soft-tissue therapies. This finding is consistent with the previously suggested trend towards the use of proprietary soft tissue therapies (e.g., Active Release Therapy, Graston technique, etc.) for patient care.[6,28] Our data suggest that the majority of chiropractors in English-speaking Canadian provinces today use a combination of manual and/or manipulative interventions directed towards the joints and soft-tissues, as well as exercise instruction and postural/ergonomic advice when they treat their patients.

Our study has some important strengths and limitations. The relatively high response rate (68%) may be considered a strength that increases the validity of the findings, however we do recognize that this was a select sample, and the chiropractors surveyed may not be representative of all Canadian DCs. The exclusion of French-speaking Canadian provinces and the Canadian territories means that our data might not be generalizable to those regions, but was necessary to avoid confounds related to language and regulatory differences. Respondents may have been influenced by social-desirability bias. The survey did not provide an operational definition for the term 'differential diagnosis', thus it is possible that some respondents misinterpreted the meaning of this term. We acknowledge that although the survey items were constructed using examples from the existing literature, the survey instrument used in this study was not previously tested or validated.

Conclusion

Differential diagnosis is a standard part of the assessment of new chiropractic patients in English-speaking Canadian provinces and this is most commonly done using orthopaedic tests, palpation, history-taking, range of motion testing and neurological examination. The clinical tests/procedures used most commonly by these DCs to determine where to apply joint manipulation are palpation and painful joint findings. These methods are consistent with the current scientific literature. Chiropractic patients in Canada's English-speaking provinces are treated with a combination of manual joint manipulation/mobilization, exercise, posture/ergonomic advice and soft-tissue therapies. These treatment methods are consistent with earlier analyses of Canadian DCs, but the data do suggest that chiropractors in Canada are increasingly using soft-tissue therapies as part of their therapeutic regimen.

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Is “fear of passive movement” a distinctive component of the Fear-Avoidance Model in whiplash?

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Objectives: *Modify the Tampa Scale for Kinesiophobia (TSK) for ‘fear of passive motion’ beliefs.*

Methods: *With permission, a 14-item modification, the TSK-PM (passive movement), was created. Test-retest reliability was tested first. Construct validity was tested in chronic whiplash patients by comparing the TSK-PM with the TSK, the Neck Disability Index (NDI) and cervical ranges of motion.*

Results: *The TSK-PM showed high test-retest reliability (r = 0.83) and high correlation with the original TSK (r = 0.84). Low, non-significant correlations were found with other variables. NDI scores were strongly correlated with ranges of motion.*

Conclusions: *While having high test-retest reliability and a single factor structure, the TSK-PM failed to demonstrate distinctive construct validity vs the original TSK. The original TSK is likely to be sufficient to assess*

Objectifs : *Modifier l’échelle de Tampa (TSK) pour l’évaluation de l’indice de kinésiophobie pour définir la « crainte du mouvement passif ».*

Méthodologie : *Un questionnaire TSK-MP (mouvements passifs) a été créé en modifiant 14 points de la TSK avec permission. Tout d’abord, on a évalué la fiabilité de test-retest. La validité conceptuelle a été testée chez des patients souffrant d’entorse cervicale chronique en comparant le TSK-MP avec la TSK, l’indice d’incapacité cervicale (NDI) et les amplitudes de mouvement cervical.*

Résultats : *Le TSK-MP a montré une grande fiabilité test-retest (r = 0,83) et une forte corrélation avec la TSK originale (r = 0,84). On a observé de faibles corrélations non significatives avec d’autres variables. Les résultats de l’indice d’incapacité cervicale étaient fortement corrélés avec les amplitudes de mouvement.*

Conclusions : *Tout en ayant une haute fiabilité test-retest et une structure à un seul facteur, le TSK-MP n’a pas démontré une validité conceptuelle distincte par rapport à la TSK originale. La TSK originale est probablement suffisante pour évaluer la crainte d’être*

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fear of being moved in neck pain patients in a clinical setting. Modifications to the current version of the TSK-PM might improve its construct validity in future studies.

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KEY WORDS: chiropractic, kinesiophobia, whiplash, reliability

déplacé chez les patients atteints de douleurs cervicales dans un cadre clinique. Les modifications apportées à la version actuelle du TSK-MP pourraient améliorer sa validité conceptuelle dans des études futures.

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MOTS CLÉS : chiropratique, kinésiophobie, entorse cervicale, coup du lapin, fiabilité

Introduction

In whiplash-associated disorder (WAD), many psychosocial factors are accounted for in the Fear-Avoidance Model.[1-13] Many of these factors have been shown to correlate strongly with current self-ratings of disability[9,11,14,15] and with prognosis[12,13].

The Tampa Scale for Kinesiophobia[16] (TSK) and the Fear-Avoidance Beliefs Questionnaire[17] assess movement-related anxiety; i.e., a patient's beliefs about the degree to which the movements they might undertake might aggravate their pain and, accordingly, whether they would perform these movements or activities. The fundamental construct being assessed is fear of moving.

These active movements undertaken by the patient, and beliefs thereof, are not the only kind of movement encountered by whiplash sufferers who become patients in a healthcare setting. Passive motions are commonly applied in both the diagnostic and therapeutic settings, especially in manual therapy. If a patient had any anxiety about these kinds of movements, it would best be termed a fear of being moved. This construct has not been well-studied. Given the frequency of circumstances where passive motion is applied to patients, especially in manual therapy, assessing a patient's attitudes and beliefs about this could make an important and distinctive contribution to the overall management of their pain condition. Modifications to therapy and education could be made to address these issues.

Accordingly, we undertook a modification of the TSK to assess 'fear of passive movement' beliefs (TSK-PM (passive movement)). We first modified the TSK for this purpose. Then, the test-retest reliability of this modified version was established in a sample of neck pain patients. Then, we explored its validity in a sample of chronic WAD patients by comparing TSK-PM scores with scores on the Neck Disability Index (NDI), the original TSK, active cervical ranges of motion. We predicted that the TSK-PM would only mildly correlate with the TSK and that it would more strongly correlate with ranges of motion and with cervical non-organic signs than the original TSK.

Methods

Revision of TSK: Permission to modify the TSK was obtained from Prof. J. Vlaeyan.[9,10] All items were reviewed by the authors for applicability. Fourteen of seventeen items were retained (original items #2, 4, 9 and 12 were excluded). Four items were retained in their original form (original items #6, 7, 15 and 16). The remaining nine items were revised by changing the wording from an active to a passive voice, principally by using the phrase "if someone moves me". The scoring was the same; responses ranged from 1 – strongly disagree, 2 – disagree, 3 – agree, 4 – strongly agree. Items 3, 7 and 13 are reversed in scoring as a validity check (See: Figure 1).

Study 1: Reliability: Subjects were recruited at a chiropractic teaching clinic. They were eligible if they presented with neck pain of at least 2 weeks duration. Both males and females 18-70 years of age were included. After providing informed consent, subjects completed the TSK-PM. Upon return to a treatment clinic for a follow-up visit within 48 hours, they completed the TSK-PM for a second time. Descriptive data were also obtained. As a very high level of correlation for test-retest reliability was expected, a sample size estimate for Pearson's Coefficient of 0.90, with a power of 0.80 determined that 19 pairs of measurements were required. Data was analyzed with ICC for test-retest reliability.[18] Internal consistency was not ana-

1.	I'm afraid that I might be injured if someone moves me	1	2	3	4
2.	My body is telling me that I have something dangerously wrong if it hurts when someone moves me	1	2	3	4
3.	My pain won't be made worse if someone moves me	1	2	3	4
4.	People aren't taking my medical condition seriously enough	1	2	3	4
5.	My accident has put my body at risk for the rest of my life	1	2	3	4
6.	Pain always means I have injured my body	1	2	3	4
7.	Just because it hurts when someone moves me does not mean that it is dangerous	1	2	3	4
8.	Being careful not to have anyone move me is the safest thing I can do to prevent my pain from worsening	1	2	3	4
9.	I wouldn't have this much pain if there weren't something potentially dangerous going on in my body	1	2	3	4
10.	My pain will let me know when to stop someone from moving me so that I don't get injured	1	2	3	4
11.	It's really not safe for a person with a condition like mine if someone moves me	1	2	3	4
12.	I can't do all the things normal people do because it's too easy for me to get injured	1	2	3	4
13.	Even though something is causing me a lot pain, I don't think it's actually dangerous	1	2	3	4
14.	No one should have to be moved by someone when they are in pain	1	2	3	4

Figure 1
Tampa Scale for Kinesiophobia – PM

lyzed, as this has been demonstrated to be adequate in the original TSK.[9,10]

Study 2: Validity: Males and females, 18-65 years of age were recruited with whiplash-related complaints of chronic neck pain (with or without headaches). Neck pain was defined as from C0-T3, anterior or posterior to the neck and laterally to the lateral scapular border. Subjects were excluded if they had radiating pain into the arms or if they had sustained a closed head injury and were exhibiting signs and symptoms of post-concussion syndrome. No WAD IV subjects were included. Subjects were not excluded if they had additional pain elsewhere in the body.

Outcome measures: In addition to the TSK-PM, the following outcome measures were used in order to compare the TSK-PM to prior studies of the TSK with respect to these measures.

1. NDI: Developed in 1991, the NDI is the most commonly used measure of self-rated disability due to neck pain.[19] It has excellent reliability and validity.[20] It is composed of 10 items; each item is scored out of 5 for a total score out of 50.

2. TSK: The TSK was developed in 1990 by Kori, Miller and Todd[16] to measure fear avoidance beliefs. Its reliability and validity have been well-documented.[21-23] It is composed of 17 items; each item is scored out of 4 for a total score out of 68.

3. Ranges of motion: Cervical ranges of motion were measured with the CROM goniometer. Head goniometers have good reported test-retest reliability.[24,25] Two trials were obtained and averaged. The data point was the total ROM summed from 6 individual ranges.

4. Age, gender, duration of complaint (time since WAD injury) and pain severity on a 100 mm VAS were also obtained.

Sample Size Estimate: At an alpha level of .01 and a power of 0.80, for r = 0.70, 18 subjects are required. Given that two primary analyses were performed (TSK-P/TSK and NDI/TSK), 40 subjects were required.

Data Analysis: Data for each variable were tested for normality with Kolmogorov-Smirnov test. For data demonstrating normality, Pearson's correlation coefficients were used to assess the univariate associations of the NDI, TSK, TSK-PM, total range of motion and pain se-

Table 1.
Mean scores of clinical variables

VARIABLE	MEAN (SD)
NDI % NDI /50	51.9 (20.5) 26 (10.2)
TSK %	65.7 (9.8)
VAS %	51 (24)
TOTAL ROM (degrees)	300.9 (68.6)

Table 2.
Univariate Correlations (Spearman correlation coefficient (p-value))

	Total ROM	NDI	TSK	TSK – PM	Pain VAS
Total ROM	1.00				
NDI	–0.30 (0.04)	1.00			
TSK	0.02 (0.86)	0.15 (0.31)	1.00		
TSK – PM	–0.00 (0.98)	0.18 (0.22)	0.76 (<0.00)	1.00	
Pain VAS	–0.24 (0.14)	0.69 (<0.00)	0.28 (0.08)	0.16 (0.31)	1.00

verity scores as well as with age. For data not demonstrating normality, Spearman's Rho was used.[26] A multivariate analysis was planned if any univariate correlations were significant. A p-value of 0.05 was considered statistically significant.

Results

Eleven (11) subjects completed the test-retest study. Forty-nine (49) subjects completed all the required measures for Study 2 (31 males, 18 females). The mean (sd) age and duration of symptoms were 39.9 (12.5) years and 9.7 (6.2) months, respectively.

Study 1: The test-retest reliability was 0.83 (95% CI from 0.72 to 0.92).

Study 2: The mean NDI, TSK, pain VAS and ROM scores are shown in Table 1. The mean total ROM represents approximately a 20% reduction in total ranges of motion (normal = 360 degrees).

None of the variables' datasets demonstrated normality. As such, Spearman's Rho was used to calculate the univariate correlations which are shown in Table 2. The highest and only significant correlation found was TSK / TSK-PM = 0.84 (p = 0.00). As no other important univariate correlations with the TSK-PM were obtained, multivariate analysis was not performed. Both forms of non-organic signs as well as the NDI had significant correlations with other variables. TSK and TSK-PM had no significant correlations with any of the other variables.

