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Contents

JCCA Vol 62 No 2 ISSN 0008-3194 (Print) and ISSN 1715-6181 (Electronic)

Original Articles

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The prevalence and characteristics of HIV/AIDS patients presenting at a chiropractic outpatient clinic in Toronto, Ontario. A retrospective, observational study

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Tony Tibbles, DC[1]

Objective: *To determine the prevalence and presenting complaints of HIV/AIDS patients attending a chiropractic outpatient teaching clinic in downtown Toronto, and explore their self-reported comorbidities, medications used, and consumption of other complementary health care.*

Methods: *A random sample was drawn from the entire clinic file collection spanning the years 2007 to 2013. Files were anonymized and coded to ensure confidentiality.*

Results: *A total of 264 files were radomly pulled from approxinately 3750 clinic files. The prevalence of HIV*

Objectif : *Établir la prévalence des symptômes des patients séropositifs ou atteints du sida fréquentant un clinique chiropratique d'enseignement au centre-ville de Toronto et étudier les comorbidités autodéclarées, les médicaments utilisés et les soins de santé complémentaires.*

Méthodologie : *On a choisi au hasard des dossiers de patients parmi tous les dossiers de la clinique, à partir de 2007 jusqu'en 2013. Les dossiers ont été anonymisés et codés pour assurer la confidentialité.*

Résultats : *Au total, 264 dossiers ont été choisis par hasard parmi les quelque 3 750 de la clinique.*

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positive patients was 5.7% (15/264), predominantly males, with 3 patients having developed AIDS. Co-infection with Hepatitis B and/or C was identified in 5/15 patients. The most common presenting complaint was neck pain (80%), followed by low back pain (47%) compared to 20% and 43% respectively for the general cohort. Eleven of 15 patients were on antiretroviral treatment (ART); The frequency of comorbidities was 8/15 (53%) however, none were identified as being dominant. In addition to chiropractic, 7/15 patients reported receiving other complementary therapies.

Conclusions: *A relatively small proportion of HIV/AIDS patients were found to be receiving treatments in this downtown chiropractic clinic situated within a community health clinic setting. The principal presenting complaint was neck pain.*

(JCCA. 2018;62(2):77-84)

KEY WORDS: HIV, complementary therapies, chiropractic

La prévalence des patients séropositifs était de 5,7 % (15/264); la plupart étaient des hommes, 3 patients avaient développé le sida. Une co-infection par l'hépatite B et (ou) l'hépatite C avait été diagnostiquée chez 5 patients sur 15. Les symptômes les plus fréquents étaient la cervicalgie (80 %) suivie de la lombalgie (47 %); la fréquence de ces symptômes étaient de 20 % et de 43 % respectivement dans la cohorte générale. Onze des 15 patients suivaient un traitement antirétroviral (ARV). La fréquence des comorbidités était de 8 patients sur 15 (53 %), mais aucune n'était considérée comme dominante. Sept patients sur 15 ont déclaré suivre des traitements complémentaires en plus des traitements chiropratiques.

Conclusions : *Une proportion relativement petite de patients séropositifs ou atteints du sida recevait des traitements dans cette clinique chiropratique du centre-ville située dans un établissement de soins de santé communautaire. La cervicalgie était le principal symptôme dont se plaignaient les patients.*

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MOTS-CLÉS : VIH, traitements complémentaires, chiropratique

Introduction

The epidemiology and outcomes of HIV infection have changed since the advent of antiretroviral treatment (ART). The life expectancy of people with HIV has increased and is approaching or equaling that of uninfected individuals in the USA and Canada.[1] People with HIV are living longer, tend to lead active lives, and may increasingly need rehabilitative services.[2] Both HIV infection itself as well as ART received by HIV infected patients lead to the development of non-AIDS defining co-morbid conditions.[3] Evidence has suggested that immune activation due to ART may result in a state of chronic systemic inflammation explaining the development of chronic pain syndromes.[4] Co-infection with Hepatitis B (HBV) and/or Hepatitis C viruses (HCV) with associated liver disease[5], as well as chronic pain syndromes[6], including musculoskeletal (MSK) conditions[7,8], have been reported as confounders of the chronic disease state in patients living with HIV/AIDS (PLWHA). Many such patients suffering from chronic health issues often seek help from a variety of complementary and alternative medicine (CAM) practitioners.[9]

The generally accepted definition of CAM is the application or utilization of therapies and treatments that lie outside the mainstream western medical health care approach.[10] The term Complementary and Alternative Medicine is now often referred to as Complementary and Integrative Healthcare. The definition provided by The National Center for Complementary and Integrative Health (NCCIH) (formerly NCAAM) is similar and its classification system lists chiropractic as a "complementary health approach", as opposed to alternative, and discusses it under the heading of "Mind and Body Practices".[11]

The use of CAM by HIV infected patients has been the subject of many investigations.[9, 12-15] A literature synthesis

by Littlewood and Vanable[12] indicated the most commonly cited reason for using CAM by HIV-positive patients is the management of infection-related symptoms and ART side effects. However, some CAM interventions may potentially interact with ART treatments prompting a need for vigilance in their use.[6,9]

Variable rates of CAM utilization have been reported by different authors.[9] For example, 55% of PLWHAs in Australia used CAM, of whom only 2% sought chiropractic services.[13] On the other hand, in a large study of CAM use in HIV positive men and women in the United States chiropractic was utilized by 25.7% of that population, although it lagged behind other CAM modalities such as massage therapy (48.8%) and acupuncture (45.4%).[14] A study of CAM use by PLWHAs attending HIV outpatient clinics in Ontario, found that 19.2% of respondents utilized chiropractic services compared to an overall CAM utilization of 89.4%.[15]

The Sherbourne Health Center (SHC) in Toronto is a multidisciplinary community-based health facility providing services to the inner city communities that are predominantly underserved including HIV/AIDS patients.[16] Among its services SHC provides complementary therapies to the community, including naturopathic treatment and also including chiropractic services through an outpatient teaching clinic embedded within the center.[17] Two papers published from the clinic in the past have discussed clinical cases of HIV/AIDS patients; one describing a patient with rabdomyolysis[18] and the other lipodystrophy involving the heels of two patients[19]. Anecdotally, a significant proportion of patients, both male and female, presenting to this clinic are PLWHAs. However, their prevalence and the reason(s) for their presentation have not been investigated. Insight into, and documentation of the prevalence of such complaints is important both from a pedagogic as well as patient management perspective. In the present study we wished to determine the prevalence of PLWHAs attending the clinic from 2007 to 2013, and in addition document their primary presenting complaint(s), any co-morbidities at presentation, and their use of medication. Furthermore the proportion of PLWHAs co-infected with HBV and/or HCV infection was investigated as a secondary outcome as co-infection of HIV with HBV and/or HCV has been well established.[20]

Methods

Study Design

The CMCC Chiropractic Clinic at the Sherbourne Health Centre was established in 2001, however, consistent with statutes of limitations files that were available for this study spanned the years 2007 to 2013. Electronic records replacing paper files in late 2013 were excluded.

Data was collected on location. Based on the total number of files available and the desired sample size, two co-investigators (KF and GC) pulled files randomly at predetermined intervals (see sample specification and sample size estimate sections below) and assigned a code number to each file in order to ensure confidentiality. Thus, the identity of patients were concealed from all other investigators/personnel involved in the study at all times. Clinic Intake Forms routinely inquired about HIV and/or HBV/HCV positivity, making self-reported raw data potentially available to determine the prevalence of these infections. Where absent, and also for finding other information required for the study, patient charts were reviewed in detail. A preconstructed template designed for the purpose of this study was used to collect data on a) demographic characteristics of patients, b) the occurrence of HIV/AIDS, HBV, HCV positives, c) the primary presenting complaint (s), d) medication(s) used, e) co-morbidities and f) other complementary therapies used. The templates were updated as new files were reviewed and were kept under lock and key in the clinic filing cabinet. Upon completion of data collection, all information on the two templates were transferred to an electronic spreadsheet by an independent research assistant. Each entry in the two data sets was checked and reconciled by the principal investigator (HSI) using a triangulation method.[21] Where a discrepancy existed (a total of 4 were detected) the principal investigator consulted the list of coded files, returned to the original file and resolved the discrepancy. The list of coded files was destroyed upon completion of the study.

Sample specification

In this retrospective study a representative sample of patient files were drawn from the entire Sherbourne clinic collection (approximate n = 3750) spanning the years 2007 to 2013.

Analysis and Justification of Sample size

Sample size was determined by the confidence interval method. For a desired precision of 4.35% on either side of our preferred estimate based on data from a previous unpublished pilot study on pre 2007 files from the same clinic suggesting a prevalence of 11%, 200 subject files would be required for a 95% confidence interval. However, for added safety, we increased the number of patient files by approximately 25%. Working with the estimated total of 3750 files, every 15th file would be drawn to yield a minimum total of 250 files.

The prevalence of HIV/AIDS patients, as well as those with HBV or HCV infections is expressed as percentages. Data pertaining to demographic trends, presenting complaints, co-morbidities, and medication usage is analysed in comparison to their occurrence in the non HIV positive cohort.

Ethics

Consent for use of personal information for research has been obtained from patients at initial presentation to the clinic. No further attempt was made to update consent prior to data collection for this study. Ethics approval was obtained from the Research Ethics Board of CMCC.

Results

Every 15th file was drawn up to a total of 264 files. These were reviewed consecutively. No files were discarded because of unavailability of data.

The demographic data indicate the median patient age in the entire population included in the study was 38.0 years (mean = 40.16 ±15.34 SD), with a male to female ratio of 4:5. The frequency of HIV infected individuals was 15/264 (5.7%) with median age of 46.0 (mean = 45.53 ±9.86 SD) (Tables 1 and 2) compared to median age of 38.0 (mean = 39.83 ±15.56 SD) for the non-HIV positive cohort (Table 2). By far the majority of PLWHAs were males (14/15) of whom 3 had developed and were under treatment for AIDS. One of the 15 HIV infected patients was also positive for HBV (6%), 3 were positive for HCV (20%) and one was positive for all three viral infections (Table 1). In contrast the frequency of HBV in the non HIV positive population examined in this study was 2/249 (0.8%) while that of HCV was 9/249 (3.6%) (Table 2).

Most HIV-positive patients in the study presented for treatment of a primary complaint of neck (80%) and low

Table 1.
Number of HIV-positive patients also having a history of AIDS, HBV and /or HCV infection.

Patient	Age	Gender	HIV	AIDS	HBV	HCV
1	46	M	X			
2	40	M	X			
3	49	M	X		X	X
4	45	M	X			
5	29	F	X			
6	65	M	X			
7	39	M	X	X		
8	47	M	X	X		
9	57	M	X			
10	41	M	X			
11	49	M	X	X		X
12	37	M	X			
13	32	M	X			
14	51	M	X			X
15	58	M	X			

Table 2.
Comparison of demographic and selected clinical characteristics between HIV and Non-HIV cohorts.

	HIV N =15		Non-HIV N = 249	
Gender	M	F	M	F
	14	1	115	149
Age	45.53 (9.86)		39.83 (15.56)	
HBV	1		0	
HCV	3		6	
Low back pain	7		114	
Neck pain	12		59	
Shoulder pain	1		42	
Knee pain	–		17	
Hip	–		11	
Thoracic spine pain	–		19	
Osteoporosis	3		2	
Hyperlipidemia	2		16	
Diabetes	–		12	
Hypertension	3		28	
Heart disease	1		1	
Renal disease	2		–	
Depression/anxiety	3		19	

Legend: ( ) = Standard deviation.

Table 3.
Summary of primary complaint of HIV-positive patients presenting to the Sherbourne Chiropractic Clinic along with self-reported medication use, comorbidities and use of other Complementary and Alternative Medicine (CAM).

Patient	Presenting complaints	Medications	Comorbid conditions	Other CAM
1	Neck and LBP	Valtrex	Herpes zoster	None
2	Neck pain	Trizivir	Osteopenia	None
3	Neck and LBP	Antiretrovirals, Effexor, Ritalin, Wellbutrin, Zanex,	Folliculitis Depression	None
4	Shoulder pain	Antiretrovirals Percocet, Valium, Tylenol 3		None
5	Neck pain	Nasonex, Nexium	Ulcer, GERD, hypercholesterolemia, hypoglycemia	Naturopath
6	Low back pain	Sustiva, Combivir, Oxycontin, Percocet, Adalat, Aggrenox, Cumadin, Atacand, Andriol, Crestor	stroke, heart attack, hypertension, cataracts, HAV, osteopenia	Naturopath
7*	Full spine+, ribs, calf, plantar, and TMJ, headaches	AZT, Kaletra, Enapril, Zopiclone, Adderall, Lyrica	Hypertension, IBS, previous kidney failure, sleep apnea, osteopenia	Meditation
8*	Neck and LBP headaches	Ziagen, Valtrex 3TC, Viramine, Retonavir, Reyataz, Wellbutrin, Neurotonin, Septra,	Depression, HPV, Kaposi's sarcoma (history of)	Physiotherapy naturopath
9	neck pain	Advil, percocet		None
10	Low back pain	HIV cocktail (3TC, D4T), Clonazepam	Anxiety, colitis/IBS, osteopenia	None
11*	Neck pain	Intelence, Ziagen	Non-Hodgkins Lymphoma, liver cirrhosis, peripheral neuropathy, tinnitus	Tai chi
12	Neck pain	HIV meds + Crestor	Hypercholesterolemia	None
13	Neck pain, wrist and hand pain, diffuse back and chest pain	Celebrex, amitriptyline, vasotec, losec, ritalin	Fibromyalgia, hypertension, IBS, depression, kidney failure	RMT
14	Neck and LBP	Kaletra, Truvada		None
15	Neck pain	Supplements, no prescription meds	Herpes virus II	naturopath

Legend: *Reported history of AIDS, + Includes neck, upper back and low back pain.

back pain (47%) (Tables 2 and 3). Two patients with neck pain also complained of multiple problems, and only one had presented with a complaint of shoulder pain. On the other hand, of the 249 non-HIV positive patients included in the study only 59 (27%) had presented with neck pain, and 114 (45%) with LBP (Table 2).

At the time of presentation, most PLWHAs (11/15) were on retroviral medication while several were, additionally on a variety of other medications including pain killers, antidepressants, proton pump inhibitors and statins (Table 3). Self-reported co-morbidities by 8/15 PLWHAs included hyperlipidemia, hypertension, cardiovascular disease, renal disease, osteopenia and depressive/anxiety disorders (Table 3), while 4/15 patients, including one with history of AIDS, reported non AIDS-defining infections namely, herpes zoster, human papillomavirus infection, folliculitis and genital herpes (Table 3). On the other hand, 3/15 patients, two of whom were on ART treatment, did not report any co-morbidities.

In addition to chiropractic treatments, 7/15 PLWHAs also reported receiving complementary therapies. Four from naturopaths, one from a naturopath and a physiotherapist, one received massage therapy, one practiced Tai Chi and one practiced meditation (Table 3).

Discussion

In the cohort of patients in this study PLWHAs represented 5.7% of the population. Acording to Ontario Ministry of Health data the estimated number of PLWHAs in Ontario, in 2008, was 26,627 while in 2012 the number had risen to 32,542.[22] The majority of PLWHAs live in Toronto[23], where an estimated prevalence of about 1/120[24] or approximately 20,000 persons in total, has been reported. Our finding of 5.7% of clinic patients being PLWHA indicates that of the entire 3,750 patient population attending the clinic between 2007 and 2013, only about 200 PLWHAs have received chiropractic care, which in the context of the entire PLWHA population of Toronto, indicates about 1% had received chiropractic care through this clinic. This proportion is disappointing when compared to the previously reported rate of 19.2% of HIV infected outpatients using chiropractic services in Ontario[15], and also in view of the mandate and location of the chiropractic clinic within the Sherbourne Health Centre[17].

Of note, only one of 15 PLWHAs in the cohort studied was a female. This ratio is substantially smaller than the nationally reported proportion of approximately one in four females being infected in Canada.[25] Nevertheless the general trend of a larger proportion of males being infected with HIV is held true, although it is likely that a larger sample size might have identified a higher proportion of female HIV/AIDS patients attending the clinic.

