UNIVERSITÉ DU QUÉBEC À MONTRÉAL

NEUROIMMUNOLOGIE :

ÉTUDES CLINIQUES POUR MESURER L'EFFET DE L'AJUSTEMENT CHIROPRATIQUE SUR LA TEMPÉRATURE CUTANÉE, LA VARIABILITÉ DU RYTHME CARDIAQUE ET LES CYTOKINES (PROTÉINE RÉACTIVE-C ET INTERLEUKINE-6)

MÉMOIRE

PRÉSENTÉ

COMME EXIGENCE PARTIELLE

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La curiosité est la base même de la prise de décision pour poursuivre des études menant à l'obtention d'un doctorat. Toutefois, malgré l'inspiration qui motive l'étudiant, il faut toujours se souvenir de l'implication et du dévouement des personnes-ressources qui encadrent cet étudiant et qui permettent au clinicien de devenir chercheur.

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AVANT-PROPOS

Ce document est une thèse par articles.

Les raisons qui ont motivé cette orientation de recherche me sont apparues simples. Dans le monde de la santé, il existe présentement trois entités commerciales qui vendent des appareils de thermométrie pour utilisation clinique. À ma connaissance, il n'y a aucune recherche sur les relations de cause à effet entre les manipulations des dysfonctions articulaires vertébrales et la thermométrie. Donc, toute utilisation ou interprétation des résultats de l'analyse par thermométrie demeure spéculative. Comme il ne fut pas démontré que cette technologie a la capacité de mesurer l'effet des manipulations des dysfonctions articulaires vertébrales, le programme de recherche de cette thèse me semble approprié, voire nécessaire aux différents domaines de la santé qui utilisent les manipulations des dysfonctions articulaires vertébrales.

Depuis le début de mes travaux de maîtrise, nous avons démontré la validité et la fidélité de la thermométrie. Nous avons également déterminé les paramètres selon lesquels les patients doivent être évalués pour obtenir des enregistrements stables de la température cutanée paraspinale (TC).

Durant les travaux associés à mes études de doctorat, les buts poursuivis étaient de mesurer, en premier lieu, les effets à court terme du traitement chiropratique sur la TC, donc d'observer les changements obtenus via une manipulation avec la technologie mécanisée (Méthode Activator) et, par la suite, avec l'ajustement manuel (Diversified). Nous nous sommes ensuite concentrés sur l'effet à plus long terme du traitement chiropratique en utilisant seulement la méthode mécanisée pour les variables suivantes: la TC, la variabilité du rythme cardiaque (VRC) et les cytokines (Protéine réactive C (PRC) et l'interleukine-6 (IL-6)).

Les limites de cette thèse reposent notamment sur le peu de recherche publiée et disponible pour aider à investiguer en profondeur les mécanismes neurologiques et/ou physiologiques associés à mes recherches. À tout le moins, il en ressort qu'il faudra développer et établir un indice de température pour la température cutanée paraspinale. Une fois cet indice développé, il sera possible, dans l'avenir e futur, d'investiguer les mécanismes qui peuvent être associés aux changements de la TC.

Dans les pages qui suivent cet avant-propos vous trouverez les remerciements. Les autres sections qui suivent sont:

La liste des figures;

La liste des tableaux;

La liste des abréviations;

Le résumé.

L'introduction générale qui suit (Chapitre I) qui explique sommairement:

La chiropratique;

La différence entre la thermographie et la thermométrie;

L'effet des manipulations vertébrales;

Les problématiques;

Les implications théoriques;

La neuro-immuno-modulation.

Le Chapitre II est intitulé, recensement de la documentation. Ce chapitre inclut une section sur la chiropratique, le système immunitaire, les paramètres physiologiques des quatre projets soit:

La TC;

La VRC;

Les cytokines, plus spécifiquement la PRC et l'IL-6.

Suite à ce recensement de la documentation, nous trouvons le chapitre III intitulé La méthodologie. On y présente une explication des quatre projets. Les projets 1, 2 et 3 dans lesquels nous avons mesuré les effets à court terme de la manipulation vertébrale, tant mécanisée (Méthode Activator) que traditionnelle (Diversified) sur la TC ainsi que sur la VRC. La méthodologie du projet quatre présente l'explication sur la mesure des effets à plus long terme de la manipulation vertébrale mécanisée (Méthode Activator) sur la TC, la VRC et les cytokines. La présentation de nos différentes hypothèses conclut ce chapitre.

Il n'y a pas de chapitre sur la présentation de résultats. Les résultats ont tous été utilisés pour la préparation des différents manuscrits soumis ou publiés dans les revues évaluées par les pairs.

Les chapitres sur les différents manuscrits soumis ou publiés, soit les chapitre IV, V, VI, et VII, suivent alors l'ordre chronologique de l'exécution des projets.

Le tout se poursuit avec le chapitre VIII intitulé Discussion générale. Cette discussion rappelle l'essentiel des différentes discussions. La conclusion générale est incluse à la fin du chapitre VIII, suivie des références (Chapitre IX) et des annexes (Chapitre X).

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BF	Basse fréquence
FC	Fréquence cardiaque
H_0	Hypothèse nulle
H_1	Hypothèse alternative
HF	Haute fréquence
IL-6	Interleukine-6
IMC	Indice de masse corporelle
n.u.	Normalised units (unités normalisées)
PRC	Protéine réactive C
TBF	Très basse fréquence
TC	Température cutanée paraspinale
UQTR	Université du Québec à Trois-Rivières
VRC	Variabilité de la fréquence cardiaque

RÉSUMÉ

L'objet de cette thèse est l'évaluation de l'effet du traitement chiropratique sur des variables physiologiques. Il y a peu d'information sur l'effet du traitement chiropratique sur la température cutanée paraspinale. De plus, il y a peu d'information sur la technologie de thermométrie utilisée pour faire ces évaluations.

Plusieurs recherches ont été effectuées pour mesurer l'effet des traitements chiropratiques cervicaux et dorsaux sur la variabilité du rythme cardiaque, mais il n'y a aucune étude qui mesure les effets des traitements chiropratiques lombaires.

La littérature fournit peu de documentation sur l'effet des traitements chiropratiques sur les hormones pro-inflammatoires. Il n'y a aucune information sur l'effet des traitements chiropratiques sur l'interleukine-6 et la protéine réactive C.

Les hypothèses visaient à mesurer s'il y a des effets produits par des traitements chiropratiques sur les variables énumérées ci-haut: la température cutanée paraspinale; la variabilité du rythme cardiaque et les hormones pro-inflammatoires.

La méthodologie était progressive. Le premier projet évaluait l'effet du traitement chiropratique sur des sujets sans douleurs au cours d'un seul traitement. Le traitement chiropratique a été effectué avec un instrument (Activator IV). Deux périodes d'adaptation furent utilisées pour mesurer la réaction de la température cutanée paraspinale selon la période d'adaptation.

Le deuxième projet évaluait l'effet du traitement chiropratique de sujets en douleurs lors d'un seul traitement traditionnel et il n'y a eu qu'une seule période d'adaptation. La période d'adaptation a été choisie à partir du projet 1 et elle représentait la période d'adaptation qui semblait la mieux adaptée cliniquement. Le traitement a été effectué avec la main, selon la méthode Diversified. Ce projet nous a permis de mesurer les effets de l'ajustement chiropratique sur la TC de sujets en douleurs et de comparer ces résultats à ceux des sujets sans douleur du projet 1. De plus, il a été possible de mesurer le transfert de chaleur de la main du clinicien et de comparer ces mesures à l'effet de l'instrument utilisé dans le projet 1.

Pour le troisième projet, nous avons recruté des sujets avec douleurs et des sujets sans douleurs. Ce projet évaluait l'effet du traitement chiropratique sur la variabilité du rythme cardiaque. Les deux techniques chiropratiques des projets 1 et 2 ont été utilisées. Il y avait une période d'acclimatation de trois minutes et les mesures de la VRC ont été enregistrées pendant les cinq minutes qui suivaient ces trois minutes initiales. Le traitement chiropratique a été effectué et il y avait une autre période d'enregistrement de cinq minutes après le traitement chiropratique. Les mesures temporelles et spectrales ont été analysées.

Le quatrième projet évaluait l'effet du traitement chiropratique sur des sujets en douleurs chroniques pour une période de neuf traitements échelonnée sur deux semaines. Il y avait un groupe-témoin dont les sujets étaient sans douleurs. Nous avons mesuré pour chaque groupe l'indice de fonctionnalité de Oswestry (questionnaire sur la douleur et la fonctionnalité); la température cutanée paraspinale; la variabilité du rythme cardiaque et les hormones pro-inflammatoires, soit l'interleukine-6 et la protéine réactive C.

Les résultats du projet 1 ont démontré que l'ajustement chiropratique avec instrumentation avait un effet sur la température cutanée paraspinale. Toutefois, pour le projet 2, il y a une différence lors de l'évaluation de la mesure obtenue immédiatement après le traitement. Dans le projet 1, il y avait un refroidissement alors que dans le projet 2, il y avait un réchauffement. Le reste des enregistrements étaient très similaires.

Les résultats du projet 3 ont été mitigés et ont révélé que la variabilité du rythme cardiaque avait subi une certaine influence provenant d'une manipulation lombaire.

Les résultats du projet 4 étaient multiples. L'indice d'Oswestry a démontré que les valeurs du groupe-traitement avaient tendance à se rapprocher des valeurs du groupe-témoin. Pour ce qui est de la température cutanée paraspinale, celle du groupe-traitement était plus froide que celle du groupe-témoin avant le traitement. Après neuf traitements, les valeurs des variables du groupe-traitement avaient tendance à se rapprocher des valeurs des variables du groupe-témoin, les valeurs pré et post des variables du groupe témoin n'ayant pas

changé. Les données sur la variabilité du rythme cardiaque ont démontré que les valeurs du groupe-traitement avaient tendance à se rapprocher des valeurs du groupe-témoin. De même, les valeurs des données de l'IL-6 et de la PRC ont démontré la même tendance, à savoir se rapprocher des valeurs du groupe-témoin.

En conclusion, même s'il y avait des effets sur la température cutanée paraspinale, il est impossible en ce moment d'utiliser la technique de thermométrie en milieu clinique. En effet, comme il n'existe aucune base de données normative, il est impossible de conclure sur la valeur de l'effet de l'ajustement chiropratique. Quant à la variabilité du rythme cardiaque, il appert que l'effet serait un réflexe d'origine supraspinale plutôt qu'un effet direct sur le système nerveux autonome. Pour ce qui est des hormones pro-inflammatoires de l'IL-6 et de la PRC, il semble que ces mesures soient similaires aux tendances des valeurs de l'indice Oswestry à la suite d'un traitement chiropratique sur des sujets en douleurs.

Mots-clés : Thermométrie, chiropratique, diagnostoque, variabilité du rythme cardiaque, cytokines.

CHAPITRE I

INTRODUCTION

1.1 Introduction

Ce premier chapitre comprend une brève description de la chiropratique, suivie d'une explication de l'effet des manipulations vertébrales faites en chiropratique et d'une énonciation des différences entre la thermographie et la thermométrie. Suivront une explication des problématiques, des implications théoriques et la description de la neuro-immuno-modulation.

1.1.1 La chiropratique

Dans le monde des médecines alternatives, la chiropratique est un système de santé utilisé par 6 à 12 % de la population selon les régions (Lawrence et Meeker, 2007). La chiropratique soigne des problèmes de santé d'ordre neuromusculosquelettique par l'utilisation des manipulations de la colonne vertébrale. Au Québec, l'enseignement de la chiropratique se fait à l'Université du Québec à Trois-Rivières (UQTR). Le programme est un doctorat professionnel de premier cycle, comme en médecine et en dentisterie. Ce programme s'échelonne sur une période de cinq ans.

Contrairement au milieu hospitalier (où les ressources financières et matérielles sont plus abondantes), le milieu clinique chiropratique dispose de peu d'outils diagnostics, outre la radiographie. Les ressources ne sont pas les mêmes qu'en milieu hospitalier. De plus, les coûts pour les soins et l'utilisation d'outils diagnostics doivent être assumés par les patients, ce qui limite la possibilité d'avoir recours à de nombreux outils. Il importe donc de déterminer si la technologie de thermométrie, qui est peu coûteuse, non-invasive et non-ionisante, est viable cliniquement.

1.1.1.1 Les effets des manipulations vertébrales

Les manipulations vertébrales existent depuis 2700 BC en Asie (Dintefass, 1970). Par la suite, la littérature montre que l'utilisation de cette thérapie s'est faite au Tibet, en Babylonie et en Amérique Centrale (Goldstein 1975, Leach 1986)

Les manipulations vertébrales sont effectuées sur les articulations du rachis. Les articulations du rachis qui sont blessées sont aussi connues sous les appellations suivantes (selon les différentes professions de la santé qui utilisent cette forme de thérapie): dysfonction articulaire vertébrale, subluxation chiropratique, complexe de la subluxation vertébrale, articulation bloquée ou fixation (Fryer, Morris et Gibbons, 2004a; Fryer, Morris et Gibbons, 2004b; Vernon et Mzorek, 2005,). Le terme dysfonction articulaire vertébrale sera employé dans cet ouvrage. Toutefois, il existe une absence de consensus sur la définition de la dysfonction articulaire vertébrale.

Dans le passé, plusieurs affirmations décrivant l'effet d'une manipulation vertébrale sur le système nerveux autonome ont été faites dans le monde de la chiropratique et de l'ostéopathie (Korr, 1975; Leach, 1986).

Les effets attendus sont des effets normalisateurs. Par exemple, si une hyperactivité sympathique est présente, on s'attend à pouvoir réduire cette hyperactivité par des manipulations dorsales. Toutefois, malgré les évidences cliniques recueillies, il n'y a pas eu d'études en laboratoire démontrant l'effet de la manipulation vertébrale sur la température cutanée (TC), ni d'études sur l'effet des manipulations vertébrales lombaires sur la variabilité du rythme cardiaque (VRC). La VRC est un indice du niveau de plasticité du système nerveux autonome (Task Force 1996a, Task Force 1996b).

Il est important de mentionner l'absence de recherche sur les manipulations vertébrales lombaires et les effets possibles sur la VRC. En chiropratique, il existe des techniques de manipulation qui se concentrent seulement sur la région lombaire ou seulement sur la région cervicale. De ce fait, il est important de savoir si les effets des manipulations lombaires sont similaires aux effets des manipulations cervicales et dorsales sur la VRC. Cela servira à corriger certaines croyances qui suggèrent que toutes les techniques de manipulation ont des effets similaires sur le système végétatif.

Cette étude propose de mesurer les effets à court terme du traitement chiropratique sur la TC et la VRC. Deux traitements chiropratiques seront utilisés: (1) une force mécanique assistée manuellement (Méthode Activator) et (2) la manipulation vertébrale chiropratique traditionnelle (« lumbar roll ») de la méthode Diversified. La dernière étude, à plus long terme, propose de mesurer les effets du traitement chiropratique effectué par une force mécanique assistée manuellement (Méthode Activator) sur la TC, la VRC et les cytokines (IL-6 et PRC) (Figure 1.1). Graphiquement, cela donne la représentation suivante:

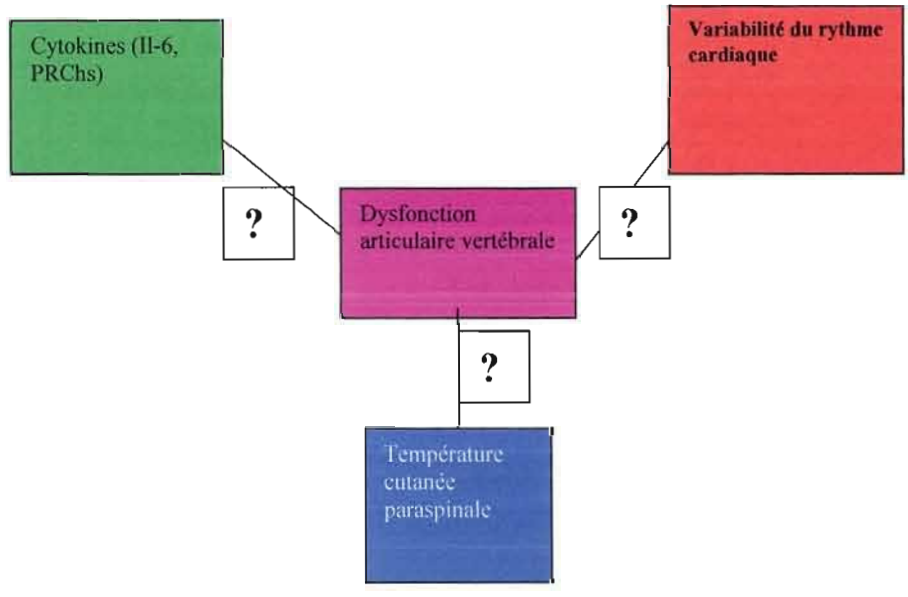

Figure 1.1 Représentation graphique des questions (hypothèses) sur les interactions physiologiques et fonctionnelles en relation avec les dysfonctions articulaires spinales.

1.1.2 La différence entre la thermographie et la thermométrie

La thermographie est une technologie non invasive servant à l'évaluation globale non segmentaire de la TC par caméras infrarouges. Cette technologie a vu le jour durant les années 1980 (Uematsu et al., 1988a, Uematsu et al., 1998b). Le système préconisé par Uematsu et al. (Uematsu et al., 1988a, Uematsu et al., 1998b) est basé sur la thermographie avec plaques photographiques refroidies. Les radiations infrarouges émises par la peau sont des rayonnements qui dépendent de la température. La thermographie est utilisée en évaluation d'angiogénèse afin d'aider à détecter la présence possible d'un cancer du sein ou pour l'étude du syndrome douloureux complexe, mais cela n'est possible pour la thermométrie.

La thermométrie est aussi une technologie non invasive. La thermométrie utilise également un système de caméras infrarouges, mais les données sont enregistrées sans imagerie. Cette technologie, couramment utilisée en milieu clinique chiropratique, ne présente aucune similitude avec la thermographie avec plaques photographiques.

La thermométrie diffère donc de la thermographie par la méthode d'enregistrement des données.

Les données de la thermographie sont représentées par une série de clichés ou photographies qui illustrent la température cutanée selon les différentes pentes thermiques (fig. 1.2). Les pentes thermiques de température sont illustrées à l'aide de différents gradients de couleurs. La couleur bleue représente une région plus froide, le réchauffement progressif passe du vert au jaune et le rouge est la région plus chaude.

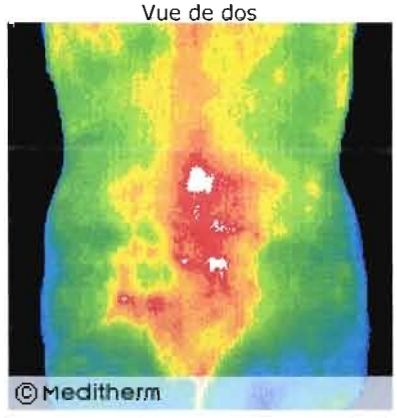

Figure 1.2 Une représentation thermographique d'une patiente qui a des douleurs avec une implication des racines nerveuses de l-2 et l-3, tant au niveau sensoriel que moteur. (Tirée du site web de la compagnie Meditherm, (Fort Myers, FLA, USA))

La thermométrie utilise des caméras avec détecteurs infrarouges. Les données sont recueillies et enregistrées directement dans l'ordinateur comme une représentation d'un thermomètre électronique. Ces données sont ensuite reproduites sous forme de graphiques (fig. 1.3). Les couleurs attribuées en thermométrie sont arbitraires. La pente thermique illustre le différentiel entre le côté gauche et le côté droit, et passe progressivement du vert (faible différentiel de la pente thermique), au jaune, au rose et au rouge (grand différentiel de la pente thermique) (Fig.1.3).

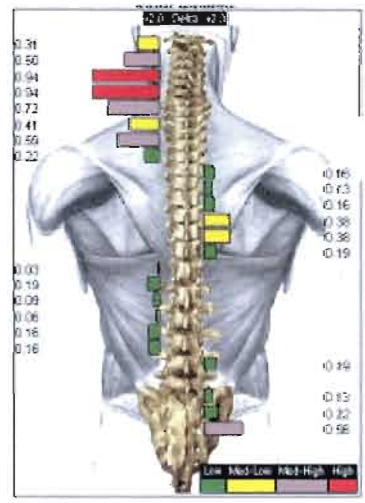

Figure 1.3 Une représentation thermométrique d'une patiente. (Tirée du site web de la compagnie Precision Biometrics, (Seattle, Washington, USA))

Avant 2006, il n'y avait aucune documentation sur la validité et la fiabilité de l'utilisation d'appareils de thermométrie. De plus, il n'y avait aucune documentation sur les périodes temporelles d'adaptation requises pour l'évaluation adéquate de la TC. En 2006, une première étude de la validité de l'utilisation de la caméra infrarouge a été publiée (Roy, Boucher et Comtois, 2006a). Une étude subséquente concernant la période d'adaptation adéquate pour obtenir une stabilisation pré-enregistrement de la TC, afin d'effectuer la prise de données adéquate de la TC, fut également publiée (Roy, Boucher et Comtois, 2006b). Il n'y a pas de documentation additionnelle ni de données normatives sur lesquelles les présentes études sur la thermométrie pouvaient se baser puisque les recherches sur cette technologie sont au niveau embryonnaire.