Discussion

This study produced a modified version of the TSK to account for the construct of "fear of being moved" or "fear of passive motion" beliefs. We found a high degree of test-retest reliability in the TSK-PM. However, in this sample of chronic WAD subjects, we failed to find a strong distinction between the original and modified versions of the TSK.

This finding may have occurred because the TSK-PM does validly measure 'fear of passive motion' beliefs, but these are simply not different enough from 'fear of active motion' beliefs. Contrarily, the modifications made to the TSK may not have adequate enough to permit valid measurement of a distinctive set of beliefs. The creation of a different instrument, not the minor modification of an existing one may be required to resolve this issue.

Our findings can be interpreted as supporting the original TSK in assessing movement-related anxiety for both active and passive movements. Should a clinician be concerned about "fear of being moved" in their patients, the original TSK probably provides an adequate measure of that attribute.

We also failed to find strong correlations between scores of either version of the TSK with scores of self-rated disability, current pain intensity, ranges of cervical motion and standard or novel cervical non-organic signs. This is contrary to other studies[4,5,12,13], and may be a statistical issue, as we found that TSK and TSK-PM scores

were considerably higher and less varied than NDI scores and scores for ranges of motion and non-organic signs. It may also be due to the fact that our subjects suffered with chronic whiplash-related pain. The situation may be different in subjects with sub-acute pain whose pain-related beliefs may not have become so entrenched.

In addition to the findings directly related to the TSK-PM, our study has other important results. The significant correlation between NDI scores and ranges of neck motion confirms the results of Howell et al.[27], although the correlation between ROM and pain VAS scores was slightly higher.

The limitations of this study pertain to the limits of interpretation of the negative results with respect to the TSK-PM: chronic WAD patients with relatively high fear avoidance beliefs. As noted above, replication in acute WAD patients is recommended.

Conclusion

While having high test-retest reliability and a single factor structure, a modified version of the TSK to account for fear of passive motion beliefs has failed to demonstrate construct validity in a sample of chronic WAD patients. In fact, we have found that this construct is likely incorporated into the original TSK. Secondarily, validity of the C-NOS tests for cervical non-organic pain behaviour in WAD patients has been given support.

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Missed appendicitis diagnosis: A case report

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Objective: *The purpose of this case report is to highlight and emphasize the need for an appropriate and thorough list of differential diagnoses when managing patients, as it is insufficient to assume cases are mechanical, until proven non-mechanical. There are over 250,000 cases of appendicitis annually in the United States. Of these cases, <50% present with classic signs and symptoms of pain in the right lower quadrant, mild fever and nausea. It is standard for patients who present with appendicitis to be managed operatively with a laparoscopic appendectomy within 24 hours, otherwise the risk of complications such as rupture, infection, and even death increases dramatically.*

Clinical Features: *This is a retrospective case report following a 27-year-old male with missed appendicitis, who presented to a chiropractor two-weeks after self-diagnosed food poisoning. On assessment, he was tender with resisted lumbar rotation. Psoas Sign, McBurney's Point, vascular exam, hip exam, were negative. A diagnosis of an abdominal strain was provided. Two weeks later, he returned to the chiropractor without an improvement of symptoms.*

Objectif : *Cette étude de cas vise à souligner la nécessité d'une liste appropriée et détaillée de diagnostics différentiels lors de la gestion des patients, car il n'est pas suffisant de supposer que les cas sont d'ordre mécanique, jusqu'à la preuve du contraire. Il y a plus de 250 000 cas d'appendicite par an aux États-Unis. Parmi ces cas, < 50 % présentent des signes et des symptômes classiques de douleur dans le quadrant inférieur droit, de fièvre légère et de nausées. Il est normal qu'un patient qui se présente avec une appendicite soit géré par une intervention chirurgicale (appendicectomie par laparoscopie) dans les 24 heures, sinon le risque de complications, telles que rupture, infection et décès, augmente considérablement.*

Caractéristiques cliniques : *Ceci est une étude de cas rétrospective qui suit un homme de 27 ans dont le diagnostic d'appendicite a été manqué lorsqu'il s'est présenté à un chiropraticien deux semaines après un autodiagnostic d'intoxication alimentaire. Son examen avait révélé une sensibilité au toucher avec une résistance à la rotation lombaire. Le signe du psoas, le point de McBurney, l'examen vasculaire et l'examen de la hanche se sont révélés négatifs. Un diagnostic de claquage abdominal a été établi. Deux semaines plus tard, il est retourné au chiropraticien sans aucune amélioration des symptômes.*

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Consent: Written informed consent was obtained from the participant for publication of this case report. A copy of the written consent is available for review from the Editor of this journal.

Intervention & Outcome*: The patient was sent to the hospital, where he was provided a diagnosis of missed appendicitis. He required a hemicolonectomy due to the associated phlegmonous mass.*

Summary: *When a patient presents to a chiropractic clinic with symptoms of abdominal pain, having a comprehensive list of non-mechanical differential diagnoses as well as mechanical differentials is crucial. Appropriate assessment and management of abdominal cases decreases the risk to patients, as missed diagnoses often require more invasive interventions.*

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KEY WORDS: chiropractic, appendicitis, diagnosis

Intervention et résultats : *Le patient a été envoyé à l'hôpital, où une appendicite manquée a été diagnostiquée. Il a fallu lui faire une hémicolectomie en raison de la masse phlegmoneuse associée.*

Résumé : *Quand un patient se présente à une clinique de chiropratique avec des symptômes de douleurs abdominales, il est crucial d'avoir une liste complète de diagnostics différentiels non-mécaniques ainsi que de différentiels mécaniques. L'évaluation et la gestion appropriées des douleurs abdominales diminuent le risque pour les patients, car les diagnostics manqués nécessitent souvent des interventions plus invasives.*

(JCCA. 2015; 59(3):294-299)

MOTS CLÉS : chiropratique, appendicite, diagnostic

Introduction

The appendix (vermiform appendix, see Figure 1) is a vestigial structure of the gastrointestinal tract found in the right lower quadrant of the abdomen. Located intraperitoneally, it is found on the posteromedial side of the caecum. While it may assume one of several orientations in relation to the caecum, it is most commonly found behind the caecum or ascending colon (75%), or descending along the pelvic brim (20%).[1] It can vary in size from 2-20cm, typically found longer in children and atrophied in adults. The three taenia coli converge at the opening lumen of the appendix to create a triangular orifice.[2]

Appendicitis is defined as an acute inflammation of the appendix, typically resulting in abdominal pain, anorexia, and abdominal tenderness[1]. In the United States, >250,000 cases of appendicitis occur each year.[3] The lifetime prevalence is approximately 5-7% in the general population, with onset usually during the third decade.[4] It occurs more commonly in males than females at a rate of 3:2 until the fourth decade, at which point it equalizes.[4] Prior to the development of surgical interventions, >50% of patients who developed this condition died. The introduction of the appendectomy reduced mortality to 15%.[5] Mortality now occurs in between 1-3% of cases.[3] The pathophysiology is commonly caused by an obstruction of the opening of the appendix.[5] Once obstructed, distension, bacterial overgrowth, ischemia and inflammation follow. If this remains untreated, perforation, and necrosis may occur.[1]

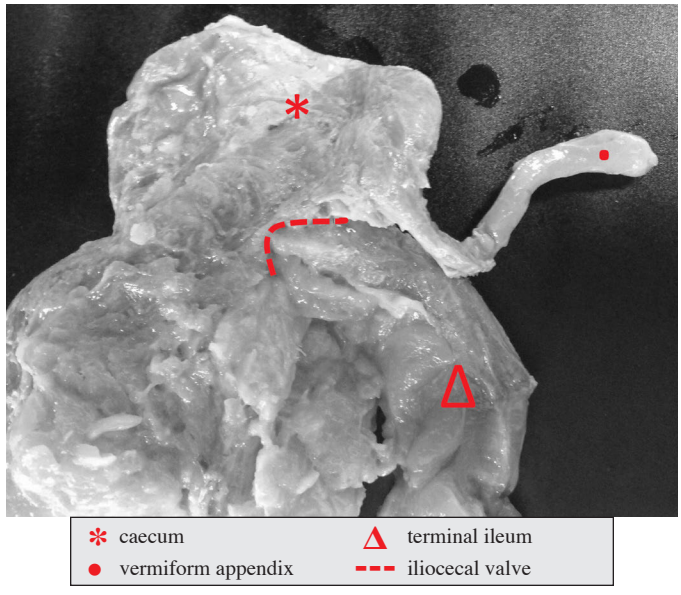

Figure 1.
Vermiform appendix in 61-year-old male cadaveric model

Current guidelines recommend correlating the clinical findings to direct further investigations, such as blood work (white blood cell count (WBC), c-reactive proteins

(CRP), and polymorphonuclear cells (PMN))[6], or diagnostic imaging[7]; however, 55% of patients do not have a "classic presentation." In a classic presentation, the patient will present with pain around the umbilicus that exacerbates when coughing, or straining. In the early stages, there may referred pain diffusely across the lower abdomen that progresses to periumbilical pain indicating early appendicitis. The pain will gradually localize to the right lower quadrant as the appendix and adjacent peritoneal tissue becomes inflamed.[8] The patient may have a low fever (~38°C), have voluntary muscular guarding that progresses to involuntary as the pain increases, and may experience nausea and/or vomiting.[1] This process occurs usually within 4-6 hours.[8] If during this time the symptoms decrease, perforation of the appendix should be suspected. When a patient does not seek care within 24h after developing appendicitis-like symptoms, a diagnosis of 'missed appendicitis' is provided. The frequency of missed appendicitis ranges from 20-40%, with children having a higher incidence.[1,10] Appendicitis is the number one cause of emergency abdominal surgery in both children and adults.[1,11]

Orthopaedic testing may contribute to the clinical picture of appendicitis.[8] The pain will present in McBurney's Point: the most distal third of an imaginary line from the right anterior superior iliac spine to the umbilicus. Palpation of this site with direct pressure causes severely painful tenderness. Some other tests include:

1. Psoas Sign: a test of resisted right hip flexion while the patient is supine, and passive extension while the patient is side-lying. Increased abdominal pain with either manoeuvre suggests irritation of the psoas created by the inflamed appendix.
2. Obturator Sign: passive internal rotation of the right hip while the patient lies supine. Pain in the right hypogastric region suggests irritation of the obturator muscle by the inflamed appendix.
3. Rovsing's Sign: a test for rebound tenderness, where the practitioner inserts their fingers deeply and evenly in the left lower quadrant, then quickly withdraws their fingers. This creates a ripple effect that will disturb the inflamed appendix, creating an exacerbation of pain.

When the physical exam supports the diagnosis, confirmatory imaging is done. While ultrasonography (US) may be easily accessed and have decreased radiation to the patient, computed tomography (CT) is the modality of choice for imaging for its greater diagnostic accuracy[1]. An exception applies to paediatric patients, as US is preferred, to reduce exposure to ionizing radiation. CT for appendicitis in practice has been reported having a sensitivity of 80-96%[12-13], exceeding that of ultrasound. However, there is a greater risk of false negatives with CT that leads to patients with appendicitis being discharged prematurely, risking the development of missed appendicitis. When the patient returns and diagnosis of appendicitis has been confirmed, surgical intervention is the next step.

There has been investigation as to which surgical intervention is most appropriate for the general population. One systematic review suggests that while laparoscopic interventions take longer to complete, they reduce wound infection, postoperative pain, duration in hospital recovery, and time to returning to work. There is also a significant decrease post-operative complication, such as abscess or paralytic ileum.[14] However, if missed appendicitis occurs, the intervention may need to be more invasive, requiring an open operation.[14]

Case Report

A 27-year-old man presented to the chiropractic clinic with a complaint of an abdominal strain of two-week duration. The pain onset a few days after having an 8-hour bout of self-diagnosed food poisoning, that he felt had passed with no persistent symptoms. He described it as a dull ache in the general right side that did not exceed 2/10 on the numerical pain rating scale. He could not determine which activities were aggravating, and found it was always short lived. The purpose of the visit was to determine why there had been no improvement after two weeks. There were no radicular symptoms or red flags in the history, such as inability to pass gas, or any changes to his bowel or bladder function. He did not have constitutional symptoms, or persistent gastrointestinal concerns, and noted that his appetite was normal.