The data collected on medications used by the HIV positive cohort revealed that 11/15 patients were on an antiretroviral medication, while four others were on a variety of non-antiretroviral therapies including one who was on supplements only. While this may suggest a higher level of choice of complementary therapies such as chiropractic and naturopathy (Table 3), several possibilities may explain why ART is excluded from the management of these patients. The US Department of Health and Human Services recommends ART initiation as early after diagnosis as possible.[26] Other leading organizations advocate ART initiation to be guided by CD4 counts and viral load levels.[27] Thus, no-ART treatment in some patients may be due to differences in time of initiation of treatment relative to first demonstration of HIV positivity. On the other hand some patients may have discontinued ART on a temporary basis. This might be the case, for example if hepatic complications occur during treatment due to co-infection with HBV and/or HCV.[28] However, none of the patients reporting no-antiretroviral medications in our cohort were co-infected with HBV or HCV (Table 1 - patients #5, 9, 13, 15) although, as expected, the frequency of infection with HBV or HCV was higher in the PLWHA cohort than in the general cohort (Table 3).

Finally, being on non-antiretroviral therapies may be a matter of personal choice with or without the knowledge of the patient's primary physician. A large population-based study of people living with HIV in Ontario, Canada has found that primary care is best provided in a model where patients are assigned to a family physician or a family physician-dominant co-management with a specialist.[29] However, there remains a dearth of evidence of direct interaction between family physicians or HIV specialists and practitioners of complementary therapies regarding the care of their HIV patients. Indeed, communication of consumption of complementary therapies by HIV patients to their primary medical practitioners is reported to be at a low level[15,30], as is also the case for the general population[31], despite evidence that effective doctor-patient communication is an important determinant of optimizing health care[32].

The self reported co-morbidities associated with HIV/AIDS included conditions/risk factors which are well established in the literature including hypercholesterolemia, hypertension, cardiovascular disease, renal disease, and mental disorders such as depression and anxiety.[4] In a population based study of PLWHA in Ontario Kendall *et al*. found mental health conditions to be the most prevalent comorbidity relative to other, "physical conditions".[33] Interestingly however, consideration of the data at hand (Table 2) does not indicate predominance of a single co-morbidity common to most in the 15 patient cohort in this study. Three files did not have documentation in regards to co-morbidities even though the two patients involved were on ART (Table 3). This may be explained by the fact that HIV- or ART related comorbidities develop later in the progression of the disease[4] and these patients may have been diagnosed recently. Nevertheless, the strong association of HIV infection as well as ART with co-morbid conditions namely the development of metabolic syndrome[34] on the one hand, and of osteopenia/osteoporosis increasing risk of bone fractures on the other[35], should be of utmost concern in the chiropractic treatment of patients.

It is well established that the infection itself or treat-

ment with anti-retroviral drugs have MSK pain consequences.[7,8] Although most such conditions reported represent rheumatologic, infectious or neoplastic cases requiring medical interventions, non-specific pain syndroms amongst PLWHA emanating from injuries to, or dysfunctions of muscles and joints cannot be precluded. Almost all PLWHA included in the current study had presented with the complaint of neck (80%) or low back pain (47%). While the frequency of LBP amongst the HIV positive cohort appears no different from that of the general patient population in the study, the frequency of neck pain is significantly higher (80% vs 20%). Both low back pain and neck pain are important contributors to the health care burden in communities globally[36,37], and are well recognized as being primary reasons for the general public to consult a chiropractor[38,39]. The high prevalence of these conditions, in particular that of neck pain, in the HIV-positive cohort underscores a need for a wider scale study in this area utilizing a larger sample size.

Conclusions

The prevalence of people living with HIV infection presenting to the Sherbourne chiropractic clinic is 5.7%. Our data indicates the most common presenting complaint to the clinic is neck pain. There appears to be a need for increased collaboration with primary care givers of PLWHA with a view of helping address some of the common MSK problems associated with HIV infection and ART.

Limitations

Sample size calculation was based on earlier observation on a pre-2007 cohort from the same clinic. This may have caused underestimation of the number of files targeted for review. Data extracted from patient files is based on self reported information and as such may be an over- or underestimation of the true demographic and/or clinical picture. Furthermore, it is fully realized that it is not possible to make generalizations on the basis of the self-reported use of medications, co-morbidities, and CAM modalities utilized by the HIV/AIDS cohort in this study.

No effort was made to extract data pertaining to time frame of initial diagnosis which would help in better understanding of the use of ART and development of comorbid conditions. Information regarding referral of patients for chiropractic treatment, whether from internal or external medical sources, as well as any evidence of communication of treating chiropractors with primary care givers would have provided valuable insights into interprofessional collaboration in the community health clinic setting. Further investigation in this area may be warranted.

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Does the Gillet test assess sacroiliac motion or asymmetric one-legged stance strategies?

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Objective: *The purpose of this study was to quantify the extent to which apparent movements of the posterior superior iliac spine and sacral base areas Gillet sacroiliac motion testing were related to (a) degree of hip flexion and (b) the examiner's palpatory pressure.*

Methods: *A preliminary exploratory study quantified relative PSIS/S2 displacements in 10 sacroiliac joints among 5 asymptomatic subjects at 10° increments of hip flexion from 0-90°. A comprehensive follow-up asymptomatic study quantified PSIS/S2 displacements at 0° vs. 30° vs. 90° hip flexion, and for light vs. firm pressure at 30° hip flexion. Displacements measured in pixels on digital photographs were transformed to mm. Mean differences for the various test conditions*

Objectif : *Cette étude visait à déterminer dans quelle mesure les déplacements de l'épine iliaque postéro-supérieure (EIPS) par rapport à la base sacrée durant le test de la mobilité sacro-iliaque de Gillet étaient reliés a) au degré de flexion de hanche et b) à la pression palpatoire exercée par l'examinateur.*

Méthodologie : *Une étude exploratoire préliminaire avait consisté à mesurer les déplacements relatifs de l'EIPS par rapport à S2 dans 10 articulations sacro-iliaques chez 5 sujets asymptomatiques, en augmentant progressivement par palier de 10 degrés la flexion de hanche, à partir de 0° jusqu'à 90°. Une étude de suivi chez des patients asymptomatiques a consisté à mesurer les déplacements de l'EIPS par rapport à S2 lorsque la flexion de hanche était de 0°, de 30° et de 90°, quand l'examinateur exerçait une pression légère et une pression forte et que la flexion de hanche était de 30°. Les déplacements exprimés en pixels sur des photographies numériques ont été convertis en millimètres. Les différences moyennes entre les diverses conditions du test ont été évaluées par tests t pour*

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were evaluated for statistical significance using paired t-testing and Wilcoxon signed rank test.

Results: *With light pressure, the left PSIS moved caudal for hip flexion ≤30° during right-legged stance, whereas the right PSIS moved cephalad relative to the sacral base. For hip flexion =90°, both PSISs moved cephalad. The use of firm palpatory pressure abolished the initial caudal movement of the left PSIS, as well as differences in the amount of cephalad PSIS movement at 30° vs. 90° hip flexion.*

Conclusions: *The results are consistent with there being left-right differences in gluteus medius and biceps femoris activation among asymptomatic individuals that result in different balancing strategies during one-legged stance. This may create the appearance of relative PSIS/SB displacement, even though the results of Gillet testing can be wholly or partially explained by pelvic obliquity owing to muscle function asymmetry. This study questions the validity of the upright Gillet test for sacroiliac motion.*

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KEY WORDS: chiropractic, palpation, ilium, anatomic landmarks, motion palpation, physical examination, sacroiliac joint

échantillons appariés et par test des rangs signés de Wilcoxon.

Résultats : *Quand l'examinateur exerçait une pression légère, l'EIPS gauche se déplaçait en direction caudale lorsque le patient se tenait sur la jambe droite et que la flexion de hanche était de ≤ 30°, alors que l'EIPS droite se déplaçait en direction céphalique par rapport à la base sacrée. Lorsque la flexion de hanche* était *de 90°, les deux EIPS se déplaçaient en direction céphalique. En exerçant une forte pression palpatoire, l'examinateur abolissait le déplacement initial en direction caudale de l'EIPS gauche de m*ême que les *différences de déplacement des EIPS en direction céphalique observées entre une flexion de hanche de 30° et une flexion de hanche de 90°.*

Conclusions : *Les résultats sont compatibles avec les différences d'activation du muscle moyen fessier et du biceps fémoral gauche et droit observées chez des patients asymptomatiques et qui expliquent les différentes stratégies d'adaptation pour le maintien de l'équilibre en position debout sur une jambe. Il pourrait en résulter un semblant de déplacement relatif de l'EIPS par rapport à S2, même si les résultats du test de Gillet pourraient s'expliquer en tout ou en partie par l'inclinaison du bassin causée par l'asymétrie musculaire. La présente étude remet en question la validité du test de Gillet en position debout pour évaluer la mobilité sacro-iliaque.*

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MOTS CLÉS : chiropratique, palpation, ilion, repères anatomiques, palpation en mouvement, examen physique, articulation sacro-iliaque

Introduction

The Gillet test[1-3] and variants of it are used by manual therapists to assess motion at the sacroiliac joint. It is also known as the step test[4, p. 64], one-legged stance test[2], and stork test[5, 6]. There is another orthopedic test involving one-legged stance and hyperextension that is also called the stork test, and is said to identify spondylolysis.[7, 8] Among the numerous variants of the Gillet test, the most common one is conducted by the examiner placing one thumb on the posterior superior iliac spine (PSIS) area and the other thumb on the sacral base (SB) at the approximate location of the second sacral tubercle. The patient flexes the hip on the tested side. The usual interpretation of the test is that if the SI joint is movable, the ilium rotates posteriorly and inferiorly during hip flexion, as evidenced by the examiner's PSIS thumb moving caudally in relation to the sacral thumb.[9]

The results of interexaminer reliability studies on the

Gillet test have been quite variable, ranging from poor to good.[6, 9-21] To explain this variability and put in question the validity of the test, Sturesson *et al*.[22-24] conducted a series of basic science studies that suggested SI joint motion was so small that examiners performing the step test would not be able to detect motion; not even among subjects with SI joint dysfunction syndrome, who were expected to exhibit joint hypermobility. A review article on three-dimensional SI movement measurements came to a similar conclusion.[25] In a study concerning the impact of palpator experience on the interexaminer reliability of SI motion assessment[17], the investigators included, unbeknownst to the palpators, two cases of ankylosing spondylitis. The fact that neither palpator found either of the SI joints fixed in these subjects also put in question the validity of the Gillet test. In the light of these studies, some manual therapists have suggested abandoning it as a test of SI excursion.[3] They suggest retooling the test as a qualitative indicator of SI stability, as evidenced by the subject's ability to maintain effective balance in one-legged stance.[6, 12]

In a prior exploratory study[26], the first author determined that a relatively small amount of hip flexion was often but not always associated with caudal movement of the PSIS; but for larger amounts of hip flexion, the subject would lean toward the support leg side, whereupon the PSIS would reverse direction and move cephalad. Arab[14] had also noticed this reversal of PSIS direction of movement as the hip increased its angle of flexion, calling it "paradoxical" PSIS motion; but this latter author did not attempt to explain this curious observation. We determined in the exploratory study, which plotted movement of the PSIS as a function of hip flexion in 10° increments, that the maximum caudal movement of the PSIS (if any occurred) was at close to 30° of hip flexion, beyond which the PSIS usually reversed direction and moved cephalad. The first author hypothesized[26] that interaction between the Gillet and Trendelenburg tests could explain these observations, not only confounding standardizing the method of executing the test but also confounding interpreting its findings. Despite the traditional practice of interpreting relative displacement of the PSIS and SB as evidence of SI movement, it seemed that the *appearance* of displacement could be explained by the induction of pelvic obliquity (lateral pelvic tilt) during one-legged stance. One would expect this pelvic obliquity as the contralateral gluteus medius contracts to maintain balance. Indeed, gross failure of this mechanism constitutes the Trendelenburg sign[27 p.491], in which sagging on the flexed hip side provides evidence of a weak gluteus medius on the support leg side.

More recently, the first author observed that in clinical settings the amount of PSIS movement during the Gillet test seemed to not only depend on the amount of hip flexion, but also on the degree of palpatory pressure upon the pelvic landmarks. More pressure seemed to diminish the amount of observed relative displacement of the PSIS and SB. The primary purpose of the current study was to quantify the amount of apparent relative movement of the PSIS in relation to the SB at 30° compared to 90° of hip flexion, using a larger sample size than was used in the earlier exploratory study. The secondary objective was to quantify the degree to which lighter vs. firmer palpatory pressure on the pelvic landmarks impacted the amount of apparent PSIS movement relative to the SB.

Methods

Experimental procedure

This study was approved by the college's Institutional Review Board. All subjects were required to provide written informed consent prior to participation. Figure 1 is a

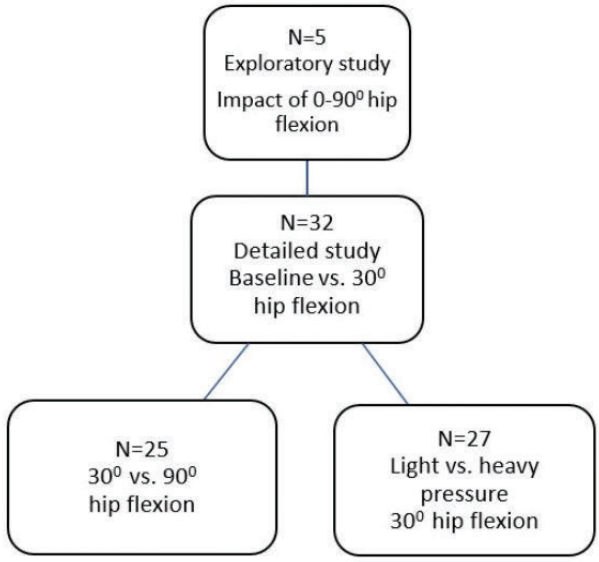

Figure 1.
Flow chart for the study.

flowchart depicting the process of data acquisition in this study.

In performing the most common version of the Gillet test, the examiner places one thumb on the PSIS and the other thumb on the SB approximately at the second sacral tubercle. Since this is an excursion test[28], it does not matter where the thumbs are exactly positioned, but it easier to determine what happens if the thumbs are pointed directly at each other and lie on a horizontal line [9, 29] (throughout this article, comments to the effect that a thumb was applied to the "PSIS" or "sacral tubercle" should be interpreted liberally, as signifying the PSIS or sacral tubercle "area."). The subject stabilizes his or her stance by facing and standing about a foot from a wall, touching the wall with the fingertips of each hand; the feet are situated directly under the hips so that the subject is neither leaning forward nor back. The subject then flexes the hip ipsilateral to the contacted PSIS and SB. Most authorities describe lifting the knee (i.e., flexing the hip) to approximately 90°, while others describe lifting the knee "as high as he can"[3,4]; one qualitative study has the subject flex the hip to only 60° [5]. This is repeated on the other side of the body.

In a small exploratory study using a convenience sample of asymptomatic young students[26], the first author used a photographic method to measure movements of the PSIS in relation to the SB as a function of hip flexion at 10° increments. The results of this small study, which suggested that movements of the PSIS relative to the SB depended on the angle of hip flexion, suggested a larger study would not only be more convincing, but be able to test various explanatory hypotheses.

The present follow-up study recruited another convenience sample of asymptomatic subjects, the inclusion criterion for which was being able to flex their hips without pain or fear of falling. Subjects stood at an arms' length from a wall in front of them and balanced themselves by contacting the wall with both hands. A digital camera was mounted on a tripod placed directly behind and above the kneeling examiner, with the lens focused on the subject's PSIS and sacral base. An experienced clinician (32 years of practice) kneeled behind each subject to perform Gillet's test. The examiner's thumbnails were marked with a line drawn in the middle of the nail and parallel to the length of the finger. The marked thumbs were then placed on the SB (near S2) and PSIS, using modest palpatory pressure. The thumbs were parallel to the floor, pointed at each other, and visibly judged to lie on a horizontal line (Figure 2). A research assistant used a universal goniometer to determine the degrees of hip flexion for each of the tested positions.

In Group A, a subset of the subjects, an initial baseline photograph was taken at 0° hip flexion. The subject was then asked to slowly flex the hip on the tested side to 30°. The examiner looked downward, to avoid visualizing the amount or direction of thumb movement. A second photograph was taken, after which the subject was instructed to return the flexed hip leg to the floor.

In Group B, another subset of the subjects, after photographic assessment at 30° the subject was instructed to return their leg to the floor, then flex the hip to 90°, whereupon another photograph was taken. The leg was then returned to the floor.