Somme toute, voici un commentaire de Budgell (2005) sur la recherche en chiropratique qui reflète bien la philosophie de la présente étude:

« [...] Nous devons sortir de notre mentalité archaïque et commencer à se demander comment et pourquoi la thérapie chiropratique fonctionne et quand elle fonctionne [...] De plus, la réputation de la

chiropratique serait-elle endommagée si on se posait des questions honnêtes sur ce que l'on ne connaît pas plutôt que d'essayer de prouver ce que nous pensons que nous connaissons. »

1.1.3 Problématiques

Depuis le début du 20^{e} siècle, la thermographie a connu un essor important. Les premiers travaux réalisés par le groupe de Uematsu et al. (1988a, 1988b) ont démontré un gradient de la TC au niveau du rachis à partir de la région cervicale jusqu'à la région lombaire. L'intérêt de la thermographie est son utilité à comparer la TC du rachis de façon bilatérale et régionale (L5-S1) (Frize, Herry et Roberge, 2003). Cet intérêt est similaire pour la thermométrie (Roy, Boucher et Comtois, 2006a; Roy, Boucher et Comtois, 2006b), mais son utilité est bilatérale et plutôt segmentaire, évaluant chaque segment individuellement. La première problématique est donc le manque de recherche et d'information sur la thermométrie.

Il a été proposé (Korr, 1975; Budgell et Sato, 1996; Budgell et Sato, 1997) que des modifications de la TC puissent être associées à un processus inflammatoire neurologique vertébral segmentaire et que ce dernier puisse être unilatéral ou bilatéral. Ces observations sont en lien avec les récents travaux de Budgell (communication personnelle, 2005) qui démontrent une augmentation de la circulation sanguine de la moelle épinière lors d'une stimulation somatique de nature nocive (Watanabe, Budgell et Kurosawa, 2005). Ainsi, la deuxième problématique est l'absence de corrélation entre le processus inflammatoire et les manipulations vertébrales.

Les mécanismes neurophysiologiques et neuro-anatomiques des systèmes végétatifs et sensitifs sont connus (Cramer et Darby, 1995). Les mécanismes de régulation du système neurovégétatif reliés à des manipulations vertébrales sont peu connus et souvent spéculatifs (Leach, 1986). Les mécanismes de soulagement des processus inflammatoires suite à des manipulations sont encore moins connus. Est-ce que les manipulations des dysfonctions articulaires vertébrales produisent un effet sur le système végétatif (Driscoll et Hall, 2000)?

Pickar (2002) résume le mieux la situation actuelle de la chiropratique:

> « [...] Malgré les évidences cliniques bénéfiques et la grande utilisation de la thérapie manuelle, les mécanismes biologiques sous-jacents aux effets des manipulations vertébrales sont encore inconnus. »

La troisième problématique est aussi un manque d'information sur l'effet des manipulations vertébrales lombaires sur la VRC et les mécanismes associés de régulation du système neurovégétatif. Pourquoi la VRC? Parce que la VRC peut être considérée comme une manifestation de l'activité du système nerveux autonome.

Plus récemment, une étude sur l'effet d'un traitement chiropratique sur la production in vitro de cytokines inflammatoires en relation avec la production in vivo du neurotransmetteur P, suite à un traitement chiropratique (Teodorczyk-Injeyan, Injeyan et Ruegg, 2006), a démontré qu'un ajustement chiropratique produit

une atténuation de la production des polysaccharides reliés aux cytokines inflammatoires. Les mécanismes demeurent toutefois inconnus. Qu'en est-il de la PRC et de l'IL-6? La quatrième problématique est le manque d'information sur l'effet des manipulations lombaires sur la PRC et l'IL-6.

Soumettre ces différents paramètres à une évaluation nous permettra de mesurer la présence ou l'absence d'effets de la manipulation d'une dysfonction articulaire vertébrale sur ces paramètres.

1.1.4 Implications théoriques

Plusieurs mécanismes peuvent agir pour moduler la TC. L'intérêt de la présente étude s'applique à la dysfonction articulaire vertébrale et à l'effet de la correction de la dysfonction articulaire vertébrale sur la TC, la VRC et les cytokines PRC et IL-6. La présence de la dysfonction articulaire vertébrale crée une hypoxie locale transitoire qui peut dégénérer en un processus inflammatoire (Jialal, Devaraj et Venugopal, 2004). Le processus inflammatoire qui accompagne l'hypoxie locale est aussi associé à la libération de la PRC qui est un indicateur global d'une évolution inflammatoire (Colloca et Keller, 2001; Ridker 2003; Lin et al., 2004; Tuzcu et al., 2005).

L'IL-6 est un précurseur de la PRC Une des questions soulevées est la suivante: est-ce que la PRC et l'IL-6, qui sont des indicateurs réflexes d'un processus inflammatoire cardiovasculaires, peuvent être associées à la dysfonction articulaire vertébrale? La littérature montre que ces biomarqueurs sont couramment utilisés afin d'évaluer la réponse inflammatoire associée à différents types d'agression tissulaire (Colloca et Keller, 2001; Lin et al., 2004; Jialal, Devaraj et Venugopal, 2004; Tuzcu et al., 2005); par exemple, des entraînements exigeants ou constants et des courses de marathons (Hoffman-Goetz, 1996; Javesghani et al., 2003), ou encore l'intensité des exercices pratiqués (Pedersen, 1997) Il importe donc de se questionner sur l'effet de la présence d'une ou de plusieurs dysfonctions articulaires vertébrales.

La VRC est un indice du niveau de plasticité du système nerveux autonome (Task Force 1996a, Task Force 1996b). Il a été démontré qu'une perte importante de la VRC due au vieillissement est réversible en effectuant de simples exercices respiratoires (Wood, Hondzinski et Lee, 2003). Les conséquences d'une perte de la VRC sont aussi associées à une morbidité accrue de complication cardiovasculaire. Des épiphénomènes permettent de relier des indicateurs biologiques à l'identification d'une problématique sous-jacente, ce qui mène à la question suivante: le traitement par manipulation vertébrale lombaire affecte-t-il la VRC ou les indicateurs biologiques comme l'IL-6 et la PRC?

À l'intérieur de cette thèse de doctorat, les objectifs spécifiques seront de:

a. Mesurer l'effet à court terme d'un ajustement chiropratique lombaire par la méthode Activator et d'un ajustement chiropratique lombaire par la méthode Diversified tout en enregistrant la présence ou l'absence d'une modification de la TC. Ceci nous permettra d'évaluer l'effet du contact sur la peau des sujets. Car l'appareil Activator est à la température de la pièce alors que la main du clinicien traitant est plus chaude que la température de la pièce.

b. Mesurer l'effet à court terme d'un ajustement chiropratique lombaire par la méthode Activator et d'un ajustement chiropratique lombaire par la méthode Diversified, tout en enregistrant la présence ou l'absence d'une modification de la VRC.

c. Mesurer l'effet à plus long terme de neufs traitements chiropratiques lombaires par la méthode Activator et enregistrer la présence ou l'absence d'une modification de la TC, de la VRC, de la PRC et de l'IL-6.

Ces objectifs permettront de développer une connaissance de base sur la corrélation variable/traitement.

Les résultats obtenus permettront alors de concevoir des expériences complémentaires pour évaluer les questions que soulèveront les résultats de la présente recherche.

1.1.5 Neuro-immuno-modulation

La neuro-immuno-modulation est une nouvelle science. Elle est la résultante de l'interaction et du regroupement de différentes composantes. Ces composantes sont un ensemble de recherches composées d'études moléculaires et cellulaires sur les facteurs chimiques, d'études cliniques descriptives et d'études sur les réponses systémiques (Silverthorn, 2004). La neuro-immuno-modulation est encore à ses débuts (Silverthorn, 2004).

Budgell (1999, 2000) mentionne que:

> « [...] Même s'il y a plusieurs études qui semblent démontrer une corrélation somato-viscérale associée à la dysfonction articulaire vertébrale; il doit dans un futur rapproché y avoir des études additionnelles sur la physiologie de base et les phénomènes cliniques associés pour pouvoir construire une explication robuste pour expliquer les observations prometteuses en thérapie par manipulation. »

Symons et al. (2000) concluent que des recherches complémentaires sur l'effet des manipulations vertébrales sont requises pour élucider les mécanismes de fonctionnement de ces manipulations vertébrales. Leboeuf-Yde et al. (1995), du Danemark, ont démontré qu'environ une personne sur quatre (23%) ressent des bénéfices non musculosquelettiques après les manipulations vertébrales; ces effets ne sont notés que de façon subjective. Nansel et Szlazak (1995) discutent des différentes théories mises de l'avant pour expliquer les mécanismes possibles du soulagement des patients avec troubles viscéraux, qui répondent positivement aux manipulations vertébrales. Après une révision de 350 articles répertoriés pendant les 75 dernières années, ils concluent qu'à ce jour, il n'y a pas d'étude qui confirme la manipulation de la dysfonction articulaire vertébrale comme stratégie thérapeutique valide. Les connaissances scientifiques actuelles ne soutiennent pas l'existence plausible des mécanismes biologiques associés à la manipulation de la dysfonction articulaire vertébrale.

Le traitement par manipulation peut, possiblement, apporter une augmentation de la réponse immunitaire chez l'humain (Vora et Bates, 1980; Teodorczyk-Injeyan, Injeyan et Ruegg, 2006; Teodorczyk-Injeyan, 2008) tout comme chez l'animal (Sato et Swenson, 1984) sans que les auteurs en comprennent les mécanismes.

Les projets de cette thèse visent à mesurer les interactions possibles entre la manipulation vertébrale lombaire et les différentes variables énumérées précédemment. Les études réalisées sont considérées comme étant représentatives de l'ensemble du domaine de la neuro-immuno-modulation.

1.1.6 Résumé

Quatre problématiques distinctes sont donc soulevées dans la présente thèse de doctorat. La première problématique est le manque d'information sur la technologie associée à la thermométrie. Les trois autres problématiques concernent l'absence d'information sur l'effet de la manipulation vertébrale lombaire en relation avec quatre variables différentes: la TC, la VRC, l'IL-6 et la PRC.

CHAPITRE II

RECENSEMENT DE LA DOCUMENTATION ET HYPOTHÈSES

2.1 La chiropratique

La chiropratique naquit en 1895. Daniel D. Palmer traita un patient par manipulation vertébrale et celui-ci fut guéri de sa surdité (Haldeman 2005). Ce premier ajustement chiropratique du rachis fut effectué alors que le patient se plaignait d'abord et avant tout d'un torticolis.

Les manipulations vertébrales tirent leurs origines de l'antiquité (Haldeman 2000, 2005). Les premiers à manipuler les articulations vertébrales (*bonesetters)* furent appelés des algébristes, provenant du nom arabe Al-Jabr (père de ce qui devint l'algèbre) qui signifie restaurer ou reconstruire les fonctions articulaires normales (Livio 2005).

Les présentations symptomatiques des patients souffrant de douleurs au bas du dos ne sont pas seulement dues à un mauvais effort ou à un traumatisme, mais cette symptomatologie apparaît à la suite de multiples facteurs. Ces facteurs sont entre autres des spasmes, une posture inadéquate, de faux mouvements, des déséquilibres mécaniques, des douleurs viscérales avec douleurs projetées, etc. Ces différents facteurs entraînent une diminution fonctionnelle des articulations résultant en une réduction de l'habileté du corps à bien gérer les stress quotidiens (Slosberg 2003).

Il y a eu plusieurs recherches, tant chez l'animal que l'humain, pour mesurer l'effet de la stimulation mécanique (Breig, Turnbull et Hassler 1966; Korr, 1975; Habler, Janig et Koltzenburg, 1990; Budgell et Sato, 1996; Budgell et Hirano, 2001; Sato, Sato et Schmidt, 1997; Pickar et Wheeler, 2001; Pickard 2002; Dishman, Greco et Burke, 2008), l'effet du traitement chiropratique traditionnel (Hessel et al., 1990; Kawchuk, Herzog et Hassler, 1992; Kawchuk et al., 2006; Triano et Schultz, 1994; Budgell et Sato, 1997; Teodorczyk-Injeyan, Injeyan et Rugg, 2006; Teodorczyk-Injeyan et al., 2008; Driscoll et Hall, 2000; Symons et al., 2000; Wood, Colloca et Matthews, 2001; Herzog, Kats et Symons, 2001; Cascioli, Corr et Till, 2003; Cleland et al., 2005; Hawk et al., 2005; Dimmick, Young et Newell, 2006; Martinez-Segura et al., 2006; Haavik-Taylor et Murphy, 2007; McNair et al., 2007; Snodgrass, Rivett et Robertson, 2007) et l'effet du traitement chiropratique à force mécanisée assistée manuellement (dans ce cas-ci la méthode Activator) (Shambaugh, Sclafani et Fanselow, 1988; Keller, Colloca et Fuhr, 1999; Nguyen et al., 1999; Driscoll et DiCicco, 2000; Wood, Colloca et Matthews, 2001; Colloca et Keller, 2001; Colloca, Keller et Gunzburg 2003; Zhang et Snyder, 2005; Kawchuk et al., 2006; Song et al., 2006).

D'autres études évaluèrent spécifiquement l'effet de stimulations mécaniques sur les hormones pro et anti-inflammatoires (Teodorczyk-Injeyan, Injeyan et Rugg, 2006; Teodorczyk-Injeyan et al., 2008), la variabilité du rythme cardiaque (Sato, Sato et Schmidt, 1981; Sato, Sato et Schmidt, 1984; Driscoll et Hall, 2000; Driscoll et DiCicco, 2000; Fegera et Braune, 2005), la circulation sanguine (Fegera et Braune, 2005; Watanabe, Budgell et Kurosawa, 2005), l'amélioration de symptômes non musculosquelettiques (Leboeuf-Yde et al., 1999), le syndrome prémenstruel (Walsh et Polus, 1999) et les maux de tête (Turk et Ratkolb, 1987). Des études récentes

démontrent que l'effet de la manipulation vertébrale sur le corps humain affecte les mécanorécepteurs de la peau et les articulations sous-jacentes (Colloca et Keller, 2001; Colloca, Keller et Gunzburg 2003).

2.1.1 L'ajustement chiropratique

Selon l'association chiropratique canadienne:

> « L'ajustement chiropratique, ou manipulation, est une thérapie manuelle qui exige des compétences acquises dans le cadre d'une formation intensive de quatre ans en chiropratique. De façon générale, les chiropraticiens utilisent leurs mains pour manipuler les articulations, en particulier celles de la colonne vertébrale, afin d'atténuer la douleur et de rétablir ou d'améliorer le fonctionnement de l'articulation. La manipulation chiropratique est un traitement précis et mesuré, adapté aux besoins particuliers de chacun des patients et qui provoque rarement de malaise. En fait, les patients ressentent souvent un soulagement de leurs symptômes dès la fin de la séance de traitement » (Canadian Chiropractic Association, 2008).

Selon l'ordre des chiropraticiens du Québec, le principe général de la science chiropratique s'énonce dans les termes suivants:

> • « La chiropratique repose sur le principe selon lequel le rapport existant entre le système nerveux et les autres systèmes du corps humain exerce une influence capitale sur la santé en général.
>
> • Il appert, en effet, que la relation entre le système nerveux et les autres systèmes du corps humain influence les fonctions de l'organisme, puisque la transmission et l'expression normales de l'énergie nerveuse sont essentielles au recouvrement et au maintien de la santé. » (Ordre des chiropraticiens, 2008).

Il existe plusieurs approches thérapeutiques en chiropratique. Pour ce projet de thèse, deux techniques seront utilisées. D'abord, la méthode traditionnelle avec la main. Celle-ci est l'application du traitement usuellement appelé « lumbar roll » par la technique *Diversified* (Esposito et Philipson, 2005). La deuxième méthode, par instrumentation, utilise un appareil mécanisé qui produit une force et une vitesse contrôlées (Haldeman, 2005). À l'intérieur de nos projets, nous utiliserons les protocoles d'évaluation de la méthode Activator et en parallèle avec la méthode traditionnelle pour le projet 3.

La technique Diversified est la plus utilisée dans la profession chiropratique. Cette technique est enseignée dans toutes les institutions d'enseignement chiropratique (Fig. 2.1). La force manuelle appliquée varie habituellement entre 157.41 N ± 24.62 N à 253.65 N ± 37.74 N pour la région lombaire, pour une durée variant de 66.92 ± 5.15 à 99.88 ± 13.89 millisecondes (Kawchuk et al., 2006). L'expérience est un facteur important dans l'application adéquate de la méthode traditionnelle (Herzog et al., 1993; Herzog, Kats et Symons, 2001; Kawchuk et al., 2006). Toutefois, cela l'est moins pour la méthode par instrumentation (Herzog et al., 1993; Herzog, Kats et Symons, 2001; Kawchuk et al., 2006). Donc, au cours des projets associés à la méthode traditionnelle, un chiropraticien ayant une expérience clinique de dix ans dans l'utilisation de la méthode traditionnelle effectuera le traitement.

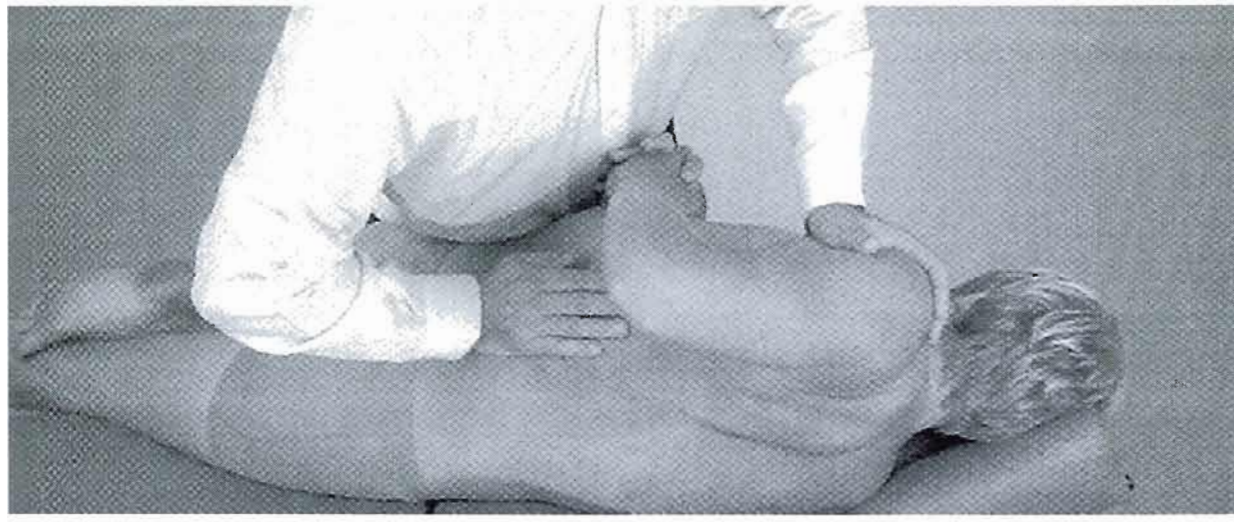

Figure 2.1 Photo démontrant la position de la technique Diversified pour une manipulation lombaire à L-5. Photo reproduite avec la permission de l'auteur (Esposito et Philipson, 2005, p: 233)

La méthode Activator fut développée en 1967 par les Docteurs Lee et Fuhr du Minnesota (Fuhr, 1983; Fuhr et al., 1997). Cette technique est maintenant une alternative aux techniques traditionnelles et elle est la deuxième technique la plus utilisée en chiropratique. De plus, elle est enseignée dans la plupart des institutions chiropratiques en Amérique du Nord et du Sud, en Australie, en Espagne, en France, au Royaume-Uni et au Japon (National Board of Chiropractic examiners, 1994).

Ainsi, l'appareil qui sera utilisé dans le cadre de ce projet de doctorat est *l'Activator IV* (Fig. 2.2). La force de l'impulsion n'est pas contrôlée par le chiropraticien. Celui-ci contrôle le vecteur et le moment du déclenchement de l'impulsion. La force de l'impulsion est inhérente à l'appareil et la variabilité est calibrée selon les différents niveaux choisis sur l'appareil Activator IV. Ces niveaux sont représentés par les chiffres 1, 2, 3 et 4 et sont respectivement associés à des forces de 76 N, 83 N, 93 N et 176 N. Le temps d'exécution d'une impulsion est identique pour chaque niveau et varie de 1.09 ± 0.08 à 1.32 ± 0.09 millisecondes pour chaque niveau de force (Fuhr et al., 1997; Kawchuk et al., 2006). Le niveau quatre sera celui utilisé pour les différents projets si l'on utilise l'appareil Activator IV.