On physical examination, there were no clinical findings on observation. His lumbar ranges of motion were full and pain-free in all directions except for left rotation, which he reported recreated his pain of chief complaint, both actively and with resisted ranges of motion. Super-

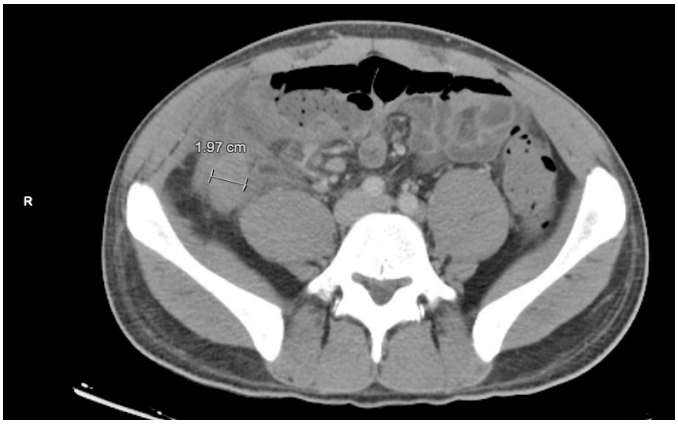

Figure 2.
Transverse Abdominal CT at L5 identifying markedly dilated appendix

Figure 3.
Coronal Section of Abdomen. Calcified appendicolith at base of appendix with significant periappendical phlegmonous appearing fat stranding and fluid.

ficial palpation of the abdominals recreated pain, worse when palpated with resisted ranges of motion. Hip range of motion was full and pain free bilaterally. His neurological assessment (motor, sensory, deep tendon reflexes of the lower limb) was intact. Lumbar spine and hip orthopaedic tests were non-contributory. An abdominal exam was performed and was normal. Vascular screen (abdominal, femoral, and pedal pulses) was normal. There were no constitutional signs. Rovsing's sign and McBurney's point were both negative.

The patient was given a working diagnosis of abdominal wall strain. He was treated with soft tissue therapy and advised to avoid aggravating behaviours until the symptoms resolved. He was also given advice to go to the hospital if he developed a fever or if his symptoms progressed rapidly, with the concern of an overlooked visceral source of pain.

Two weeks later, he returned to the clinic to report that though he had stopped aggravating behaviours, the pain in his abdomen had not resolved. He noted that specifically on that day only, whenever his heel struck when stepping off of a step, the pain in his abdomen was worsened to a level of 6-7/10. His oral temperature was 38°C. He was sent to the emergency room to rule out appendicitis or infection, due to the progression of pain symptoms and lack of response to conservative care.

At the hospital, the patient's CT results found phlegmonous appendicitis (see Figures 2 and 3). After a failed trial of conservative care (antibiotics and fluids), he required an emergency hemicolonectomy due to the massive inflammation that encased and adhered the ruptured appendix and ileum, to the abdominal wall.

The patient returned to the chiropractic clinic six weeks later, after clearance from his surgeon for post-surgical core rehabilitation. He was re-assessed and found to have full ranges of motion in the lumbar spine and bilateral hips. The patient was started on a course of progressive rehabilitative exercises to re-train his abdominal muscles.

Discussion

The classical presentation of appendicitis is right lower quadrant pain that is exacerbated by coughing, sneezing and straining. It comes on insidiously and progresses to severe pain within hours. Lack of appetite, low-grade fever and abdominal rigidity is typical, with inflammatory markers present in the blood. However, this presentation

is only present in <50% of adults presenting to the emergency department.[9] There are many reasons for this, as previously discussed. Blood markers may not be elevated on assessment until the appendix is compromised[1].

As chiropractors, there is a battery of tests that are taught to aid in the diagnosis of appendicitis. They include Psoas sign, Obturator sign, Rovsing's sign, rebound tenderness and palpation of McBurney's Point. According to a 2006 study of the presentation of acute appendicitis at an emergency surgical ward in Iran, the sensitivity and specificity of the Psoas sign is 23% & 50%, respectively.[15] However, another Spanish study indicated the psoas sign to have a sensitivity of 16% and specificity of 95% in an emergency surgical unit.[16] The obturator sign works under a similar concept as the psoas sign. The same paper from Iran mentioned previously reported a sensitivity of 15% and a specificity of 75% for patients in the operating room with appendicitis, however, the diagnostic accuracy of the Obturator test is poorly tested.[15] Interestingly, the authors were unable to find any evidence supporting the use of the Rovsing's test in a clinical or research context. It appears to be unreliably executed and has not been adequately tested to assess validity or accuracy.

The blood markers evaluated (WBC, CRP, PMN) are specific for acute infection.[6] WBC has been extensively studied and is routinely elevated in appendicitis. Recent research suggests that a WBC count of >10,000 increases diagnostic sensitivity, but not specificity.[6] It is insufficient to use WBC alone as a diagnostic modality due to the poor specificity and variety of other conditions that create elevated WBC counts.[6] CRP is an acute phase reactant that begins to rise 8-12 hours after the onset of an inflammation process, and peaks in 24-48 hours. CRP is suggested to be a strong indicator of perforated appendicitis, though a poor marker for simple (not perforated) appendicitis.[6] PMN cell counts that are >11x10^9/L are reported to have a specificity of 92% with the largest likelihood ratio over any other laboratory test.[6] The greater the PMN value, the greater the likelihood ratio.[6]

Pain may not be felt due to the multiple possible orientations of the appendix when the inflammation occurs.[9] If the appendix is oriented posteriorly, the inflammation may be walled off before freely perforating into the abdomen. Early intervention is imperative for appendicitis successful management of appendicitis. When the appendix becomes perforated, the mortality rate increases from 0.8 per 1000 to 5.1 per 1000. The increased mortality is more common in very young or elderly patients.[1] The average rate of perforation when a patient presents to the emergency department is 16-30%.[14]

As primary contact healthcare providers, it is extremely important for chiropractors to be well versed in possible differential diagnoses (See Table 1).[17] It is pertinent that we use our clinical tools to investigate an unusual history,

Table 1.
Selected Differential Diagnoses of Abdominal Pain[17]

Region	Differential
Right Upper Quadrant	Biliary: cholecystitis, cholelithiasis, cholangitis Colonic: colitis, diverticulitis Hepatic: abscess, hepatitis, mass Pulmonary: pneumonia, embolus Renal: nephrolithiasis, pyelonephritis
Epigastric	Biliary: see above Cardiac: myocardial infarction, pericarditis Gastric: esophagitis, gastritis, peptic ulcer Pancreatic: pancreatitis, mass Vascular: aortic dissection, mesenteric ischemia
Left Upper Quadrant	Cardiac: angina, myocardial infarction, pericarditis Gastric: esophagitis, gastritis, peptic ulcer Pancreatic: mass, pancreatitis Renal: nephrolithiasis, pyelonephritis Vascular: aortic dissection, mesenteric ischaemia
Periumbilical	Colonic: early appendicitis Gastric: esophagitis, gastritis, peptic ulcer, small bowel mass, obstruction Vascular: aortic dissection, mesenteric ischemia
Right Lower Quadrant	Colonic: appendicitis, colitis, diverticulitis, IBD, IBS Gynecological: ectopic pregnancy, fibroids, ovarian mass, torsion, PID Renal: nephrolithiasis, pyelonephritis
Suprapubic	Colonic: appendicitis, colitis, diverticulitis, IBD, IBS Gynecological: ectopic pregnancy, fibroids, ovarian mass, torsion, PID Renal: cystitis, nephrolithiasis, pyelonephritis
Left Lower Quadrant	Colonic: colitis, diverticulitis, IBD, IBS Gynecologic: ectopic pregnancy, fibroids, ovarian mass, torsion, PID Renal: nephrolithiasis, pyelonephritis
Any	Abdominal wall: herpes zoster, muscle strain, hernia Other: bowel obstruction, mesenteric ischaemia, peritonitis, narcotic withdrawal, sick cell crisis, porphyria, IBD, heavy metal poisoning

RUQ = right upper quadrant; LUQ = left upper quadrant;
LLQ = left lower quadrant; RLQ = right lower quadrant;
IBD = inflammatory bowel disease; IBS = irritable bowel syndrome;
PID = pelvic inflammatory disease
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an unusual or progressive symptom presentation, or when the physical exam does not seem to correlate as expected with the given history. There are many different visceral complaints that can replicate mechanical symptoms. It has been reported that complementary and alternative practitioners, while trained in appropriate medical evaluation of patients, lack confidence in appropriate and timely referrals of patient presentations with possible non-mechanical diagnoses.[18]

Summary

This report aims to highlight the importance of discerning non-mechanical differentials from mechanical differentials when assessing patients, especially when they do not respond to your care. Clinical index of suspicion in place of 'classic' signs and symptoms will help the clinician appropriately manage their patient in urgent cases such as the one reported. Further, the physical tests taught in the chiropractic curriculum may be antiquated. As such, it is pertinent that chiropractors co-manage patients who present with complaints that may be visceral in origin.

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What is the pain source? A case report of a patient with low back pain and bilateral hip osteonecrosis

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Background: *Low back pain is a common symptom arising from many possible sources and includes the possibility of the contribution of remote pathology. This report describes a patient with bilateral osteonecrosis of the femoral heads presenting with a primary symptom of low back pain.*

Case presentation: *A 37-year-old male presented for evaluation of dominant pain that existed for approximately 6-12 months and was located in the right low back. Milder pain was also reported in the right hip. Low back and hip pain were both aggravated by weight-bearing activities. An evidence-based diagnostic evaluation revealed little indication for a primary*

Historique : *La lombalgie est un symptôme commun découlant de nombreuses sources possibles et comprend la possibilité de la contribution d'une pathologie distante. Cette étude décrit un patient atteint d'ostéonécrose bilatérale des têtes fémorales présentant un symptôme primaire de lombalgie.*

Exposé de cas : *Un homme de 37 ans s'est présenté pour l'évaluation d'une douleur dominante dans le bas du dos, côté droit, qui existait depuis environ 6 à 12 mois. Une douleur plus légère a également été signalée à la hanche droite. Ces deux douleurs s'aggravaient pendant des activités où il fallait porter une charge. Une évaluation diagnostique fondée sur des preuves a révélé peu d'indication d'une source de douleur primaire provenant de structures lombaires. Les radiographies*

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Trial registration: ClinicalTrials.gov with the ID number NCT01670292 (August 2012).

pain source originating from low back structures. Radiographs revealed bilateral osteonecrosis with evidence of left femoral head collapse.

Conclusion: *Hip osteonecrosis may have contributed to an atypical presentation of low back pain due to aberrant localization of pain and/or combined with altered biomechanical loading of musculoskeletal structures.*

(JCCA. 2015; 59(3):300-310)

KEY WORDS: low back pain, hip joint, osteonecrosis, diagnosis, chiropractic, avascular necrosis

ont révélé une ostéonécrose bilatérale avec une constatation de l'effondrement de la tête fémorale gauche.

Conclusion : *L'ostéonécrose de la hanche pourrait avoir contribué à une présentation atypique de douleurs lombaires en raison de la localisation aberrante de la douleur ou de la combinaison avec la charge biomécanique altérée des structures musculosquelettiques.*

(JCCA. 2015; 59(3):300-310)

MOTS CLÉS : douleur lombaire, articulation de la hanche, ostéonécrose, diagnostic, chiropratique, nécrose avasculaire

Background

Low back pain (LBP) is a common symptom arising from many potential anatomic sources such as nerve roots, myofascial structures, bone, joints, intervertebral discs, and organs within the abdominal cavity.[1,2] Symptoms can also spawn from aberrant neurological pain processing[3,4] and are influenced substantially by psychosocial elements[5-10]. Thus, the diagnostic evaluation of patients with LBP often requires complex clinical decision-making.[11]

LBP can also be caused by remotely located or concurrent conditions.[12-15] An example of LBP remotely generated from the hip was reported by Ben-Galim et al., who studied 25 patients diagnosed with hip osteoarthritis and concomitant LBP. Patients underwent total hip arthroplasty and experienced both a reduction in hip and LBP sustained for at least 2 years following surgery.[16] Similarly, Sembrano et al. studied 368 patients with LBP originating from a combination of spine and hip (8%) and spine and sacroiliac joint (7.5%) pathology. LBP was reported by patients with pathology identified only in the hip region in 2.5% of cases.[17]

LBP generated from hip pathology is likely due to the functional interdependence of related regions[18,19] and has been labeled hip-spine syndrome[20]. Briefly, this syndrome describes altered spinal alignment with changes in transmitted forces and muscle length in the presence of hip pathology. Indirect evidence for this concept is demonstrated by patients with LBP who also exhibit reduced ROM, strength, and muscular endurance in the hip[21-23] and by those who achieve measurable clinical improvement in LBP symptoms following treatment directed at the hip region[24,25].