In group C, yet another subset of the subjects, after photographic assessment at 30° of hip flexion using modest pressure on the PSIS and SB, the examiner applied a soft tissue algometer to the PSIS and increased the pressure until the subject stated it had approximated the force previously applied by the examiner's thumb on the PSIS. The assessment was then repeated at 30° but with firmer pressure applied by each of the examiner's thumbs. The subject was then instructed to return the leg to the floor. The examiner applied a soft tissue algometer to the PSIS and increased the pressure until the subject stated it had approximated the force applied by the examiner's thumb on the PSIS at this heavier pressure level.

Analysis of photographs

Digital photographs were analyzed using a graphics program (GIMP, Gnome.org) that permitted identification of the x-y coordinates of the thumb positions at the PSIS and SB areas. The y-axis coordinates for each were identified and recorded for each photograph. Pixel distances on the screen were transformed into millimetric equivalent distances by using a conversion factor based on the width of the examiner's thumbnail as measured in both pixels and millimeters. Since the data were gathered in four different sessions in which the distance of the camera to the subjects and the settings of the lens were somewhat different, the conversion factors deployed were unique for each session.

	Left		Right	
30° hip flexion		PSIS and sacral base thumbs even at 30° hip flexion.		PSIS thumb accidentally lower at 30° hip flexion.
30° hip flexion		PSIS thumb drops compared to 30° hip flexion. Body slight shift right.		Slight rise of PSIS thumb compared to 30° hip flexion, no body shift.
90° hip flexion		PSIS thumb rises compared to 30° hip flexion. Major body shift right.		Major rise of PSIS thumb compared to 30° hip flexion, no body shift.
30° hip flexion, heavy pressure		Heavy pressure abolishes both PSIS thumb dropping and body shifting.		Heavy pressure abolishes PSIS thumb drop, no body shift.

Figure 2.
Representative example of effect of variable hip flexion and thumb pressure.

Statistical analysis

To assess intra-examiner reliability in the photometric analysis, the first author repeated his assessment of the PSIS and sacral base thumb positions in 10 randomly chosen photographs one week later, thus generating 20 test-retest measurements (10 subjects, 2 SI joints per subject), to test for intraexaminer reliability. To assess inter-examiner reliability both authors analyzed another randomly chosen subset of 10 photographs, thus generating another 20 test-retest measurements to assess interexaminer reliability in the photo assessment. Intraclass correlations (ICC) were calculated using SPSS, v.19, published by IBM. Intraclass correlation coefficient (ICC) is a widely used reliability index in test-retest, interexamainer, and interexaminer analyses for continuous data.[30]

For eight comparisons drawn under a variety of test conditions, a paired sample t-test was conducted (SPSS, v.19, IBM) to determine whether the mean difference between two pairs of observations was different from zero. These eight comparisons were:

- PSIS/SB difference at 0° vs. 30° hip flexion, left
- PSIS/SB difference at 0° vs. 30° hip flexion, right
- PSIS/SB difference at 30° vs. 90° hip flexion, left
- PSIS/SB difference at 30° vs. 90° hip flexion, right
- PSIS/SB difference at 0° vs. 90° hip flexion, left
- PSIS/SB difference at 0° vs. 90° hip flexion, right
- PSIS/SB difference at 30°, light vs. heavy pressure, left
- PSIS/SB difference at 30°, light vs. heavy pressure, right

For each comparison, the Shapiro-Wilk statistic (http://sdittami.altervista.org/shapirotest/ShapiroTest.html) was used to assess the normality of the paired differences. The Wilcoxon signed-rank test (http://vassarstats.net/wilcoxon.html), the nonparametric equivalent of the paired samples t-test, was used to supplement the analysis for sample data that were not normally distributed.

Results

Exploratory study, N=5 (10 SI joints)

A convenience sample of five young asymptomatic subjects was recruited, 60% male. All screened potential subjects satisfied the inclusion criteria.

Among these five subjects there was an initial caudal movement of the PSIS relative to the SB in eight of 10 joints, creating the appearance of posterior ilium rotation and thus SI motion. However, in each case after this initial caudal movement there was a reversal of direction as the hip flexed to 90°, whereupon the PSIS rose. On average, the reversal of direction occurred at 24.5°, which for convenience may be rounded off to 30°. In the two SI joints in which there was no initial PSIS drop with hip flexion, PSIS elevation accelerated after approximately 60°. With increasing hip flexion the subject's torso invariably tilted away from the side of hip flexion, with associated cephalad movement of the innominate bone (i.e., "hip-hiking") on the flexed hip side. Stated otherwise, the subject manifested increasing iliac crest height on the flexed hip side as hip flexion increased from 30° to 90°.

Comprehensive study, N=32 (64 SI joints)

In the present comprehensive study, the subjects were a convenience sample of 32 asymptomatic students, 47.6% males, 52.4% females. All screened subjects satisfied the inclusion criteria. Their mean age was 25.1 (s=2.7) years, weight 71.4 (s=13.0) kg, height 171.8 (s=7.6) cm, and BMI 24.1(s=3.59) kg/m^2.

We first determined the inter- and intraexaminer reliability of measuring distances on the digital photographs. The intraexaminer reliability in a convenience sample of 20 measurements was as follows: intraclass correlation (2,1)=0.99 (95% CI=0.97, 0.99). The intraexaminer reliability in another convenience sample of 20 measurements was as follows: intraclass correlation (2,1)=0.99 (95% CI=0.98,1.00).

Table 1 summarizes the results of a series of paired t-tests conducted on the measurements taken from the digital photographs in subject Groups A, B, and C. These t-tests addressed whether the mean change in PSIS/SB displacement was statistically different under a variety of Gillet test conditions. Data are reported for 0° vs 30° vs. 90° of hip flexion, as well as for light vs. heavy pressure on the pelvic landmarks at 30° of hip flexion. When the measurement for PSIS/SB displacement was negative, the PSIS moved caudal in relation to the SB between test conditions; when the measurement was positive, the PSIS moved cephalad between test conditions

Group A: 0° vs. 30° hip flexion, N=32

There was an apparent statistically significant *caudal* movement of the left PSIS relative to the SB at 30° of hip

Table 1.
Paired Samples t-test.

Subject group	Condition	Mean diff, mm	SD diff	SE of mean	t	p	Lower 95% CI	Upper 95% CI
A N=32	0° vs. 30°, left	–2.69	3.58	0.64	–4.18	0.00	–4.00	–1.38
	0° vs. 30°, right*	1.32	3.94	0.71	1.87	0.07	–0.12	2.76
B N=25	30° vs. 90°, left*	7.14	3.69	0.75	9.49	0.00	5.59	8.70
	30° vs. 90°, right	6.94	3.10	0.63	10.98	0.00	5.64	8.25
	0° vs. 90°, left	4.38	5.22	1.07	4.11	0.00	2.18	6.58
	0° vs. 90°, right	8.02	4.93	1.01	7.96	0.00	5.94	10.10
C N=27	Light vs. firm pressure, 30°, left	3.55	3.62	0.71	5.00	0.00	2.09	5.01
	Light vs. firm pressure, 30°, right*	–0.10	4.33	0.85	–0.11	0.91	–1.84	1.65

Negative values signify caudal movement of PSIS relative to SB between test conditions. Abbreviations: PSIS=posterior superior iliac spine, SB=sacral base, diff=difference in mm, SE=standard error SD=standard deviation, CI=confidence interval, 2-tailed. * signifies the paired differences data are not normally distributed.

flexion compared to 0°: M=-2.69mm, SD=43.58, p=0.00. There was an apparent *cephalad* movement of the PSIS on the right, that did not quite reach statistical significance: M=1.32, SD=3.94, p=0.07. Since the distribution was non-normal, the Wilcoxon signed-rank test was used to determine the probability that the difference was due to chance: p(2-tail)=0.03, confirming a significant difference.

Group B: 0° vs. 30° vs. 90° hip flexion, N=25

There was a statistically significant apparent *cephalad* movement of the left PSIS relative to the SB at 90° of hip flexion compared to 30°: M=7.14mm, SD=3.69, p=0.00. Since the distribution was non-normal, the Wilcoxon signed-rank test was used to determine the probability that the difference was due to chance: p(2-tail): p=0.00, confirming the difference was significant. There was a statistically significant apparent movement of the PSIS on the right at 90° compared to 30°: M=6.94mm, SD=3.10, p=0.00.

There was a statistically significant apparent *cephalad* movement of the left PSIS relative to the SB at 90° of hip flexion compared to 0°: M=4.38mm, SD=5.22, p=0.00. There was a statistically significant and *greater cephalad* apparent movement of the PSIS on the right at 90° compared to 0°: M=8.02mm, SD=4.93, p=0.00.

Group C: Light vs. firm pressure, 30° hip flexion, N=27

The results of using a soft-tissue algometer to heuristically calibrate the mean pressure applied to the PSIS were as follows: "light" pressure was perceived equivalent to 2.1kg, whereas "heavy" pressure was perceived equivalent to 3.4kg. Since kilograms can be converted to Newtons by multiplying by 9.807, these measurements were equal to 20.6 and 33.3 Newtons, respectively.

The tendency of the left PSIS to apparently move *caudally* on left hip flexion to 30° was abolished by the application of firm pressure to the PSIS and SB. With firm pressure, the left PSIS moved *cephalad*: 3.55mm, SD=3.62, p=0.00. The previously-described tendency of the right PSIS to apparently move cephalad on hip flexion was unaffected by the application of firm pressure: M=-0.10mm, SD=4.33, p=0.91. Since the distribution on the right was non-normal, the Wilcoxon signed-rank test was used to determine the probability that the difference was due to chance: p(2-tail): p=0.98, confirming there was no difference.

Discussion

The Shapiro-Wilk test is commonly regarded to be the best choice for testing the normality of data.[31] The paired t–test is used when there are multiple pairs of observa-

tions, testing whether the mean difference in the pairs is different from zero.[32] The Wilcoxon signed-rank test may be used as an alternative to the paired t-test when the differences are severely non-normally distributed.[33] Although paired t-testing assumes that the means of the different samples are normally distributed, only 20 to 30 subjects are needed for the sample means to approximate normality.[33, 34] Therefore, although the non-normal distributions of three of these comparisons did not preclude paired t-testing, it seemed prudent to add confidence to the findings by performing supplemental Wilcoxon testing for these three comparisons.

Since the Wilcoxon p value was <0.05 for 0° vs. 30° hip flexion on the right, and for 30° vs. 90° of hip flexion on the left, the null hypothesis that the difference was due to chance was rejected in both, supporting the t-test finding that the differences were statistically significant. In the case of light vs. firm pressure, at 30° hip flexion on the right, the Wilcoxon p value was >0.05, supporting the t-test conclusion that there was no difference.

Exploratory (n=5) study

Our initial n=5 exploratory study found the Gillet test most sensitive for detecting this caudal movement of the PSIS at approximately 30°. By comparison, Hungerford found maximum posterior rotation of the innominate occurring at approximately 70° of hip flexion.[3] In her study, skin-mounted 15mm balls and a six-camera system and software package were used to record and analyze motion.[3] Despite the relatively high-tech methodology, Hungerford cautioned that there may have been movement of the skin markers in relation to bony landmarks. She concluded that the main emphasis in her study was on *patterns* of bone motion, rather than range of motion. In the present study, the pressure of the examiner's thumbs on the pelvic landmarks presumably "clamped" the skin to the underlying bone to some extent, to minimize movement of the thumbs independently of the overlying skin.

Comprehensive (n=32) study

It the n=32 comprehensive study, for hip flexion ≤30°, one-legged stance on the right resulted in an apparent caudal movement of the left PSIS compared with the SB, whereas one-legged stance on the left resulted in a relative apparent cephalad movement of the right PSIS. If the traditional understanding of the Gillet test as a form of SI motion palpation were correct, our findings were tantamount to finding that most left SI joints are movable, and most right SI joints hypomobile. The investigators, thinking this interpretation of the study findings implausible, formulated alternative explanations for the study's findings: first, there appear to be opposite strategies for left and right one-legged stance, at least for hip flexion ≤30°; and second, asymmetry in left/right hamstring muscle tone results in relatively more movement of the left PSIS relative to the skin during Gillet testing. Hypotheses 1-4 below provide a detailed account of these explanations.

In the n=25 module of the study the apparent initial caudal movement of the left PSIS at hip flexion ≤30° was abolished as the hip flexed higher. Apparent cephalad movement of the PSIS was directly proportional to hip flexion for hip flexion > 30°. Hypotheses 1 and 2 address these findings.

Hypothesis 1: Asymmetric balancing strategies in left and right one-legged stance

With modest flexion of the left hip to approximately 30°, the pelvis tends to sag slightly on the left, resulting in apparent caudal movement of the PSIS relative to the SB. Rather than reflecting left SI joint movement, the apparent displacement of the PSIS and SB may be fully or partially accounted for by pelvic obliquity, inferior to the left. When flexing the right hip to approximately 30°, subjects tend to lean toward the left, hiking the right hip such that the PSIS appears to move cephalad in relation to the SB. Rather than reflecting hypomobility of the SI joint, this effect can be fully or partially accounted for by pelvic obliquity.

This asymmetry in left vs right balancing strategies in one-legged stance may reflect left/right differences in muscle function, probably related to handedness. One-legged stance involves several supporting muscles, including the hip extensors and abductors, primarily gluteus maximus and medius.[35] The left hip extensors tend to be stronger than those on the right[36], and the left gluteus medius muscle tends to be stronger than the right gluteus medius[37, p.76]. According to Kendall *et al*., the gluteus medius tends to be weaker on the side of handedness, usually the right [37, p.76]. The iliac crest tends to be elevated on this same side,

gluteus medius being in a state of stretch-weakness which is the result of being elongated (however slightly) for prolonged periods of time. The asymmetry of gluteus medius strength is especially pronounced in a symptomatic population, with right-sided weakness occurring 71% of the time in males and 90% of the time in females; by comparison, the left gluteus medius is weak only 15% of the time in males, and 6% in female.[37, p.8] The delayed activation or lesser strength of the right gluteus medius for modest amounts of left hip flexion would therefore explain the sagging on the left and hip-hiking on the right during Gillet testing; and thus the appearance but not necessarily the actuality of SI movement.

Hypothesis 2. Asymmetric hamstring tone
Yet another typical muscle function asymmetry may play a part in the opposite apparent movements of the left/right PSISs during hip flexion ≤30°. The long head of the biceps femoris, one of the hamstring muscles, attaches to the sacrotuberous ligament, a part of which (the long dorsal SI ligament) attaches to the caudal aspect of the PSIS. As the hamstring tightens during hip flexion, the sacrotuberous and long dorsal ligaments transmit a caudal tug on the PSIS. Since the left hamstrings tend to be tighter and less flexible than the right hamstrings[38], this tug on the PSIS during hip flexion would be more pronounced on the left, resulting in pelvic obliquity, inferior to the left. This would provide the appearance of relative PSIS/SB displacement, without there necessarily having been very much, if any SI movement. As the hip flexes to 90°, this small pelvic drop would be overwhelmed by hip hiking, as part of the balancing strategy. The less contracted state of the right hamstring would not produce an equivalent caudal tug on the right PSIS during one-legged stance on the left. The right biceps femoris would simply elongate, accommodating right-sided hip hiking.

In the n=27 light vs. firm pressure module of the study, conducted at 30° hip flexion, PSIS movements were pressure-sensitive on the left but not on the right. Hypotheses 3 and 4 address these findings.

Hypothesis 3. The pelvic compression effect
The one-legged stance balancing mechanism may be more efficient with greater palpatory pressure due to pelvic compression, which presumably leads to enhanced activation of the left/right gluteus medius muscles. According to this hypothesis, firmer pressure would negate the inherent relative weakness or delayed activation of the right gluteus medius, the premise of Hypothesis 1. In support of Hypothesis 3, we may invoke the findings of the active straight leg raise test (ASLR), which assesses pain provocation and the ability to load the pelvis through the lower extremity. In the ASLR, the supine patient is instructed to lift the tested leg 20 cm off the table.[39] It has been demonstrated that compression of the pelvic girdle with a trochanteric belt can increase the ease of supine leg raising among patients with pregnancy-related pelvic pain.[40] Manual pelvic compression has been shown to have a similar effect in pelvic pain patients.[41] Although the subjects in our student were asymptomatic, we may hypothesize that SI compression produced by increased palpatory pressure on the PSIS and SB enhanced activation of the right gluteus medius, abolishing the initial caudal movement of the left PSIS, although not impacting the movement of the right PSIS.