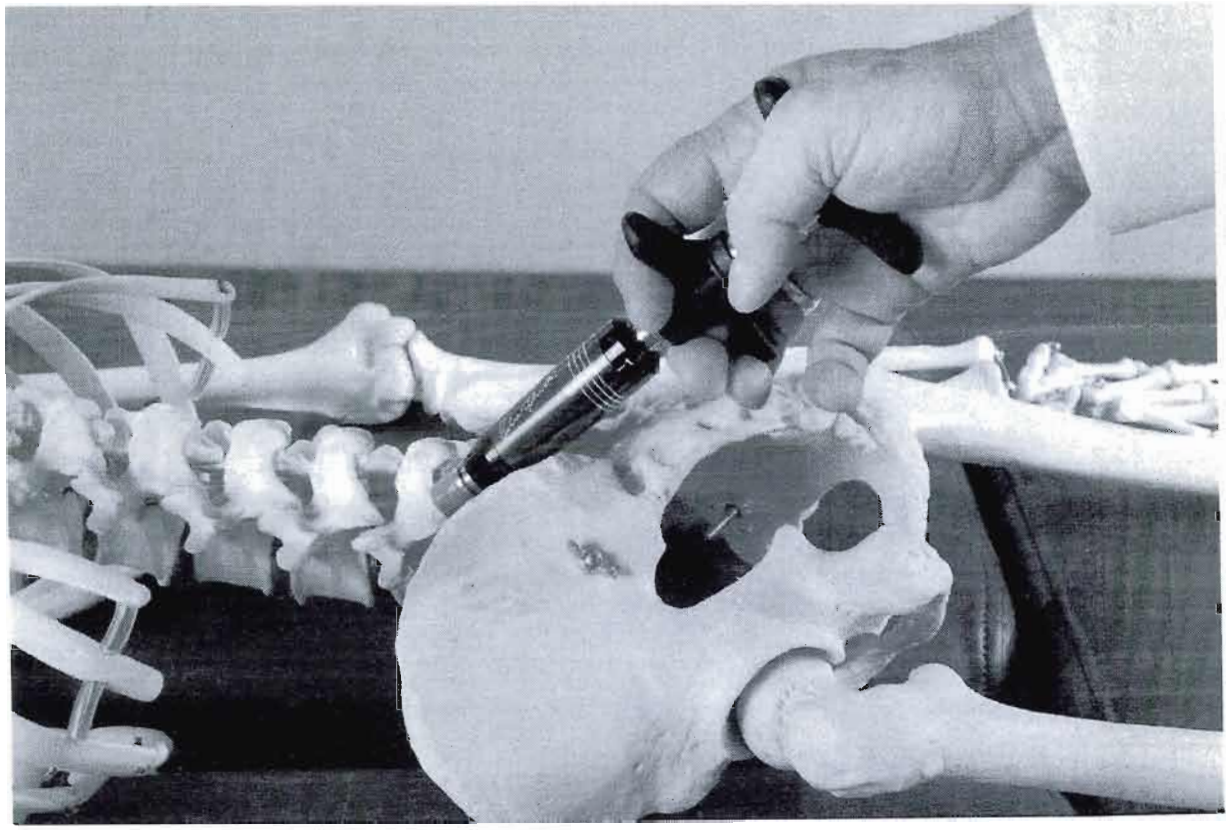

Figure 7-24 Adjustment for fifth lumbar Line of Drive is anterior-superior

Figure 2.2 Photo démontrant la position de la technique Activator pour une manipulation lombaire de L-5. Photo reproduite avec la permission de l'auteur (Fuhr et Fischer, 2009; page 160).

Ces deux techniques, Activator et Diversified, seront donc utilisées respectivement dans les projets 1et 2 et les deux techniques seront utilisées pour le projet 3.

Selon Bolton et Budgell (2006), les manipulations vertébrales peuvent stimuler les récepteurs de la musculature centrale. Gillette (1987) écrit que l'ajustement chiropratique produit une force mesurée à plus de 100 N. Cette force est suffisante pour activer une grande variété de récepteurs mécaniques (36N). ligaments spinaux (26N), muscles paraspinaux (20N). Il y a donc des mécanorécepteurs qui sont activés durant par la manipulation vertébrale, soit: les signaux provenant des mécanorécepteurs A-alpha-beta-delta et des propriocepteurs. Il y a aussi ceux qui produisent un signal après la manipulation vertébrale, soit les mécanorécepteurs A-delta et les récepteurs nocicepteurs polymodaux C. Dishman, Greco et Burke (2008) ont démontré que les manipulations vertébrales

produisent une facilitation post-synaptique des motoneurones α et/ou des cortico-motoneurones qui innervent les muscles paraspinaux.

Selon Fuhr et Fischer (2009), la vitesse d'exécution de l'impulsion et la force générée par l'appareil *Activator IV*, plus spécifiquement au niveau 4 pour l'ajustement des lombaires, sont suffisantes pour créer un mouvement dans les articulations du rachis lombaire. Cela fut démontré par Colocca, Keller et Gunzburg (2003) et Kawchuk et al. (2006). L'utilisation de l'appareil d'ajustement *Activator* permet une réduction de la douleur et de l'hyperalgésie chez le rat (Song et al., 2006). Nous nous attendons à des résultats similaires chez l'humain pour le projet quatre.

2.1.2 Effets physiologiques des stimulations somatiques

Chez le modèle animal, les travaux les plus longs et les plus élaborés furent ceux de Sato, Sato et Schmidt (1997).

Au début des années 1960, Sato, Sato et Schmidt (1997) ont élaboré une ligne de recherche pour approfondir les connaissances des voies neurologiques spinales et supraspinales des réflexes somato-sympathiques. Les résultats de leurs travaux nous permettent de continuer l'exploration chez l'humain afin de mieux comprendre l'effet de la manipulation vertébrale.

2.1.2.1 Système somato-sensoriel

Le système somato-sensoriel perçoit ses informations en trois étapes, soit:

1- Un stimulus physique;
2- Une série d'évènements qui transforment ce stimulus en impulsions neurologiques;
3- La réponse à ce signal, sous la forme de perception ou d'une expérience consciente de la sensation.

Par la suite, le système somato-sensoriel produit quatre types d'informations lorsqu'il est stimulé. Ces informations sont:

1- La modalité: c'est-à-dire quels sont les sens et les récepteurs associés qui sont stimulés;
2- La localisation: l'étendue de la stimulation sur les champs récepteurs;
3- L'intensité: représentée par la dépolarisation qui est proportionnelle à l'amplitude du stimulus;
4- Durée du stimulus: représentée par le début et la fin de la réponse des récepteurs stimulés.

Dans le système somato-sensoriel humain, quatre sens somatiques, aussi appelés modalités, sont présents:

1- Le toucher;
2- La proprioception;
3- La douleur;
4- La température.

Les mécanorécepteurs du système somato-sensoriel modulent le sens du toucher, les sensations de proprioception musculaires (contraction ou étirement) et le sens du positionnement articulaire. De plus, les informations des mécanorécepteurs et des propriocepteurs passent par le corps cellulaire d'un neurone sensitif et ces derniers produisent des potentiels d'action rapide. Les nocicepteurs mécaniques, thermiques et polymodaux modulent le sens de la douleur. Les récepteurs thermiques modulent le sens de la température. Les nocicepteurs et les récepteurs thermiques produisent des potentiels d'action lente.

Dans le corps humain, les récepteurs du système somato-sensoriel se retrouvent selon l'ordre de profondeur suivant: les récepteurs cutanés et sous-cutanés, ceux des muscles squelettiques et des tendons ainsi que les récepteurs articulaires (Silbernagl et Despopoulos, 2001; Sato, Sato et Schmidt, 1997).

2.1.2.1.1 Les récepteurs sensoriels cutanés et sous-cutanés

Il y a deux catégories de récepteurs sensoriels cutanés et sous-cutanés qui concernent la présente thèse, soit les mécanorécepteurs et les thermorécepteurs.

Les récepteurs associés au toucher sont des mécanorécepteurs cutanés. Ils sont représentés par les corpuscules de Meissner, les cellules de Merkel, les corpuscules de Pacini et les terminaisons de Ruffini. Les corpuscules de Meissner et les cellules de Merkel ont de petits champs récepteurs et sont aussi plus sensibles à une pression appliquée par un petit objet. Les corpuscules de Meissner et de Pacini s'adaptent rapidement à un stimulus constant alors que les cellules de Merkel et les terminaisons de Ruffini s'adaptent lentement à un stimulus constant (Sato, Sato et Schmidt, 1997). Chacun de ces mécanorécepteurs peut être influencé par les deux types de manipulation vertébrale.

Les thermorécepteurs cutanés sont des récepteurs de la perception du chaud ou du froid. Ces récepteurs cutanés ne sont pas affectés par un stimulus mécanique à l'intérieur d'une certaine limite d'intensité. Dans le contexte de cette thèse, les récepteurs thermiques pour le chaud et le froid ne sont étudiés que pour le projet 2, lorsqu'il y aura contact de la main du clinicien lors de l'application de la manipulation traditionnelle.

2.1.2.1.2 Les récepteurs sensoriels musculaires et tendineux et les récepteurs des tissus articulaires

Les récepteurs associés à la proprioception sont des mécanorécepteurs musculaires et articulaires. Il existe trois types de mécanorécepteurs dans les muscles et les articulations. Il y a les mécanorécepteurs qui signalent la position stationnaire; ceux qui signalent la vitesse et ceux qui signalent la direction de l'articulation qu'ils innervent. Ces trois types de mécanorécepteurs se nomment respectivement les récepteurs du fuseau neuromusculaire, les organes tendineux de Golgi et les récepteurs des capsules articulaires. De plus, les cellules de Merkel et les terminaisons de Ruffini transmettent l'information posturale (Sato, Sato et Schmidt, 1997). Tous ces récepteurs sont affectés par les dysfonctions articulaires retrouvées sur les radiographies en dynamique de stress des sujets du projet 4. De plus, les dysfonctions articulaires des sujets sains (projet 1-3) et en douleurs (projet 2-3) sont aussi des stress mécaniques qui affectent la proprioception. Ces trois types de mécanorécepteurs peuvent être influencés par les différents types d'ajustements chiropratiques.

L'activation des afférents mentionnée ci haut, soit le Corpuscule de Pacini, les corpuscules de Meissner, les disques de Merkel et les organes de Ruffini, peuvent affecter le système nerveux autonome sympathique et possiblement affecté la VRC (Sato, Sato et Schmidt, 1997).

Les récepteurs articulaires sont des afférents qui réagissent à des stimulations mécaniques. Ils sont stimulés par des changements de direction plutôt que par des pressions mécaniques nocives. Ces récepteurs ont une fonction proprioceptive et ne sont probablement pas impliqués dans la douleur ou la nociception articulaire (Sato, Sato et Schmidt, 1997), mais peuvent être influencés par les différents types d'ajustements chiropratiques.

En conclusion, les récepteurs sensoriels cutanés et sous-cutanés, ainsi que les récepteurs musculaires, tendineux et articulaires, sont ceux qui semblent les plus impliqués en regard de la présente thèse de doctorat.

2.2 Le système immunitaire

2.2.1 L'inflammation

En chiropratique, lorsque l'on parle d'une inflammation causée par le dysfonction articulaire vertébrale, on mentionne souvent les signes accompagnateurs suivants: rougeur, enflure, chaleur, douleur et perte de fonction (Scott et al., 2004). C'est Celsus (Scott et al., 2004) qui établit les quatre premiers paramètres et Galen (Scott et al., 2004) qui y ajouta la perte de fonctionnalité. Par la suite, Metchnikoff en 1908, parla de la défense cellulaire envers les agents pathogènes (Scott et al., 2004) pour faire suite à Lewis en 1927, qui parla de la triple réponse, caractérisée par la circulation contrôlée par la chimie et la neurologie du corps (Scott et al., 2004).

L'inflammation est un phénomène complexe. Ce phénomène provient d'une série de changements cellulaires et métaboliques qui peuvent produire des résidus organiques et des cicatrices dans les tissus (Diakides, 2008). Voici la chaîne des événements du processus inflammatoire (Diakides et Bronzino, 2008):

Il existe 2 phases:

Phase vasculaire: Vasodilatation et augmentation de la perméabilité vasculaire. La vasodilatation locale a pour but d'augmenter la circulation du sang afin d'évacuer les cellules mortes et les toxines et d'apporter les éléments nécessaires à la guérison, notamment des globules blancs (lymphocytes) pour combattre les corps étrangers. Ce gonflement local des vaisseaux sanguins provoque la rougeur et la sensation de chaleur, ainsi qu'un épanchement de l'eau du plasma sanguin par osmose vers les tissus, ce qui provoque l'œdème. L'œdème comprime les nerfs et provoque la sensation douloureuse et les démangeaisons (Friel, 1974). En chiropratique, en plus des manipulations, on peut utiliser le froid pour combattre l'inflammation. Le froid provoque une vasoconstriction, fait diminuer le gonflement et calme la douleur.

Phase cellulaire

« D'abord une brève constriction des artérioles débute suivie par une vasodilatation prolongée des artérioles, capillaires et des vénules. Il y a une augmentation de la perméabilité aux protéines de plasma créant

un exsudat séreux, ce dernier est lentement absorbé par le système lymphatique. Les fibrinogènes restants se changent en fibrines. L'augmentation de la perméabilité lors du processus inflammatoire est attribuée à l'action des histamines, quinines, prostaglandines et autres médiateurs. Le processus final se manifeste par une enflure résultante des exsudats, des rougeurs et d'une augmentation de la chaleur environnante des tissus blessés provenant de la vasodilatation et l'augmentation du débit sanguin. (Diakides et Bronzino, 2008) »

L'inflammation, si elle est une réaction de défense, peut poser en soi un problème; par exemple, dans le cas du traumatisme d'une articulation, le gonflement peut gêner l'examen clinique. Cliniquement, une perte fonctionnelle de l'unité motrice vertébrale est observée. Une douleur superposée à cette perte fonctionnelle peut aussi être présente. Toutefois, la problématique suivante se pose:

-L'absence d'un processus inflammatoire malgré la présence d'une dysfonction vertébrale.

Ce processus sera soumis à une évaluation lors du projet 1 afin de mesurer les changements de la TC suite à un traitement *Activator* sur la région lombaire. Selon les périodes d'adaptation, les segments l-4 et l-5 seront ajustés. Le segment l-5 sera utilisé pour le groupe ayant une période d'adaptation environnementale à partir de la huitième minute et le segment l-4 sera utilisé pour le groupe ayant une période d'adaptation environnementale à partir de la trentième minute (Voir la section Méthodologie pour les détails supplémentaires).

2.3 Les paramètres physiologiques d'intérêt des quatre projets

Les paramètres qui seront évalués suite à l'ajustement chiropratique sont:

La TC; la VRC; les cytokines: IL-6 et la PRC.

Ci-dessous, chaque paramètre est présenté et expliqué ainsi que l'aspect rationnel de nos projets.

2.3.1 Température cutanée (TC)

2.3.1.1 La thermorégulation

2.3.1.1.1 Équilibre thermique et thermorégulation

L'humain est un être homéotherme, il possède une température centrale constante même lorsque la température ambiante varie. Il peut accomplir ce fait par la capacité de sa peau et de ses membres qui eux sont poïkilothermes (température variable) (Guénard et al., 1996; Silbernagl S et Despopoulos, 2001; Ganong, 2005).

Comme nous allons mesurer la température cutanée paraspinale, en quoi la thermorégulation doit-elle être prise en considération?

D'abord, d'où provient la production de chaleur? Ce qui nous intéresse est la situation au repos. Au repos, la proportion de chaleur varie et provient surtout de la peau et des muscles (18%), des viscères thoraciques et abdominaux (56%), du cerveau (16%) et du reste du corps (10%). La chaleur produite par l'intérieur du corps est distribuée par le flux sanguin vers la surface du corps. La chaleur est ainsi dirigée vers la peau seulement si la température cutanée est plus basse et/ou que la température centrale du corps devient trop élevée. Par conséquent, pour nos sujets qui seront en jaquette dans une pièce maintenue a 23° C, il y aura une perte de chaleur et la thermorégulation agira pour qu'ils puissent maintenir l'homéostasie thermique (Silbernagl S. et Despopoulos, 2001).

Cette perte de chaleur se présente sous différentes formes. Il y a la radiation; une chaleur environnementale amène le corps à vouloir se refroidir tout comme un environnement froid amène le corps à se réchauffer. Ces sensations sont perçues par la peau et transmise à l'hypothalamus.

Il peut aussi y avoir perte de chaleur par conduction et/ou convection. Voila pourquoi il est important de bien maintenir la température de la pièce entre 23° et 28° C. Cette zone est considérée comme étant une zone de température de confort.

Par conduction, tout ce que l'humain touche qui est plus chaud ou plus froid que sa température apporte une sensation qui nécessite respectivement un refroidissement ou un réchauffement si les écarts sont trop grands. Si les écarts sont maintenus dans une certaine limite, le corps s'adaptera pour atteindre une nouvelle homéostasie temporaire. Ainsi, pour nos projets, les sujets se coucheront en décubitus ventral sur une table en cuir qui est à la température ambiante. Le seul isolant thermique entre la table et la peau du sujet est la jaquette que le sujet porte et celle-ci est ouverte sur la région dorsale. Ceci peut représenter une perte de chaleur initiale avec accommodation thermique éventuelle combinée à l'effet de convection.

Par convection, on parle des courants d'air, raison supplémentaire pour bien contrôler l'environnement dans une pièce fermée. La bouche de ventilation ne doit pas produire de déplacement d'air tangible, autre facteur à contrôler. De plus, il faut éviter d'avoir des fenêtres dans la pièce. Cela pourrait apporter une source de chaleur (en été) ou de refroidissement (en hiver) qui est hors de notre contrôle.

L'évaporation représente une adaptation à la présence d'une chaleur très grande et le corps n'est pas capable de réduire sa température centrale autrement que par ce procédé combiné aux autres procédés déjà mentionnées. Cela s'applique surtout à des températures ambiantes élevées supérieures à 32° C ou durant une activité physique où la température centrale excède sa valeur de consigne qui peut varier entre 36.4 et 37.6° C. Cet aspect du contrôle homéostatique par la production sudorale ne semble pas être un facteur important pour les zones de température dans lesquelles nous travaillerons, quoiqu'il soit préférable que la zone d'humidité se situe autour du 50%.

Finalement, l'âge des sujets pourrait être un aspect non négligeable qui pourrait affecter la thermorégulation. Dufour and Candas (2007) mentionnent que de sujets d'âge moyen ou plus avancé devraient

avoir une TC plus élevée que de jeunes adultes. Wilson et al. (2004), nous indiquent que la raison est que les sujets plus âgés peuvent possiblement souffrir d'une dysfonction physiologique circulatoire.

2.3.1.1.2 Équilibre thermique et méthodologie

Les notions présentées ci-haut permettent de comprendre les commentaires émis par Roy, Boucher et Comtois (Roy, 2005; Roy, Boucher et Comtois, 2006a, 2006b) lorsqu'ils mentionnent avoir retrouvé deux périodes d'enregistrements stables. La première période démontre la capacité du corps à s'adapter à son environnement en utilisant le flux sanguin, la conduction et la convection pour se stabiliser après une période d'adaptation de huit minutes. Durant cette première période d'adaptation qui s'étend sur huit minutes, la température centrale continue de s'abaisser. A la seizième minute, la TC n'est plus stable et la prochaine période de stabilisation commence vers la trentième minute et dure jusqu'à la quarante-cinquième minute. Pour cette dernière période, la température centrale et la TC présentent une stabilité lors des enregistrements (Roy, Boucher et Comtois, 2006a; Roy, Boucher et Comtois, 2006b). Mais laquelle des ces deux périodes sera la plus propice à répondre et démontrer le meilleur effet d'un ajustement chiropratique? Nous ne le savons pas et c'est pour cela que le premier projet inclura les deux périodes d'adaptation.

La période d'adaptation qui nous permettra d'obtenir la meilleure démonstration sera donc utilisée pour le projet 2.

Le système nerveux autonome est impliqué dans la régulation de la température cutanée en réponse aux informations reçues par le cerveau. La régulation des réflexes neurologiques pour la TC est associée au système nerveux autonome, plus spécifiquement à la partie sympathique. Cette régulation permet de maintenir la température centrale du corps stable (Coote et Dowman, 1966). Il existe des thermorécepteurs dans le système nerveux central (internes). Ils sont localisés dans la région pré-optique de l'aspect antérieur de l'hypothalamus, dans le bulbe rachidien inférieur, dans le rachis et dans la musculature squelettique (Sato, Sato et Schmidt, 1997).