Osteonecrosis (ON), or avascular necrosis, of the hip is characterized by disruption or loss of nutrient blood supply to the femoral head resulting in progressive osseus breakdown, often leading to structural failure of the cortical surface.[26] Estimates suggest that up to 20,000 new cases of hip ON are diagnosed each year in the United States alone[27,28] and up to 60% occur bilaterally[29]. ON etiology can be categorized as traumatic by direct injury to the hip, or non-traumatic by factors such as collagen vascular disease, sickle cell hemoglobinopathy, and possibly long-term exposure to corticosteroid drugs.[30-33] Non-traumatic ON most commonly occurs between the 3rd and 5th decade[34] exhibiting variable progression, though many cases develop femoral head collapse within 3 years following diagnosis[35]. In addition to hip pain, patients with ON report concomitant pain in the low back, buttock, groin, thigh, and knee.[36-38]

This case report describes an adult male with chronic low back pain who presented for an eligibility examination before enrollment in a clinical trial involving chiropractic care for patients with LBP.[39] The case presented in this article was unique in that our in-office evaluation

revealed little diagnostic evidence for a symptom source located in the lumbar region. Radiographic imaging, however, revealed bilateral osteonecrosis of the femoral heads.

Case presentation

Clinical history

A 37-year-old African-American male with a varied work history reported LBP which he first experienced upon waking approximately 6-12 months before evaluation at our clinic. No traumatic incident or injury was reported prior to symptom onset. At exam, his most severe pain, rated at 5/10 on a numerical rating scale, was located over the right posterior iliac crest. Milder pain was also reported in the anterior right hip region. Both the low back and hip pain were sharp in quality and exhibited varying intensity. Walking, twisting the torso, and initiating movements such as rising from a chair provoked both hip and low back symptoms. Palliative activities included lying down and sitting. The patient denied any previous evaluation or treatment for these symptoms. Health history included childhood onset asthma, a 4-pack/year smoking history, one acute asthma hospitalization with corticosteroid therapy (1 year prior), and a recent frostbite injury to the left foot. Alcohol consumption of ≥ 4 drinks per day reportedly occurred 9 times in the past year with an average of 2 drinks per week. Current medication consisted only of the bronchodilator albuterol, as needed, for asthma symptoms.

Examination

Clinical evaluation was conducted using an evidence-based diagnostic classification system for LBP developed by Vining et al.[40] The system incorporates a checklist tool to aid practitioners in synthesizing and organizing the historical and examination information to confirm or rule out diagnoses. Briefly, the checklist includes between 1 and 6 criteria supporting a specific diagnosis for LBP and a screening category indicating the need for additional evaluation or referral. When a criterion is met, a checkbox is marked indicating evidence for a particular diagnosis. Evidence is demonstrated by meeting clinical prediction rules or multiple criteria within a category. Conversely, evidence against a diagnosis is demonstrated by failing to meet a sufficient number of criteria within a category. An example of the diagnostic checklist tool is provided in Appendix 1.

Gait observation revealed a slight stiff-legged limp guarding the left lower extremity, attributed by the patient to plantar foot surface sensitivity persisting since his frostbite injury. Pulse, respiration, blood pressure, and temperature were within normal limits as were active and passive lumbar and hip ranges of motion. Pain did not centralize on repeated lumbar end range loading. Likewise, thigh thrust, sacral thrust, iliac compression, anterior superior iliac spine compression, and the lumbar extension-rotation test did not reproduce pain. Achilles and patellar deep tendon reflexes were normally symmetrical and responsive. Muscle strengths of the tibialis anterior, extensor hallicus longus and peroneus were +5 and symmetrical. The Leeds Assessment for Neuropathic Symptoms and Signs score was 0 indicating pain was arising from a nociceptive instead of a neuropathic source.[41]

Only 3 examination maneuvers mildly reproduced the patient's LBP: Gaenslen's test on the right, femoral nerve stretch on the right, and active lumbar extension. Patrick's test and passive external rotation of the right hip produced right hip pain. No examination procedures produced pain in the left hip. Lumbar segmental hypomobility and mild paraspinal hypertonicity were also noted.

The health history and symptom characteristics combined with few and mild examination findings (described above) did not result in evidence suggesting locally- generated LBP. Likewise, there was no historical, symptomatic, or examination evidence for neuropathic pain.[5,40] Two examination maneuvers resulted in hip pain creating some suspicion for hip pathology. Lumbar pathology was still considered possible due to chronicity, failure to meet any diagnostic criteria, and lack of an event that initiated symptoms. Thus, the decision was made to conduct a radiographic examination of the lumbar spine and pelvis.

Imaging and diagnosis

Radiographic examination revealed a slight left lumbar convexity without notable degenerative change in the lumbar spine or sacroiliac joints. Right and left femoral heads showed a mixed sclerotic pattern (See Figure 1). The left femoral head demonstrated a mild loss of sphericity, indicating early cortical collapse (See Figure 2). Al-

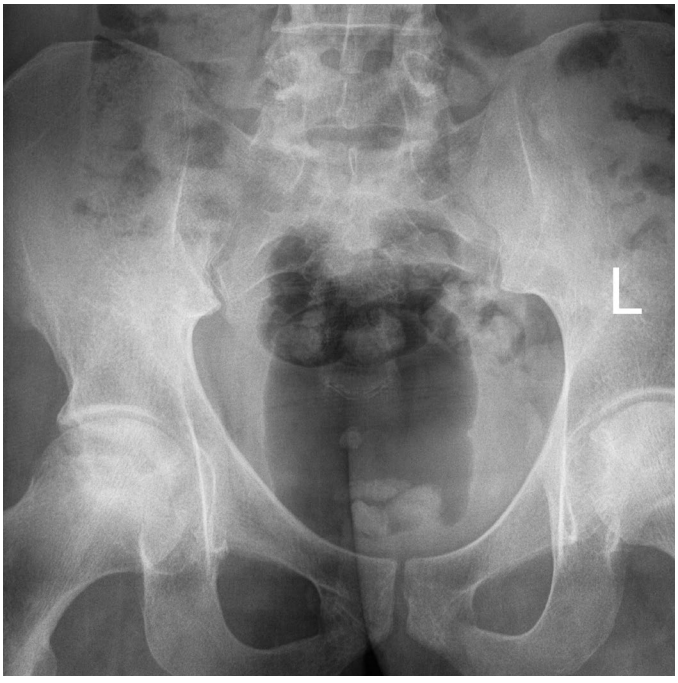

Figure 1.
Radiographic image showing bilateral mixed or patchy sclerosis represented by areas of non-uniform density in the superior femoral heads extending toward but not into the femoral necks.

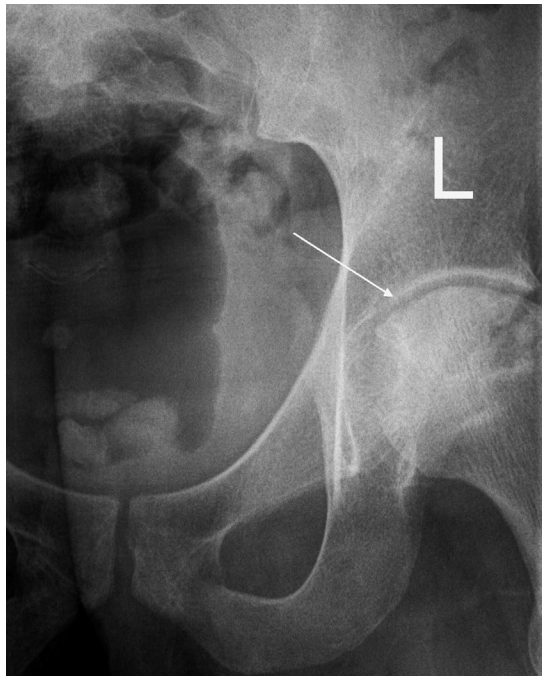

Figure 2.
Radiographic image of left hip. Subtle flattened area (Arrow) on the superior medial cortical surface of the femur represents impaction fracture of underlying necrotic bone.

tered density in the femoral head(s) accompanied by collapse of the femoral cortical surface (impaction fracture) are findings consistent with a diagnosis of osteonecrosis.[42]

Outcomes

The patient was informed of the diagnosis and that he was ineligible for the clinical trial because he needed a surgical evaluation and a condition causing the LBP originating from the low back region could not be confirmed.[39] The doctor of chiropractic discussed the potential detrimental health effects of alcohol consumption due to reported levels that categorized him with a slight risk for dependence or abuse.[43] The patient was then referred to a primary care provider to further evaluate ON etiology and to facilitate a surgical consultation. An orthopedic surgeon concurred with the diagnosis of bilateral ON and considered the most likely etiology to be that of prior corticosteroid use, possibly in combination with prior alcohol consumption. Bilateral total hip arthroplasty was recommended. Chiropractic treatment (i.e. palliative manipulative therapies, exercises designed to relieve LBP and/or hip symptoms, and/or activity modifications that reduce weight-bearing on the affected joints) was not pursued because care at our clinic is not available for patients outside those enrolled in ongoing clinical trials. At the time this manuscript was submitted for publication, the patient had not undergone corrective surgery due to an elective decision to postpone.

Discussion

In this case, the patient's clinical history and examination did not indicate a primary source of LBP originating from low back structures and imaging revealed no latent pathology in the lumbar spine. Hip examination findings were only mildly suggestive of several potential condi-

tions, such as femoroacetabular impingement and osteoarthritis[44,45] which require more advanced testing to confirm a diagnosis[46-49]. Radiographic imaging demonstrated bilateral ON with the left hip showing greater structural deterioration despite normal examination findings and the absence of symptoms on that side. Incongruity between the severity of imaging findings and symptoms is not uncommon in many musculoskeletal conditions.[50,51]

Bilateral ON was visible with standard radiography because the condition had reached a level of progression demarcated by relatively advanced bony disorganization and collapse. Had ON been strongly suspected without radiographic evidence, we likely would have recommended magnetic resonance imaging because it is a more sensitive diagnostic tool capable of detecting early ON pathology.[52,53]

Though there is no definitive method available to confirm the dominant source of pain, the lack of evidence supporting a local LBP diagnosis in conjunction with the radiographic evidence compelled us to theorize the symptom contribution in this case. We posit hip ON contributed to an atypical presentation of LBP most likely due to altered biomechanical loading of pelvic and low back structures or combined with referred pain or aberrant localization.

Risk factors for non-traumatic ON include corticosteroid use, alcohol abuse, sickle cell disease, systemic lupus erythematosus, renal failure and hematologic disorders.[35,52] More than 90% of non-traumatic hip ON cases are estimated to occur secondary to alcohol and corticosteroid use[54] possibly via mechanisms that result in fatty infiltration of bone marrow leading to intraosseus hypertension, vascular compression, and diminished vascularity to the femoral head[55,56]. However, the causal relationships between ON and alcohol and corticosteroid use is unclear because it is difficult to separate pharmacologic side-effects from underlying disease.[57] The patient described here had a relatively recent history of short-term corticosteroid use. The suspected mechanisms by which corticosteroids can cause ON suggest that long-term use, instead of short-term, is necessary for increasing risk.[58] Therefore, corticosteroids may not have contributed to the development of ON in this case. Likewise, the quantity of prior alcohol use did not suggest long-term abuse and may not have played a contributing role. No other substantial risk factors were identified.