Hypothesis 4. The clamping effect
The examiner's thumb, which is said to "contact the subject's PSIS", is in fact placed upon soft tissue and not directly on the bone. Therefore, its position could be affected by soft tissue movement in relation to the underlying osseous structure. As described above, hip flexion produces increased tension in the biceps femoris, which in turn tightens up the sacrotuberous ligament and eventually tugs at the long dorsal ligament, which attaches to the inferior aspect of the PSIS. With typical modest palpatory pressure, the soft tissue overlying the PSIS would presumably be carried caudally by this tension, creating the appearance of SI motion. Since the left hamstrings have been found to be tighter and less flexible than the right hamstrings[38], this movement of the overlying skin relative to the PSIS would be greater on the left than on the right.

> With heavier palpatory pressure, the soft tissue would be more "clamped "to the underlying bone. In effect, this would abolish the apparent caudal movement of the left PSIS presumed in Hypothesis 2 to result from greater hamstring tone on the left.

The traditional expected normal finding in performing the Gillet test is generally understood to be posterior rotation of the innominate bone, with caudal movement of the PSIS on the flexed hip side relative to the SB.[2] Kapandji explains: hip flexion results in hamstring tension, thus drawing the innominate bone posteriorward.[42, p. 70] Manual therapists would add, given the oblique plane of the SI joint, that this posterior rotation is coupled with medial movement as well. Absent or diminished motion is considered abnormal and rationalizes a manipulative or other manual therapy procedure to restore motion.

Our study, on the other hand, suggests pelvic obliquity during one-legged stance can create the appearance of SI movement, especially on the left. Another line of research has questioned the utility of the Gillet test based on the demonstration that sacroiliac movement is so slight even in stressed positions of the joint, that an examiner would be unlikely to perceive movement in Gillet testing positions. Sturreson *et al*.[23, 24, 43] inserted tantalum balls into the ilium and SB, then used radiology to investigate the movements that occurred during Gillet testing in a variety of test positions. Not only did they find very little movement, but that both ilia moved as a unit in relation to the sacrum during the performance of the test; only very small movements (<1°) were produced. Hence, the investigators concluded that the Gillet test "cannot be recommended as a diagnostic tool for evaluating joint motion in the SIJs." Goode *et al*.[25] reviewed studies similar to those of Sturesson *et al*., and came to similar conclusions. It remains to be seen how the results of these high-tech studies showing relatively slight SI movements can be reconciled with the results of lower tech studies that detect greater movements.[44]

Our study suggested that in asymptomatic individuals there is efficient activation of the left gluteus muscle during ipsilateral one-legged stance for modest amounts of hip flexion, ≤30°. The underlying explanation may be that most people are right-handed, which correlates with preferring to use the right leg during motor activities.[45] Athletes usually use their right foot to kick during various sporting activities that involve kicking, while using their left leg for support.[45] One would expect the subjects in this study, most of whom were young, active students and right-handed, to manifest among these tendencies.

Although our study did not exclude the possibility that the Gillet test can detect movement, it did suggest that detection of such movements may be confounded by the subject's balancing strategy during one-legged stance, as well as by differences among examiners in the amount of pressure they apply to the pelvic structures. Indeed, the failure to control for the degree of hip flexion and/or the amount of examiner pressure used may account for the mostly poor interexaminer reliability that has been reported for the Gillet test.[46]

Pelvic obliquity during one-legged stance is typical, as the contralateral gluteus medius contracts to maintain balance. Indeed, failure of this mechanism marks the well-known Trendelenburg sign.[22, p.491] In a normal test finding, the body shifts weight toward the stance leg, positioning the center of gravity above the support leg to balance body weight. Our data suggest, given the observed asymmetry in one-legged balance strategies among asymptomatic subjects for hip flexion ≤30°, that the hip flexion or leg lifting during Trendelenburg testing should be >30° to reduce the risk of false positive test results. That stated, the magnitude of the caudal movements of the PSIS seen in our study, limited to just a few mm, are unlikely to be confused with a *bona fide* positive Trendelenburg sign.

Limitations

Since this study was not intended to address the reliability of the Gillet test, all observations were performed by one examiner; other examiners may have achieved different results. Although we believe using direct manual palpatory methods of detecting SI motion avoids the primary problem of slippage when using skin markers, we cannot rule out some deviation of the palpated landmarks from the bony landmarks, especially approaching 90° of hip flexion. Our study did not measure movements on the stance side during the Gillet test, as did Hungerford.[6] Since there was only one left-handed individual in the study, no inferences could be drawn based on handedness. No effort was made in this study to directly determine hamstring tightness or gluteus medius activation, granted that the hypotheses advanced depended on their activation efficiency. Although we suspect the caudal

movement of the PSIS on the left relative to the sacral base reflects pelvic tilt more than SI movement, no effort was made to measure pelvic tilt other that these apparent PSIS/SB displacements on the Y axis. Apart from the gender mix, which was known, the other demographic data from the original N=5 exploratory study were not available. The asymptomatic subjects in our study were not representative of patients who generally undergo Gillet testing; it is possible that using symptomatic subjects would have resulted in different findings. Some studies have reported asymmetric gluteus medius activation in injured subjects.[36, 47] Although we believe our data are most consistent with asymmetric one-legged stance strategies, two other hypotheses could be considered: although the Gillet test may be valid for assessing sacroiliac motion (a) the palpator in this study may have exhibited systematic bias, finding the great majority of right sacroiliac joints hypomobile compared with left joints; or (b) the great majority of right sacroiliac joints are actually hypomobile compared with left joints.

Conclusions

This study found that using relatively light palpatory pressure, with hip flexion ≤30°, the left PSIS appeared to move caudal and the right PSIS cephalad to the sacral base. For hip flexion =90°, both PSISs appeared to move cephalad to the sacral base. Firm palpatory pressure mostly abolished these apparent PSIS movements relative to the sacral base. The data suggest slight pelvic tilting, the result of asymmetric muscle activation patterns and tone, may account for all or part of the appearance of sacroiliac movement during Gillet testing.

Future studies on this topic should include additional subjects, some with and some without symptoms, so that a better representation of SI motion during the Gillet test can be ascertained. Since the present study as well as other basic science studies showing very little SI movement diminish our confidence in the traditional interpretation of the Gillet test, clinicians and investigators might put more emphasis on other SI motion palpation procedures, including but not limited to the sitting flexion test.[21, 48] The authors suggest that the limitations of our study ought to mitigate against any tendency to immediately and completely reject the Gillet test; just as it was not appropriate to immediately accept its validity.

There may be ways to mitigate the impact of asymmetric one-legged stance strategies by performing a Gillet-like motion palpation test in a non-weightbearing position. In principle, this would allow discrimination of SI movement from pelvic obliquity as a determinant of relative PSIS and SB positions.

Conflicting commercial interests

Neither of the authors has any commercial interest in the outcome of this study.

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Tendon neuroplastic training for lateral elbow tendinopathy: 2 case reports

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Objective: *To report 2 cases of lateral elbow tendinopathy treated with a novel adaptation of tendon neuroplastic training (TNT).*

Clinical features:

Patient 1: A 61-year-old male machine operator presented with one year of bilateral lateral elbow pain related to his occupation of using torque wrenches.

Patient 2: A 37-year-old male electrician presented with two months of recurrent left lateral elbow pain related to repetitive motions of gripping and pulling at work.

Intervention and outcome: *Both patients underwent 8 weeks of a novel rehabilitation program, including TNT, which involved pacing their resistance exercises to a metronome. Both patients experienced clinically meaningful improvements in pain and functional outcome scores that were sustained at the 3-month follow-up.*

Summary: *Recent evidence suggests that the*

Objectif : *Présenter 2 cas de tendinopathie latérale du coude traitée par un nouveau type d'entraînement neuroplastique tendineux (ENT).*

Caractéristiques cliniques :

Patient 1 : Un opérateur de machines de 61 ans se plaignait d'une douleur latérale aux deux coudes, apparue il y a un an, et qui était liée à l'utilisation de clés dynamométriques sur les lieux de travail.

Patient 2 : Un électricien de 37 ans se plaignait d'une douleur latérale récurrente au coude gauche, qui était apparue il y a deux mois et qui était reliée à des mouvements répétitifs de serrage et de traction effectués au travail.

Intervention et résultat : *Les deux patients ont suivi un nouveau type de programme de rééducation, d'une durée de 8 semaines, y compris un ENT, qui consistait à exécuter des exercices de résistance avec un métronome. Les deux patients ont éprouvé un soulagement cliniquement significatif de la douleur et les scores obtenus sur l'échelle d'évaluation des capacités fonctionnelles se sont maintenus durant le suivi de 3 mois.*

Résumé : *Des preuves récentes semblent indiquer*

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central nervous system may play a role in chronic tendinopathies. It is possible that TNT may address the central nervous system component of chronic/recurrent tendinopathy that is not addressed by traditional passive therapies. However, further research is needed.

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KEY WORDS: chiropractic, elbow, tendinopathy, tendon neuroplastic training, tennis elbow

que le système nerveux central pourrait jouer un rôle dans les tendinopathies chroniques. L'ENT pourrait permettre d'intervenir sur la composante neurologique des tendinopathies chroniques ou récurrentes associée au système nerveux central, alors que les traitements passifs classiques ne le permettent pas. Mais d'autres travaux de recherche pourraient s'avérer nécessaires.

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MOTS CLÉS : chiropratique, coude, tendinopathie, entraînement neuroplastique tendineux, épicondylite

Introduction

Lateral elbow tendinopathy, often referred to as "tennis elbow", is a common condition in athletes and the general population.[1,2] Risk factors for this condition include repetitive and forceful movements, smoking, and obesity.[2] Many conservative treatment options are available including rest, bracing, cryotherapy, manual therapy, instrument-assisted soft-tissue mobilization, eccentric exercise, acupuncture, and extracorporeal shockwave therapy as well as injection of various agents.[3–10] Despite the multitude of treatment options available, up to 10% of cases continue to experience long-term pain and disability[11], with 89% of patients taking up to one year to recover[3].

Anatomically, pathologic tendons experience an increase in tenocyte cell size and number, disorganization of collagen, increased proteoglycan and water content, and neovascularization.[12] In addition to structural, functional, and biochemical changes seen in tendinopathy[13,14], recent evidence has also demonstrated alterations to the motor cortex in patients with this condition[15–17]. This includes measureable changes in corticospinal excitability and short-interval cortical inhibition.[18,19] Traditional passive treatments may not address these motor control issues and therefore might lead to less than desirable outcomes or chronicity of symptoms. In 2015, Rio *et al*.[20] introduced a tendon rehabilitation protocol aimed at addressing these motor control deficits seen in patients with tendinopathy. Tendon neuroplastic training (TNT) combines isometric or isotonic strength training with an externally-paced audio or visual cue. Patients perform a strength training task that loads the affected tendon, such as a single leg squat to load the patellar tendon. Rather than a self-paced eccentric-concentric maneuver, the patient matches the speed of the exercise to the audio and/or visual cue provided by a metronome. This type of externally-paced exercise has been shown to improve motor control in an acute strength training session[19] as well as in patients with patellar tendinopathy[20]. To our knowledge, TNT has not been applied for upper extremity tendinopathies.

The purpose of this manuscript is to describe the rehabilitation of two cases with a clinical diagnosis of lateral elbow tendinopathy using a novel TNT protocol.

Case Presentations

Two patients were seen in a private multi-disciplinary clinic for lateral elbow pain, and both provided written, informed consent to publish their data.

Patient 1 was a 61-year-old machine operator with a one year duration of bilateral elbow pain caused by repetitive torque wrench use. The pain was worse in his left elbow at the time of examination. He described the pain as achy, sharp when aggravated, and reported relief with rest. Previous treatment included ultrasound, laser, and a cortisone injection six months prior with only temporary relief. He also used an elbow brace, which provided some mild relief. The patient reported the pain as 7/10 on the visual analog scale (VAS) when aggravated. Plain radiographs were unremarkable for pathology. The patient's medical history included essential tremor (i.e. a nerve disorder causing uncontrollable shaking), lumbar discectomy, and high cholesterol. The patient took medications including a statin, beta-blocker, and low dose aspirin

Table 1.
Patient examination findings.

	Patient 1	**Patient 2**
Inspection: Elbow, Forearm, Wrist regions	Unremarkable	Unremarkable
Cervical Spine Screen: ROM testing	Full and pain-free	Full and pain-free
Upper Extremity Neurological Screen: Reflex, Motor, Sensory testing	DTRs 1+ Bilateral C5-7 Motor 5/5 Bilateral C5-T1 Sensory Bilaterally intact C5-T1	DTRs 1+ Bilateral C5-7 Motor 5/5 Bilateral C5-T1 Sensory Bilaterally intact C5-T1
Elbow ROM: Active and Passive	Full and pain-free	Full and pain-free
Location of Symptoms	Bilateral common extensor tendon	Left common extensor tendon
Strength	Wrist extension: 5/5 with pain	Wrist extension: 5/5 with pain
Orthopedic Tests	+ Cozen's + Maudsley's + Mill's	+ Cozen's + Mill's
Palpatory Findings	Recreate chief complaint with palpation of common extensor tendon	Recreate chief complaint with palpation of common extensor tendon
QuickDASH Disability/Symptom Score	45.5	36.4

DASH = Disabilities of the Arm, Shoulder and Hand; DTR = deep tendon reflex; ROM = range of motion

daily. He did not report experiencing any other tendon pain.

Patient 2 was a 37-year-old electrician with a two month duration of left elbow pain, which was re-exacerbated following an original onset one year prior. At present the pain was aggravated with performing his daily duties as an electrician, such as pulling electrical cord and using hand tools. He rated the pain 6/10 on the VAS and reported rest as the only relieving factor. For this current episode, the pain was not improving and was affecting his ability to perform his job. His medical history was unremarkable.

A thorough global and regional examination including observation, range-of-motion (ROM), neurological, and orthopedic testing (Cozen's, Mill's, Maudsley's)[21,22] was performed on each patient by the same chiropractor, with notable findings presented in Table 1. Based on history and physical examination findings, both patients fit the typical diagnostic criteria for tendinopathy including pain on palpation, pain with tendon loading, and the reduction of pain during activity, also known as the "warm-up phenomenon."[14] As such, both patients were diagnosed with lateral elbow tendinopathy.

Self-reported outcome measures included the QuickDASH disability/symptom score and numeric pain-rating scale (NPRS). The QuickDASH disability/symptom score is a valid and reliable instrument used to measure disability and symptomatology in patients with shoulder, arm, and hand pain.[23] The minimal clinically important difference has been reported to be 19 points with minimal detectable change being 11 points.[24]

Intervention and Outcomes

Both patients performed a novel, eight week TNT protocol (Table 2) for the elbow without modifying any of their ongoing self-care strategies (i.e. bracing, rest), and

Table 2.
8-week tendon neuroplastic training protocol for lateral elbow tendinopathy.

WEEK	SETS	REPS	TEMPO	WEIGHT (LBS)
1	4	8	3sec up - 3sec down*	3
2	4	8	3sec up - 3sec down*	3
3	4	8	3sec up - 3sec down*	3
4	4	8	3sec up - 3sec down*	3
5	4	8	3sec up - 3sec down*	5
6	4	8	3sec up - 3sec down*	5
7	4	8	3sec up - 3sec down*	5
8	4	8	3sec up - 3sec down*	5

sec = seconds
*Externally-paced with an audio/visual metronome (ProMetronome; http://eumlab.com/pro-metronome/). 2-minute rest between sets

they continued to perform their regular duties at work. In addition to the TNT protocol, Patient 1 received low-frequency electro-acupuncture in the elbow (LI10-11, supinator; 8 minutes; 2.5Hz) each week to help reduce his pain so that he could perform his rehabilitation protocol. He chose to have the left side treated only, as it was more symptomatic, and to use the right side as a control. Due to scheduling issues, Patient 2 performed the TNT protocol in isolation, only on the symptomatic side.

The TNT protocol was to be performed on three non-consecutive days per week for eight consecutive weeks. The exercise involved isolated wrist extension and flexion with a dumbbell (Figure 1 & Supplementary Video online), paced to an external audio/visual cue on the patients' smartphone (ProMetronome; http://eumlab.com/pro-metronome/). The patients were to listen to the sound and track the movement of the metronome with their eyes, as pacing to these types of external cues has been shown to modulate corticospinal excitability.[18,19,25] The pace of the metronome was set to 20 beats per minute such that each beat was three seconds apart. This allowed a three second concentric and three second eccentric phase. Four sets of eight repetitions were to be completed with a two minute rest in between each set. These parameters were adapted from previous supplementary data by Rio *et al*.[20] The patients were instructed to begin with a three to five pound weight and to ensure that this did not cause pain to exceed a severity of 5/10 during exercise. Gradual progression of weights was attempted at four week intervals, within tolerance.