Comme il est connu que les systèmes sympathique et parasympathique agissent en opposition, il est surprenant de constater que le système parasympathique n'a qu'un effet mitigé, qui n'entraîne pas d'effets physiologiques importants sur les artérioles de la peau et des muqueuses (Koizumi et Brooks, 1974; Tortora et Grabowski, 2001). Le système nerveux autonome sympathique est le grand responsable de la vasoconstriction et de la vasodilatation des artérioles de la microcirculation de la peau et des muqueuses (Koizumi et Brooks, 1974; Tortora et Grabowski, 2001). Lorsque le système sympathique est actif, une vasoconstriction se produit tandis que la vasodilatation provient d'une diminution de l'activité tonale (tonique) des nerfs vasomoteurs du système sympathique (Koizumi et Brooks, 1974; Sato, Sato et Schmidt, 1997; Michikami et al., 2001).

2.3.1.2 Température cutanée (TC)

La TC est une variable indiquant la modulation de l'activité sympathique (Koizumi et Brooks, 1974; Sato, Sato et Schmidt, 1997; Fegcra et Braune, 2005).

Mohammadian et al. (2004) mentionnent qu'à la suite d'une manipulation 0à la région dorsale, ils n'ont pas réussi à démontrer une modification de la circulation sanguine cutanée de l'avant-bras. Cependant, les sujets rapportèrent une diminution de la sensation de douleur dorsale. Lors de l'évaluation de la musculature douloureuse et de la circulation sanguine de la région atteinte, une diminution significative de la circulation sanguine musculaire du côté ipsilatéral à la douleur fut notée (Fryer, Morris et Gibbons, 2004a; Fryer, Morris et Gibbons, 2004b).

L'évaluation dc la TC par thermométrie pourrait être une méthodologie d'analyse paraspinale dans le domaine de la santé pour l'évaluation de dysfonctions vertébrales. L'observation de la TC pourrait alors permettre de mesurer les effets, à court terme et à long terme, d'une manipulation vertébrale lombaire chez des sujets sans douleur et chez des sujets en douleur chronique.

2.3.2 Variabilité du rythme cardiaque (VRC)

Le signal cardiaque qui est enregistré en médecine cardiovasculaire est l'électrocardiogramme. Ce signal contient des informations qui peuvent être obtenues lorsque de longues périodes d'enregistrement sont analysées. La durée de l'enregistrement peut varier de cinq minutes à 24 heures (Fleisher, 1996; Task Force, 1996a, 1996b; Yilmaz et al., 2007). Les données obtenues peuvent être utilisées pour effectuer l'analyse de la VRC (Fleisher, 1996; Stauss, 2003). Il n'y a pas de différences de mesure entre la VRC enregistrée le matin et celle enregistrée l'après-midi pour les enregistrements de courte durée, soit dix minutes (Kalisnik et al., 2001). Toutefois, il faut faire attention de bien standardiser les conditions dans lesquelles les enregistrements sont faits (Parsons, Scott et MacDonald, 1992).

Les systèmes qui prédominent et qui contrôlent la VRC sont deux composantes du système nerveux autonome: le système rénine-angiotensine et la thermorégulation (Appel, Burger et Saul, 1989; Mallani et al., 1991; Akselrod et al., 1981; Akselrod, Gordon et Madwed, 1985); il y a aussi le niveau supraspinal où le cortex insulaire est aussi directement impliqué (Oppenheimer, Kedem et Martin, 1996). On considère la VRC comme une caractéristique du rythme cardiaque qui permet d'obtenir une estimation de l'activité du système nerveux autonome et les analyses temporelles et spectrales sont basées sur les intervalles R-R successifs normaux qui peuvent démontrer cette variabilité (Task Force 1996a, 1996b; Kuo et al., 2003).

Pour l'analyse temporelle, les intervalles R-R successifs (Task Force 1996a, 1996b; Kuo et al., 2003) normal-normal (N-N) qui sont utilisées pour référer aux intervalles stricts correspondent aux contractions des ventricules entre les complexes normaux QRS. L'analyse temporelle des intervalles R-R normaux est nommée l'écart-type (déviation standard) des intervalles N-N (SDNN). Le SDNN représente la variation globale du rythme cardiaque à l'intérieur d'une série d'intervalles R-R, c'est-à-dire l'écart-type des R-R moyens, mesuré sur un minimum de 256 battements normaux. Une autre mesure calculée à partir des différences entre les intervalles R-R est le N-N50. Ce N-N50 représente le nombre successif d'intervalles R-R qui diffère par plus de 50 ms et à partir duquel est calculé le pN-N50 (le pourcentage de N-N50 > 50ms) (Tarvainen et Niskanen, 2006).

L'analyse spectrale de la VRC permet d'identifier les zones de fréquences suivantes:

1- Les hautes fréquences (HF) (puissances entre 0.15 à 0.40 Hz), qui représentent l'activité du système parasympathique (Fleisher, 1996; Lombardi et al., 1996; Stauss, 2003; Gaudemaris, Frimat et Chamoux, 1998) et sont aussi influencées par le rythme respiratoire (Eckberg, 2003);

2- Les basses fréquences (BF) (puissances entre 0.04 à 0.15 Hz) qui représentent à la fois l'activité du système sympathique et l'activité du système parasympathique (Fleisher, 1996; Lombardi et al., 1996; Task Force 1996a, 1996b, Stauss, 2003; Gaudemaris, Frimat et Chamoux, 1998);

3- Les très basses fréquences (TBF) (puissances entre 0 à 0,04 Hz) qui représentent l'activité cardiaque reliée aux systèmes autonomes associés à la thermorégulation, le contrôle vasomoteur périphérique et le système rénine-angiotensine (Fleisher, 1996; Lombardi et al., 1996; Stauss, 2003; Gaudemaris, Frimat et Chamoux, 1998);

4- Le ratio BF/HF qui représente l'équilibre sympathique-parasympathique. Le stress psychologique peut affecter ce ratio vers le haut (Pagani et al., 1991).

La VRC a un potentiel considérable dans l'évaluation des fluctuations du système nerveux autonome chez les patients en santé, tout comme chez les patients affligés d'un problème cardiovasculaire (Task Force 1996b) ou chez les obèses (Freeman et al., 1995). Les niveaux d'activité physique et les émotions ont un effet profond sur la VRC (Kleiger, Stein et Bigger, 2005).

Budgell et Hirano (2001) rapportent une augmentation du ratio BF/HF suite à des manipulations cervicales. Driscoll et Hall (2000) rapportent une diminution du ratio BF/HF et de la BF suite au traitement initial et une augmentation du ratio BF/HF après le neuvième traitement. Par contre, aucune mention n'est faite en relation avec le rythme respiratoire qui affecte les HF. Ils concluent que ces changements peuvent possiblement être le reflet d'un changement de l'équilibre entre le système sympathique et le système parasympathique (Driscoll et Hall, 2000; Budgell et Hirano 2001).

Dans une autre étude (Zhang et Snyder, 2005), les chercheurs n'ont trouvé aucune différence statistiquement significative de la fréquence cardiaque (FC) ou de la VRC suite à des manipulations douces et de longue durée (15 à 45 secondes) de la région dorsale. Cependant, dans une autre étude, Zhang et al., (2006) ont démontré qu'il y a diminution de la FC, augmentation de la HF et augmentation de la BF suite à des traitements chiropratiques des régions dorsales et cervicales. Il n'est cependant pas spécifique sur le type, la fréquence ou la combinaison des manipulations utilisées. Une étude (Grimm, Cunningham et Burke, 2005) comparant un groupe de sujets ayant une blessure musculosquelettique et un groupe contrôle de sujets sains, a démontré une différence statistiquement significative de la VRC entre les deux groupes; la différence se situant dans les valeurs des intervalles R-R qui étaient inférieures pour le groupe blessé par rapport aux valeurs des intervalles R-R du groupe sain.

L'âge d'un sujet a un impact significatif sur la VRC mais pas son sexe (Bonnemeier et al., 2003; Zhang, 2007). La VRC peut démontrer une diminution de la BF chez les hommes qui souffrent du syndrome de douleurs pelviennes chroniques (Yilmaz et al., 2007) et une diminution de la HF chez les femmes qui souffrent du syndrome du côlon irritable (Cain et al., 2007). La VRC a démontré une réduction de la HF et une augmentation de la BF associées à l'arthrite rhumatoïde, (Evrengul, Dursunoglu et Cobankara, 2004), mais il n'y a pas de changements de la VRC en relation avec la spondylite ankylosante (Yildirir et al., 2001). Toutefois, il y a des changements en présence de blessure médullaire (Bunten et al., 1998; Ditor et al., 2005). La HF augmente avec l'ingestion de caféine (Hibino et al., 1997). La présence de ces syndromes peut être considérée comme un facteur d'exclusion.

Le recensement de la documentation confirme qu'il n'existe pas de recherches sur l'effet de l'ajustement chiropratique lombaire sur la VRC ou de lien avec des changements de la TC. L'évaluation de la mesure de la VRC permettra de déterminer s'il y a un effet de la manipulation vertébrale lombaire sur les différentes fréquences associées à la VRC. Nous nous attendons à une réduction du ratio BF/HF puisque les études sur les manipulations vertébrales cervicales et dorsales démontrent une augmentation de ce même ratio (Driscoll et Hall, 2000; Budgell et Hirano, 2001). Ci-dessous, une représentation graphique (Fig. 2.3) des trois fréquences qui seront étudiées (Su et al., 2005).

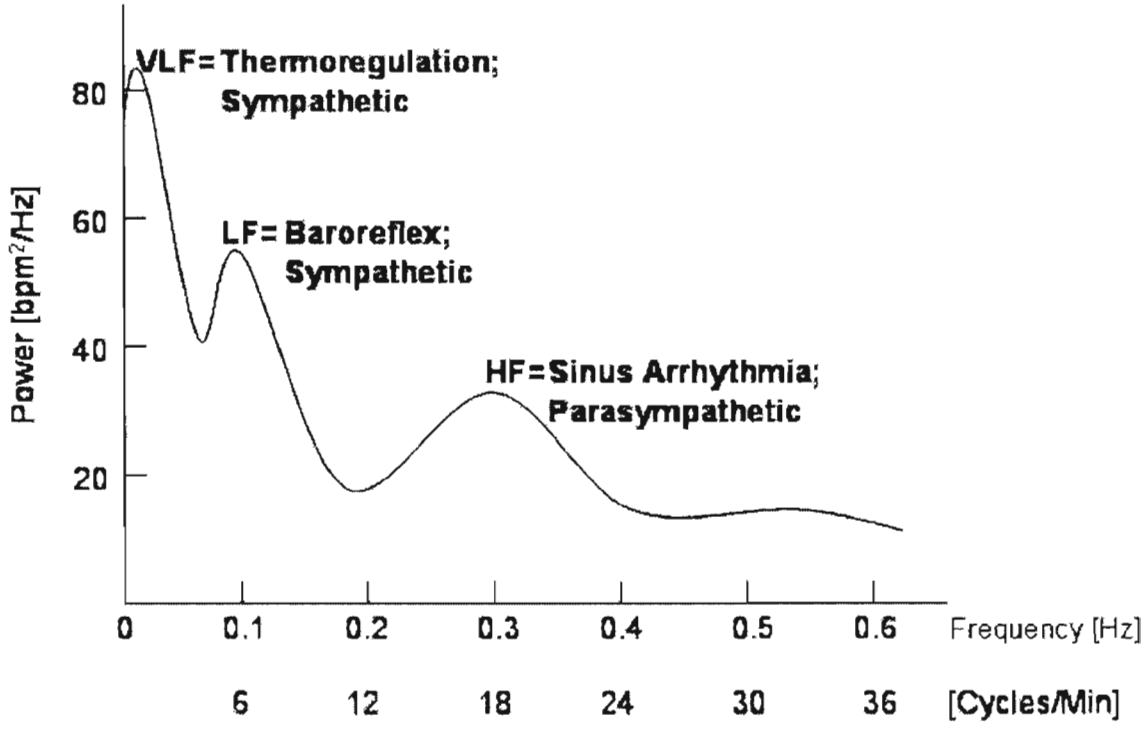

Figure 2.3 Graphique démontrant les trois fréquences en relation avec leur fréquence respective (X) et la puissance (Y). D'après Su et al., (2005)<

2.3.3 Cytokines

Les cytokines exercent un contrôle sur la réponse immunitaire. Elles peuvent être produites suite à une réaction inflammatoire (Ganong, 2005).

Le résultat d'une réponse inflammatoire est dicté par une variété de facteurs incluant la pathogenèse, la durée d'un stimulus et l'équilibre entre la réponse pro-inflammatoire et la réponse anti-inflammatoire (Waterer et Wunderink, 2003). Les cytokines sont de plus en plus reconnues comme étant des molécules de régulation et de communication puissantes et essentielles (Whiteside, 1994). Le réseau des cytokines anti-inflammatoires devient actif afin de prévenir les dommages aux tissus et éviter un effet systémique (Whiteside, 1994). Undem (1994) nota que la stimulation neurologique peut affecter la croissance et les fonctions des cellules inflammatoires. Brennan et al. (1992) ont remarqué que lorsqu'un ajustement chiropratique de la région thoracique est effectué, la réponse des neutrophiles polynucléaires provenant d'échantillons sanguins récoltés 15 minutes après cet ajustement est significativement plus grande que dans les échantillons récoltés 15 minutes avant ou 30 et 35 minutes après. Dans une étude plus récente (Teodorczyk-Injeyan, Injeyan et Rugg, 2006), il fut observé que la manipulation vertébrale diminuait la quantité de cytokines pro-inflammatoires « tumor necrosis factor-α » et « interleukine-1β », mais aucun changement de la substance P ne fut observé. Ces changements suggèrent le potentiel des cytokines comme marqueurs biologiques résultant de la manipulation d'une dysfonction articulaire vertébrale (Pickar, 2002).

L'évaluation des deux cytokines mentionnées ci-dessous pourra fournir des indications quant aux effets de la manipulation vertébrale chez des sujets sans douleur et chez des sujets ayant des douleurs chroniques.

2.3.3.1 Protéine réactive C (PRC)

La PRC fut la première protéine associée à la phase de réponse inflammatoire aigüe (Danesh et al., 2000). Elle est un marqueur biologique systémique très sensible à l'inflammation et aux tissus endommagés (Pepys et Hirschfield, 2003) et elle fait partie de la réponse immunitaire innée (Black, Kushner et Samols, 2004). La phase de réponse aigüe comprend les réponses physiologiques et biochimiques non spécifiques de la plupart des formes de tissus endommagés, des infections et des tumeurs malignes (Pepys et Hirschfield, 2003).

La PRC est une protéine sanguine produite de façon innée comme une réponse immunitaire face à une infection ou à une blessure tissulaire (Gershov et al., 2000). La synthèse de la PRC est dépendante de l'activité de l'IL-6 (Gershov et al., 2000; Juffrie et al., 2001; Pepys et Hirschfield, 2003). Lorsqu'une inflammation est présente, le facteur de production de la PRC par l'IL-6 est de l'ordre de 1000 fois sa quantité habituelle (Gershov et al., 2000).

Les niveaux quantifiés se situent sur une échelle de risque. Ils sont établis comme suit: 1.0 mg/L et moins (faible), entre 1.0 et 3.0 mg/L (moyen) et plus de 3.0 mg/L (élevé). Ces niveaux représentent l'échelle de risque (Jialal, Devaraj et Venugopal, 2004). Il est important de reconnaître que la PRC est non spécifique et qu'elle répond à plusieurs inflammations qui ne sont pas nécessairement reliées à des conditions cardiovasculaires

(Pepys et Hirschfield, 2003). Par exemple, la présence de la PRC peut être un marqueur qui précède la démonstration radiologique de la présence d'arthrite inflammatoire (Sharif et al., 2000).

Les facteurs de risques associés à une présence accrue de la PRC sont: l'âge, l'indice de masse corporelle (IMC), la pression artérielle systolique, le tabagisme, les lipoprotéines à haute densité et la thérapie de remplacement d'hormones (Bermudez et al., 2002). Les niveaux de PRC augmentent avec l'âge et cela peut possiblement refléter une incidence de pathologies sous-cliniques (Pepys et Hirschfield, 2003).

2.3.3.2 Interleukine-6 (IL-6)

L'IL-6 est associée à la phase de réponse aiguë (Gabay et Kushner, 1999). Elle joue un rôle dans l'inflammation tissulaire (Hashimoto et al., 2001; Ridker, 2003; Jialal, Devaraj et Venugopal, 2004; Lin et al., 2004). L'IL-6 est aussi un marqueur biologique très sensible (Sharif et al., 2000).

La présence de tissus adipeux chez les obèses est un facteur important d'un niveau faible d'inflammation chronique qui se reflète par une présence accrue de l'IL-6, de la « Tumor necrosis factor-α » et de la PRC (Yudkin et al., 1999; Anty et al., 2006). L'Il-6 augmente fortement après un marathon, sans être influencée par l'âge ou le sexe (Nieman et al., 2001). La présence de l'IL-6 et de la PRC augmente chez les patients souffrant d'œdème pulmonaire en haute altitude (Hartmann et al., 2000). Donc, la valeur moyenne de l'IL-6 et de la PRC augmente avec le nombre croissant des facteurs de risques cliniques. Pour l'IL-6, entre autres, il y a: l'âge, l'indice de masse corporelle (IMC), l'alcool, le tabagisme, la pression sanguine systolique, le diabète et la fréquence d'activité sportive.

L'évaluation des concentrations d'IL-6 et de la PRC permettra d'observer si l'effet du traitement chiropratique peut se manifester par un changement, tant biochimique que neurologique.

L'intérêt lié à ces deux cytokines est leur présence parallèle au cours de certains processus inflammatoires. Nous espérons être capables de mesurer une réduction parallèle de la valeur de ces deux cytokines.

2.4 Imagerie infrarouge

L'intérêt pour l'imagerie infrarouge renaît à travers le monde, principalement à cause des innovations technologiques et électroniques (Diakides et Bronzino, 2008). La thermographie est utilisée comme outil diagnostique pour la détection du cancer du sein et de plusieurs autres problèmes de santé liés à la circulation sanguine (Diakides et Bronzino, 2008). Les recherches sont surtout axées vers les systèmes d'imageries biomédicales. Toutefois, peu de recherches existent concernant les évaluations musculosquelettiques paraspinales.

L'évaluation de la température cutanée fut, pendant plusieurs siècles, une observation subjective due à l'absence d'appareil de mesure de la température interne ou externe du corps. Le thermomètre clinique fut développé en 1868 par le Dr Carl Wunderlich. Son traité sur la température corporelle est une œuvre qui s'échelonna sur plusieurs années (Diakides et Bronzino, 2008).

Par la suite, la radiation infrarouge fut découverte (Diakides et Bronzino, 2008). L'utilisation électronique de la détection et de l'acquisition des images infrarouges fut développée durant les années 1980 (Uematsu et al., 1998a; Uematsu et al., 1988b). Toutefois, les derniers progrès électroniques, tant pour l'acquisition des données que pour l'analyse de celles-ci, permettent d'être plus précis dans l'utilisation de la thermométrie comme outil diagnostique pour la chiropraxie (Diakides et Bronzino, 2008).

Les chiropraticiens utilisent la thermométrie. Cette technologie utilise des caméras avec détecteurs infrarouges pour mesurer la TC le long du rachis. La thermométrie est comparable aux anciens systèmes de mesures par thermomètres ou thermistors. Les caméras infrarouges sont en fait des thermomètres électroniques à détecteurs infrarouges qui enregistrent une mesure précise, valide (Roy 2005; Roy, Boucher et Comtois, 2006a, 2006b) et fidèle. La précision des instruments à détection infrarouge se situe à <0.05°C (0.09°F). Lors des évaluations cliniques, il est important de contrôler et d'enregistrer la température ambiante ainsi que l'humidité relative (Roy 2005; Roy, Boucher et Comtois, 2006a, 2006b). Afin d'éviter la vasoconstriction réactionnelle à la température ambiante, il serait souhaitable que la température ambiante du local d'évaluation se situe entre 22 et 24°C (Diakides et Bronzino, 2008).

La température cutanée est affectée (Kandjov, 1998; Wenger, 2001) par l'activité cellulaire, musculaire et métabolique, tout en étant en relation directe avec les fonctions régulatrices de la température centrale du corps (Wenger, 2001; Diakides et Bronzino, 2008).

Une contraction musculaire contribue à la distribution de la chaleur du corps. Un spasme musculaire aigu peut être mis en évidence par la présence accrue de chaleur. Toutefois, un spasme ou une blessure musculaire chronique engendre un refroidissement de la région affectée résultant d'un manque d'activation des fibres musculaires (Cannon et Querido, 1924; Hobbins et Ammer, 1996). Ce phénomène se produit également sur les articulations ayant une amplitude de mouvement réduite en raison de la présence d'inflammation (Ammer 1995).