Table 1.
Radiographic imaging findings associated with Ficat-Arlet stages of osteonecrosis of the hip

Stage		Radiographic Findings
0	Preclinical	Normal or near-normal
I	Preradiographic	Normal or near-normal
II	Prior to head collapse or sequestrum formation	• Trabecular pattern changes • Sclerosis, decalcification, or a mix of both
III	Collapse	• Crescent sign and broken contour of the femoral head • Sequestrum • Normal or increased joint space due to collapse
IV	Degenerative	• Flattened contour of femoral head • Decreased joint space • Acetabular osteophytes

Classification and management options

Clinical and radiographic findings can be grouped in stages to help diagnose and track the progress of ON. The Ficat-Arlet classification system categorizes ON based on pathological progression. Table 1 lists common imaging findings associated with each classification stage.[59] In cases where cortical collapse occurs and/or hip degeneration is present causing pain or compromised articulation (Ficat-Arlet stage III or IV), total hip arthroplasty is likely the only treatment option that will allow patients to remain ambulatory in the long-term.[60]

Conservative early-interventional (pre-cortical collapse) approaches include activity and lifestyle modifications that significantly limit weight-bearing, and therefore, compressive loading of the femoral head.[35,54] Encouraging patients to reduce alcohol consumption and supporting smoking cessation may also be helpful.[61] Other conservative treatments intended to stimulate revascularization and bone regrowth include extracorporeal shockwave therapy, pulsed electromagnetic field therapy, and hyperbaric oxygen therapy.[34,35] Pharmacotherapy options include bisphosphonate compounds which treat ON by depressing osteoclast activity and inducing apoptosis, thereby delaying trabecular collapse. However, in a review of therapies for non-traumatic ON, Lee et al. concluded that sufficient evidence is not currently present to

support the routine use of pharmacologic agents.[34] Two surgical procedures designed to prevent collapse and stimulate regrowth are core decompression and vascularized bone grafts. No clear evidence points to either procedure as a more effective approach, perhaps due in part to the heterogeneity of specific presentations and co-morbid conditions contributing to ON.[35,57]

Following cortical collapse, total hip arthroplasty or femoral head resurfacing may be recommended. Unfortunately, evidence indicating either procedure as most appropriate or predictive of outcomes also appears mixed.[60,62,63] In this case, only 1 femoral head demonstrated collapse, and bilateral total hip arthroplasty was recommended.

Conclusion

This report describes a patient with bilateral hip ON possibly contributing to atypical LBP via referred pain or altered biomechanical loading of pelvic and low back tissues. The case demonstrates the value of performing an evidenced-based diagnostic investigation for patients with LBP, including substance use exposure and detailed health history, and having a working knowledge of clinical management options for those identified with ON. ON can occur in combination with other conditions commonly treated by manual therapy practitioners, and similar cases present opportunities to co-manage patients and collaborate with other healthcare professionals.

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Appendix 1
Diagnostic classification checklist for patients with chronic low back pain.
Reprinted with permission from the Journal of the Canadian Chiropractic Association [40].

Screening

Is there evidence of progressive neurological deficit?	❑ No	❑ Yes
Is there evidence of pathologic fracture, infection or malignancy?	❑ No	❑ Yes
Are there gait difficulties, spasticity or other signs of myelopathy?	❑ No	❑ Yes
Recent history of unplanned or unexplained weight loss?	❑ No	❑ Yes
Is there evidence of seronegative spondyloarthropathy?	❑ No	❑ Yes

Nociceptive Pain

Discogenic Pain

Centralization with repeated motion	❑ No	❑ Yes
Any two: (Centralization w/ repeated motion, vulnerable/apprehensive when stooped, & exten. loss)	❑ No	❑ Yes

SI Joint Pain (3 or more of 6 tests)

Three or more of 6 + SI Joint tests without centralization with repeated motion (Gaenslen's L & R, Thigh Thrust [symptom side], Distraction, Iliac Compression, Sacral Thrust)	❑ No	❑ Yes

Zygapophyseal (Facet) Joint Pain (3 or more)

Age > 50	❑ No	❑ Yes
Pain relieved when walking	❑ No	❑ Yes
Pain relieved when sitting	❑ No	❑ Yes
Onset of pain was paraspinal	❑ No	❑ Yes
Positive Extension-Rotation test	❑ No	❑ Yes

Myofascial Pain

Ache-type pain with aggravation by use of involved muscle	❑ No	❑ Yes
Trigger point in muscle with possible radiation	❑ No	❑ Yes

Neuropathic Pain

Compressive Radiculopathy

Absent ankle/knee reflex	❑ No	❑ Yes
Leg pain worse than back pain?	❑ No	❑ Yes
Dermatome distribution (cough, sneeze, strain)	❑ No	❑ Yes
Paresis (extremity motor strength loss)	❑ No	❑ Yes
Finger floor distance during flexion >25cm	❑ No	❑ Yes
LANSS score >12	❑ No	❑ Yes

Non-compressive Radiculopathy

LANSS score >12	❑ No	❑ Yes
Compressive Radiculopathy criteria are satisfied	❑ No	❑ Yes

Neurogenic Claudication

Score of 7 or more on clinical prediction rule	❑ No	❑ Yes
ABI greater than 0.9 (if indicated)	❑ No	❑ Yes

Central Pain

Pain disproportionate to injury/pathology	❑ No	❑ Yes
Disproportionate, non-mechanical, unpredictable pattern of aggravating/relieving factors	❑ No	❑ Yes
Strong association with maladaptive psychosocial factors (neg. emotions, poor self efficacy, maladaptive beliefs & pain behaviors, conflicts [family, work…])	❑ No	❑ Yes
Diffuse or non-anatomic distribution of tenderness to palpation	❑ No	❑ Yes

Functional Instability (Lumbar Segmental Instability)

Prone passive lumbar extension positive	❑ No	❑ Yes
One or more lumbar hypermobile segment(s)	❑ No	❑ Yes
One or more lumbar hypomobile segments	❑ No	❑ Yes

Other diagnoses

Evidence for other diagnoses (Thoracolumbar syndrome, Piriformis syndrome, Hip pain)	❑ No	❑ Yes

Leeds Assessment of Neuropathic Symptoms and Signs (LANSS Pain Scale)

Does the pain feel like strange unpleasant sensations on the skin (e.g. pricking, tingling, pins/needles)? 5

Does skin in the painful area(s) look different (mottled, more red or pink than usual)? 5

Is the skin in the painful area abnormally sensitive to touch? (e.g. lightly stroked, tight clothes) 3

Does your pain come on suddenly? (e.g. electric shocks, jumping, or bursting) 2

Does the pain feel as if the skin temperature in the painful area has changed abnormally (e.g. hot, burning)? 1

Exam: Does stroking the painful area of skin with cotton produce pain? 5

Exam: Does a pinprick at the painful area feel different than a pinprick in an area of normal skin? 3

0 – 12 = likely nociceptive, Score > 12 likely neuropathic **Total**: ..... _____

Adapted from: Bennett, M.I. (2001). The LANSS Pain Scale: The Leeds assessment of neuropathic symptoms and signs. *Pain, 92*(1-2), 147–157.

Neurogenic Claudication Clinical Prediction Rule (Score of ≥ 7)

Age 60-70 2

Age >70 3

Onset over 6 months 1

Symptoms improve when bending forward 2

Symptoms improve when bending backward ..... -2

Symptoms exacerbated while standing 2

Intermittent claudication symptoms (symptoms while walking and relieved by rest) 1

Urinary incontinence 1

Total ..... _____

Adapted from: Sugioka T, Hayashino Y, Konno S, Kikuchi S, Fukuhara S. Predictive value of self-reported patient information for the identification of lumbar spinal stenosis. Fam Pract 2008;25:237-244.

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Robert M. Wingfield, DC: A conscientious chiropractor

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"I slept and dreamed that life was beauty. I woke – and found that life was duty." This quote from the poet Ellen Sturgis Hooper, could be attributed to Robert Wingfield, who has persevered in his quest for personal and professional excellence. This historical biography begins with his genealogy, going back to the 11th century in Merry England and ends in 2015, with his relatively quiet existence still centred in Ontario. The essay scrutinizes Dr. Wingfield's accomplishments for the Ontario Chiropractic Association (OCA), Canadian Chiropractic Association (CCA) and Ontario Board of Directors of Chiropractic (BDC). Moreover, it attempts to give the reader a glimpse into his personal endeavours, to help us fathom how he tackles (as William Shakespeare would say) "the thousand natural shocks that flesh is heir to."

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« Je dormais et je rêvais que la vie était joie. En m'éveillant, je trouvai que la vie était devoir ». Cette citation du poète Ellen Sturgis Hooper pourrait être attribuée à Robert Wingfield, qui a persévéré dans sa quête de l'excellence personnelle et professionnelle. Cette biographie historique commence par sa généalogie, remontant au 11e siècle dans la joyeuse Angleterre, et se termine en 2015, avec son existence relativement calme toujours centrée en Ontario. L'essai examine les réalisations du Dr Wingfield pour l'Ontario Chiropractic Association (OCA), l'Association chiropratique canadienne (ACC) et le Conseil d'administration de l'ordre des chiropraticiens de l'Ontario (BDC). En outre, il tente de donner au lecteur un aperçu de ses réalisations personnelles pour nous aider à comprendre comment il aborde (comme William Shakespeare disait) « les mille chocs naturels dont la chair est l'héritière ».

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Ancestry

The Wingfield clan predates to the 11th century invasion and conquest of England under an army of Norman, Breton and French soldiers led by Duke William II of Normandy, who would become William the Conqueror, King of England, in 1066. According to Bob, "the original name was de Wynfeld, c. 1087, with large holdings in Suffolk, and it gradually became anglicized over the next 200 years or so." [Email, Wingfield to the author, Oct. 17, 2014] Bob's father, Frederick C. Wingfield, was 16, when

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he emigrated with his dad, from Loughton, Essex, England, to Dunnville, Ontario, in 1910, and was hired by the Monarch Knitting Mills, before enlisting in the Canadian Overseas Expeditionary Force in 1914.

During the course of World War I (WWI), Fred served gallantly in every major Canadian battle and was awarded Meritorious Service and Distinguished Conduct Medals. Acting Company Sergeant Major Wingfield was discharged in 1919 and in 1968 was one of only two veterans invited to represent the Canadian Corps of Guides at the 50th Anniversary of the WWI Armistice at the Ottawa Parliament Buildings.[1]

The Formative Years

Returning to Dunnville after the War, Fred was introduced to Ferne Atkinson, who lived on a nearby farm and was part of a large family. In due course they married, moving to Hamilton where Robert was born, May 3, 1933. Bob remembers they always lived in the same home, in a stable middle class environment, close to a public school and churches. He had part-time jobs delivering groceries for the corner store on weekends and Globe Newspapers in the early morning. When attending Central Collegiate, Bob got average grades, played football and basketball and joined the school rifle team. In 1950, his team competed at Bisley, England and won seven international long-range target matches against British Empire teams.[2]

In 1924 Bob's father was working for the National Steel Company (Stelco) in Hamilton, where he rose to the stressful level of General Foreman and manager of over 200 electricians. When Bob was a teenager, his father began suffering from high blood pressure, for which the only medical treatment at the time was bed rest and a salt free diet. Bob and his parents had occasionally visited drugless practitioners in Hamilton. Two of them were Henry Avonde, DC, and Sydney Albin, ND, who were joint owners of the Avenue Clinic, on Main Street, East. Another was Richard S. Wynn, DC, ND, who graduated from the National College of Chiropractic c. 1945, taught technique at the Canadian Memorial Chiropractic College (CMCC) 1947-49, and sat on CMCC's Board of Management until 1964, while running an office in Toronto at the south-west corner of St. Clair and Avenue Road.[3] In the late 1940s, Dr. Wynn started practising in the Avenue Clinic and in the early 1950s was attending patients in Dr. Avonde's home on Lakeshore Road in Burlington.

Figure 1.
CMCC Painting 1945, 252 Bloor St W, Toronto

Bob's father was now over 50, off work because his blood pressure was out of control and threatened with early retirement. Bob began driving him to Burlington to see what Dr. Wynn had to offer. "Against what we thought were impossible odds, my father's blood pressure started to go down and after many weeks of attending Dr. Wynn he was cleared to return to Stelco," manning his post four years beyond the normal retirement age and living to savour his 82nd birthday.