Outcomes for each patient can be seen in Table 3. The same chiropractor who performed the initial evaluations also oversaw each treatment session and performed

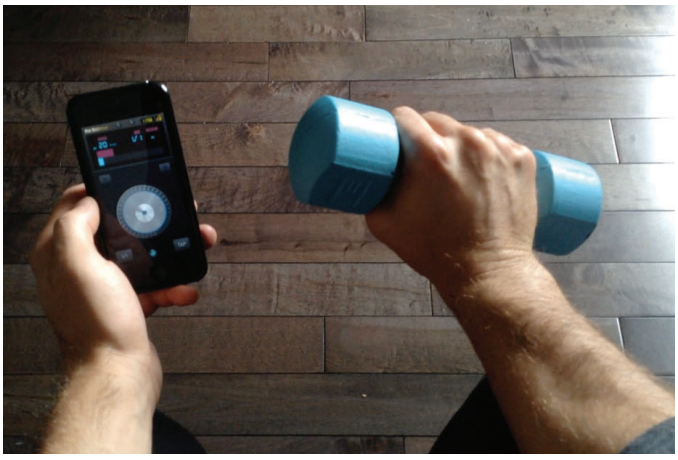

Figure 1.
Wrist extension exercise paced to an audiovisual metronome (see supplementary video).
(ProMetronome; http://eumlab.com/pro-metronome/)

Table 3.
Outcome measures at pre- and post-intervention.

	Patient 1	Patient 2
PRE NPRS score	7	6
POST NPRS score	3	1
NPRS change	4	5
PRE QuickDASH Disability/Symptom score	45.5	36.4
POST QuickDASH Disability/Symptom score	25.0	11.4
QuickDASH Disability/Symptom change	20.5	25.0

DASH = Disabilities of the Arm, Shoulder and Hand; NPRS = Numeric Pain Rating Scale

final evaluations and discharge. Following the novel TNT protocol, both patients had clinically meaningful improvements in pain and function. Both patients self-reported higher than 90% compliance with the TNT protocol.

Patient 1 received eight electro-acupuncture treatments once per week over eight weeks. At the end of the trial of care, he reported significant reduction in the frequency and intensity of pain, with the occasional flare up if he had performed more strenuous activities at work. He also noted some improvement in the right elbow symptoms, which had not undergone treatment or rehabilitation. At three month follow-up, the patient's symptoms had remained stable and he had begun performing the TNT protocol on the opposite arm.

Patient 2 did not receive any passive treatment and only performed the TNT protocol. At eight weeks the patient reported significant improvements in his ability to work with reduced pain and with increased strength. He continued the TNT protocol for an additional four weeks. At three month follow-up, he had ceased the rehabilitation protocol because he was able to perform all of his duties at work pain-free and no longer experienced any symptoms.

Both patients were able to perform the protocol and achieve significant recovery without reducing the frequency or intensity of their work duties.

Discussion

Tendinopathies are common in the general and athletic populations and many conservative treatments fail to resolve these injuries.[1,26–29] These cases were the first to describe a novel rehabilitation protocol for lateral elbow tendinopathy using TNT. Many structural and biomechanical pain generators have been identified for tendinopathy[13,14], however recent evidence also suggests that the central nervous system may play a role[30]. This can be measured using transcranial magnetic stimulation (TMS), an electromagnetic method used to stimulate small regions of the cerebral cortex. Corticospinal excitability and short interval cortical inhibition, both quantitative measures of motor control, have been shown to be altered in tendinopathy.[16,20] A study by Heales *et al*.[15] also found bilateral sensory and motor deficits on the unaffected side of patients with unilaterally identified tendinopathies in both the lower and upper extremity. In our two cases, these sensorimotor deficits may have contributed to their condition, however this type of quantitative measurement is not common in clinical practice and was not available.

Several methods have been proposed to address these deficits in motor control. It has been demonstrated that corticospinal excitability can be increased when skill training is externally-paced using a metronome.[31] Furthermore, Leung *et al*.[19] found that metronome-paced strength training can reduce short interval cortical inhibition and increase corticospinal excitability compared to self-paced training in healthy individuals. In our two cases, addressing these deficits through metronome-based training may have contributed to the successful outcome, as traditional self-paced strength training does not alter motor control.[19] As TNT is proposed to address the central nervous system component of tendinopathy, it is plausible to also consider that our first case saw improvement in the untreated arm due to the crossover phenomenon.[32] Due to several neuroanatomical connections between the left and right brain, it has been observed that strength training of one limb can lead to strength gains of the opposite limb.[32] This may provide the opportunity for a clinician to recommend rehabilitation of the contralateral limb in a painful tendinopathy, when the condition is too painful to begin training on the affected side.

Our protocol was adapted from Rio *et al*.[20] and involves using an audiovisual metronome to pace the exercise. A weighted wrist extension was chosen to target the extensor carpi radialis brevis, as this accounts for 90% of lateral elbow tendinopathies.[3] Compared to other conservative therapies, TNT addresses the motor control deficits present in tendinopathy. The mainstay of tendon rehabilitation is eccentric training, and there is more recent evidence to support the efficacy of heavy slow resistance training.[33] These training modalities address the tensile strength deficits present in tendinopathy through progressive loading, but fail to adequately address the deficits in the central nervous system. TNT is a combination of resistance exercise and metronome-based training; therefore, this technique may adequately address both the deficits in tendon strength and motor control seen in tendinopathy. However, further research in needed to validate this claim.

Limitations of these case reports are inherent in their study design. Due to the lack of a control group, we cannot rule out the possibility that the patients' improvement was due to the treatment provided, the multimodal treat-

ment (in the case of Patient 1), or some other unidentified confounding factor. Owing to the chronic/recurrent nature of the condition, it seems unlikely that natural history led to the resolution of the patients' symptoms. Additional research is needed to demonstrate improvement in motor control in patients with tendinopathy, as current evidence has not studied these techniques in this population. Furthermore, randomized controlled trials are needed to determine the efficacy of TNT compared to other conventional treatment methods for tendinopathy.

Summary

Tendon neuroplastic training is a novel technique that aims to address the central nervous system involvement of tendinopathies. Combining resistance exercise with metronome-based training can potentially improve the tensile capacity of the tendon and reduce motor control deficits. This two-patient case series presents a new intervention for lateral elbow tendinopathy using TNT concepts. Both patients achieved clinically meaningful changes in the Quick Dash and the NPRS, without time lost from work, after performing the eight week rehabilitation program.

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Adolescent knee pain: fracture or normal? A case report.

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Background: *Knee injuries are the second to fourth most common injuries in youth soccer. In this population, sprains/strains, fractures and contusions are most common. Due to variations in the developing skeleton, it can be difficult to rule out fractures.*

Case Summary: *We present a case of a 13-year-old presenting to the emergency department (ED) with patellar pain after pivoting during a soccer game. After radiographic clearance, he was allowed to return to sport. Following another fall and ED visit, his full leg was casted. He presented to a chiropractor after cast removal, who made recommendations for progressive rehabilitation owing to the lack of evidence for fracture on radiographs.*

Summary: *We suggest a thorough history, physical and Ottawa knee rules to determine whether*

Contexte : *Les blessures au genou viennent au deuxième, troisième et quatrième rang des blessures courantes chez les jeunes joueurs de soccer. Dans cette population, les foulures ou entorses, les fractures et les contusions sont très fréquentes. En raison des variances de développement du squelette, il peut être difficile d'écarter les fractures.*

Résumé de cas : *On présente le cas d'un jeune de 13 ans admis dans un service des urgences (SU) en raison d'une douleur au genou apparue à la suite d'une torsion durant une partie de soccer. Après avoir constaté une absence d'anomalies sur les clichés radiographiques, on a autorisé le patient à jouer de nouveau au soccer. Mais l'automne suivant, lorsque ce patient a été admis de nouveau au SU, on a lui mis toute la jambe dans le plâtre. Il a consulté un chiropraticien après le retrait de son plâtre. Comme il n'y a avait aucun signe de fracture sur les radiographies, le chiropraticien lui a recommandé de suivre un programme de rééducation progressive.*

Résumé : *On recommande un examen minutieux des antécédents, un examen physique et l'utilisation des*

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The patient involved in the case has provided consent for it to be used in a case report.

radiographs are indicated in the management of a pediatric knee injury. Due to normal skeletal variance, we recommend bilateral radiographs and if findings are ambiguous, consultation with a radiologist to confirm clinical suspicions.

(JCCA. 2018;62(2):105-110)

KEY WORDS: chiropractic, knee pain, adolescent, normal variant

règles d'Ottawa pour le diagnostic des pathologies du genou pour savoir si la prise de radiographies est pertinente dans la prise en charge des blessures au genou chez l'enfant. En raison des variantes anatomiques de la normale, on recommande la prise de radiographies bilatéralement et si les résultats d'examen sont ambigus, la consultation d'un radiologue pour confirmer les soupçons.

(JCCA. 2018;62(2):105-110)

MOTS CLÉS : chiropratique, douleur au genou, adolescent, variante de la normale

Introduction

The prevalence of reported pediatric knee injuries in soccer players varies in the literature. In a study by Rossler *et al*., knee injuries were the second most common injuries in children playing soccer after the ankle.[1] While Kerr *et al*. report that knee injuries are the fourth most common in youth and adolescent soccer players, after head/face, ankle and hand/wrist injuries.[2]

Epidemiological studies identify that 14 to 17 year olds tend to sustain more injuries than younger age groups and males tend to be injured more often than females.[2–4] Therefore, it appears that maturation and sex may have an effect on the incidence and type of injury. For example, youth who have not reached full skeletal maturation seem to have more fractures, and fewer strains and sprains, as well as more upper body injuries compared to older age groups who have reached full maturity.[1] Males had a greater proportion of fractures and lacerations, whereas females had a higher proportion of concussions.[2]

In the pediatric population, the most common diagnoses were sprains/strains (30.5-34%), fractures (15.4-23%) and contusions (12.5-17.7%).[1–5] More than 50% of acute fractures were in the upper body and almost half of these were a direct result of a fall.[1] When looking at fractures alone, 62.5% occurred in the upper limbs, 35% in the lower limbs and 2.5% in the trunk (ribs).[1] Acute fractures had increasing incidence rates from younger to older players.[1,3,6] Sprains and strains tended to be more common in older age groups.[3] Similar prevalence were found in both sport teams and emergency department populations.[1]

In non-acute fractures, approximately 63% were growth related and involved the knee (Osgood-Schlatter syndrome) or the foot (Sever's disease).[1] The incidence of non-acute fractures peaked between 11 and 12 years old.[1] Osgood-Schlatter syndrome occurs at the tibial tuberosity where the apophyses cannot withstand the forces exerted by the quadriceps muscles.[7] This results in micro-avulsions of the quadriceps tendon insertion and may present as an enlarged tibial tuberosity.[7,8] The development of Sever's disease is similar to Osgood-Schlatter syndrome, differing in location, where it can be identified at the attachment of the Achilles tendon to the calcaneus.[7,9] Clinically, these conditions can be diagnosed with pain on palpation of the tendinous insertion, potentially an enlargement of the insertion and tension in the associated musculature due to the differential growth rate of the bones and muscles during maturation.[7] Specifically, the rectus femoris and hamstrings in Osgood-Schlatter syndrome, and the triceps surae in Sever's disease.[7] In addition, Sever's disease tends to present in boys between 8 to 12 years old, whereas Osgood-Schlatter syndrome tends to present comparatively later in adolescence.[7,8] Both of these conditions are aggravated by activity and relieved by rest.[7,8] Radiographic diagnosis is not recommended in the management of these conditions, however, they should be considered if pain is predominantly unilateral or pain is persistent.[7,9]

When a youth or adolescent patient presents with an injury, it is first important to gather information from the history and physical exam to inform in which case

radiographs would alter the clinical management.[10] It is also valuable to corroborate the mechanism of injury with coaches or parents who were present, which may provide more information than the youth athlete can recall. The Ottawa knee rules (OKR) and/or Pittsburgh decision rules (PDR) were developed to reduce the number of radiographs ordered and more accurately determine those in need of radiographs after acute knee injuries. In the adult population, the OKR are 100% sensitive to detect clinically significant fractures in adults with knee injuries.[6,11] The OKR recommend radiographs for patients with acute knee injury, and at least one of the following: older than 55 years, tenderness at the head of the fibula, isolated patellar tenderness, inability to flex the knee to 90 degrees, and inability to weight bear immediately and in the emergency room.[6,11] In children, the OKR were also 100% sensitive, with only a 42.8% specificity, using all criteria for those more than 55 years old.[10,11] The interobserver reliability was 0.85 overall, ranging from 0.62 in the youngest age group to 1.0 in the oldest.[11] This study even included Salter Harris type I and II fractures.[11] The PDR recommend radiographs for fall or blunt-trauma as mechanism of injury and age less than 12 or greater than 50 years old, or the same mechanism of injury with the inability to walk or weight bear four steps in the emergency department.[12] Sensitivity ranges from 77-100% and specificity ranges from 57-79%.[11,12,13] In a study comparing the OKR and PDR, they had similar sensitivities (85%), but the PDR had greater specificity, however in others, the OKR may have greater sensitivity.[12,14] The recommended normal series of radiographs are the anterior-posterior and lateral knee views.[10]

The purpose of this case report is to highlight the importance of using clinical information and radiographs to determine the appropriate plan of management in pediatric knee injuries. Specifically, recommending the use of the OKR or the PDR, bilateral radiographs if radiographs are warranted and getting a second opinion if needed.

Case Presentation

A 13-year old right-foot dominant male soccer player presented to a sports chiropractor (Fellow of the Royal College of Chiropractic Sports Sciences – Canada) complaining of right knee pain at the distal pole of the patella, most apparent to the patient when descending stairs. He presented six days after having a full-length leg plaster cast removed. Three and a half weeks prior to his visit to the chiropractor, he experienced a "popping" pain (10/10 using the Numeric Pain Rating Scale (NPRS)) during a directional change with the right leg planted while playing soccer. The pain was in the medial aspect of the right knee. He was assisted off the field, unable to weight bear, and was transported to the local emergency department (ED) by his parents. The ED radiographs prompted a referral to the fracture clinic for orthopaedic consultation due to a lucency identified in the inferior pole of the patella (Figure 1). Upon orthopaedic consultation, he was discharged, and immediately allowed to return to play, as this finding was deemed normal. Two and a half weeks after the initial injury, the athlete inadvertently fell onto his right knee, causing extreme pain. This prompted a return to the ED, another set of radiographs and a recommendation to cast the entire leg (foot to hip). The cast was subsequently removed after two weeks, with further recommendations to rest.

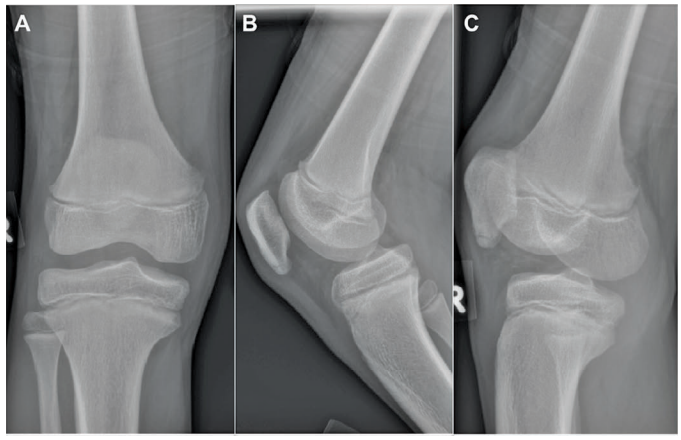

Figure 1.
Right knee radiographs from ED first visit.
A) AP knee B) Lateral knee
C) Oblique knee.