Une diminution de la température cutanée fut notée sur des articulations ostéoarthritiques sans que les mécanismes ne soient compris (Vecchio et al., 1992; Ammer et al.,1998). Une entorse ligamentaire et même une fracture de stress peuvent être identifiées par le changement de la température cutanée adjacente, avant d'être visibles sur des radiographies (Collins et Colsh, 1970; Devereaux, 1984; Ring et Ammer, 1998). Cela est tout aussi vrai dans le cas d'autres formes de blessures musculaires ou articulaires (Ring et Collins, 1970; Thomas et Savage, 1989). La thermométrie pourrait nous permettre de faire un meilleur suivi clinique du traitement et de l'amélioration de la condition des patients (Devereaux, Hazleman et Thomas, 1985).

Les connaissances de la physiologie associée à la thermographie ont changé et sont en constante évolution (Mercer et Simon, 2001; Iannetti et al., 2003). Toutefois, ce n'est pas le cas de la thermométrie qui fut toujours négligée dans le secteur de la recherche. Les présents travaux furent entrepris afin d'élucider les effets des manipulations vertébrales sur la TC.

La documentation scientifique ne présente aucune étude concernant la thermométrie et son utilité diagnostique. Par conséquent, l'utilisation chiropratique de cet outil clinique demeure controversée.

2.5 Hypothèses

Suite au recensement de la documentation, la grande question est la suivante:

« Est-ce que la manipulation vertébrale lombaire, à court et/ou long terme, produit un changement chez les variables suivantes: la TC, la VRC et les cytokines: Il-6 et PRC? »

Ce qui conduit à notre hypothèse générale (H):

$H_{générale}$: La manipulation vertébrale lombaire produit un effet mesurable chez les variables suivantes: la TC, la VRC et les cytokines Il-6 et PRC.

À l'intérieur de chaque projet, le processus identifiera des hypothèses spécifiques.

Notre hypothèse sera évaluée en une série de projets. Le premier projet nous permettra de mesurer l'effet d'une manipulation vertébrale lombaire mécanisée sur des sujets libres de douleur, les buts étant de mesurer tout changement sans aucun apport thermique de la part de l'instrument et de déterminer laquelle des deux périodes d'adaptation environnementale est la plus appropriée. Suivra le projet 2 où le même processus sera répété avec les changements suivants: il n'y aura qu'un seul niveau (L-5) qui sera traité et les sujets seront en douleurs. Ce projet nous permettra de mesurer si la main est une interface qui créée une chaleur résiduelle pouvant affecter nos mesures de la TC, combien de temps dure cet effet et s'il persiste après notre intervention. Le projet 3 est en lui-même indépendant des deux premiers projets, mais nous permet d'évaluer si les composantes de la VRC sont affectées par une manipulation vertébrale lombaire mécanisée ou traditionnelle. Les composantes de la VRC nous indiquent les réactions autonomiques possibles et cela peut nous permettre de comprendre d'où proviennent les réponses associées à la manipulation vertébrale lombaire. Enfin, le projet 4 est une évaluation temporelle des trois premiers projets. En effet, la question que nous soulevons est celle-ci: « Est-ce que les changements obtenus de façon ponctuelle se reflètent tout aussi bien dans une évaluation temporelle »? Nous continuons, ci-dessous. avec nos hypothèses spécifiques à chaque projet.

2.5.1 Énumération des hypothèses spécifiques

2.5.1.1 Projet 1

Dans le projet 1, le segment fautif pour chaque sujet fut d'abord identifié et le sujet fut assigné au groupe relatif au segment identifié. La TC sera mesurée avant et après une manipulation vertébrale lombaire avec *Activator* au niveau de L-4 ou L-5, selon la période d'adaptation du sujet. Il y aura deux périodes d'adaptation pour stabiliser le sujet à son environnement. Une période de 8 à 16 minutes et une période de 30 à 45 minutes.

Initialement, il y aura deux segments évalués. Chaque segment est associé à une période d'adaptation. Le segment L-4 sera choisi, selon le protocole *d'Activator Method.* Les comparaisons seront faites avec le groupe dont le segment L-5 sera utilisé, selon le protocole *d'Activator Methods.* Comme un à deux segments de chaque côté de l'articulation ajustée bougent par l'oscillation produite par l'ajustement (Fuhr et al., 1997), il ne devrait

pas y avoir de différence entre les groupes, ceux-ci incluant des participants qui sont sans douleur. La composante de friction est négligeable.

Il y aura une comparaison du changement observé de la TC entre les deux périodes d'adaptation. Cette comparaison nous permettra d'évaluer s'il y a une différence de la réponse de la TC entre les deux périodes. La période d'adaptation qui nous permettra d'observer la réponse de la TC qui sera la plus significative sera la période d'adaptation utilisée pour les projets deux et quatre.

Hypothèse spécifique au projet 1.

P1-H_1: La manipulation vertébrale d'une dysfonction vertébrale lombaire par *Activator* crée un réchauffement significatif de la TC.

Hypothèse nulle

P1-H_0: Il n'y a aucun changement.

Si la démonstration de P1-H_1 n'est pas validée, la poursuite des projets de recherche continuera avec les mesures des marqueurs biologiques et physiologiques proposées pour les projets 3 et 4, afin de continuer l'évaluation de l'effet de la manipulation vertébrale lombaire sur les variables suivantes: la VRC et les cytokines IL-6 et PRC. Il en sera de même avec le projet 2 où on utilise une toute autre technique de manipulation vertébrale lombaire.

2.5.1.2 Projet 2

Pour chaque sujet, le segment fautif fut d'abord identifié par la méthode Activator et confirmé par le clinicien traitant en utilisant la palpation statique et dynamique. La TC sera mesurée, avant et après une manipulation vertébrale lombaire au niveau de L-5, par la méthode *Diversified*. Un réchauffement de la TC à l'endroit ajusté est donc attendu, indépendamment de l'application d'une force de friction entre la main du clinicien et la peau du sujet, et malgré la chaleur possiblement induite par la main du clinicien.

Hypothèse spécifique au projet 2.

P2-H_1: La manipulation vertébrale lombaire par la méthode traditionnelle crée un réchauffement significatif de la TC et la chaleur de la main du praticien a une influence négligeable.

Hypothèse nulle

P2-H_0: Il n'y a aucun changement.

Si la démonstration de P2-H_1 n'est pas validée, la poursuite des projets de recherche continuera quand même avec les mesures des marqueurs biologiques et physiologiques proposées pour le projet 3 afin de poursuivre l'évaluation de l'effet de la manipulation vertébrale lombaire sur la VRC. Il en sera de même avec le projet 4 qui mesure l'effet à long terme de la manipulation vertébrale lombaire.

2.5.1.3 Projet 3

La VRC (analyse temporelle et spectrale) sera mesurée suite à une manipulation vertébrale lombaire traditionnelle (*Diversified*) par rapport à une manipulation vertébrale lombaire mécanisée (*Activator*).

Hypothèse spécifique au projet 3.

P3-H_1: La manipulation vertébrale lombaire par *Activator* produit une diminution significative du ratio BF/HF de la VRC.

P3-H_2: La manipulation vertébrale lombaire par *Diversified* produit une diminution significative du ratio BF/HF de la VRC.

Hypothèse nulle:

P3-H_0: Il n'y a aucun changement.

Si les hypothèses alternatives sont rejetées, la poursuite des projets de recherche continuera quand même avec le projet 4 pour mesurer l'évaluation de l'effet de l'ajustement chiropratique lombaire par *Activator* à long terme.

2.5.1.4 Projet 4

L'effet à long terme de l'ajustement chiropratique lombaire par *Activator* sera mesuré sur des patients souffrant d'une lombalgie chronique (minimum de 6 mois en douleur, sans soulagement préalable avec toute autre thérapie ou médication), n'ayant pas reçu de manipulation vertébrale lombaire. Les travaux du projet quatre ont pour but de répondre à la question suivante: la manipulation vertébrale lombaire par *Activator* peut-elle produire un changement sur les éléments suivants? Nous nous attendons à une réduction du ratio BF/HF puisque les études sur les manipulations vertébrales cervicales et dorsales démontrent une augmentation de ce même ratio (Driscoll et Hall, 2000; Budgell et Hirano, 2001).

1- La TC au niveau du rachis lombaire;

2- La VRC, (analyse temporelle et spectrale);

3- Les cytokines IL-6 et la PRC.

Hypothèses spécifiques au projet 4.

P4-H_1 La manipulation vertébrale lombaire par *Activator* augmente de façon significative la mesure de la TC.

P4-H_2: La manipulation vertébrale lombaire par *Activator produit une diminution* du ratio BF/HF de la VRC.

P4-H_3: La manipulation vertébrale lombaire par *Activator* réduit la présence de l'une et/ou l'autre des cytokines, IL-6 et PRC.

Hypothèse nulle:

P4-H_0 Il n'y a aucun changement de la TC, de la VRC et de tous les marqueurs biochimiques.

2.6 Résumé

Il y a peu de preuves scientifiques qui supportent la thermométrie. L'effet de deux types de manipulation vertébrale lombaire sera évalué à court terme sur la TC chez des patients n'ayant pas de douleur et des patients ayant des douleurs.

De plus, l'effet de ces deux types de manipulation vertébrale lombaire à court terme sur la VRC sera mesuré.

Finalement, l'effet à plus long terme de la manipulation vertébrale lombaire par *Activator* sera mesuré sur la TC, la VRC et les cytokines l'Il-6 et PRC.

CHAPITRE III

MÉTHODOLOGIE

3.1 Justification des méthodes utilisées

3.1.1 Le type de traitement chiropratique

Pour les projets; 1, 3 et 4, nous avons utilisé l'appareil produit par *Activator Methods International (Phoenix, Arizona, USA)*. Celui-ci est reconnu comme étant un outil stable et efficace. Le protocole technique est enseigné dans plusieurs institutions chiropratiques à travers le monde. Cet instrument ayant un point de contact caoutchouté ne produit et n'absorbe pas de chaleur et le facteur de traction de la peau est négligeable. L'appareil apparaît donc comme l'outil idéal pour initier la prise de mesures en thermométrie, puisqu'il permet de réduire les effets externes le plus possible.

La méthode traditionnelle (*Diversified*) a été utilisée pour les projets 2 et 3. Le but était d'évaluer l'effet additionnel du contact de la main, source de chaleur probable. Ces deux techniques sont les plus utilisées dans le monde de la chiropratique.

3.1.2 Les sujets

Pour le projet 1, les sujets n'avaient pas de douleur. Le but de ce projet était d'observer s'il y avait un changement de la TC en l'absence de douleur et quelle période de stabilisation était la plus adéquate pour observer les changements de la TC. Ce projet allait donc permettre d'établir une base d'informations avant de procéder avec des patients qui ont des douleurs et avec la technique qui utilise le contact avec la main.

Pour le projet 2, les sujets avaient des douleurs. L'objectif était de mesurer s'il y avait un changement de la TC en présence de douleurs et l'effet du contact avec la main. Ce projet allait permettre d'obtenir une base de données comparatives pour la TC entre les projets 1 et 2.

Pour le projet 3, il y avait un groupe de sujets n'ayant pas de douleur et un groupe de sujets qui avaient des douleurs. Les mesures de la VRC ont été enregistrées et comparées entre les deux groupes afin de d'établir s'il y avait des réactions différentes entre ces groupes.

Pour le projet 4, le groupe témoin était composé de sujets qui suivaient un traitement chiropratique de maintien. Les sujets n'avaient pas de douleur, mais présentaient des dysfonctions articulaires vertébrales à la région lombaire. Leur recrutement ciblait un échantillonnage connu. Le groupe traitement était composé de sujets en situation chronique depuis au moins six mois. Auparavant, ces sujets n'avaient obtenu aucun soulagement de leurs douleurs lombaires. Les sujets ont été recrutés à l'extérieur de la clinique, par voie publicitaire, pour une série de traitement d'une durée de deux semaines. Ces sujets n'avaient jamais reçu de manipulations vertébrales. Pour chaque projet, nous avons essayé d'avoir des groupes d'âge similaires.

Le but du projet 4 était de comparer les mesures de la TC, de la VRC et des cytokines (IL-6 et PRC) des patients ayant des douleurs chroniques comparativement à des patients n'ayant pas de douleur, à la suite de neuf traitements chiropratiques qui s'échelonnaient sur une période de deux semaines.

3.1.3 Période d'adaptation

Pour le projet 1, les deux périodes d'adaptation qui ont été utilisées sont celles connues pour obtenir une température cutanée stabilisée à l'environnement du sujet. La première période d'adaptation se situe entre 8 et 16 minutes. Durant cette période, la température cutanée est stable mais la température centrale continue de diminuer (Roy, 2005; Roy, Boucher et Comtois 2006b). Cette diminution continue de la température centrale représente l'adaptation continue à l'environnement par thermorégulation. Toutefois, il est connu qu'à partir de la trentième et jusqu'à la quarante-cinquième minute, la TC redevient stable, tout comme la température centrale qui s'est aussi stabilisée (Roy, 2005; Roy, Boucher et Comtois, 2006b).

Il était important de distinguer les effets de la manipulation vertébrale sur la TC entre ces deux périodes d'adaptation. Il était essentiel de choisir la période la plus pertinente pour les projets 2 et 4. Les résultats du projet 1 confirmèrent que la période de 8 à 16 minutes était la plus adéquate pour la prise de mesure thermométrique.

3.1.4 Choix du site de traitement

Dans le projet 1, deux sites de traitement ont été utilisés, soit L-4 et L-5. Cette décision a été expliquée au point 2.5.1.1 de la thèse (p. 50). Dans le projet 1, L-5 est la région qui a été traitée durant la période d'adaptation se situant entre huit et 16 minutes. Cette période d'adaptation fut choisie comme étant la plus adéquate et fut utilisée pour les autres projets (2 et 4) sur la TC. Donc, pour le projet 2, le segment L-5 fut choisi, et ce pour la période d'adaptation se situant entre huit et 16 minutes. Le but était de mesurer et comparer les effets entre le contact sans source de chaleur (*Activator IV*) et le contact avec la main qui est une source de chaleur probable.

Pour le projet 3, le site de traitement L-5 a été choisi afin de cibler un site de la région lombaire. En effet, il existe déjà des recherches qui démontrent l'effet de l'ajustement chiropratique cervical et/ou dorsal sur la variabilité du rythme cardiaque.

Le but était de mesurer l'absence ou la présence d'un changement significatif de la variabilité du rythme cardiaque suite à une manipulation vertébrale à la région lombaire, par *Activator* ou *Diversified*. L'objectif était également d'identifier si la douleur ou l'absence de douleur était une variable qui pouvait influencer les mesures de la variabilité du rythme cardiaque.

Dans le projet 4, le site d'intervention a été étendu pour inclure les segments situés entre D-12 et L-5. Il fallait tenir compte de la région D-12-L-1, puisque cette région est connue pour créer des symptômes de lombalgie et imiter des symptômes discaux lombaires. Ce syndrome thoraco-lombaire fut découvert par le Dr. Robert Maigne, orthopédiste français (Maigne, 1972, 1980). L'expansion du site de traitement a permis de traiter les sujets de façon plus complète lorsqu'il présentait des symptômes de lombalgie.

Les sujets ayant des douleurs chroniques furent évalués pour identifier la présence accrue possible des cytokines IL-6 et PRC.

3.1.5 Les différents projets

Comme mentionné plus tôt (section 2.5, p. 51), cette thèse est composée de quatre projets spécifiques:

Le premier projet a servi à mesurer l'effet de l'ajustement chiropratique par *Activator* et le changement de la TC à court terme. Les résultats furent publiés: *Roy, Boucher et Comtois. 2008 Effects of a manually assisted mechanical force on cutaneous temperature. J Manipulative Physiol Ther 2008;31:230-236.*

Le deuxième projet a servi à démontrer l'effet de l'ajustement chiropratique sur la TC à court terme par *Diversified.* Les résultats furent publiés: *Roy, Boucher et Comtois. 2010a. Paraspinal cutaneous temperature modification after spinal manipulation at L5. J Manipulative Physiol Ther. 2010;May;33(4):308-14.*

Le troisième projet a servi à démontrer l'effet de l'ajustement chiropratique à court terme sur la VRC, par *Diversified* et par *Activator*. Les résultats furent publiés: *Roy et al. Heart rate variability modulation after a manipulation in pain free patients versus patients in pain. J Manipulative Physiol Ther. 2009 May;32(4):277-86.*

Le quatrième projet comportait l'évaluation de l'effet à long terme de l'ajustement chiropratique *Activator* sur la TC, la VRC, la PRC et l'Il-6. Le manuscrit est accepté pour publication: *Roy, Boucher et Comtois. 2010b. Inflammatory markers modulation following a short term treatment course in subjects with and without chronic low back condition. Accepted for publication. Journal of chiropractic medicine.*

3.1.6 Déontologie et éthique

Tous les projets d'évaluation furent soumis pour évaluation au Comité d'éthique de l'Université du Québec à Montréal. Pour chacun des projets, lorsque les sujets se présentaient au laboratoire d'évaluation à leur première visite, ils lisaient et signaient un formulaire de consentement. Avant de signer ce formulaire, ils avaient eu le loisir de poser toutes les questions qu'ils désiraient et ils conservèrent le droit de se retirer des expérimentations en tout temps.

3.1.7 Participants

Afin d'établir le nombre de sujets nécessaires par groupe, la méthode recommandée par Kirk (1982, 1995) a été utilisée, c'est-à-dire utiliser les tableaux de Cohen (1969, 1992) conjointement à une étude récente sur la validité (Roy, Boucher et Comtois, 2006b). Puisque la validité de cette étude variait entre 18% et 83% (selon les segments vertébraux analysés), la fiabilité la plus faible a été sélectionnée, soit 18%. En utilisant une puissance de 80%, il a été possible d'établir le nombre minimal de sujets à huit par groupe. Toutefois, 10 sujets ont été sélectionnés par groupe. Le critère d'inclusion était que les participants soient des patients qui recevaient déjà des traitements dans une clinique chiropratique, sauf pour le dernier projet où les participants du groupe traitement furent recrutés par voie de publicité dans un journal local. Par la suite, pour chaque projet, il y avait des consignes d'exclusion, soit que tous les sujets devaient être exempts des conditions suivantes (rhume, grippe, post-ovulation, pré-menstruation et toute autre condition thermogénique) qui pouvaient affecter leur température cutanée. Les

sujets furent assignés à chaque groupe de façon aléatoire, puis divisés en deux groupes égaux et similaires pour les différents projets. Les sujets ont donné leur consentement écrit pour participer au projet auquel ils étaient assignés.

Les projets comportant l'utilisation de l'appareil à percussion (*Activator Methods*) furent exécutés par un chiropraticien traitant formé pour utiliser cette technique et possédant un niveau acquis de compétences avancées dans la technique chiropratique "*Activator Methods Chiropractic Technique*™ (AMCT) ». Les projets comportant l'utilisation de la méthode traditionnelle (*Lumbar roll Diversified*) furent exécutés par un chiropraticien traitant formé pour utiliser cette technique et possédant un niveau acquis de compétences dans cette technique chiropratique.

3.1.8 Recrutement des sujets

3.1.8.1 Projet 1

Soixante-six sujets furent recrutés à partir de la base de clients/patients du Dr Richard Roy, Chiropraticien, DC, M.Sc., LaSalle, Québec, H8N 1X7. Trente-trois sujets pour chaque période d'enregistrement (2 périodes) furent subdivisés en sous-groupes: traitement, contrôle et témoin (n=11/groupe).

3.1.8.2 Projet 2

Vingt sujets furent recrutés à partir de la base de clients/patients du Dr Sylvain Fafard, Chiropraticien, DC, Ville LaSalle, Québec, H8R 1Y8. Les sujets furent assignés de façon aléatoire au groupe traitement ou témoin (n=10/groupe).

3.1.8.3 Projet 3

Vingt sujets furent recrutés à partir de la base de clients/patients du Dr Sylvain Fafard, Chiropraticien, DC, Ville LaSalle, Québec, H8R 1Y8. Les sujets étaient destinés aux deux groupes de la méthode traditionnelle, soit le groupe traitement et le contrôle (n=10/groupe). Par la suite, 31 sujets furent recrutés à partir de la base de clients/patients du Dr Richard Roy, Chiropraticien, DC, M.Sc., LaSalle, Québec, H8N 1X7. Ces participants furent répartis dans les trois groupes de la méthode *Activator*, soit le groupe traitement (n=10), le groupe contrôle (n=10) et le groupe témoin (n=11).

3.1.8.4 Projet 4

Les sujets du groupe traitement (n=10) furent recrutés à partir d'une publicité spécifique au projet dans un journal local, Le Messager de LaSalle, et le groupe témoin (n=10) (sans douleur) fut recruté à partir de la base de clients/patients du Dr Richard Roy, Chiropraticien, DC, M.Sc., LaSalle, Québec, H8N 1X7.

3.1.9 Mesure de la température de la pièce

Toutes les données furent recueillies à la température de la pièce. La température ambiante et l'humidité relative furent obtenues avec un THR-1000 (ACR Systems Inc, Surrey, British Columbia). Les températures furent maintenues entre 20 et 22° C.

3.2 Protocole expérimental

Pour chacun des projets, les mesures anthropométriques des sujets incluaient les informations suivantes: âge, poids, grandeur, sexe et indice de masse corporelle (IMC).