Choosing a Career

In high school, Bob considered becoming a geologist or metallurgist. He had a summer job at Stelco for four years, staying full time for an additional year in the metallurgical lab after obtaining his senior matriculation. By then he had abandoned this idea and was contemplating chiropractic. In 1954, Bob visited CMCC at 252 Bloor Street West. Although he thought the Meadonia Hotel where the College was housed "a little odd," he enrolled and rented a room on Prince Arthur Avenue for seven dollars a week.

Tuition at CMCC was affordable at $250 a year if paid in advance until 1958, when it jumped to $400. Nevertheless, middle class families in that era were considered better off than most with a gross income of $100 a week and Bob was on a tight budget. He had a part-time bartender's job at the Royal York Hotel, worked in the mailroom of the T. Eaton Company during Christmas seasons and spent his summers in the lab at Stelco. Russ Wagg operated the College snack bar. If Bob ran short of money

on Friday, he would borrow two dollars from Russ for bus fare to Hamilton and repay him on Monday morning.

At CMCC Bob was studious, obtained good grades, engaged in extracurricular sports and performed in "Practichiro." Originally produced and directed by Rich Luck (CMCC 1954), these annual variety show extravaganzas were resounding successes.[4] And Bob was already flexing his political muscles. As Vice-President of the Student Administrative Council (SAC), his job was arranging school dances and as President of the Senior Class he organized its graduation banquet.

Wingfield has fond memories of Major H.B. Stevens, B.Sc., who taught histology and embryology, Howard Gauthier (CMCC 1949), the clinic director, Vera Littlejohn (Palmer School of Chiropractic 1932), who lectured in Specific Upper Cervical technique and A. Earl Homewood (Western States Chiropractic College 1941). Dr. Homewood arrived at CMCC in 1945. By 1952 he was "handling a full teaching schedule during the day, embalming cadavers at night and carrying the burdens of Business Manager and Dean."[5] Bob recalls Homewood lecturing in the anatomy lab at 8:00 in the morning, using his hypnotically humming, Balopticon projector to display pages from Gray's Anatomy onto a flickering screen. Students called it a "sleep machine."

As well Dr. Homewood taught Bob's class Carver technique. Developed by Willard Carver, LLB, DC, and refined by Homer G. Beatty, DC, Dr. Homewood emphasized attention to detail and drilled his pupils to cultivate a controlled, dynamic adjustive thrust.[6] Bob says Homewood taught them "what to look for in patients who had respiratory symptoms." In childhood, Bob had asthma. While severe at times, it was relieved through vigorous sports competitions but returned once the games ended. He described his condition to Dr. Homewood, who used him for class demonstrations and adjusted Bob in the clinic. By the end of his third year, Wingfield's asthma had vanished.

On May 14, the 40-member CMCC Class of 1958 held its graduation exercises at the Trinity United Church in Toronto.[7] That evening, the class, guests and dignitaries gathered in the glistening Crystal Ballroom of the King Edward Hotel to rejoice in the College's 13th Annual Graduation Dinner and Dance. Dr. Kenneth Wood, SAC President, was Master of Ceremonies and Dr. Robert Wingfield replied to the toast to the Graduation Committee.[8]

Figure 2.
The Wingfields' second home/office
2095 Caroline St, Burlington, ON

Personal Advancement

By graduation day, Dr. Wingfield was betrothed to a talented and energetic young woman, Anne Harvey Williams. They spent much of the summer of 1958 seeking a small town where they could settle and located a promising spot in Burlington, ON, at 604 (now 600) Brant Street. Bob and Anne rented the ground floor of what had been a residential building and did the refurbishing themselves. Their one room office faced the street. It contained two curtained change booths, one side-posture table, one Zenith Hylo table, a mobile x-ray machine, a desk and some chairs. Behind the office was a cramped apartment.

Just prior to opening, Wingfield had spent two weeks covering for Eleanor H. Ellsworth (Toronto Chiropractic College 1922), at her busy clinic in Hamilton. Dr. Ellsworth was an aunt of Robert E. Kinsman (CMCC 1953). He and classmate Wm. Lloyd Stackhouse had also practiced with Dr. Ellsworth for a year after they graduated from CMCC.[9] Dr. Ellsworth was unorthodox, using radionics in the diagnosis and treatment of many patients, still Bob found her coaching worthwhile. Not only did he see how a profitable, established practice functioned, he

Figure 3.
Dr. Wingfield's Clinic
464 Locust St, Burlington, ON

Figure 4.
Hamilton District Chiropractic Council Members
Drs R. Wingfield, R. Thurlow, J. MacRae, R. Oswald & R. Elford

observed the wide cross section of health problems handled by chiropractors of the day. "Like other chiropractors of that era, Dr. Ellsworth had strong convictions about the nature of illness and the therapeutic effect of spinal adjustments in the restoration of health." [Email, Wingfield to the author, Sept 16, 2012]

Anne and Bob opened their Brant Street office in August 1958 and got married in October. It was here that David, the first of their three children, was born. In the beginning, Anne pitched in financially by maintaining her jobs in the accounts receivable and promotions departments at radio station CKOC in Hamilton.

In 1960 the Wingfields, having outgrown their initial location, purchased a large home at 2095 Caroline Street. The office was on the first floor; the family occupied the second. They considered this to be permanent but by 1980, "the facility that had served us so well had become inadequate." Discovering a neglected, historic building at 464 Locust Street they hired "an architect to revamp and oversee its complete restoration into a modern and spacious chiropractic clinic."[10] Anne owned the building, leasing the clinic space to Bob and renting two new apartments on the second floor.

David A. Chapman-Smith, LLB, interviewed Dr. Wingfield for the August 1988 edition of the OCA News. David pronounced Bob's offices to be "frankly the most impressive chiropractic premises I have ever been in," but wondered why the adjusting rooms had no modalities, considering his mentor Dr. Avonde used electrotherapy extensively. Wingfield comments that –

> *"There is no one correct way to practise chiropractic… However, I have come to hold firm personal convictions concerning hand adjusting… Following x-ray, the centre of my examination is use of the hands and motion. In my experience a patient invariably knows when I have found a problem… The logical response to this obvious mechanical problem is again through the hands and motion; by adjustment of the spine. When this is done properly the patient knows there has been correction… For me, modalities and other treatments tend to obstruct this essential chiropractic approach. I obviously understand the need for modalities and anti-inflammatory medication where appropriate, and often make referrals for these treatments, concurrent with chiropractic care."*[11]

Professional Advancement 1958-1999

Hamilton District Chiropractic Council (HDCC)

Shortly after graduation, Dr. Wingfield joined the HDCC and was President in 1962-63. The council met monthly

Figure 5.
OCA Posture Booth at the CNE, 1966-67

in Hamilton's Fisher Hotel at 9:00 pm and had busy agendas. "Ron Elford (CMCC 1954) and I spawned posture contests in local high schools and the council actually arranged for some limited chiropractic coverage with Wenco, a local credit union insurance company".[12] This was several years before the inclusion of chiropractic in the Ontario Hospital Services Insurance Plan (OHSIP).

Ontario Chiropractic Association 1964-1972

Dr. Wingfield was elected to the OCA Board in 1964 and was quickly designated Chair of the Public Relations (PR), Industrial Relations, and Newsletter Committees. As PR Chair, Bob enlisted some of his Hamilton Council colleagues to build a large, conspicuous, OCA Posture Check Booth at the Canadian National Exhibition (CNE). Using a Posturometer crafted by Lyman Johnston (CMCC 1950)[13], droves of people were checked for spinal irregularities, handed the results and directed to their local chiropractor. In 1966-67, chiropractors from Hamilton, Niagara and Mississauga occupied the booth for the full run of the CNE. "They felt great about what they were doing and there was no trouble filling the staffing requirements." [Email, Wingfield to the author, Jan 14, 2015]

Bob's Industrial Relations Committee fashioned an OCA Pre-Employment Exam "that went nowhere" but he wrote a speech about "The Incidence of Back Pain and Disability in Industry" and was asked to talk to a couple of service clubs. Bob also lectured at Industrial Accident Prevention Association (IAPA) regional meetings where he delineated the social and economic costs of industrial injury and preventative measures relative to precise situations. Wingfield hired a commercial artist to fabricate posters to illustrate his material and was guest speaker at the IAPA annual convention in Toronto, April 22, 1969. He told the delegates spinal injuries were responsible for an annual loss of $100 million in Ontario and stressed that if employers had more knowledge about how the back functions, "a substantial advance could be made in protecting staff from costly injuries at work and home."[14] Wingfield's remarks were favourably received and widely disseminated through articles in Ontario newspapers.

In 1969, Bob was Vice-President of the OCA and attending Ontario Hospital Insurance Plan (OHSIP) meetings with the Honourable Thomas Wells, who had just been approved as Ontario's Minister of Health. Our profession was gratified since he "did not need to be 'sold' on the merits of chiropractic care or the fact that chiropractors should be included in OHSIP… he was more concerned about the costs… "[15] Wingfield "was struck by Tom Wells' concept there should be no discrimination in the application of coverage under universal health care." Wells felt patients deserved freedom of choice and wanted all primary contact health practitioners to become portals of entry, unlike the British system where medical doctors were the only way in. [Wingfield interview by the author, July 10, 2008]. Dr. Lloyd MacDougall (CMCC 1950) was at these sessions as the OCA's Legislative Chair. "He got along famously with Tom Wells" and strongly influenced the Conservative Government's decision to include chiropractic in what became known as OHIP (Ontario Hospital Insurance Plan), on July 1, 1970. Initial coverage was $5 a visit up to $100 per fiscal year, plus $25 for x-rays.

In 1966, the Ontario Government formed the Committee on the Healing Arts (CHA) to study all Ontario health providers and report on how legislation affecting the healing arts could be protected and refurbished. By the fall of 1970 Bob was President of the OCA and began challenging a CHA report[16] "which… if carried out… would have reduced chiropractors to the level of technicians, under direct supervision of the medical profession[17]." In 1971**,** Oswald Hall, PhD, one of Canada's senior, pioneer sociologists, emerged as Chair of the "Task Force on the Education and Practice of Chiropractors," for the Ontario

Figure 6.
OCA Board 1970
Seated L to R – P. Holtom, S. Stolarski, R. Wingfield, K. Wood & L. Rosenberg
Standing L to R – P. Hemingway, L. Stackhouse, L. Taylor, L. MacDougall, J. Price, R. Thurlow, D. Gleeson & R. Oswald

Council of Health (OCH). Other members were: George Connell, PhD, Professor, Faculty of Medicine, University of Toronto (U of T); Cameron Gray, MD, Executive Medical Director, Ontario Thoracic Society; Donald Sutherland, DC, Executive Secretary, CMCC; and Robert Wingfield, Immediate Past President, OCA.

The task force received extensive documentation and held four meetings between February 1 and 24, 1972, regarding scope of practice and regulation of chiropractors. Its first report to the OCH assumed that chiropractic is a recognized health service in Ontario and directly accessible to the public. Its Scope of Practice Recommendation 1 indicated that "Chiropractors may undertake the care of the spine and immediately related anatomical structures with respect to both the maintenance of health and differential diagnosis and treatment of mechanical disorders of spinal origin." Recommendation 2 stated "That chiropractors be regulated through licensing by a regulatory body under the Health Disciplines Board."[17]

In its appearance before the OCH, March 14, 1972, the task force admitted that its scope of practice statement was controversial because it was meant to be acceptable to both physicians and chiropractors. Dr. Hall hoped this would assist chiropractors to regulate their members, raise the level of their education and establish a convincing research base for the profession.

Between April 11, 1972 and January 11, 1973, the task force presided over 13 meetings on the second phase of its investigation; "defining educational objectives and relating these to an appropriate educational program." In its closing report to the OCH, the committee lists eight recommendations. Although recommendation 1, states CMCC should be maintained as a distinctive institution, recommendation 2, concedes that ultimately, "It is desirable that the College be joined to a university."