Upon presentation to the sports chiropractor, the right quadriceps was visibly atrophied (25.5 cm on the right, compared to 27 on the left, measured 4 cm above the patella). There was no swelling apparent on either the medial or lateral aspect of the patella, or at the tibial tuberosity. The patient was unable to squat beyond 90 degrees of knee flexion due to increasing pain and pressure around the patella, with valgus also noted during the

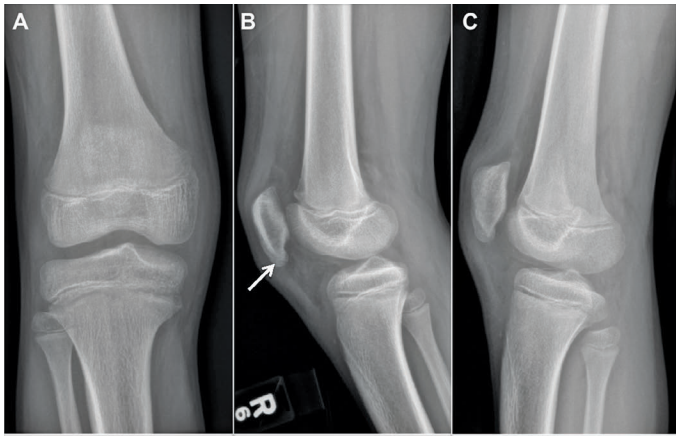

Figure 2.
Right knee radiographs from ED second visit. A) AP knee B) Lateral knee C) Oblique knee. Arrow indicates subcortical blurring.

movement. Meniscal orthopaedic testing was negative, including Thessaly's test, McMurray's and joint line tenderness. ACL laxity was noted bilaterally during anterior drawer and Lachman's tests. Posterior drawer, valgus and varus stress tests, and ligamentous palpation were all negative. Thomas test revealed quadriceps tightness bilaterally (right knee flexion at 120 degrees, and 110 degrees on the left), with hip flexor tone within normal limits. Upon palpation, there was exquisite tenderness at the inferior pole of the right patella (8/10 NPRS) with moderate tenderness in the middle of the patellar tendon and the tibial plateau (3-4/10 NPRS). The differential diagnoses of the sports chiropractor included right-sided Sinding-Larsen-Johansson disease, Osgood-Schlatter syndrome, patellar tendinopathy and the previously suspected patellar fracture.

Anterior-posterior and lateral radiographs were available from both visits to the ED. Upon review by the chiropractor, there was a high suspicion that the radiographs were normal for a boy of this age. Therefore, the chiropractor received a second opinion from a chiropractic radiologist, to ensure his recommendations to the patient were appropriate. Figure 1 includes radiographs from the patient's first visit to the ED and Figure 2 includes radiographs of the second visit to the ED.

The radiology report stated that bone density was adequate with unfused physes and apophyses. The cortices and trabeculae were intact. No widening of the physes or displaced apophyses were visualized. The patellar height was well maintained. The medial and lateral femorotibial joints and patellofemoral joints were well maintained. The Hoffa's fat pad was intact and no swelling of the suprapatellar recess was visualized. The radiologist's impressions were an unremarkable radiographic study of a skeletally immature right knee.

A clinical comment was included regarding the follow-up radiographic study of the right knee, showing slight cortical blurring at the anterior aspect of the inferior half of the patella with a faint subcortical oblique lucency. No adjacent soft tissue swelling was seen. This likely represents bony resorption secondary to bone contusion to this region. The faint irregular lucency at the inferior pole of the patella on the initial study was not present on the second study and as such, does not represent a non-displaced fracture.

Having ruled out a patellar fracture, the patient was given technical instruction for the squat movement patterns to reduce valgus stress and was encouraged to begin a progressive rehabilitative return to play program with his soccer club. This included box squats to 90 degrees and progressive lowering with reduced pain and progressive and regressive angular isometric loading contractions in 15° increments from a seated position. The patient was instructed to increase his protein intake to 5 servings of 20 grams of protein per day.[15–17] Three weeks after initial presentation to the sports chiropractor, the patient had a 0.5 cm discrepancy in girth of the quadriceps, was squatting to 130 degrees without pain, and demonstrated the ability to perform agility, speed and soccer specific activities without pain (including running figure eights, cutting, jumping, sprint and striking a soccer ball). The patient was cleared to resume soccer activities at this time.

Discussion

Patellar fractures are not a common injury in children. Only one percent of patellar fractures occur under the age of 15.[10] While patellar fractures can occur from direct and indirect mechanisms, direct forces through the patella are the most common cause.[10] The smaller prevalence of patellar injuries in the pediatric population is thought to be due to a smaller extensor muscle mass reducing the forces on the patella in indirect injuries and a cushioning effect of the surrounding cartilage in direct mechanisms.[10]

With regards to the clinical note by the chiropractic radiologist, showing slight cortical blurring at the anterior aspect of the inferior half of the patella suggesting bone resorption secondary to a bone contusion, this was made on the basis that bone being resorbed is much less dense than normal bone.[18] This is associated with the remodelling phase of bone.[18] When combined with clinical and radiographic findings, such as the lack of soft tissue swelling, clinically and radiographically, as well as the change in the cortical lucency first demonstrated on the radiograph, it was concluded that this finding was not associated with fracture, but likely to a bone contusion to the patella.

It is imperative to remember that the developing skeleton has a number of secondary growth centres that appear irregular upon visualization on radiographs.[10] To add to the complexity, not only can they be irregular, they can also be asymmetrical.[10] For example, irregularities in the lateral and medial epiphysis of the femur can be mistaken for pathologies such as osteochondritis or destructive processes, although they are a normal developmental stage.[10] Other normal findings include a notch or groove for the tendon of the popliteus on the lateral aspect of the lateral femoral condyle, specifically visible in adolescents, and the os fabella, a sesamoid bone in the gastrocnemius.[10] Therefore, we suggest that bilateral radiographs be taken if a fracture is suspected around a joint to determine the normal appearance of secondary growth centres of the involved bones.

There are many normal variants of the patella during development, as demonstrated in this case.[10] Ossification begins around three to five years of age, and begins as multiple centres that coalesce over time.[10] The initial ossification can appear granular or irregular, and may appear as radio-opaque densities in the soft tissues.[10] In addition, secondary ossification centres can be easily mistaken as fractures.[10] The most common ossification centre of the patella is of the superolateral corner, which is known as a bipartite patella if it remains unfused.[10] Other accessory ossification centres can also be found at the upper and lower poles of the patella, such as in the case presented, or on the medial or lateral borders.[10] These are often variable and asymmetric.[10]

Other ossification centres in the knee include the tibial tubercle, which begins to ossify between seven to nine years, beginning at the distal end, enlarging proximally and anteriorly.[10] The main tibial ossification proceeds in the opposite direction, down toward the tubercle.[10] Epiphyseal cartilage remains between these ossification centres until near physeal maturity.[10] On the occasion where the ossification centre appears prominent, irregular or fragmented, it may indicate a possible avulsion or the presence of Osgood-Schlatter's syndrome, however, it is more often than not, a normal variant of this region.[10] It is important to note that Osgood-Schlatter's syndrome must also be differentiated from Sinding-Larsen-Johansson syndrome, a traction apophysitis of the distal pole of the patella.[10] Sinding-Larsen-Johansson syndrome is characterized by pain at the inferior pole of the patella with fragmentation of or calcification at the pole upon imaging.[19] The prevalence of this condition is lower than Osgood-Schlatter's syndrome, ranging between two to five percent in healthy 10 to 14 year olds.[19] Radiographic changes of the inferior pole of the patella can often be difficult to discern due to the variants in ossification centre, emphasizing the need for bilateral radiographs to identify differences from the symptomatic to asymptomatic sides.[19,20] The physis of the proximal tibia is undulating in shape, appearing different on different radiograph views, which can be mistaken for an epiphyseal fracture.[10] Localized angulations in the physis appearing as depressions in the metaphysis, may also appear abnormal, but again, can be a normal developmental variant.[10] It is possible that areas of accessory ossification centres relating to the epiphysis and physis appear small and irregular and should not be mistaken for fractures.[10]

The differential diagnoses considered in this case included Sinding-Larsen-Johansson syndrome, driven by the age of the patient and location of the chief complaint at the inferior pole of the patella[10], Osgood-Schlatter syndrome, a common condition in the active pediatric population[1], patellar tendinopathy, due to the location of the pain, aggravating activities and demands of the sport (running, jumping and change in direction) and the previously suspected fracture. If a fracture is on the list of differential diagnoses, it is important to take the necessary steps to rule out its involvement, but also, to be sure it is a fracture, if this diagnosis is made. As demonstrated in this case, even two weeks of cast immobilization can have a significant impact on muscle atrophy, in an otherwise healthy young athlete. Evidence suggests that significant muscle atrophy can occur after five days of immobiliz-

ation.[21] A 3.5% loss in quadriceps cross-sectional area occurred after five days of immobilization, increasing to 8.4% loss after 14 days.[21] This is associated with a 9% and 22.9% decrease in quadriceps muscle strength after five and 14 days of immobilization, respectively.[21]

Summary

According to FIFA, as of 2006, soccer has at least 265 million participants worldwide.[22] Of these, approximately 22 million players are youth.[22] Depending on the source in the literature, knee injuries are the second to fourth most common injuries in youth and adolescent soccer players.[1,2] These knee injuries can range from acute fractures, non-acute fractures, to sprains and strains; the prevalence of which vary based on age and sex.[1–3,6] The OKR are an important tool that can be used to determine if the patient should have radiographs taken, which can help the clinician rule out fractures, or other serious injuries. Given the normal variance possible in this population, clinicians should be cautious in diagnosing normal findings as fractures, as this may have significant functional implications for the patient.[21] The use of bilateral radiographs, in addition to the history and physical examination should be used to inform their diagnoses. Given a situation where they may be unsure, it is always prudent to get a second opinion from a radiologist.

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Conservative management of a chronic recurrent flexor hallucis longus stenosing tenosynovitis in a pre-professional ballet dancer: a case report

Matt Wentzell, BKin, DC[1]

Objective: *To describe the successful conservative management of a chronic recurrent flexor hallucis longus (FHL) stenosing tenosynovitis.*

Clinical Features: *A 20-year-old female pre-professional ballet dancer presented with medial ankle and mid-foot pain of 7.5 months duration. Pain was constant but exacerbated with training and assuming the en pointe and demi-pointe dance positions. Plantar flexion of the great toe was pain provoking. Triggering of the great toe and audible and palpable crepitus were noted with active and passive great toe range of motion. A diagnosis of a chronic recurrent FHL stenosing tenosynovitis was made based on the history and physical exam.*

Intervention and Outcome: *Soft tissue and joint mobilization and manipulation, laser therapy, kinesiology tape application and rehabilitative exercise was used over 4 months. The patient reported an*

Objectif : *Présenter le traitement conservateur efficace de la ténosynovite sténosante chronique récurrente du muscle long fléchisseur de l'hallus (MLFH).*

Caractéristiques cliniques : *Une danseuse de ballet préprofessionnelle de 20 ans avait depuis 7-½ mois une douleur* à la partie médiale d'une cheville et à la partie moyenne d'un pied. Cette douleur était constante et *exacerbée par l'entra*înement, les positions sur pointes et les positions sur *demi-pointes. La flexion plantaire du gros orteil déclenchait de la douleur. Un craquement audible et palpable de même que le déclenchement de la douleur au gros orteil étaient observés lorsque les amplitudes des mouvements passifs et actifs étaient effectuées. Le diagnostic de* ténosynovite *sténosante chronique récurrente du MLFH* a été établi à la lumière de l'anamnèse et des résultats de l'examen physique.

Intervention et résultat : *La mobilisation et la manipulation des tissus mous et des articulations, les traitements au laser, l'utilisation de bandes de kinésiologie et des exercices de rééducation ont été les stratégies d'intervention utilisées durant 4 mois. On a*

[1] Private practice

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The involved patient provided consent for case publication.

8-point decrease in her numeric pain rating scale score and a 15-point improvement in her Lower Extremity Functional Scale score.

(JCCA. 2018;62(2):111-116)

KEY WORDS: chiropractic, stenosing tenosynovitis, ballet

observé une réduction de 8 points du score obtenu sur l'échelle numérique d'évaluation de la douleur et une amélioration de 15 points du score obtenu sur l'échelle d'évaluation fonctionnelle des membres inférieurs.

(JCCA. 2018;62(2):111-116)

MOTS CLÉS : chiropratique, ténosynovite sténosante, ballet

Introduction

The flexor hallucis longus (FHL) is a muscle originating on the posterior aspect of the distal two-thirds of the fibula and interosseous membrane.[1] The FHL courses posterior and inferior to the medial malleolus through a fibro-osseous tunnel before attaching to the plantar surface of the distal phalanx of the great toe.[1] It functions primarily as a plantar flexor of the metatarsophalangeal (MTP) and interphalangeal joints of the great toe, however its orientation provides a secondary function as a torque producer through the subtalar joint and the joints of the first ray.[2]

Injury to the FHL can occur in those who perform activities involving repetitive, forceful or prolonged plantar flexion maneuvers.[3,4] Ballet is one activity where the FHL is frequently injured due to the demanding foot and ankle positions required in the dance genre. En pointe and demi-pointe are two weight-bearing positions which can contribute to the development of an FHL injury (Figure 1). The en pointe position involves maximal ankle plantar flexion with the first MTP joint in a neutral position relative to the longitudinal axis while the demi-pointe position involves maximal ankle plantar flexion with 80-100° of extension at the first MTP joint.[5] In both positions the FHL aids in ankle and foot stabilization and balance which lends credence to its reputation as the dancer's Achilles tendon.[1] En pointe and demi-pointe positions put substantial stress on the FHL, with muscles crossing both the ankle and the MTP joints working 2.5 to 3 times harder than muscles that cross the ankle only.[1,5] En pointe work may be more provocative since the FHL tendon may become directly compressed as it passes through the flexor retinaculum that is posterior and inferior to the medial malleolus.[2,3,5]

The frequency in which the FHL is injured in ballet led to the term dancer's tendonitis being used as early as the 1970's to describe aggravation of this structure.[6] Dancer's tendinitis is a layman term for FHL injuries and not all cases of dancer's tendinitis are true cases of tendinitis. Reports of partial longitudinal tears, stenosing tenosynovitis, and intrasubstance degeneration of the FHL are documented in the literature.[2] In the case of stenosing tenosynovitis, chronic irritation of the FHL tendon between the sesamoids of the first MTP joint, along the knot of Henry or under the flexor retinaculum can lead to swelling, nodule formation, hypertrophy and tearing of the FHL as it courses through its synovial sheath.[3,5,7] This can result in pain and limited passive and active first MTP range of motion and may be accompanied by triggering

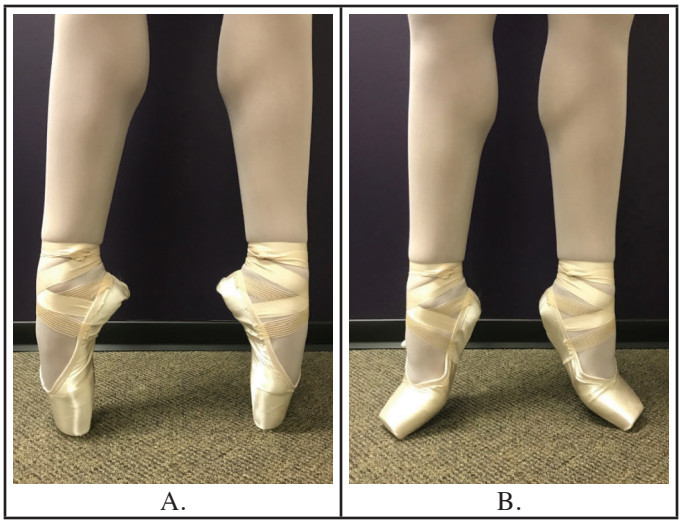

Figure 1.
A) *En pointe position*. B) *Demi-pointe position*.

of the great toe and audible and palpable crepitus over the FHL tendon.[3,5,7]

Conservative measures are recommended for the initial management of FHL injuries. Resting the affected structure[1,3-5,7-9], anti-inflammatory medication[1,3-5,7,8], massage[3], subtalar and first MTP joint mobilization[1], ultrasound[3], physical therapy[5], stretching[3], core strengthening[4], and correcting biomechanical faults related to forcing turnouts[5] are recommended.

Surgical intervention should be considered if three to six months of conservative measures have failed[4], if there is triggering with great toe range of motion[5,8], a full rupture of the FHL is suspected[4], the injury is disabling or recurrent[7,9,10], or if the patient is not compliant with activity restriction[4].

The purpose of this case report is to present the successful rehabilitation of a chronic recurrent FHL stenosing tenosynovitis in a pre-professional ballet dancer who presented with several of the aforementioned factors that are recommended for the consideration of surgical intervention.