Les sujets furent informés de ne pas boire de café ou toute autre boisson qui contenait de la caféine (ex.: boisson gazeuse avec cola, thé) et de ne pas fumer ou mâcher de tabac pour une période de deux heures avant la session d'enregistrement. Lors de la journée d'enregistrement, un des examinateurs demandait aux sujets s'ils avaient respectés les consignes d'inclusion.

Pour l'ensemble des projets, les sujets furent vêtus uniquement d'une jaquette en coton ayant une ouverture à l'arrière, sur la colonne vertébrale, et gardaient leurs sous-vêtements. Les mesures furent effectuées en plaçant les sujets en position de décubitus ventral sur une table chiropratique afin de faciliter l'accès à la région lombaire (L-4 et/ou L-5). La tête du sujet fut placée dans une position neutre en ajustant la pièce de la table qui soutenait la tête. Pour tous les projets, les sujets se levèrent de la table et revêtirent leurs vêtements après le dernier enregistrement. Les sujets furent remerciés d'avoir participé au projet.

3.3 Matériaux

3.3.1 Projet 1

Les caméras infrarouges qui mesuraient la TC transmettaient les données acquises directement dans le boîtier de la *Subluxation Station Insight 7000*™ (Mahwah, New Jerey, USA). Le protocole du traitement comprend l'utilisation de l'appareil « *Activator Instrument IV* ». Le niveau de force indiqué pour un ajustement lombaire était de 4 et la durée de l'impulsion était de 1.09 ± 0.08 à 1.32 ± 0.09 millisecondes, avec un déplacement axial de 1,62 mm et une force de 176N (Fuhr et Fischer, 2009).

3.3.2 Projet 2

Les caméras infrarouges qui mesuraient la TC transmettaient les données obtenues directement dans le boitier de la *Subluxation Station Insight 7000*™ (Mahwah, New Jerey, USA). Le protocole de l'évaluation était la méthode traditionnelle *Diversified.*

3.3.3 Projet 3

Les données furent obtenues avec un cardiofréquence-mètre (Suunto T6, Surrey, British Columbia, Canada). Ce cardiofréquence-mètre permettait de mesurer l'écart R-R dans l'analyse temporelle et spectrale de la VRC. Le protocole d'évaluation était l'utilisation des deux techniques chiropratiques utilisées précédemment, soit la méthode traditionnelle *Diversified* et le protocole du traitement utilisant un « *Activator Instrument IV* ». L'analyse fut exécutée avec un ordinateur personnel et un logiciel spécialisé de chez Kubios, Biosignal Analysis and Medical Imaging Group, Département de Physique, University of Kuopio, Kuopio, Finlande (Tarvainen and Niskanen; 2006).

3.3.4 Projet 4

Les caméras infrarouges qui mesuraient la TC, le long du rachis de C-1 à L-5, transmettaient les données obtenues directement dans le boîtier Myovision™ (Seattle, Washington, USA).

La fréquence cardiaque fut enregistrée par le cardiofréquence-mètre (Suunto T6, Surrey, British Columbia, Canada). L'analyse temporelle et spectrale de la VRC fut mesurée à partir du rythme cardiaque,

Le matériel biologique était le sang des participants qui fut analysé au laboratoire de l'hôpital St-Luc, Montréal, Québec H9R 4S3, par l'équipe du Dr. Lyne Labrecque, PhD. Une infirmière qualifiée et licenciée prélevait des échantillons de sang (10 ml par échantillon) pour la mesure des données biochimiques. La $PRCh_s$ fut prélevée dans un tube SST-jaune de 5 ml centrifugé 30 minutes après la coagulation. Le sérum fut décanté dans un tube de transport et congelé a -20°C pour être transporté sur glace sèche. L'IL-6 fut prélevée dans un tube lavande de 4 ml et le tube fut centrifugé à froid 30 minutes après le prélèvement. Le plasma fut décanté dans un tube de transport et congelé a -20°C pour être transporté sur glace sèche. Un numéro, plutôt qu'un nom, identifiait les sujets. Par contre, la date de naissance et le sexe des sujets étaient inscrits. Les différentes variables biologiques furent l'IL-6 et la PRC.

3.4 Procédures spécifiques relatives à la température cutanée

Tel qu'il fut démontré (Roy 2005), il est nécessaire de laisser la peau s'acclimater à la température de la pièce. Ces fenêtres de mesure se situent entre huit et 16 minutes ou 30 à 45 minutes et furent utilisées pour le projet 1. Pour tous les projets, les sujets durent se coucher en décubitus ventral et rester dans cette position, vêtus d'une jaquette avec ouverture vers l'arrière, avant que le début des enregistrements de température cutanée paraspinale. Une seule lecture fut effectuée par session afin de ne pas créer de stimulation cutanée en repassant les caméras. La période d'adaptation dont la fenêtre se situe entre huit et 16 minutes fut choisie pour les projets 2 et 4.

3.4.1 Procédure expérimentale spécifique

3.4.1.1 Projet 1

Les sujets se présentaient à la clinique. La rencontre commençait par la complétion des formulaires de consentement. Par la suite, les sujets devaient se dévêtir pour se couvrir d'une jaquette avec ouverture vers l'arrière. Les sujets passaient dans une salle de traitement et se couchaient en décubitus ventral pour une période minimale de 18 minutes ou une période maximale de 40 minutes, selon le groupe assigné. À partir de la 8^{e} minute ou de la 30^{e} minute, la TC était mesurée aux étapes temporelles suivantes: avant le traitement, lors du traitement et aux intervalles suivants après le traitement: 1^{e} minute, 3^{e} minute, 5^{e} minute et 10^{e} minute. Les mesures de la TC furent obtenues avec les caméras infrarouges. Toutes les températures furent enregistrées en degrés Fahrenheit.

L'évaluation du sujet était effectuée avec le protocole *d'Activator Methods* afin de vérifier la présence d'une dysfonction articulaire vertébrale. Le côté de la déficience pelvienne fut noté, ainsi que le côté de la dysfonction articulaire vertébrale. La déficience pelvienne se caractérise par l'apparence relative d'une jambe plus courte en décubitus ventral. Le côté où la jambe semble plus courte est considéré comme le côté où se situe la déficience pelvienne. Par la suite, les enregistrements pouvaient commencer. Les caméras infrarouges furent positionnées à 4 cm latéralement à l'apophyse épineuse postérieure du segment traité.

3.4.1.2 Projet 2

Les sujets se présentaient à la clinique. La rencontre commençait par la complétion des formulaires de consentement et le choix d'un billet qui permettait d'assigner les sujets de façon aléatoire. Par la suite, les sujets devaient se dévêtir pour endosser une jaquette avec ouverture vers l'arrière. Les sujets passaient dans une salle de traitement et se couchaient en décubitus ventral pour une période minimale de 8 minutes. A partir de la 8^{e} minute, la température cutanée paraspinale était mesurée aux étapes temporelles suivantes: avant le traitement, lors du traitement et aux intervalles suivants après le traitement: 1^{e} minute, 3^{e} minute, 5^{e} minute et 10^{e} minute.

3.4.1.3 Projet 3

Les sujets se présentaient à la clinique. La rencontre débutait par la complétion des formulaires de consentement. Par la suite, les sujets devaient se dévêtir pour se couvrir d'une jaquette avec ouverture vers l'arrière. Lorsque le sujet était en position debout, le cardiofréquence-mètre et la courroie à la poitrine furent installés en vue de mesurer la variabilité du rythme cardiaque. Une période d'adaptation de trois minutes était d'abord allouée. Les cinq minutes suivantes, qui précédaient la manipulation vertébrale, permettaient d'enregistrer les mesures de VRC pré-manipulation. À partir de la 8^{e} minute, le sujet recevait une manipulation vertébrale. Par la suite, il y avait une autre période d'enregistrement de la VRC post-traitement.

3.4.1.4 Projet 4

Les sujets se présentaient pour une première session d'enregistrement. La rencontre commençait par la complétion des formulaires de consentement, suivie du questionnaire Oswestry sur les activités quotidiennes d'une personne souffrant de douleurs lombaires. Par la suite, il y avait la prise de sang. Un prélèvement sanguin de 10 ml était effectué afin d'analyser l'IL-6 et la PRC, suivi de la prise des radiographies dynamiques. La prise de radiographies dynamiques servait à évaluer les dysfonctions vertébrales. Le tout était suivi de l'installation du cardiofréquence-mètre pour mesurer la variabilité du rythme cardiaque. Par la suite, les sujets se couchaient en décubitus ventral pour une période minimale de 8 minutes. Ceci se poursuivait par une période d'adaptation de trois minutes. Les cinq minutes suivantes permettaient d'établir les mesures de VRC pré-manipulation. À partir de la 8^{e} minute, la température cutanée paraspinale était mesurée. Cela représentait la fin des enregistrements et les sujets étaient remerciés.

Les sujets du groupe témoin étaient soumis à la même procédure que lors de la première évaluation du groupe traitement.

Le traitement commençait alors avec l'accord des patients du groupe traitement. Avant chaque intervention en clinique, les sujets furent interrogés sur leur état de santé. Les traitements furent exécutés à l'aide d'un appareil à impulsion (*Activator IV*), tel que mentionné plus tôt. Les sujets du groupe traitement reçurent neuf traitements et participèrent en tout à 11 visites. Après le dernier traitement, le patient avait un rendez-vous pour réévaluation complète, comme à la première visite.

Le patient complétait le questionnaire Oswestry, puis un deuxième prélèvement sanguin était effectué, suivi de la réévaluation radiologique puis de l'installation du cardiofréquence-mètre et de l'évaluation par caméras infrarouges. Les sujets furent remerciés d'avoir participé à l'étude et quittèrent la clinique. Les données recueillies électroniquement furent transférées dans une base de données pour analyse ultérieure.

Pour le groupe témoin, il n'y avait aucune intervention pour la période de deux semaines. Les sujets prenaient un rendez-vous après leur visite initiale en vue d'une réévaluation complète qui se situait à la fin de la période de deux semaines du groupe traitement. Cela représentait la fin de l'expérience et les sujets étaient remerciés.

CHAPITRE IV

MANUSCRIT PUBLIÉ

EFFECTS OF A MANUALLY ASSISTED MECHANICAL FORCE ON CUTANEOUS TEMPERATURE

Ce chapitre est la version publiée de l'article mentionné dans le titre du chapitre.

Le projet consistait à évaluer l'effet d'un traitement chiropratique sur la TC de deux groupes de patients sans douleurs. Les deux groupes étaient évalués sur deux périodes différentes d'adaptation. Les périodes d'adaptation à la température de la pièce étaient de 8 minutes ou de 30 minutes. Ceci nous permettait d'évaluer deux critères. D'abord, est-ce que le traitement chiropratique a un effet sur la TC et deuxièmement, est-ce que la période d'adaptation est un élément dont on doit tenir compte? Nos conclusions sont que le traitement chiropratique à un effet sur la TC de patients sans douleurs et que la période d'adaptation de 8 minutes est la meilleure.

4.1 Page couverture du manuscrit

Effects of a manually assisted mechanical force on cutaneous temperature.

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4.2 Résumé du manuscrit

Abstract

Objective

Digitized infrared segmental thermometry (DIST) is a tool used for measuring cutaneous temperature (CT). This project ascertains the effect of a manually assisted mechanical force producing a chiropractic adjustment in the lumbar spine after the Activator Methods Chiropractic Technique on CT during 2 different time recording periods (TRPs).

Methods

Sixty-six healthy subjects (36 women and 30 men) without acute low back conditions or symptoms were recruited. Subjects were randomly divided into 2 groups based on the length of the acclimatization period (8 or 30 minutes; TRP_8 and TRP_{30}, respectively). In turn, each recording period group was divided into 3 subgroups (n = 11 per subgroup): treatment, sham, and control subgroups. Bilateral DIST was conducted at L-4 (TRP_{30}) and L-5 (TRP_8) using infrared cameras (Subluxation Station Insight 7000; Chiropractic Leadership Alliance, Mahwah, NJ).

Results

Before treatment ($t_{-0\,5}$), the TRP_8 CT was significantly different between the ipsilateral and the contralateral sides for all subgroups. At 10 minutes (t_{10}) after intervention, CT increased significantly ($P < .05$) for the treatment group but not for the sham and control groups. In contrast, there were no significant differences in the TRP_{30} CT before treatment between the ipsilateral and the contralateral sides; but at t_{10}, CT was significantly ($P < .05$) greater for all 3 subgroups compared with preintervention CT.

Conclusion

Contacting the skin with the instrument with (treatment group TRP_{30}) or without (sham group TRP_{30}) a thrust with a sustained pressure stronger than the loading principle taught in the Activator Methods Chiropractic Technique protocol or a thrust respecting the standard loading principle (treatment group TRP_8) of the instrument produced a CT cooling immediately after the adjustment. Furthermore, we observed that when contacting the skin with the instrument with a thrust respecting the standard loading principle (treatment group TRP_8) of the instrument, it produced a secondary cooling at t_5 followed by a rewarming at t_{10}. Finally, contacting the skin with the instrument without a thrust and respecting the standard loading principle (sham TRP_8) of the instrument did not produce a CT change.

Key Indexing Terms: Manipulation; Chiropractic; Thermography

Roy RA, Boucher JP and Comtois. AS. Effects of a manually assisted mechanical force on cutaneous temperature. J Manipulative Physiol Ther 2008;31:230

4.3 Corps du texte du manuscrit

4.3.1 Background

Cutaneous temperature (CT) is an intrinsic part of the body temperature complex. It is a function of the body temperature and is precisely regulated by supraspinal centers and the sympathetic nervous system (Massett et al., 2000; Tortora et Grabowski, 2001; Leach, 2004; Bicego, Barros et Branco 2007). In chiropractic medicine, paraspinal CT evaluation has been in use since 1924 (Ebrall, 2004; Leach, 2004). Studies using thermography recordings to investigate CT have shown that there are temperature gradients along the length of the spine (Feldman et Nickoloff , 1984; Uematsu et al., 1988a; Uematsu et al., 1988b; Oerlemans et al., 1999; Zhang, Kim and Cho, 1999; Herry et Frize, 2004; Roy, Boucher et Comtois 2006a). However, to our knowledge, there are no studies reporting measurements of spinal segmental CT and its relevance for chiropractic clinical application.

Recently, it has been shown that digitized infrared segmental thermometry (DIST) is valid (Roy, Boucher et Comtois 2006a) for measuring CT at the spinal level. It has also been shown that there are 2 stable time recording periods (TRPs) available to determine CT after the subjects acclimatized to the surrounding environment while resting prone on an examination table (Roy, Boucher et Comtois 2006b). A first period of paraspinal CT stabilization occurs between 8 and 16 minutes (TRP_8), while core temperature is still adapting to its environment; and a second occurs at 30 minutes (TRP_{30}), at which time core temperature is more stable. Therefore, there are 2 periods at which paraspinal CT can be reliably measured: TRP_8 and TRP_{30}.

It has been hypothesized that temperature differences from each side of the spine at the same segmental level, as noted with CT thermometry, may be indicative of somatospinal inconsistencies requiring a chiropractic adjustment (However, no specific values have been established for diagnostic purposes. Consequently, controversy still exists concerning the effects of chiropractic adjustments on CT and the clinical capacity to obtain valid measurements of CT changes.

The objective of the present study was to evaluate the effect of a manually assisted mechanical force (MAMF) chiropractic lumbar adjustment on CT during 2 different TRPs (8 and 30 min). In addition, CT on each side of the segmental level was evaluated to establish statistical differences that may be useful for diagnostic purposes.

4.3.2 Methods

4.3.2.1 Participants

The required number of subjects was calculated using the results from a previous study (Roy, Boucher et Comtois, 2006a). Based on an effect size of 0.25°F, a type I error of 0.05, and a power of 80% and according to Cohen's table (1969), 8 subjects per group was required. We elected to have 11 subjects per group. A total of 66 healthy subjects (36 women and 30 men) were recruited between July 2004 and July 2006 from a chiropractic clinic. The inclusion criterion was that all subjects were receiving maintenance chiropractic care and were pain free. In addition, all subjects were free of any underlying conditions (acute or chronic diseases, cold, menses, and/or any thermogenic disease) that could have affected their CT. Subjects were also instructed not to drink any coffee or any other beverages containing caffeine (eg, caffeinated soft drinks, tea) and not to smoke or chew tobacco at least 2 hours before the recording session. Compliance with the instructions was verified on the recording day. All subjects had been previously examined and radiographed. All subjects had 5 lumbar vertebrae. Subjects were also preselected according to the Activator Methods Chiropractic Technique protocol (AMCT) (Fuhr et al., 1997) for the presence of either an L-4 or L-5 subluxation.

Anthropometric characteristics of the subjects are shown in Table 4.1. The research protocols for the evaluation and adjustment were approved by the Université du Québec à Montréal ethics committee. Written informed consent was obtained from all subjects. There was no need for subject follow-up.

4.3.2.2 Experimental Conditions

Four independent variables or conditions were evaluated: periods, groups, sides, and tests. There were 2 between factors, periods (TRP_8 and TRP_{30}) and groups (control, sham, and treatment), and 2 within factors, sides (ipsilateral and contralateral) and tests (t_{pre}, t_0, t_1, t_3, t_5, and t_{10}). Subjects were randomly assigned to the recording period groups: TRP_8 and TRP_{30}. Each recording period group was divided into 3 subgroups (n = 11 per subgroup): treatment, sham, and control groups. There were 6 consecutive tests or time markers: before the intervention (ie, adjustment for the treatment groups and sham procedure for the sham groups) or t_{pre} (2 minutes before for TRP_{30} or t_{-2} and 30 seconds before for TRP_8 or $t_{-0.5}$); at the time of the adjustment (t_0); and 1, 3, 5, and 10 minutes after the adjustment (t_1, t_3, t_5, and t_{10}). The randomization was done by having each subject pick a number from a closed envelop. Each number was discarded after it had been picked by a subject. The participants were blinded to the intervention. Those administering the intervention were not blinded to the group assignment.

4.3.3.3 Measurements

All temperatures were recorded in degrees Fahrenheit using infrared cameras (IRCs) calibrated on-site using the manufacturer's procedure. The recording sites for both the TRP_8 and TRP_{30} groups were defined at the level of the lumbar spine: left and right L-5 for TRP_8 and left and right L-4 for TRP_{30}. To keep consistent half-inch distance between the IRC and the skin, as recommended by the manufacturer, wooden sticks (popsicle style)

were secured on each side of each IRC casing, one on the medial aspect and one on the lateral aspect. The CT was recorded by the Subluxation Station Insight 7000 (Chiropractic Leadership Alliance, Mahwah, NJ). All data were collected at room temperature in a normal clinical setting (one private clinic).

4.3.3.4 Limitations in the Thermal Measurements

There were no attempts to blind the thermal assessment because the data were recorded directly into the computer after each measurement. At each test or time marker, only 1 recording was taken. The examiner could not know the value during measurement. The risk of influencing thermal assessment was kept to a minimum by ensuring that the measurement protocol was respected by the examiner.

4.3.3.5 Interventions

Subjects of the groups received a standard AMCT evaluation; and subsequently, only the treatment groups received the usual treatment at L-4 (TRP_{30}) or L-5 (TRP_8). The side on which the adjustment was produced was considered the ipsilateral side for our recordings, whereas the opposite side was identified as the contralateral side. The subjects in the treatment group received a single thrust from the instrument and no other treatment. The MAMF was produced using an Activator Instrument IV at the indicated level 4 for the lumbar adjustment. The attending chiropractor held an advanced proficiency rating in AMCT (Fuhr et Pavia 2006). The treatment protocol followed the AMCT protocol for clinical application of the instrument (Fuhr et al., 1997). The instrument was loaded to engage the stylus, producing minimal tissue pull; and the handle was pressed to release the hammer and produce the adjustment for the TRP_8 and TRP_{30} treatment groups.

Subjects in the sham group only received application of the instrument loaded to engage the stylus producing maximal (TRP_{30}) or minimal (TRP_8) tissue pull or pressure. The AMCT instrument was placed on the evaluated site, producing a skin fold without the thrust or adjustment. As for the treatment groups, the side on which the sham procedure was applied was considered the ipsilateral side for our recordings, whereas the side opposite the procedure was deemed the contralateral side. The sham groups were included in this study to distinguish the effects of the pressure component, without adjustment, on CT. Subjects in the sham group were told that they had received no adjustment only after the recording session had been completed.

Subjects in the control group did not receive any treatment. They were evaluated, and the side that should be treated was noted. The side that should be treated was considered the ipsilateral side for our recordings, whereas the opposite side was considered as the contralateral side. A control group was included in this study to isolate the effect of the sham procedure and the treatment.