Dr. Wingfield perceived that, "Dr. Hall was impressive, impartial, very fair and broad-minded… He stated we would have to stop thinking in terms of independent disciplines and accept the concept of interdependent professions… Dr. Hall wanted to develop the profession, not restrict it… In the end, the task force helped us define ourselves as a profession." [Wingfield interview by the author, June 18, 2003]. Dr. Hall was not as optimistic. "The Ontario Council of Health asked us to explore the question as to whether the study of chiropractic belonged in a university setting. Both the committee and the Council announced a clear 'Yes.' However, the departments of health and of education were cool to the idea and it remained in limbo." [Letter, Hall to the author, Oct 5, 2001]

Canadian Chiropractic Association 1972-1981

In 1972, Dr. Wingfield had been elected to the CCA Board

and declared Chair of its Public Relations (PR) Committee. Canada's needs were determined centrally and the production distributed among the provinces. For example: Alberta published the CCA News and Ontario, under the prolific Ruth Hammond, generated pamphlets, films and news releases for national distribution while a wide network of CBC and CTV stations across the country carried her TV promos and she acted as PR consultant to the OCA.[18] By 1977, Bob was sitting on several legislative advisory panels and helping the OCA upgrade its x-ray program.

In 1978, Wingfield was elected President of the CCA at its Convention in Quebec City. On May 21, he addressed CMCC's class of 1978, during its convocation exercises at the University of Toronto Convocation Hall. Bob requested the graduates to "Always work for the betterment of chiropractic and for its growth… " reminding them the College is "a privately owned, higher education institution which exists and even thrives with no government support. Were it not for the financial aid of virtually every Canadian chiropractor, through their associations, none of us would be here today."[19]

Dr. Wingfield told the audience, "Chiropractic graduates of today are in an enviable position. My explanation comes from a classmate of mine, Gordon E. Potter, MB, BS, DC, who now practices medicine and chiropractic in Saskatchewan." Bob took the following four points from a paper Dr. Potter published in the JCCA, in which he compares chiropractic as a profession to a hypothetical ideal.

A. *A good ratio of help vs. harm. In a study of 744 cases seen in my own office in 1975, I worsened 0.6%. Iatrogenisity is at a minimum.*
B. *Significant help to significant numbers. Again, in my own study, averaging all categories of back pain, with all degrees of severity and chronicity, 70% achieved complete or almost complete relief. Few specialties can approach this.*
C. *Efficient use of time. The only specialty I have observed with volume potential approaching that of chiropractic, is dermatology.*
D. *Credibility and respect; a healthy referral attitude. This is far from perfect but improving.*

Dr. Potter's last piece of advice to the novice chiropractor is: "Do not underestimate the value of the spinal adjustment. It is one of the cornerstones of therapy. It always has been and always will be… learn, above all to adjust."[20]

1978 was the year Wingfield commenced a two year term on an independent agency, formed and sponsored by the CCA, called The Council on Chiropractic Education (Canada) Inc. CMCC had been an affiliate member of the Council on Chiropractic Education in the USA for many years, but it was not until June 1978 that its Board of Governors committed the College to accreditation.[21]

"Some Board weaknesses had been identified in the 1981 Status Study but no plan had been developed for correcting them and no sense of urgency existed."[22] The Resolution of the Commission on Accreditation of March 1982 reads in part: "The CMCC Board of Governors does not totally formulate a broad policy consistent with the Charter, Bylaws, nature and purpose of the College."[23] That year, Bob participated in an external review of the Board that resulted in a detailed report of its strengths, weaknesses and a set of recommendations for improvement. Through a series of planning retreats and instructional seminars the Board drafted its goals and objectives, used them to write its mission statement and devised a strategy for renovating the Board.

Four years later, major changes in the structure and functions of the Board had been realized and November 22, 1986, CMCC was granted Accredited Status by the Commission on Accreditation of CCE (Canada).[24]

In 1978 the New Zealand Commission on Chiropractic was inaugurated and as CCA President, Dr. Wingfield formed the "Canadian Resource Committee to the New Zealand Chiropractic Association (NZCA)," for the Commission of Inquiry. October 23, 1979, the New Zealand Commission released its report. Termed "the most comprehensive and detailed independent examination of chiropractic ever undertaken in any country," the 377 page document "validates the efficacy of chiropractic as it does the skill of the chiropractor; furthermore, it negates the attempts of other professions making value judgements on chiropractic care and methods." Dr. Wingfield and his committee, Drs. Tom Maxwell (CMCC 1955), Robert Thurlow (CMCC 1952) and Leo Rosenberg (CMCC 1961), were commended for providing the NZCA with "significant and voluminous information."[25]

All witnesses brought before the Commission were subject to cross-examination under oath. One was a Canadian physician who was also an official of the Consumer's As-

sociation of Canada. Compelling evidence about this individual's credibility had been given to the Commission by the CCA Committee, resulting in his disqualification.

May 1979 signalled the inception of a new threat to Ontario chiropractors when Dr. Kenneth W. Taylor, a medical radiologist, issued a news report disclosing that patient x-ray exposures in some examining rooms of a large Toronto hospital differed by factors of up to 30, from exposures measured in other rooms.[26] Immediately, the Consumers Association of Canada, Canadian radiologists, physiotherapists and members of the provincial legislature used this as an excuse to denounce the chiropractic use of x-rays. In June, the Ontario Ministry of Health (MOH) asked the OCA to assemble a Chiropractic Advisory Committee. In October, the CCA published an extensive rebuttal to the Consumers Association of Canada titled, "The Chiropractic Need For X-ray." This brief was presented to the federal and all provincial ministers of health, all members of parliament and provincial legislatures, as well as media from coast to coast. That same month the Ontario MOH formed The Advisory Committee on Radiology. Chaired by Dr. R. Brian Holmes, Dean, U of T Faculty of Medicine, its mandate was to develop a comprehensive strategy for x-ray safety throughout Ontario. Tabling its report in March 1980, its recommendations contained elements of the new x-ray safety legislation within Bill 177 (The Healing Arts Radiation Protection Act, 1980) and the HARP Commission came into existence.[27]

In November 1979, professional advisory committees were struck for medicine, chiropractic, dentistry, podiatry, osteopathy and x-ray technology. The chiropractic committee comprised Drs. R. Thurlow (Chair), R. Wingfield and Andrew Rainbow, PhD, McMaster University Department of Physics. It met regularly to develop an x-ray safety code for chiropractic x-ray facilities that would meet requirements yet to be determined by the Minister's advisory committee and was assisted by a sub-group drawn from the OCA, CCA, CMCC and the BDC. Ministry officials used Dr. Wingfield's clinic to assess the parameters of a typical chiropractic x-ray unit. "Much testing of exposures and darkroom procedures was done there in conjunction with Dr. Andrew Rainbow. An official later told me he was pleased that I was recording information from a pencil dosimeter and using an array of aluminum filters and lead shielding."[28]

On February 8, 1986, the BDC in conjunction with the OCA, presided over an intensive X-ray Legislation Seminar in Toronto, attracting chiropractors from all parts of the province. Moderated by Drs. Barnes and Donald Henderson (CMCC 1975), the speakers were Wingfield, Thurlow, Rainbow and Bert Vanderham (CMCC 1976). Topics included: The history of x-ray legislation in Ontario; HARP regulations; radiation doses and risks; how to comply with quality assurance requirements; and peer review of image quality. The work of the Advisory Committees and the HARP Commission ended in 1988.

Ontario Board of Directors of Chiropractic 1981-1987

Chiropractors in Ontario had been governed under the umbrella legislation of the Drugless Practitioners Act (DPA) since 1925. In 1952, the Ontario Government created the BDC. This was the first independent chiropractic regulatory body in the province. In 1974, Dr. Wingfield was part of the liaison group between the profession and the MOH, when the first six parts of a new Health Disciplines Act (HDA) which provided for an overseeing Health Disciplines Board and covered dentistry, medicine, nursing, optometry and pharmacy, were passed into legislation. At this juncture, Stephen E. West, DC, became Chair of the BDC.[29] The next government move was to strike a committee to make recommendations for chiropractors, optometrists, chiropodists and osteopaths (COCO). From then until he stepped down as Chair in 1984, Dr. West and BDC Vice-Chair Dr. Barnes, worked long and hard with OCA and CMCC reps, to negotiate with the MOH for new chiropractic legislation. [Steve West interview by the author, May 22, 2008] Barnes remembers attending 35 meetings, to no avail. Negotiations were difficult because the chiropractic profession was adamant that the scope of practice include diagnosis, the right to use x-ray and treatment of the nervous system. They were also complicated because in 1982 the MOH had established the Health Professions Legislative Review (HPLR) to examine 21 health professions, including those in the HDA legislation of 1974, rather than just four. [Fred Barnes interview by the author, Jan 29, 2009] Bob Wingfield recalls that, "Many meetings were held over a span of 18 years. It was like a great waltz. The government played the music while we danced on and on. We were getting nowhere but didn't want to stop the discussions." [Wingfield interview by the author re. Steve West, July 10, 2008]

Figure 7.
BDC Directors 1982
Seated L to R – F. Barnes, S. West & K. Wood
Standing L to R – R. Wingfield, D. Grant & S. Stolarski

In September 1981, Dr. Wingfield had been appointed to the BDC by an Order in Council of the Ontario Conservative Government and by 1982, was assisting with the arduous process of supplying briefs to the HPLR. The review explored many avenues of professional regulation but focused on: Identifying health professions to be regulated; developing frameworks for the operation of a governing body that are common to all health professions; and resolving scope of practice statements and licensed acts unique to each profession. Because 21 disciplines were being regulated, all possessed professional associations, regulatory bodies and possibly educational components, there were over 60 submissions for each round of HPLR requests. The BDC, OCA and CMCC submitted their individual briefs simultaneously, on each topic identified by the HPLR, but each from its own perspective. This involved extraordinary cooperation among the chiropractic organizations.[30]

Wingfield recalls that, "David Chapman-Smith, LLB, had been hired as an expert advisor to the OCA and retained as a consultant to the BDC. David's perspective and advice were invaluable in discussions with the review team on the subject of scope of practice." Chapman-Smith had been introduced to chiropractic as counsel for the New Zealand Chiropractic Association, while appearing before the 1978-79 Commission of Inquiry into Chiropractic. In 1982, he took a two year leave of absence from his law partnership, arriving in Toronto in May, to aid the OCA in solving two puzzles.

The first involved protecting the rights of chiropractors to take diagnostic x-rays. David Chapman-Smith was the main protagonist in preparing an extensive submission for the Ontario Government. Wingfield says, "it is a remarkable document… and could only have been written by someone who had intimate knowledge based on the NZ Royal Commission and its positive cross examination findings about our profession." [Email, Wingfield to the author, Dec 22, 2014]. It was also fortuitous that the Honourable Larry Grossman was MOH February 1982 to July 1983. Before becoming MOH he had opposed his predecessor Frank Miller's decision to shut down the Kensington Hospital in Grossman's riding, so he was the perfect politician to promote chiropractors taking diagnostic x-rays.[31]

Chapman-Smith's second conundrum was more convoluted. It entailed drafting appropriate new chiropractic legislation under the previously mentioned HPLR of 1982. Now, instead of dealing with MOH representatives with whom they had interacted since 1974, the profession had to begin anew with an independent consulting body headed by lawyer Alan Schwartz. David Chapman-Smith originally thought the process would take two years, but deliberations were protracted and the new Regulat-

ed Health Professions Act (RHPA), containing the new Chiropractic Act, did not receive Royal Assent until December 1991. "However, it produced a new approach to regulating the health professions that was widely admired and subsequently followed in Alberta, then other provinces and internationally." [Letter, Chapman-Smith to the author, Mar 21, 2012]

Dr. Wingfield remained a BDC Member until February 1986, when he assumed the role of Chair. In July 1986, the Board adopted an important policy revision on chiropractors use of the title "Doctor" on signage, letterhead, etc. This was in response to a complaint Wingfield had received on February 25, 1986, from John R. Carlisle, MD, Associate Registrar of the College of Physicians & Surgeons of Ontario (CPSO). The CPSO had canvassed a large number of Toronto chiropractors whose phones were answered, "Dr. so and so's office" and Dr. Carlisle wanted the board to order the offenders to cease and desist referring to themselves as "Dr" and report back to assure him of their future compliance.