Case Presentation

A 20-year-old female pre-professional ballet dancer presented with right medial ankle and mid-foot pain of 7.5 months duration. The patient reported that the pain started gradually with continued training after incurring a right-sided lateral ankle sprain several weeks prior. Initially, the pain was sharp and stabbing with dance and a constant dull ache with daily activities that worsened at night. At its peak, her pain was rated as an 8/10 on a numeric pain rating scale (NPRS). The patient continued dancing five to six hours per day five days per week and was forced to take six weeks of rest after four months of failed conservative management. The conservative management of her injury continued during her forced break from dance which consisted of daily foot and ankle exercises and regular strength Ibuprofen in the evenings. At the end of her break, she reports her pain diminished to a 4/10 on an NPRS with exercise and walking for long periods and a 2/10 on an NPRS with other activities of daily living. Upon returning to dance, she reported a snapping sensation in the medial ankle that accompanied the pain. The patient took a two week break a month and a half after resuming dance which was unrelated to her injury. Her injury was then re-aggravated to an 8/10 pain on an NPRS with a quick return to dance after the shorter second break. This pain consisted of a more pronounced snapping sensation in the medial ankle and triggering of her great toe with flexion. From the seven-month mark to the date of her initial appointment, she had modified her dance training to two hours per day five days a week. She also modified the volume of her ballet-related jumping exercises from nine to ten exercises per day to two to three exercises per day. Each exercise consisted of ten to twelve repetitions per leg, per exercise. From the onset of her pain to the date of her initial examination, her pain was most pronounced while assuming the en pointe and demi-pointe positions.

A Lower Extremity Functional Scale (LEFS) of 55/88 and an NPRS score of 8/10 was obtained during the initial examination. Rest was the only relieving factor reported by the patient. A secondary complaint consisting of a non-painful difficulty in "turning out" the right hip was described by the patient.

No red flags were identified during the initial examination. The patient reported weekly cardio and strength training outside of her dance training. The patient reported an alcohol consumption of one to two glasses of wine per week and no cigarette use or caffeine consumption. No allergies were reported. The only medication or supplement use reported was 2000IU of Vitamin D3 daily and regular strength Ibuprofen in the evenings when her pain was 8/10 on an NPRS. No past or present conditions, illnesses or surgeries were reported. The patient reported a history of minor ankle, low back, mid back and neck injuries, all of which have been managed conservatively.

Clinical Findings

Visual inspection revealed mild oedema around the right medial malleolus over the tarsal tunnel and was void of any bruising or rubor. The patient's pain was provoked by passive great toe extension with the ankle in dorsiflexed, neutral and plantar flexed positions and resisted great toe flexion in weight bearing and non-weight bearing positions. Triggering of the great toe was noted with passive great toe flexion and extension and was accompanied by audible and palpable crepitus posterior to the medial malleolus and in the tarsal tunnel. Range of motion testing for the right lower extremity revealed limitations in subtalar supination and adequate active and passive internal and external hip rotation with a patient-reported increased dif-

ficulty in reaching end range in both internal and external right hip range of motion. All other passive and active lower extremity ranges of motion were unremarkable.

Using the Total Tenderness Scale (TTS), palpation revealed grade 1 tenderness through the superficial posterior compartment of the right leg and grade 2 tenderness through the right deep hip external rotators, posterior hip capsule, anterior fibers of the right gluteus medius, gluteus minimus and tensor fascia lata. Moderate pain provocation and moderate mechanical tension was noted with palpation of the deep posterior compartment of the right leg. The patients' pain was most pronounced with palpation of the flexor hallucis longus as it coursed from the posterior aspect of the medial malleolus into and distal to the tarsal tunnel. Flexor hallucis longus tenderness was minimal at and distal to the Knot of Henry.

Neurological testing of the lower extremities including percussion of the posterior tibial nerve was unremarkable.

Therapeutic Intervention

The patient underwent a course of 25 treatments over the span of four months. Treatment consisted of seven minutes of laser therapy at 8W for a total of 3240.0 J (LiteCure Lightforce™ Pro) along the length of the flexor hallucis longus tendon posterior and distal to the right medial malleolus, kinesiology taping application to the right ankle and foot (Figure 2), Functional Range Release® techniques to the affected soft tissues, mobilization and manipulation of the right subtalar joint, mobilization of the right hip using a mobilization strap and a gradual introduction to a series of exercises based on Functional Range Conditioning® principles. The patient was also given a 30-day course of a natural anti-inflammatory product (Douglas Laboratories Quercetin Bromelain Complex) to be taken during the initial stages of her treatment.

Figure 2.
Kinesiology tape application to the FHL. The ankle was dorsiflexed and pronated with no stretch in the tape as it was applied. This application provided a "lifting" of the skin as the patient assumes a plantarflexed ankle position.

The patient continued with two hours of dance training daily during the first two months of treatment. Triggering of the great toe was absent after the fourth treatment. The audible and palpable crepitus along the FHL tendon was absent after the fifth treatment. The swelling around the tarsal tunnel lessened over this time.

The patient gradually increased in the number of ballet-related jump exercises from two to three exercises per day during the first visit to six to seven exercises by the sixth visit, eight exercises by the ninth visit and nine exercises by the eleventh visit. All exercise progressions were made without pain provocation. The patient reported a notable increase in hip strength and mobility by the seventh visit and improvements in muscular strength and endurance while in the en pointe and demi-pointe positions by the tenth treatment. The patient gradually increased her rehearsal time over the last two months to a maximum of 6 hours per day with no re-aggravation of her condition.

The patients NPRS score dropped from 8/10 to 0/10 and the LEFS score improved from 55/80 to 70/80 by the 25th treatment.

Discussion

The collective incidence of musculoskeletal (MSK) injuries in pre-professional and high-school level dancers ranges from 17% to 90% and the lifetime prevalence of MSK injury in university and pre-professional dancers ranges from 26% to 51%.[11,12] The majority of these injuries occur around the ankle and are often attributed to overuse.[11-14] Motta-Valencia (2006) suggests this may be due to dancers continuing to dance and train despite injury for reasons including emotional, financial and social well-being.[9]

Despite some general conservative treatment recommendations being proposed [1,3-5,7-9], there is a paucity of detailed and well researched conservative treatment protocols on FHL stenosing tenosynovitis available to al-

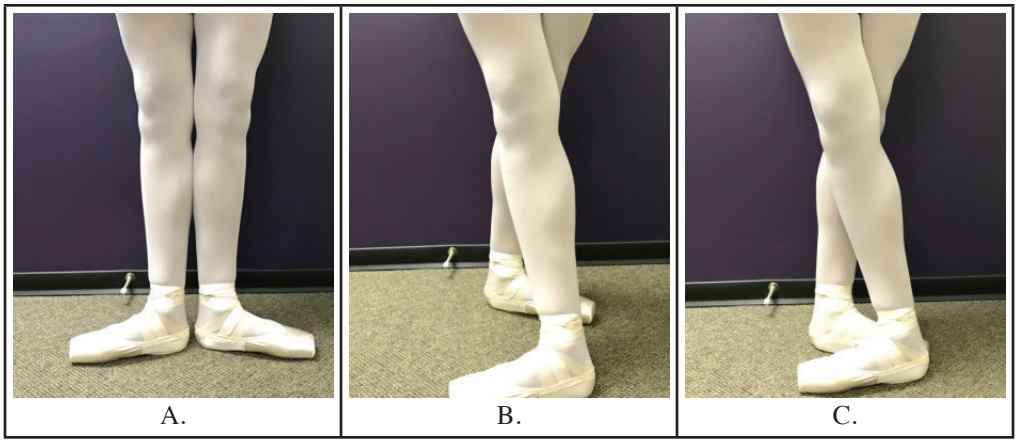

Figure 3.
Foot and ankle placements requiring turn out of the hip.
A) *First Position* B) *Fourth Position (Croisé)* C) *Fifth Position*.

lied health professionals. Surgical intervention has been recommended if three to six months of conservative treatment has failed[4], if there is triggering of the great toe[5,8], if the injury is disabling or recurrent[7,9,10], and if the patient is noncompliant with activity restriction[4]. Although the patient presented with a number of variables that suggest the consideration of surgical intervention, the patient opted for conservative management due to dance obligations.

An assortment of treatment methods were used to address the patients complaints. Some treatments were directed at the injured tissue and a large focus was put on working on the tissues and joints proximal and distal to the painful region. It is interesting to note that although the patient related a gradual onset of symptoms following a lateral ankle sprain she incurred several weeks prior, she also had reported difficulty in assuming turn out positions with her right lower limb. Turnout requires the lower limbs to be externally rotated so the feet are placed 90 degrees from the sagittal plane (Figure 3).[5] The hips should contribute 60% of the external rotation for the turnout position with the remaining 40% coming from the knees, ankles and feet.[9] In the event that the dancer cannot achieve 60% of the turnout position through the hips, the dancer may force the position by placing increased stress on the medial side of the foot, ankle, tibia and knee which amplifies the injury potential for the tissues spanning these areas.[5,9] Over time, forcing turnouts can make the ligaments and musculature of the medial foot, ankle and leg weak and fatigued and subsequently lose their ability to support the medial arch of the foot.[15] It is possible that the dancer's secondary complaint contributed to the development of her chronic recurrent FHL stenosing tenosynovitis and may explain why the injury could not be resolved with prior conservative management.

The lack of right subtalar motion is a possible contributor to the patients FHL stenosing tenosynovitis. Ahonen (2008) reports that subtalar supination is needed to create force closure of the midtarsal joints and is always linked to external rotation of the lower limb.[15] A disconnect between these two variables may contribute to a lack of control in the demi-pointe position and put undue stress on the ankle-foot complex.[15] It is interesting to note that the patient reported more ease in the en pointe and demi-pointe positions when mobilization of the subtalar joint was introduced by the eighth treatment.

Graded rehabilitative exercise was lacking from the patient's original management. The dancer was given a series of ankle, foot and great toe open kinetic chain Theraband exercises which provided little relief in the short and long term. She continued with these exercises while new exercises were prescribed throughout the management of this case. The new exercises were based on concepts and principles that are discussed in the Functional Range Conditioning® certification. The progression of the exercises prescribed, in addition to the other treatment modalities used during the management of this case was

based on the practitioner's clinical experience rather than a protocol template. Despite the patient continuing with the initial exercises she was prescribed, it is unlikely they had a significant influence on her improvement given that she had experienced little improvement with them since the onset of her symptoms.

The author acknowledges this case was not without its limitations. Despite the recommendation that disorders of the FHL require relative rest as a part of a conservative management approach[1,3-5,7-9], the patient continued to train and rehearse despite injury. While the outcome of this case may signify the efficacy of the treatment provided, it is possible that resting the injured tissues may have accelerated the recovery time. The absence of imaging to determine the extent of the injury or the presence of complicating factors is also a likely limitation of this case. MRI and diagnostic ultrasound are two imaging modalities that are frequently used to help diagnose FHL disorders. The presence of an accessory FHL muscle[16], boney edema[4,8,9], fluid collection along the FHL tendon[4,8,9], os trigonum[9], or a partial or complete tear of the FHL[9] can be visualized using MRI and may help explain the painful condition. Diagnostic ultrasound can provide a dynamic and cost-effective means to assess the FHL for tendinosis[4] or a partial or complete tear[9]. In the event that early conservative treatment was unsuccessful, imaging modalities could have been recommended for further investigation. It should also be noted that the patient received five acupuncture treatments throughout the management of this case. The acupuncture treatment was focused on the patient's chief complaint and was not rendered by the professional depicted in this manuscript. The points needled during these sessions are unknown.

Summary

FHL stenosing tenosynovitis is a common and often debilitating dance injury. There is a paucity of definitive conservative treatment protocols for FHL stenosing tenosynovitis and a number of recommendations on when surgical interventions should be considered. This case demonstrates successful conservative management of a chronic recurrent FHL stenosing tenosynovitis in a pre-professional ballet dancer who presented with several indicators for surgical candidacy. It is important for clinicians to understand the injury mechanism and the biomechanical and physiological demands of the patient's sport or activity. Clinicians should address both the injured tissue and any painful or non-painful dysfunctions above and below the injury site. In the case of FHL stenosing tenosynovitis, hip mobility and subtalar motion should be assessed and treated accordingly.

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A scoping review of chiropractic management of female patients with infertility

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Background: *Debate concerning chiropractic management of female infertility occurs largely in the absence of reference to the extant literature.*

Methods: *A scoping review was conducted of primary (original) data publications on the chiropractic management of female infertility based on searches of the Index to Chiropractic Literature and Pubmed, supplemented by papers from one author's archive.*

Results: *Ten articles, all case studies, met the review's inclusion criteria and documented the experiences of 11 women (mean age 31 years; mean period of infertility 3 years). Pregnancy occurred, on average, after 5 months of treatment with spinal manipulation and adjunctive modalities. No adverse events were reported.*

Discussion: *There are very few original data articles documenting responses of infertile females treated with spinal manipulation.*

Conclusions: *In the absence of a robust body of primary data literature, the use of spinal manipulation*

Contexte : *Les controverses au sujet de la prise en charge chiropratique de l'infertilité féminine sont en grande partie liées à l'absence de référence à la littérature existante.*

Méthodologie : *On a effectué une revue exploratoire de publications de données primaires (d'origine) sur la prise en charge chiropratique de l'infertilité féminine en consultant l'Index to Chiropractic Literature, Pubmed et divers documents provenant des archives d'un auteur.*

Résultats : *Dix articles, qui étaient tous les études de cas, satisfaisaient les critères d'inclusion de la revue. Ils visaient à documenter l'expérience vécue par 11 femmes (âge moyen : 31 ans; durée moyenne de l'infertilité : 3 ans). En moyenne, ces femmes sont devenues enceintes au bout de 5 mois de traitement par manipulations vertébrales et des modalités d'appoint. Aucun effet défavorable n'a été signalé.*

Discussion : *Il existe très peu d'articles documentant les réponses de femmes infertiles traitées par manipulations vertébrales.*

Conclusions : *En l'absence de corpus robuste de littérature sur des données primaires, il conviendrait*

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in the management of female infertility should be approached with caution.

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KEY WORDS: chiropractic, infertility, scoping review

de faire preuve de prudence en ayant recours aux manipulations vertébrales dans la prise en charge de l'infertilité féminine.

(JCCA. 2018;62(2):117-124)

MOTS-CLÉS : chiropratique, infertilité, revue exploratoire

Introduction

Female patients affected by infertility not uncommonly seek complementary and alternative (non-medical) treatment for their complaint.[1-4] One of the most popular forms of complementary and alternative care in western nations is chiropractic and there are a number of reports of successful pregnancies following institution of chiropractic care (for a review, see[5]).

Based on a substantially stronger body of literature, chiropractic care is generally recognized as one reasonable option in the management of biomechanical problems of the spine. Indeed, this is the 'bread and butter' of chiropractic, making up the overwhelming majority of cases managed by chiropractors.[6-10] On the other hand, chiropractic management of what may be thought of as visceral disorders does not enjoy such strong support inside or outside of the profession.[11,12] A report from a chiropractic practice-based research program published in 2001 revealed that only 1 of 4511 female patients surveyed presented with a chief complaint of infertility.[13] A large survey of the profession in the United States, published in 2005, showed that practitioners, on average, managed 0.6 cases of female infertility per year.[8] In fact, the preferred strategy of chiropractors was to refer the infertile patient to another health care practitioner or to co-manage the patient. In something of a contrast and depending upon the cohort of practitioners surveyed, a small[14] to sizeable[10] minority of chiropractors nonetheless believe that chiropractic care may be of benefit to some infertile female patients. It appears that patients who seek complementary and alternative care in general[3,4,15], and chiropractic in particular, are wealthier and better educated than those who attend medical practitioners[16]. Otherwise, however, little is known about the distinguishing features of females who receive chiropractic care for infertility, or about the nature of the care which they receive.

Therefore, the purpose of the present review was to conduct a scoping review of the literature to determine the characteristics of female patients presenting for chiropractic care of infertility, and to characterize the treatments received and outcomes achieved. Furthermore, since spinal manipulation is the hallmark treatment of chiropractors[8], but chiropractors may employ any number of adjunctive techniques, this review was limited to studies in which spinal manipulation was among the treatment techniques employed for each patient.