4.3.3.6 Experimental Procedures

When the subjects arrived for a recording session, they were asked to remove their clothing except underwear. They were provided with a cotton gown that had an open slit in the back. Subjects then proceeded to lie prone on an activator chiropractic table. The chiropractor evaluated the subjects according to the AMCT

protocol for the presence of a subluxation. The pelvic deficiency side and the side of the lumbar subluxation were both noted. Subjects remained in a prone position for the required acclimatization period they had been assigned, after which the recording session began. The DIST was used to measure CT on 6 consecutive tests or time markers: before the intervention (ie, adjustment for the treatment groups and sham procedure for the sham groups) or t_{pre} (2 minutes before for TRP_{30} or t_{-2} and 30 seconds before for TRP_8 or $t_{-0.5}$); at the time of the adjustment (t_0); and 1, 3, 5, and 10 minutes after the adjustment (t_1, t_3, t_5, and t_{10}). Subjects of the control groups were also tested 6 times respecting the same between-test delays. After the last recording (t_{10}), subjects were instructed to get up and get dressed and were thanked for participating in the study. Subjects in the control group proceeded to lie prone on an activator chiropractic table and did not receive any treatment. There was no protocol deviation, and there were no adverse events for all subjects throughout the study.

4.3.3.7 Statistical Analysis

Those assessing the outcomes were not blinded to group assignment. First, descriptive statistics (mean ± SD) were computed for all conditions. Afterward, a 4-way, periods by groups by sides by tests, factorial analysis of variance model with repeated measures on the last 2 factors (Winer, 1971), also referred to as a *split-plot factorial design*(Kirk, 1982), was used to compare all main effects and interactions. When the level of significant difference of $\alpha = .05$ was obtained, the Tukey honest significant difference post hoc test was performed to identify specific significant differences. The results are provided by giving the F ratio along with the obtained levels of type I error and statistical power. No other ancillary analysis was performed.

4.4 Results

Table 4.2 presents the results of the analysis of variance. Several significant differences were obtained and are presented in detail below. The side main effect ($F_{1, 60} = 41.763$, $P = .000$, power = 0.999) and the side by period interaction ($F_{1, 60} = 72.748$, $P = .000$, power = 0.999) yielded statistically significant differences. At the initial measurement (t_{-2}) for TRP_8, the ipsilateral side (side of the subluxation) was cooler by 2.34°F (±0.18°F) in average for all 3 groups (Figure 4.1A), that is, 3.0°F for the treatment group, 2.2°F for the sham group, and 2.3°F for the control group. Figure 4.1B (TRP_{30}) shows that there were no consistent between-group differences comparing the CT measurements of the ipsilateral and the contralateral sides.

Furthermore, the tests main effect ($F_{5, 300} = 10.548$, $P < .000$, power = 0.999) along with the tests by periods ($F_{5, 300} = 4.485$, $P < .001$, power = 0.970) and the different sides by tests (sides by tests: $F_{5, 300} = 4.899$, $P < .001$, power = 0.981; sides by tests by period: $F_{5, 300} = 3.683$, $P < .003$, power = 0.928; sides by tests by periods by groups: $F_{10, 300} = 2.016$, $P < .032$, power = 0.882) interactions were found to be statistically significant, revealing a different test adaptation from one side to the other and from one period to the other. For instance, Figure 4.2A, B shows the average CT measurements for the ipsilateral and contralateral sides of the treatment, sham, and control groups for TRP_8. The ipsilateral side (subluxation side on Fig. 4.2A) was cooler than the contralateral side (control

side on Fig 4.2.B). This difference holds true throughout the total recording period (from t_{-2} through t_{10}) and all groups. However, CTs in the sham and control groups from $t_{-0.5}$ to t_{10} appear almost identical on their respective sides, whereas the CT in the treatment group appears systematically lower. Specifically, the treatment group CT on the ipsilateral side showed an effect starting from t_0, whereas the contralateral side CT behaved similarly to the other groups while being slightly colder.

Figure 4.2C, D shows the average CT measurements taken from the ipsilateral and contralateral sides for the treatment, sham, and control group for TRP_{30}. There was a mix of temperature ranges with no consistent pattern, except for a warming trend starting at t_1 for all groups and on both sides. Figure 4.3 shows the groups by sides by tests information from TRP_8 and TRP_{30} expressed as the difference from the initial value at $t_{-0.5}$. For TRP_8, Figure 4.3A shows a cooling in the treatment group CT on the ipsilateral side at the moment of the adjustment. After the adjustment (after t_0), there was a warming over time on the ipsilateral side followed by a second cooling-warming sequence starting at t_5. However, the ipsilateral CT progression for the sham and control groups was almost identical. Figure 4.3B also illustrates that the contralateral side of the sham and control groups remained relatively stable. In the treatment group (Fig. 4.3B), there was a continued warming from t_0 until t_{10}. Figure 4.3C shows the effect of the treatment and sham groups for the TRP_{30} period. After t_0, there was a warming of the CT with time on the ipsilateral side. From t_1, the progression was very similar for all 3 groups and both sides. As shown in Figure 4.3D , all 3 groups expressed a similar CT pattern.

4.5 Discussion

The main finding is that an MAMF adjustment (treatment groups in both TRP_8 and TRP_{30}) as well as a sustained mechanical pressure, higher than what is recommended by the AMCT treatment protocol (sham group in TRP_{30}), produced an immediate cooling in CT followed by a normalization of the CT that takes place within 3 minutes after the adjustment. However, the CT adaptation in response to the adjustment during TRP_8 reveals 2 cooling-warming cycles: the first occurring between t_0 and t_3 and the second between t_3 ant t_{10}. Furthermore, when a mechanical pressure at the recommended level is applied (sham group in TRP_8), no CT adaptation is measured. This suggests that acute CT cooling may occur specifically in response to an MAMF adjustment executed as recommended, or because of a high and sustained pressure. The following discussion suggests the possible theories and mechanisms that may help explain the measured CT response or adaptation.

4.5.1 Physiological Responses to a Mechanical Stimulation

The initial decrease in CT on the ipsilateral side associated with the MAMF adjustment (treatment groups in both TRP_8 and TRP_{30}) and the sustained mechanical pressure (sham group in TRP_{30}) may be interpreted as a cutaneous circulation response to the mechanical stimulus that produces a change in the local blood flow. Blood flow has a thermoregulatory response that can vary by as little as 1 mL/100 g of skin to as much as 150 mL/100 g of skin (Ganong, 2005). The two reactions to a mechanical stimulus include a whitening reaction and a

reddening reaction (Guénard, 1996; Ganong, 2005). The whitening reaction is indicative of a contraction of the precapillary sphincters. This response appears after a light mechanical contact on the skin. This precapillary sphincter contraction reduces cutaneous blood flow and could be responsible for the cooling measured on the ipsilateral side.

The post adjustment (t_0 to t_3) warming on the ipsilateral side (Fig 3C) may be interpreted as a reddening reaction that appears when the skin is more firmly stroked, producing a longer-lasting effect. This whitening/reddening response has 3 stages: (1) the whitening reaction is the initial skin reaction produced by the mechanical deformation of the skin due to the adjustment or pressure application; (2) the reddening reaction is a capillary dilatation, a direct response to the mechanical thrust or pressure; and finally, (3) local swelling could ensue because of the increased permeability of the capillaries and venules. It is also important to note that reddening could appear because of arteriolar dilatation. This 3-stage response is a normal adaptive reaction to a mechanical stimulus applied to the skin and is considered the result of an axonal reflex (Guénard, 1996; Ganong, 2005).

According to Ganong, (2005) impulses from the sensory nerves are relayed antidromically along other branches of sensory nerve fibers. This could be a reaction of the skin as it receives a potent mechanical stimulus (Keller, Colloca et Fuhr , 2000): a prolonged mechanical stimulation (5 seconds) and 200 N in 1.0 millisecond, such as in the treatment group, or a prolonged mechanical stimulation (5 seconds) from the pressure application, such as in the sham group. According to Aller et al., (2007) mechanical energy can stimulate the endothelium, which plays an important role in regulating the vascular system. In addition, when stimulation is too strong, such as during a muscle spasm or sustained pressure, a generalized cutaneous vasoconstriction may occur in addition to the local 3-stage response. Therefore, a reactive hyperemia hypothesis could be considered. Accordingly, as the muscle spasms due to the adjustment subside, the amount of blood in the region's circulation is increased and reestablished after a period of occlusion. This cascade of events could also take place in the presence of a chronic vertebral subluxation complex.

The role of segmental sympathetic reactions could also be entertained. Studies by Sato and Swanson (1984) using an animal model and human studies by Budgell and Hirano (2001) demonstrated a sympathetic response after a vertebral lateral flexion movement was induced. Pickard and Wheeler (2001) investigated paraspinal muscle manipulation on the cat and determined that it is possible for sensory impulses to evoke visceral reflexes affecting the sympathetic nervous system. Such sympathetic nervous system reactions can help us understand the CT adaptation findings of this study. However, to confirm the herein suggested sympathetic reactions, other specific variables need to be measured, such as changes in heart rate variability by spectral analysis known to be associated with these reactions (Kurvers et al., 1996; Sabharwal et al., 2004).

4.5.2 The Physiological Immunological Response

Cooling at the time of the adjustment could be due to a compression of the local tissue reducing superficial blood flow as discussed. The rewarming of the area to its original level would be the expected response

after the release of the tissue tension from the adjustment. The tendency for the adjusted area to keep warming due to increased perfusion would be helpful because it would remove residual inflammatory metabolites from the chronic injury site. We must be aware that no known vasodilator nerve fibers extend to cutaneous vessels. The vasodilatation is possibly brought forth by a decrease in constrictor tone of the sympathetic nervous system as well as local production of vasodilator metabolites (H^+, K^+ADP, NO, and cytokines) (Kurvers et al., 1996; Ganong, 2005). Again, these hypotheses deserve scientific attention to be tested.

4.5.3 CT Adaptation to Thermoregulation Controls

Cutaneous temperature levels are directly related to thermoregulation functions (Guénard, 1996; Ganong, 2005). Thermoregulation functions are controlled by the optic nucleus of the hypothalamus (Tortora et Grabowski, 2001). The neurological influx from thermogenesis centers stimulates the sympathetic nerves connected to blood vessels (Tortora et Grabowski, 2001). The CT response can be seen as a 2-level assessment/reassessment of the individual temperature that implies the coordination of 2 control levels over time in the following fashion: (1) the acute CT normalization (from t_0 to t_3) is controlled locally through segmental reactions, as discussed above, whereas (2) the CT normalization occurring from t_3 to t_{10} may represent the implication of a higher center in the hypothalamus, which could produce a release of vasodilator metabolites.

We also suggest that the CT adaptations measured might have to do with axonal reflexes, the release of some type of chronic muscle spasm, as well as normal tissue response to mechanical stresses. However, the continued warming could receive regulation from either a neurological supraspinal control or a physiological cellular reaction from either the vascular or the immunological systems. We posit that the information generated by the MAMF adjustment could be modulated by any of the 3 systems previously mentioned.

Finally, a significant difference in CT between the adjusted (ipsilateral) and the nonadjusted (contralateral) sides was found in TRP_8. This difference could be associated with a normal blood perfusion of local tissues or with a segmental sympathetic reflex reaction mediated through skin sensory receptors in reaction to the tissue compression. Again, these hypotheses require further research.

4.5.4 Other Considerations

The CT measurements taken during TRP_8 appeared to be more susceptible to changes, demonstrating systematic side and treatment effects. Our results, taken at TRP_8, also show a consistent cooling of 2.34°F (±0.18°F) on the side of the subluxation. Hence, we recommend recording of CT measurements when the patient has acclimatized for 8 minutes in a controlled environment until the limit of the 8-minute recording period (TRP_8), which is the 16th-minute mark.

4.6 Conclusion

Contacting the skin with the instrument with (treatment group TRP_{30}) or without (sham group TRP_{30}) a thrust with a sustained pressure stronger than the loading principle taught in the AMCT protocol or a thrust respecting the standard loading principle (treatment group TRP_8) of the instrument produced a CT cooling immediately after the adjustment. Furthermore, we observed that when contacting the skin with the instrument with a thrust respecting the standard loading principle (treatment group TRP_8) of the instrument, it produced a secondary cooling at t_5 followed by a rewarming at t_{10}. Finally, contacting the skin with the instrument without a thrust and respecting the standard loading principle (sham TRP_8) of the instrument did not produce a CT change. At present, these findings do not imply clinical effectiveness. More research needs to be done to understand the neurological, vascular, and immunological mechanisms involved in the control of CT adaptations to external stimulation or dysfunction. Future research will bring both researchers and clinicians closer to a better understanding of the effects of chiropractic adjustments and their relationship to CT adaptations.

4.7 Acknowledgment

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4.8 Author's contribution

RAR carried out the conception, design and acquisition of data, analysis and interpretation of the data and was involved in the drafting of the manuscript. JPB carried out a review of the conception, design and acquisition of data, analysis and interpretation of the data and was involved in the drafting and revising of the manuscript for important intellectual content. ASC carried out a review of the conception, design and acquisition of data, analysis and interpretation of the data and was involved in the drafting and revising of the manuscript for important intellectual content and as well the supervision of physiological content.

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4.9 Tables

Table 4.1

Anthropometric measurement of the subjects

Groups	TRP_8			TRP_{30}		
	Treatment	Sham	Control	Treatment	Sham	Control
Weight (kg)	77.4 ± 12.6	65.4 ± 11.8	67.4 ± 13.6	68.1 ± 11.0	69.9 ± 16.2	69.3 ± 14.8
Height (m)	1.70 ± 0.1	1.60 ± 0.1	1.70 ± 0.1	1.70 ± 0.09	1.71 ± 0.1	1.66 ± 0.05
BMI	26.7 ± 3.8	24.7 ± 5.6	24.5 ± 3.9	23.5 ± 3.0	23.6 ± 3.4	25.0 ± 5.0

Values are expressed as mean ± SD.*BMI*, Body mass index.

Table 4.2

Analysis of variance table

Sources of variance	SS	DF	MS	F	*P*	Power
Between	2360.898	65				
P	0.137	1	0.137	0.004	.952	
G	1.671	2	0.836	0.022	.978	
P × G	102.460	2	51.230	1.362	.264	
Within	975.362	726				
S	201.616	1	201.616	41.763	.000	0.999
S × P	351.200	1	351.200	72.748	.000	0.999
T	9.595	5	1.919	10.548	.000	0.999
T × P	4.080	5	0.816	4.485	.001	0.970
S × T	2.169	5	0.434	4.899	.000	.981
S × T × P	1.631	5	0.326	3.683	.003	.928
S × T × P × G	1.785	10	0.179	2.016	.032	.882
Total	3336.260	791				

SS, Sums of squares; DF, degrees of freedom; MS, mean squares; F, F ratio; P, probability of type I error; P, period; G, group; S, sides; T, tests.

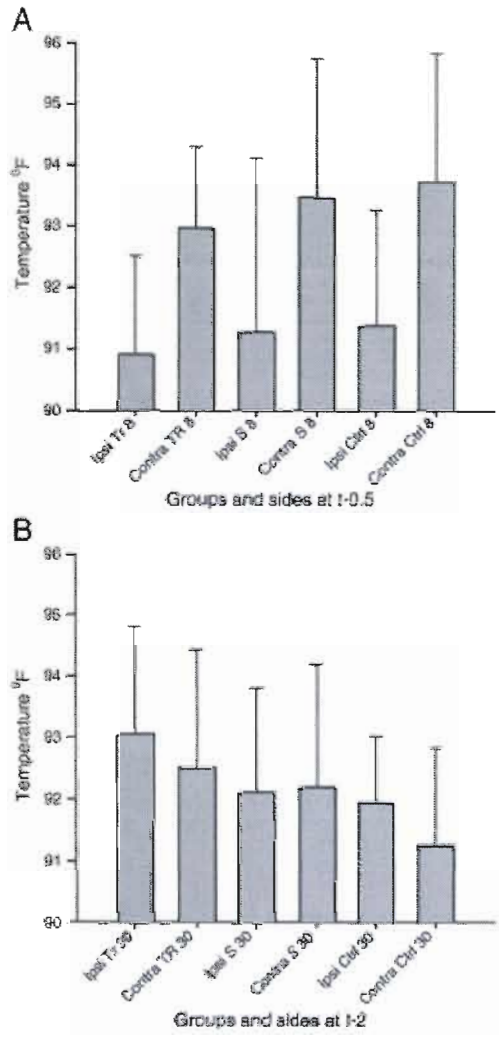

Figure 4.1.A Average Cutaneous temperature (CT) measurements at $t_{-0.5}$ expressed in degrees Fahrenheit of the ipsilateral and the contralateral sides of all 3 groups in TRP_8. Bars represent the standard deviation of all measurements recorded over the total recording period.

Figure 4.1.B Average CT measurements at t_{-2} expressed in degrees Fahrenheit of the ipsilateral and the contralateral sides of all 3 groups in TRP_{30}. Bars represent the standard deviation of all measurements recorded over the total recording period.

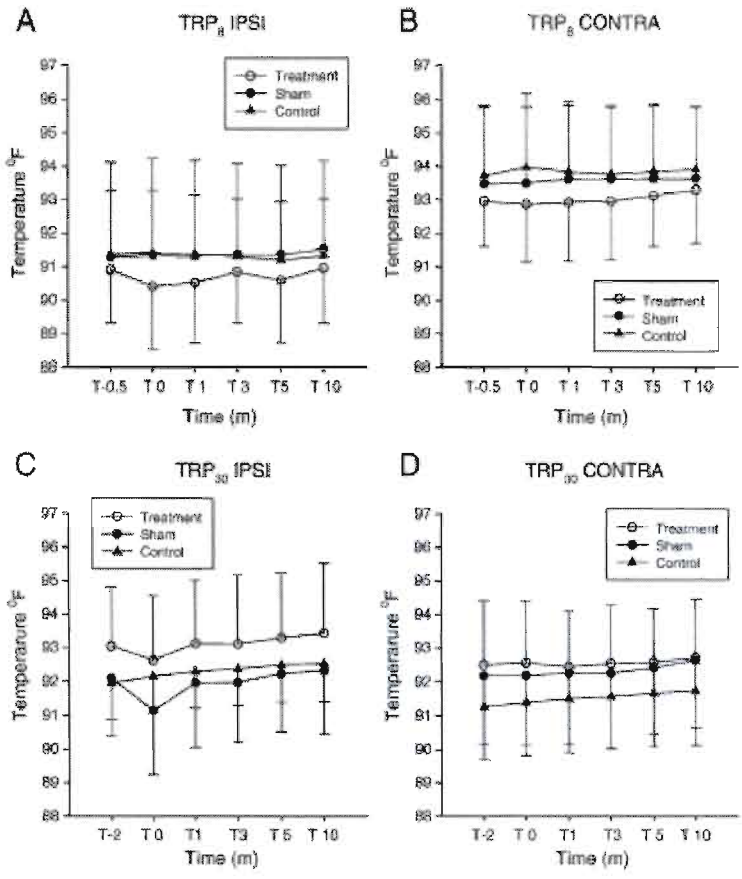

Figure 4.2 Average CT measurements for all the time sequences expressed in degrees Fahrenheit of the ipsilateral (A) and the contralateral (B) sides of all 3 groups in TRP_8. Average CT measurements for all the time sequences expressed in degrees Fahrenheit of the ipsilateral (C) and the contralateral (D) sides of all 3 groups in TRP_{30}. Bars represent the standard deviation of all measurements recorded over the total recording period.

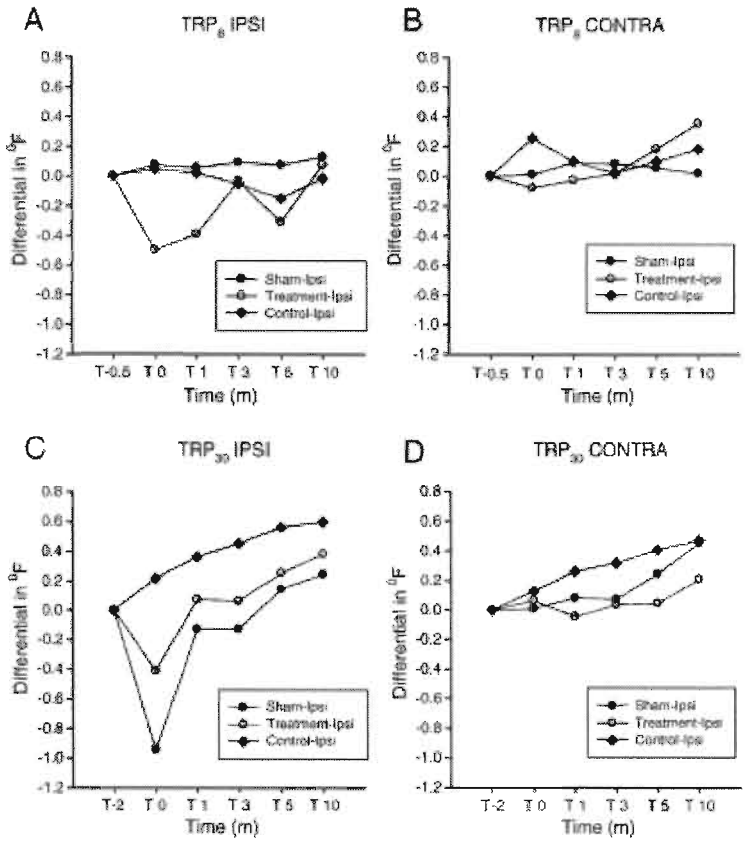

Figure 4.3 Average temperature differential of the CT in relation to the t−0.5 time sequence measurements for all the time sequences expressed in degrees Fahrenheit of the ipsilateral (A) and the contralateral (B) sides of all 3 groups in TRP8 and average temperature differential of the CT in relation to the t−2 time sequence measurements for all the time sequences expressed in degrees Fahrenheit of the ipsilateral (C) and the contralateral (D) sides of all 3 groups in TRP30. Bars represent the standard deviation of all measurements recorded over the total recording period.