This was consistent with long standing BDC policy and with what Bob had been taught in Ontario jurisprudence lectures at CMCC, but the process rankled him and he restudied an "Office Consolidation" edition of the DPA to better comprehend the intent of its authors.[32] In Chapter 137, 6 (f), under Regulations, Bob noted that the Board may make regulations "for designating the manner in which a person registered under this Act may describe his qualification or occupation… " and under Regulation 228, Designation 13, he saw that "As an occupational designation chiropractors may describe themselves as chiropractors only" and came to the realization that neither the DPA, the Regulations nor for that matter the Medical Act, prohibited a qualified chiropractor from using the title "Doctor," as long as registrants also identified themselves as being chiropractors.

Wingfield rationalized that these facts empowered the Board to establish policy in this regard. The BDC and its solicitor, Donald J. Brown, QC, agreed with Bob's recommendations. This precedential policy was transmitted to the OCA executive and then carried forward into the HPLR discussions.

The BDC had been located at 20 Prince Arthur Avenue, Toronto, for decades. In December 1986, it relocated to a larger, modern office space at 130 Bloor Street West and February 13, 1988, Robert Wingfield's position as Chair and last term as a Director on the Board expired.

In December 1991, the RHPA, including the new Chiropractic Act, received Royal Assent and chiropractors were listed among the few self-governing health professions with a defined scope of practice that includes diagnosis and the definitive right to use the title "doctor." Among the controlled acts are, "communicating a diagnosis" and "moving the joints of the spine beyond their usual range of motion using a fast, low-amplitude thrust."[33]

December 31, 1993, the RHPA was proclaimed and the BDC replaced by the College of Chiropractors of Ontario (CCO) which had its first meeting March 26, 1994. In 1995 Steve West was called upon to join the CCO Education Committee. Headed by Bertram L. Brandon (CMCC 1966), the Committee orally evaluated graduates applying for licensure in Ontario, primarily on their clinical skills. Steve could not remember anyone failing this exam however, they were soon entangled in a more exhaustive process and Wingfield was brought aboard.

The new system involved testing nine candidates at a time, but in separate rooms, by nine examiners and nine patient/actors simulating the same condition. Each room contained video equipment and an adjusting table. Applicants were given the scenario to be played by all the actors. They were expected to conduct a consultation and examination, arrive at a diagnosis, simulate an adjustment and/or provide advice regarding nutrition, home remedies and future treatment. All proceedings were video-taped and the candidates graded by the examiners. Afterwards, the examiners themselves could be evaluated on the appropriateness of their findings.

The new approach was described as complex, costly, time-consuming and unnecessary, because the candidates were being tested on areas that had been thoroughly covered by the respective chiropractic educational institutions. In addition, they had passed the National Boards set by the Canadian Chiropractic Examining Board (CCEB) and should have been tested on their knowledge of the laws in Ontario. In 1999 the Education Committee was disbanded, ending Dr. Wingfield's tenure with the CCO.

Insight

Dr. Wingfield may wear glasses to read but his vision into the future can be startling. Ontario Chiropractors achieved partial coverage of their services under OHIP on July 1, 1970. At the OCA annual meeting in September, President Wingfield congratulated the membership for

enabling this "quantum leap forward in public and professional respectability" but warned, that "health care costs are sky-rocketing" and increased demands for chiropractic services are "inevitable" now that some are covered by OHIP. "We must agree to hold the line on our fees … We must co-operate with other health delivery groups to reduce costly duplication of services." Because the government is paying chiropractors' bills "we can expect to be dissected and examined more closely than ever." Bob finished by assuring the audience, "We have nothing to fear providing our training is sound and our standards high."[34]

Despite the fact chiropractors received their last fee-for-service increase of 15 cents in 1989, freedom of accessibility was maintained until December 1, 2004 when the Progressive Conservative Party was overturned and chiropractic care completely de-listed by the Liberal Party under Premier Dalton McGuinty. In an interview by the author July 10, 2008, Wingfield made the following paraphrased statements:

> *Our profession has always talked to the government about the need for more money and larger fees; never about accessibility. The Liberal Government replied: Sorry, we can't afford your services. Goodbye!*
>
> *Chiropractors are not proactive in regards to planning for health care. We need advisers to tell us what government policy will be in the future so we can prepare. One way is by cultivating political networking.*
>
> *In the last four decades we have lost public acceptance while gaining far more scientific legitimacy. Now our equilibrium seems to have returned and public favour is slowly responding.*

Scientific legitimacy has been won through research. Twenty years ago Allan C. Gotlib, CM, DC (CMCC 1976), Director of Research for the CCA and Editor of the JCCA, had the intellect and drive to begin expanding the profession's research capacity by establishing university-based Chiropractic Research Chairs and Professorships from coast to coast in Canada. Greg Kawchuk, DC, PhD (CMCC 1990), assumed the first chair at the University of Calgary, AB, in 2001 and Simon French, BAppSc(Chiro), PhD, University of Melbourne, Australia, became the 15th chair at Queen's University, Kingston, ON, in 2013.[35] By the end of 2014, the profession had 30 DC, PhD's in full-time research and 19 DC, PhD candidates training in university-based PhD programs across the country.

Figure 8.
CMCC President, David J. Wickes signs a Memorandum of Understanding with 3 faculties at the U of T. Photograph courtesy of the University of Toronto.

CMCC's research agenda is geared toward elevating the quality of patient outcomes and has three on-site centres: The Centre for the Study of Mechanobiology; the Centre for Inter-professional Health Dynamics; and in 2013, the University of Ontario Institute of Technology (UOIT) – CMCC Centre for the Study of Disability Prevention and Rehabilitation. Campus labs support these centres by exploring biomechanics, neurophysiology, cellular biology and histology. Since 2011, the College has encountered a surge in the number of universities interested in some form of mutual cooperation. In 2011 CMCC developed an arrangement with the Anglo-European College of Chiropractic, Bournemouth, England; in 2012, CMCC penned its inaugural articulation agreement with the UOIT; in May, 2014, the College inked a similar agreement with the University of Winnipeg. On October 27, 2014 CMCC approved a Memorandum of Understanding with the Hong Kong Baptist University and on December 4, 2014, our new President David J. Wickes, DC (NCC 1977), MA, signed a Memorandum of Understanding with the University of Toronto, through the Faculty of Medicine, Leslie Dan Faculty of Pharmacy,

and the Faculty of Kinesiology and Physical Education, to explore education and research collaboration.[36]

Acclaim

Wingfield's efforts have not gone unnoticed. In 1972, Bob earned the title OCA Chiropractor of the Year, in 1983 he was named a CCA Honour Member and in 1988 he received a HARP Service Award. Feb 29, 1992, was particularly pleasant. That day, 400 OCA members and friends, flocked into the Bristol Place Hotel, Toronto, to celebrate passage of the new Chiropractic Act. Many people were thanked for giving of themselves to make this dream come true, but it was acknowledged that 10 stalwarts deserved special commendation. These were: Drs. Colin Greenshields, Lloyd Taylor, Lloyd MacDougall, Harold Beasley, Don Sutherland, Leo Rosenberg, Herb Vear, Steve West, Fred Barnes and Bob Wingfield.

Wingfield is aware that his chiropractic administrative adventures flourished because he was surrounded by colleagues who cheerfully accompanied him on this long, tortuous journey. Bob gives his wife Anne credit for much of his good fortune, asserting his involvement would not have been as pervasive without her devotion and expertise at orchestrating the minute details of their private domain. Anne was prolific in her own political realm. In three municipal elections she received more votes than any of the other candidates and was elected to the Burlington Hydro Electric Commission four times, assuming the chair on three occasions. Anne belonged to five different City of Burlington sub committees and chaired one. She was appointed as a Public Member of the College of Audiologists and Speech Language Pathologists of Ontario and is an Honorary Life Member of the Burlington Historical Society. In 1993, The Honourable Henry Jackman, Lieutenant Governor of Ontario, presented Anne with, "The Queen's Medal to Commemorate the 125th Anniversary of the Dominion of Canada." This was "awarded to those persons who have made a significant contribution to Canada, Their Community and to Their Fellow Canadians."

Recreation

From 1958 until he sold his business in 2002, Dr. Wingfield practiced Monday, Tuesday, Wednesday and Friday, theoretically giving him lots of free time for leisure activity. In his first decade Wingfield golfed frequently on Thursdays with local chiropractors Don Moore, Earl Sawyer, Yosh Sugimura, Jim Barrow, Mert Holmes and Vern Thompson. That was until sailing caught Bob's eye and then, true to form, he became an enthusiast. With a newer and larger boat every few years, he and Anne ended up with a Cuthbertson & Cassian (C&C) 27 ft. yacht. Now, instead of golfing on Thursdays he sailed with his friend Dr. Dick Wynn. After mooring at the Burlington Sailing and Boating Club, they returned to Dick's home on Lakeshore Road, where they talked shop and exchanged adjustments. Weekend cruises were with his family, mainly on Lake Ontario, but also in the North Channel and once chartering a boat to sail in the Virgin Islands.

Figure 9.
The Wingfield family's country home on the farm they call Backacres

Sailing was curtailed for the Wingfields after 1970, when they purchased an abandoned, 100-acre farm in Grey County, they call "Backacres" and Bob took courses at the University of Guelph to find out what to do with it. They decided to take advantage of the Ontario Govern-

ment's tree planting incentive and raise several thousand trees instead of cows, because they don't require fences or pasture. In 2005, they had their first commercial logging operation, which took six weeks to complete.

Built in 1870, the farmhouse was in poor condition, the barn had been taken down to the stone foundation and there was much to be done, indoors and out. Everyone pitched in, including their three children, who were all under 10 years of age. "Winter access from the county road by car was impossible so we trekked in by snowshoe, pulling a sled filled with our supplies and tools." Purchasing all the wood from a dismantled Anglican Church, they transported it to their property in a borrowed hay wagon one summer and spent the next few years rebuilding a storage barn on part of the old foundation.

The Wingfields' farmhouse is heated by electricity but they have a fireplace which consumes a lot of wood that is stored in a purpose-built woodshed. Originally they felled the trees with chain saws and split the wood with axes. Inevitably there were wood splitting competitions. As the ménage has grown through marriage, there are no longer any contests but rather work parties of three generations, just to fill the woodshed. "When the whole tribe is here, it is customary to play board games on the dining room table and on a recent Thanksgiving weekend, the traditional day trip to Blue Mountain or Beaver Valley was supplanted by a long hike along the trails of our own forests." [Wingfield email to the author, Feb 23, 2015]

Semi-Retirement

In 2002, Dr. Wingfield sold his practice and later his office and now (2015) practices Monday evenings and Wednesday mornings. He has served on Municipal Committees and is currently a member of the Burlington Conservative Association and the Burlington Waterfront Committee. Bob's family is close, because he has applied the same principles around the dining table that he did around the board room table; namely treating others with respect, preserving dignity, taking responsibility and expecting the same in return.

For decades, Bob has been accumulating information about his father's exploits in WWI and in 2014 it culminated in the publication of Bob's book, "Frederick Cecil Wingfield In The Great War, 1914-1918." Inquisitiveness about this subject dates back to his childhood when WWII, dominated the news. Wanting to compare that

Figure 10.
Anne & Bob relaxing on their balcony in Burlington

with WWI, Bob asked his father a lot of questions. His children were fond of their grandfather and also curious about his past. Now Anne and Bob's grandchildren have accepted the challenge. Hayley, their eldest granddaughter, is in her fourth year at Queen's University, majoring in history and doing tutorials on WWI.

Bob's concentrated probes for explicit data "included two trips to European war sites (one with our son David and one with Anne) and extended correspondence with a noted author of 12 war history books." In 2013 Bob wrote a full draft with the intent of passing it along to his father's family tree. "I really had not considered publishing a book. I thought it was beyond my competence."

The Wingfields' son-in-law, Brian Forsey and daughter Candace saw the draft and offered to find a print shop and manage the technical details to publish the book. The idea caught on and their other son-in-law, Rob Coulman and daughter Alison, volunteered to do the formatting, layout and initial editing, while Hayley attended to the bibliography. David had been editor of the Queen's Law Review and with a long history of writing legal briefs, he suggested the editing principles Bob should follow to ready the volume for final revision. "As it turned out, there were nine sets of revisions. Had our family not banded together, this book would not have been published." [Email, Wingfield to the author, Feb 2, 2015]

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