Methods

A scoping review of the literature was conducted, using the framework of Levac *et al*.[17], to identify and analyze the corpus of peer-reviewed, primary (original) data literature documenting the chiropractic management of the infertile female patient. To that end, a search of the Index to Chiropractic Literature (ICL) was performed (Figure 1) on November 11, 2016 using the search string "All Fields:gynecology OR All Fields:pregnancy OR All Fields:*fertility, Peer Review only." A search of PubMed conducted on April 25, 2017 using the search string "chiropractic [Title/Abstract} AND infertility [Title/Abstract] yielded no original data articles pertaining to chiropractic management of female infertility. Secondary references were identified from retrieved articles and supplemented from one of the authors' archives. No language limitations were placed on the searches, but all of the arti-

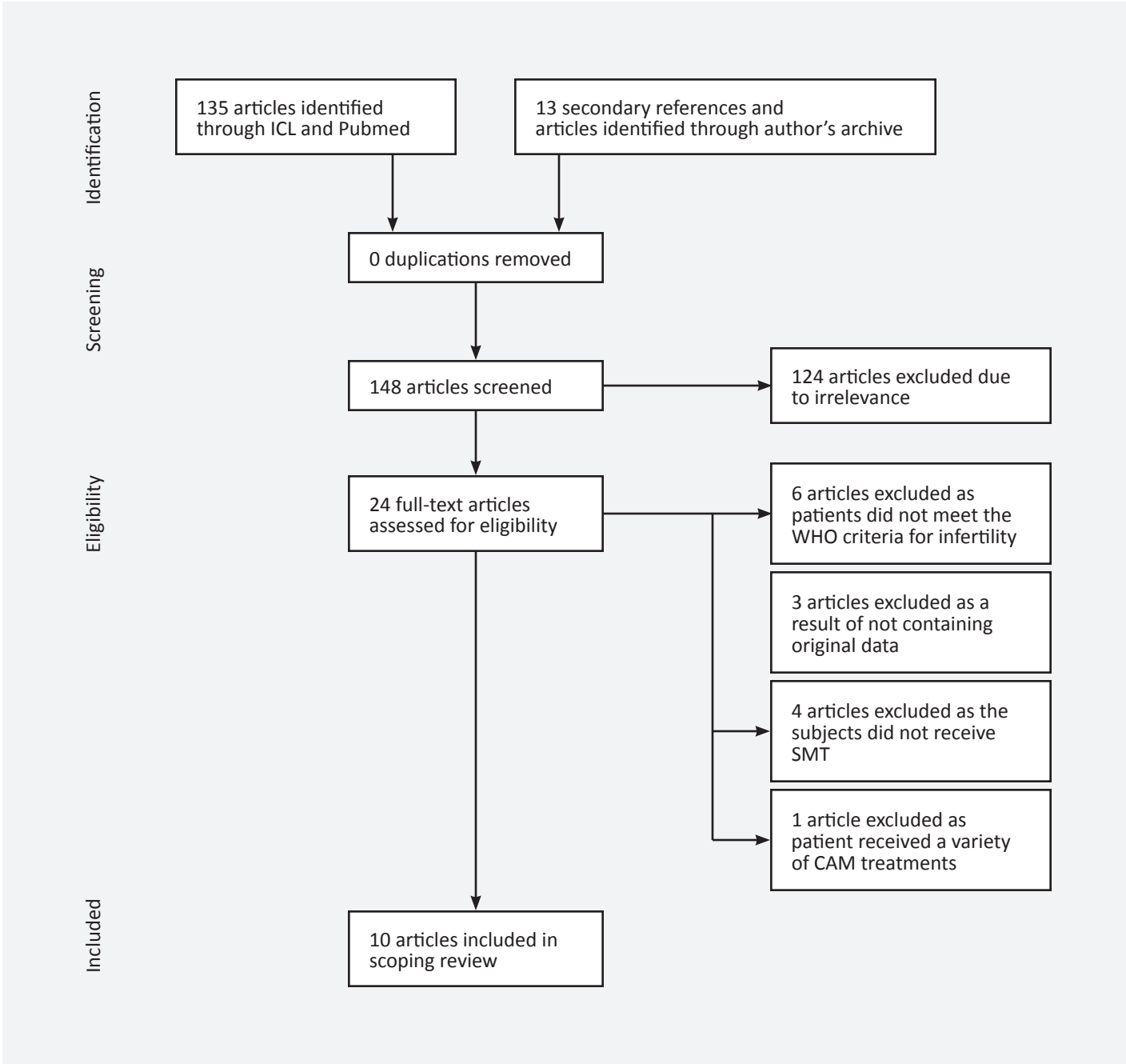

Figure 1.
Article flow through the review process.

cles identified were written in English. For the purposes of this study, the WHO definition of infertility was adopted; i.e. "a disease of the reproductive system defined by the failure to achieve a clinical pregnancy after 12 months or more of regular unprotected sexual intercourse[18]."

One hundred and thirty-five peer reviewed articles were identified via ICL. Additionally 13 secondary references were identified from retrieved articles and from one author's (BB) archive. Articles which did not contain original data (e.g. reviews and commentaries) were excluded. Hence, a total of 24 full text manuscripts were retrieved and assessed to determine whether they met our inclusion criteria which were: i) original data, ii) failure to achieve a clinical pregnancy after 12 months or more of regular unprotected sexual intercourse, iii) treatment included spinal manipulation. Six articles were excluded because the patients did not clearly meet the WHO criteria for infertility; 4 papers were excluded because the subjects did not receive spinal manipulation; 3 papers were excluded because they did not contain original data; 1 paper was excluded because the patient received different types of CAM treatment from multiple practitioners, making the patient history difficult to decipher (Figure 1).

Both authors read all papers included in our analysis and extracted data to a spreadsheet (Tables 1 and 2). The extracted data included patient age, duration of infertility, diagnostic techniques used (e.g. palpation, postural exam, thermography), nature of treatment (e.g. spinal regions treated, whether HVLA or low force techniques were used), duration of treatment, outcome (pregnancy), causation (if known) and its temporal relationship to infertility, adverse events and any biological rationale for treatment affects offered by the study authors.

Because of the small number of cases reported, no attempt was made at a statistical analysis beyond descriptive statistics.

Results

The 10 papers included in our analysis were all case studies dating from 2003 to 2013, and documenting the treatment of 11 patients in total.[19-28] The articles were all identified through searching the Index to Chiropractic Literature and each was published in either the Journal of Vertebral Subluxation Research or the Journal of Pediatric, Maternal and Family Health. The patients ranged in age from 22 to 39 years (mean and median ages: 31 years) (Table 1). In the 10 instances where the number of years of infertility was stated (one case[20] simply reported 'a number of years'), the duration ranged from one to eight years (mean: 3 years, median: 2 years) (Table 2). In the eight cases where time from commencement of treatment to time of conception could be estimated, the duration of treatment was one to 20 months (mean: 5 months, median 2 months). One patient reported resolution of amenorrhea after 8 months of treatment, but no pregnancy was recorded.[24] In five instances the mother delivered at full term, and in one instance a healthy baby was delivered in the 8th month[25]. In one case, no pregnancy was reported[24] and in three cases the outcome of the pregnancy was not reported[20,21,27]. In one case, the patient was only followed to the 6th month of pregnancy (Table 1).[22]

Within chiropractic, spinal manipulation may be performed entirely by hand, or with the assistance of any of a variety of devices which deliver a relatively low force when compared to manual manipulation. In our study eight patients received manual manipulation, four patients received device-assisted manipulation, and one patient received a combination of the two. Regions of the spine manipulated were not specified in three papers, but where reported included cervical: n= 5; thoracic: n=7; lumbar n=5, and sacral/sacroiliac joints: n=8. Hence, most patients received manipulation to more than one region of the spine. Four patients also received nutritional advice, and three patients were encouraged to perform exercises at home (Table 1).

A number of methods were used to determine where in the spine to apply manipulation (Table 1). All but one author used manual palpation of the spine. Additional conventional methods used in the papers reviewed were postural examination, orthopaedic tests such as range of motion, and the assessment of functional leg length inequality. Six patients received spinal x-rays. Additionally, six patients were subjected to both spinal thermography or thermometry, and surface electromyography. Four patients were subjected to manual muscle testing. One patient was subjected to analysis of heart rate variability.

In one instance, the patient had previously delivered a healthy child, but was unable to conceive following a sacral fracture.[19] In no other case was there an apparent link between spinal trauma and development of infertility.

In each paper, the authors offered a neurological ration-

Table 1.
Age, diagnostic testing, and treatment of patients.

First author and reference	Age	Diagnostic techniques	Treatment techniques	Treatment duration and outcome
Adams JP[19]	22	Palpation, leg length, AK	HVLA to T/S and sacrum Uterine manipulation and lymphatic drainage	20 months 'Healthy baby' delivered
Anderson-Peacock E[20]	35	Palpation, postural exam, ROMs, leg length, thermography, electromyography, x-ray	Low Force to C/S, T/S, L/S and sacrum	2.5 months to conception Birth not reported
Anderson-Peacock E[20]	36	Palpation, postural exam, ROMs, leg length, thermography, electromyography, x-ray	Low Force to C/S, T/S, L/S, sacrum and cranium Home exercise	~ 2 months to conception Delivered full term
Bedell L[21]	27	Palpation, leg length, AK, postural exam, electromyography, thermography	Low Force C/S and sacrum Nutritional advice Craniosacral therapy	2 months to conception Birth not reported
Borkhuis S[22]	31	Palpation, postural exam, x-ray, thermography, SEMG, HRV	HVLA to unspecified sites Nutritional advice Exercise	1 month to conception Followed to 6 months of pregnancy
Kaminski TM[23]	31	Palpation, thermography, SEMG, leg length	HVLA and Low Force to unspecified sites	9 months to conception Delivered full term
Ko M[24]	39	Palpation, postural exam, ROMs, AK, leg length, x-ray	HVLA to T/S, L/S and sacrum Nutritional advice Exercise	8 months to resolution of amenorrhea No pregnancy reported
Lyons DD[25]	27	Thermography, SEMG, x-ray	HVLA to C/S, T/S, L/S and sacrum	1 month to conception Delivered healthy baby in 8th month
Phillips G[26]	37	Palpation, MMT, leg length	HVLA to C/S, T/S, L/S and sacrum	4 months to ovulation and IVF Delivered full term
Schwanz JW[27]	29	Palpation, thermometry x-ray	HVLA to sacrum	1 month to conception Birth not reported
Wolcott E[28]	28	Palpation, postural exam x-ray	HVLA to unspecified sites	Time to conception not reported Delivered full term

Legend: AK=applied kinesiology; ROMs=ranges of motion; SEMG=surface electromyography; HRV=heart rate variability; MMT=manual muscle testing; HVLA=high velocity, low amplitude adjustment

Table 2.
Case features contributing to rationale for diagnosis and treatment.

First author and reference	Duration of infertility	Rationale		
		Causality/insult	Temporality	Author's biological explanation
Adams JP[19]	perhaps >1 year	No trauma. History of tilted uterus confirmed by gynecologist	4 months after care, she experienced first menses and 22 months after first adjustment she became pregnant	Attributes patient's dysfunction to a number of nerve roots
Anderson-Peacock E[20]	2 years	Initial onset of low back pain was subsequent to fractured sacrum. Had given birth 1 year before accident, but unable to conceive thereafter.	10 weeks of treatment and patient became pregnant	Attributes patient's dysfunction to a number of nerve roots
Anderson-Peacock E[20]	''a number of years"	No trauma. Fully blocked left fallopian tube and a partially blocked and damaged right fallopian tube	8 weeks of treatment and patient became pregnant	Attributes patient's dysfunction to a number of nerve roots
Bedell L[21]	perhaps >1 year	No trauma. Had history of 2 miscarriages and ulcerative colitis	90 days after beginning care, she discovered she was pregnant	Implicates S2, S3, S4 branches to the pelvic floor muscles and these mediate PNS control over pelvic organs
Borkhuis S[22]	3 years	No trauma. Menses last 2 weeks in duration	After 19 visits, patient reported being 6 months pregnant	Attributes patient's dysfunction to a number of nerve roots
Kaminski TM[23]	>1 year	No trauma. Diagnosed with "lazy system" and irregular ovulation.	9 months after care, patient became pregnant	Attributes patient's dysfunction to a number of nerve roots
Ko M[24]	4 years	No trauma. Had secondary amenorrhea since age 18	Following the 2nd visit, the patient reported the onset of her first menstrual cycle in 3 months	Implicates nerve roots T8-L1 and correction of sacral subluxations.
Lyons DD[25]	5 years	No trauma. Patient was very active (marathons, karate and kickboxing)	Conception estimated to have taken place on the day after the 14th visit	Implicates the upper lumbar nerves as well the pelvic nerves. Also implicates the twisting of the pelvis which could have torqued the uterus or fallopian tubes to prevent conception or gestation.
Phillips G[26]	3 years	History of endometriosis (duration not specified). History of LBP for 18 months and had long commutes to and from work (60-90 min)	After 4 months of care, patient went for 5th attempt of IVF and became pregnant	Implicates nerve roots T10 and T11 which supply the ovaries
Schwanz JW[27]	8 years	No trauma. Menstrual cycles typically lasted 40-60 days in length	19 days after her first adjustment, the patient reported a positive Early Pregnancy Test and obstetrician confirmed she was 4 weeks gravid. Therefore possibly pregnant at time of initiating care.	Suggests that there is a neurological explanation for the complaint and discusses other case reports that talk about possible neurological explanations
Wolcott E[28]	2 years	Ovarian cancer (9years prior to initial visit). Had surgical removal of tumor	After 14 visits, patient conceived naturally	Vertebral subluxations in the cervical, thoracic, lumbar and pelvic regions were corrected

ale for either the complaint or the management strategy (Table 2). Furthermore, the rationale invariably invoked the segmental innervation of organs of the reproductive system, implying that alteration in autonomic output to one or another organ was the root cause of the patient's infertility.

Discussion

A systematic search of an electronic data base of the chiropractic literature, supplemented by papers from one author's archive, revealed only 10 original data papers dealing with the use of spinal manipulation in the management of female infertility. All of the papers were retrospective case studies dealing with, in total, 11 patients. All of the papers were identified through the Index to Chiropractic Literature, as the source journals are not indexed in PubMed. The most common reason for original data papers being excluded from this review was that the authors either did not report the duration of infertility, or reported a duration which was less than 12 months; i.e. did not meet conventional diagnostic criteria. Editors and authors of future papers on this topic should perhaps be alert to this consideration. Additionally, four papers were excluded because the patients did not receive spinal manipulation and three of 10 included papers did not specify the level(s) of the spine to which manipulation was targeted. Editors and authors will understand that the usefulness of papers is enhanced when information on 'dosage' is included – what is done, where and how often. The volume of papers and the design of each study does not provide for a strong body of evidence to guide clinical decision making. However, beyond this, the value of papers could have been improved by the thoughtful inclusion of clinical information which was almost surely at hand when the papers were authored.

The patients whose cases were reviewed were all in their 20s and 30s, hence likely in the midst of their reproductive years. In only one instance was there a recorded insult to the spine prior to the period of infertility.[20] Furthermore, different clinicians located sites for spinal manipulation variously in one or multiple regions of the spine. Hence, from the cohort of cases reviewed, it is difficult to discern how a clinician would identify, among infertile patients, those who would be "likely responders" to spinal manipulation.

Additionally, if one examines in detail the diagnostic and treatment regimes employed, it is difficult to identify a model pattern of care. While all but one author reported the use of manual palpation to detect the vertebral level to manipulate, an approach supported by the literature, all authors reported the use of additional diagnostic methods which do not appear to be clinically justified. These included manual muscle testing, thermography, thermometry, surface EMG and assessment of heart rate variability, none of which have been shown to be valid or reliable methods of determining the level of the spine to manipulate.[29] If in fact unvalidated or unreliable methods are used to locate the site(s) at which to apply manipulation, it is difficult to know what importance to attach to the responses to manipulation at these sites. Nonetheless, all authors reported conventional methods of spinal manipulation, and most often applied manipulation to multiple regions of the spine.

Limitations

Readers will be aware that scoping reviews such as this are a relatively new genre for which there is only developing consensus on methodology and quality assessment. Scoping reviews are typically used to assess the breadth and depth of available literature, rather than to weigh levels of evidence and reach conclusions about the value of interventions.[17] Consequently, readers should understand that the observations provided herein are not intended to directly influence clinical decision making.

Conclusions

As one might expect with case reports, positive outcomes predominated in our scoping review of chiropractic management of infertility, and this may not represent the aggregate clinical experience of the chiropractic profession. While the duration of their complaint was 3 years on average, and resolution was experienced on average within a few months, these temporal relationships do not provide strong evidence that in these particular cases chiropractic care played a role in resolution of the patients' complaints. Further, as readers recognize, case studies do not provide comparisons to other treatments or no treatment – alternatives which may well have resulted in the same outcomes. Thus, in the absence of prospective studies, and particularly randomized controlled trials, it is not possible to say whether the patterns of care discerned from our corpus should be taken as models likely to lead to clinical success in the patient population at large.

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