CHAPITRE V

MANUSCRIT PUBLIE

PARASPINAL LUMBAR CUTANEOUS TEMPERATURE MODIFICATION FOLLOWING A SINGLE LUMBAR SPINAL MANIPULATION

Ce chapitre est la version de l'article accepté pour publication, mentionné dans le titre du chapitre.

Le projet consistait à évaluer l'effet d'un traitement chiropratique sur la TC d'un groupe de patients en douleurs. La période d'adaptation choisie est celle de 8 minutes. Ceci nous permettait d'évaluer s'il y avait un effet du traitement chiropratique sur la TC pour les patients en douleurs. Nos conclusions sont que le traitement chiropratique à un effet sur la TC de patients souffrants avec une période d'adaptation de 8 minutes.

5.1 Lettre de présentation

July 29th, 2009

JMPT Manuscript Processing Department

To whom it may concern:

Please find enclosed the manuscript entitled "Cutaneous temperature modification after a spinal manipulation." The manuscript has not been submitted elsewhere while it is being reviewed by the editorial board of your journal.

Thank you in advance for considering the manuscript for publication in JMPT.

Kindest regards,

Alain S. Comtois, Ph.D.

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5.2 Page couverture du manuscrit

Paraspinal lumbar cutaneous temperature modification following a single lumbar spinal manipulation

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Disclaimer: Nothing of value related to this research was received from a commercial entity.

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- A spinal manipulation creates a warming of the paraspinal cutaneous temperature;

- Thermometry is still in its infancy age and it is still considered a technology under investigation and it is different from thermography;

-Using thermometry has an evaluation tool will reveal pre and post changes. But whatever this information means, it is all speculation at the moment. None of the mechanisms are understood yet.

5.3 Résume du manuscrit

Abstract

Purpose: The purpose of this paper was to investigate local paraspinal cutaneous temperature (CT) modifications following spinal manipulative therapy at L-5.

Methods: Twenty subjects, suffering from an acute low back condition, were randomly assigned to either a treatment or a sham group (n = 10 per group). Subjects underwent an eight-minute acclimatizing period. Temperature was measured bilaterally with infrared cameras at the L-5 level. In the treatment group, a traditional lumbar roll technique with a pisiform contact on the ipsilateral mamillary of L-5 was executed, while with the sham group the same technique was used, but no thrust was applied. CT control (CTL) measurements were taken 2 mins before (t_{-2}) and immediately after the intervention (t_0) and at 1', 3', 5' and 10' post-intervention (t_1, t_3, t_5 and t_{10}, respectively).

Results: At t_0, CT in the treatment group on the treatment side (ipsilateral side) warmed up by 0.2 ^{0}F, while in the sham group there were no significant temperature modifications on either side. At t_3 relative to t_0, CT in the treatment group on the treatment side warmed by ~0.6 ^{0}F, while the contralateral side (non-treatment side) cooled. In the treatment group significant differences were noted between sides ($F = 13.36$, $p = 0.002$, $P = 0.932$) and sides*times ($F = 2.97$, $p = 0.016$, $P = 0.838$).

Conclusion: The effects of a lumbar spine manipulation appear noticeable by changes in paraspinal CT measurements at the level of L-5. However, the meaning and mechanisms of CT modifications at L-5 are still being investigated.

Key indexing term: Spinal Manipulation; Thermography; Diagnostic technique.

Roy RA, Boucher JP and Comtois, AS. Paraspinal cutaneous temperature modification after spinal manipulation at L5. J Manipulative Physiol Ther 2010;33:308-314.

5.4 Corps du texte du manuscrit

5.4.1 Introduction

The application of thermometry principles has been proposed as potentially useful in chiropractic medicine (Ebrall, 2004). It has recently been shown that paraspinal cutaneous temperature (CT) can be reliably measured clinically by thermometry under controlled conditions (Hart et Owens, 2004; Roy, Boucher et Comtois 2006a; Roy, Boucher et Comtois 2006b). Recently, a study, using a handheld thermographic scanner, evaluated the interexaminer and intraexaminer reliability where it was found to be very high (Owens et al., 2004). In another study (Roy, Boucher et Comtois 2006a), fifteen subjects were evaluated with 30 spot-shot repeated measures per day of recording (15 in the lumbar area at L-5 and 15 in the cervical area at C-5) on five different occasions and at different times of day, for a total of 2,250 recordings. The total of these recordings was used to establish infrared camera CT validity and reliability, were strong significant correlations between skin thermistors and infrared camera recordings at L-5 were established.

Optimal time period for CT measurement has also been a subject of interest. Hart and Owens (2004) have shown that a 16 minute acclimation period is necessary for the purpose of pattern analysis of paraspinal CT. In another study conducted by Roy, Boucher and Comtois (2006b), two stabilisation periods were identified as acceptable for adequate CT recordings, one occuring between minute 8 and 16 and a second between minute 30 and 45. Roy, Boucher and Comtois (2006b) proposed that for a clinical setting the 8 to 16 minute stabilisation period is more practical, but a controlled environment (stable room temperature, ~22 ± 1.0 C) is necessary to obtain valid and reliable recordings.

Thermometry based on paraspinal differences at the same segmental level has been proposed by several authors that it may be indicative of somatospinal inconsistencies requiring a chiropractic adjustment (Ebrall, 2004; Hart et Owens, 2004; Roy, Boucher et Comtois 2006a; Roy, Boucher et Comtois 2008). Several studies using CT thermography recordings have shown that there are temperature gradients along the length of the spine (Uematsu et al., 1988a; Uematsu et al., 1988b; Herry et Frize, 2002). However, to the best of our knowledge, there is one scientific study done with humans that have evaluated the effect of a spinal manipulative therapy on paraspinal CT. The study measured the effect of a manually assisted mechanical force on lumbar paraspinal CT using an instrument in order to limit the possible heat transfer from the clinician's hand unto the patient CT (Roy, Boucher

et Comtois, 2008). CT was modified following the intervention but mechanisms involved at this time are entirely speculative. In addition, a study by Harris and Wagnon (1987) has shown that a chiropractic adjustment can modify fingertip CT depending on the specific region of spine adjustment (C1-C7 and/or L4-L5). Thus, it appears that spinal manipulations can alter CT; however, the effects of these spinal manipulations are still unknown on lumbar paraspinal CT.

To this day new emerging technologies are being explored, such as visible and infrared light, microwaves, terahertz rays, and intrinsic and applied electric and magnetic fields (Wolbarst et Hendee, 2006). Also, the utilization of handheld thermometric equipment is well advertised and its use is empirical at best. In spite of this and as mentioned earlier, there is still a lack of concrete objective data in the scientific literature on changes to paraspinal CT procured by spinal manipulative therapy.

Nevertheless and as stated by Plaugher (1992), continued investigation is needed in the area of thermographic research. It has been proposed that future research should focus on thermography as a non-invasive outcome measure and improved interpreter reliability (Plaugher, 1992). Thus, based on the above succinct review of CT measurements in the field of chiropractic practice, the goal of the current study was to investigate the local CT modifications following spinal manipulative therapy at L-5. We hypothesized that spinal manipulation at the level of L-5 would modify the paraspinal CT.

5.4.2 Methods

5.4.2.1 Participants

The required number of subjects was calculated from a previous study (Roy, Boucher et Comtois 2006a). The following equation was used, from Cohen (1969), based on the statistic *d*, where:

x_1 = the average measurements in group 1

x_2 = the average measurements in group 2

SD_1 = the standard deviation in group 1

SD_2 = the standard deviation in group 2

$d = (x_1 - x_2) / \sqrt{(SD_1^2 + SD_2^2)/2}$.

The two averages used were 93.35 ± 2.06 and 91.54 ± 1.75 F. The difference of the averages gave 1.81 and both standard deviations were used in the above formula to calculate *d*.

$d = 1.81/1.91 \qquad d = 0.95$

Thus, the calculated Cohen's *d* was determined as 0.95. In our validity and reliability study (Roy, Boucher and Comtois 2006 a) with repeated measures, the R value (we also calculated but not published) was 0.81. This allowed us to calculate *d'* using the following formula:

$$d' = d \Big/ \sqrt{1 - R}$$

The resulting $d' = 2.17$.

Using Cohen's formula:

$$n = \frac{n_{d=0.01}}{100 \times d^2} + C$$

Where,

n = the number of subjects required,

$n_{d'=0.1}$ = the number of subjects for $d'=0.1$ which according to Cohen's table is 1571 for 80% power (0.80) or 2102 for 90% power (0.90),

C = 1 for an $\alpha = 0.05$

We obtained the resulting number of estimated subjects required for an n at power of 0.80 = 4 and for an n at a power of 0.90 = 6. In summary, Cohen's (1969) table was used, with $p = 0.05$ at a Power of 90%, and it was determined that a minimum of 6 subjects per group were necessary. Thus, we elected to have 10 subjects per group. Twenty subjects in all were recruited between the period of February 2006 and May 2006, twelve females and eight males. The subjects were suffering from an acute low back condition requiring chiropractic care. Anthropometric characteristics of the subjects are shown in Table 1. Subjects were randomly divided into two

groups (n=10 per group), a treatment group and a sham group. Ethics approval was obtained from the IRB of the Université du Québec à Montréal (UQAM). Informed written consent was obtained from all subjects.

The inclusion criteria were that all subjects be free of any underlying pathological conditions (acute or chronic diseases, cold, and/or any thermogenic disease) that could affect their CT outside of the condition requiring chiropractic care. The subjects were instructed not to drink any coffee or any other beverages containing caffeine (e.g.: caffeinated soft drinks, tea) and to abstain from smoking or chewing tobacco at least two hours prior to the recording session. In addition, female subjects were asked to present themselves at a later time if they were having their menses. On the day of recording, subjects were asked if they had complied with the inclusion criteria, if not they were asked to present themselves at a later time.

5.4.2.2 Experimental Conditions

The assessor (person setting the equipment and doing the recordings) was blinded to the allocation of the patients to different groups and did not interact with the patients or the clinician. The person administering the adjustment (clinician) was not blinded to the group assignment.

Two independent variables composed the research design: groups (Treatment and Sham) and sides (manipulation side identified as ipsilateral and non manipulation side identified as contralateral). Subjects of both groups received orthopedic, chiropractic and neurological evaluation, radiographs and history before the day of recording by the clinician, including motion palpation, static palpation, and range of motion. Subsequently, on the day of recording, after the acclimation period and the initial CT measurement, the subjects received a spinal manipulation at L-5, in the side posture. The technique utilized was a traditional lumbar roll, with a pisiform contact on the ipsilateral mamillary of L-5 (Esposito et Philipson, 2005). The site of interest was defined at the level of the lumbar spine, left or right L-5. The side of contact was always considered the ipsilateral side. This specific level was chosen because anecdotally, it is the articulation that is most often adjusted in cases of low back pain. The technique of spinal manipulation was the diversified chiropractic technique of the basic lumbar roll (Esposito et Philipson, 2005).

The sham group subjects were administered a five second pressure with the clinician's hand without the thrust associated with a spinal manipulation. Sham group subjects also lied in side posture for the sham treatment. A sham group was included in this study to distinguish the effect of a simple pressure from that of a spinal

manipulation on CT. The sham group was told that they had received no manipulation only after the recording session had been completed.

5.4.2.3 Measurements

The CT measurements were obtained with infra red cameras (Roy, Boucher et Comtois, 2006a). All temperatures were recorded in degrees Fahrenheit (°F). The infra red cameras were calibrated on site using the manufacturer's recommendations. The cameras used were not the rolling type cameras but the hand held square box like cameras. To introduce a constant half-inch distance between the infra red cameras lens and the skin surface, wooden sticks (Popsicle style) were secured to the side of each infra red camera casing. When the end tip on the Popsicle stick touched the skin the camera lens were half-inch away from the skin. This was a spot-shot at L-5. The subluxation protocol used was for the hand held non rolling instrument. The technician waited until the recording settled, as seen on the computer screen when the CT recording was done. That period of settling varied between five to 10 seconds. When the temperature settled on the screen the technician would then depress the recording pedal. The hand held units were held on the sides over the wooden sticks, in order to avoid heat transfer from the technician and affect the recordings. The target area was identified by the clinicians with two felt pen markings four inches lateral to the spinous process of L-5, outside the recording area of the lenses. The recordings were all done in the prone position and the treatment was in the side posture, it took less than 30 seconds for the subjects to return to the prone position form the side posture. CT was measured at the following six specific time points: before the spinal manipulation (t_{-2}) that served as a control (CTL) period, at the time immediately after the spinal manipulation (t_0), and 1, 3, 5, and 10 min after the spinal manipulation (t_1, t_3, t_5 and t_{10}, respectively).

Infrared cameras recorded directly into the Subluxation Station Insight 7000™ (Chiropractic Leadership Alliance, Mahwah, New Jersey, USA). All data were collected at a room temperature of 21.95 ± 1.0 °C (data not shown).

5.4.2.4 Experimental Procedures

When the subjects arrived for a recording session, the subjects were greeted, then completed and signed all the required documentation. The randomization of subjects was performed by having each subject pick a number from an envelope. Each number was discarded after it had been picked by a subject. The participants were aware of the intervention to come. They proceeded to the treatment room and donned a cotton gown that

had an opened slit in the back. The subject then proceeded to lay prone on a chiropractic table. The head was placed in a neutral position by adjusting the headrest portion of the table. The patient rested on a chiropractic table for eight minutes. Then the initial recording (t_2) was executed. After the initial recording, the chiropractor began the adjustment for the treatment group and the pressure for the sham group, of the pre-evaluated subjects, for an L-5 spinal dysfunction. Then, the spinal recording session continued. The total recording session lasted 10 minutes. After the last recording, the subjects were instructed to get up, get dressed and were thanked for their participation in the study. There was no protocol deviation. There were no adverse events for all subjects throughout the study.

5.4.2.5 Statistical analysis

Descriptive statistics (mean ± SD) were computed for all conditions. Then, a factorial Groups *Sides * Time ANOVA model with repeated measures (Kirk, 1982) was used to compare all main effects and interactions (SPSS 15.0, SPSS Inc. Chicago IL, United States). When the level of statistical significance established at α= 0.05 was obtained, Tukey's HSD post-hoc tests were performed to determine specific significant differences. The results are provided by giving the F ratio along with the obtained levels of type I error (p) and observed power (P). Subsequent to our initial analysis we performed a within subject ANOVA for each group, see Table 3 and 4.

5.5 Results

Table 1 presents the anthropometric representation of both groups. There were significant differences in age (p=0.04), weight (p=0.0004) and body mass index (p=0.002) between the groups, but there were no significant differences in height.

Table 2 presents ANOVA results from both groups. There were statistically significant differences (shown in bold characters) between CT taken on different sides ($F_{1, 18}$ = 13.363, p= 0.002, P= 0.932) and times ($F_{5, 90}$ = 3.238, p= 0.01, P= 0.872). There was a significant interaction between sides*time ($F_{5, 90}$ = 2.970, p= 0.016, P= 0.838. There were no significant differences between groups.

Tables 3 and 4 respectively illustrate the results of the ANOVA for the treatment and sham groups. Only the treatment group had significant side and side * time differences. Figure 1 presents the initial measurement at t_2 for each group and side. The side ipsilateral to the spinal manipulation, or subluxated side, was warmer than the

non-subluxated side for both groups, but the difference was not statistically significant. The sides are identified as ipsilateral and contralateral in relation to the side of subluxation. The sham group is cooler than the treatment group. The average CT at L-5 was 33.7 ± 0.90 °C for the treatment group and 32.98 ± 0.80 °C for the sham group (data not shown), but this difference was not statistically significant. Similarly, the response to the intervention seems non significant between groups, as demonstrated in Table 2. However, when we analyze each group separately, we can observe in Tables 3 and 4 the significant differences seen in the treatment group, but not in the sham group.

The average pre-intervention CT at L-5 for the treatment group was 92.67 ± 1.60 ^{0}F and for the sham group was 91.37 ^{0}F ± 1.42 (data not shown) and was not statistically different ($F_{1,5} = 1.493$, $p = 0.238$). Figure 1 shows CT (^{0}F) measurements over time (t_{-2}, t_0, t_1, t_3, t_5 and t_{10}) following the 8 min acclimation period. Figure 1 shows temperatures of the ipsilateral (manipulation side) and contralateral (non-manipulation side) sides at L-5 for both the treatment (Fig. 1A) and sham (Fig. 1B) groups. In the treatment group, the treated side was cooler by 0.46 ^{0}F immediately after the adjustment (t_1) and later warmed by 0.49 ^{0}F at the t_{10} mark in relation to t_{-2} and 0.95°F in relation to t_1, while the contralateral side cooled down for the entire recording period and at t_{10} was 0.17 °F cooler in relation to t_{-2}. Note that the asterisks represent significant differences for the time slots of sides * times interactions (see Table 2 and 3). In the sham group, both sides remained parallel to each other (Fig 1B). There was an initial warming from t_{-2} to t_0, which culminated in a total warming effect at t_{10} of 0.75°F and 0.76 ^{0}F, respectively for the ipsilateral and contralateral side. There were no significant differences for sides*times interactions.

Figure 2 shows CT measurements expressed as differential of temperature, in relation to the initial measurement at t_{-2}, over time (t_{-2}, t_0, t_1, t_3, t_5 and t_{10}) following the 8 min acclimation period. Figures 2A and 2B represent treatment and sham groups, respectively. In the treatment group (Figure 2A), there was a separation in the two curves, while in the sham group, the curves were almost superimposed. In the treatment group, the CT on the ipsilateral side was significantly greater at all iso-time points, except for t_{-2} and t_1, when compared to the contralateral side.

5.6 Discussion

The main finding was a significant change in CT in the treatment group on the ipsilateral side (treatment side) compared to the contralateral side (non-treatment side), (see Fig. 1A and table 3). This was in sharp contrast to the sham group, which showed similar, ipsilateral and contralateral CT responses following a sham intervention (see Fig. 1B and table 4). It was also observed that a warming of CT occurred in both the treatment and sham groups immediately after the intervention (t_{-2} to t_0). One possible explanation is that the initial post treatment rise in CT was probably due to heat transfer caused by the chiropractor's hand during the intervention. This point will be discussed later.

5.6.1 Treatment group

Figure 1A shows the results obtained from the spinal manipulation performed in a side posture position that appears to produce a warming effect on the ipsilateral side (treatment/adjustment side) and a cooling effect on the contralateral side. This observation represents a multiphasic CT response described as follows. A drop in CT was observed on the ipsilateral side one minute (t_1) after the intervention followed by a CT rise till t_3. At t_5 a second drop in CT was observed and again was followed by a continuous CT rise till t_{10}. This was typical on the ipsilateral side for every subject in the treatment group. On the other hand, the treatment group contralateral side had an opposite monophasic reaction that showed a constant CT decay until t_{10} when compared to the ipsilateral side. A possible explanation for the multiphasic CT reaction of the ipsilateral side is at least twofold. The first CT rise (t_1 to t_3) is probably a vascular reaction caused by the chiropractor's contact on the spine that compresses local tissues and causes a reactive/ischemic hyperemia upon contact release. A neurological sympathetic vascular reaction is also possible and there are probable links of both blood pressure and heart rate variability (BPV and HRV, respectively) modulations that can be linked to CT modifications (Lee et al., 2007; Roy, Boucher et Comtois, 2008). The second CT rise (t_5 to t_{10}) is most probably associated to a response release of cytokines and other pro and anti inflammatory mediators (Pedreira et al., 2006). The inflammatory response of the tissue is of great value, isolating the damaged area, mobilizing effector cells and molecules to the site, and in the later stages promoting healing (Pedreira et al., 2006). Thus, the multiphasic warming (t_3, t_5, t_{10}) measured by CT could be regulated by either a neurological supraspinal control, a physiological cellular reaction from the cutaneous or deep tissue blood vessels, or the immunological systems.

For clinicians, the warming measured by thermometry can reveal valuable information about tissue response following a manipulation. Briefly, the effect of the adjustment initially creates a reactive circulation (reactive/ischemic hyperemia) that may be a simple blood perfusion following applied pressure on the skin. The tendency of the adjusted area to continue warming is likely a positive inflammatory response reflex removing residues from the injured area via increased blood flow. CT changes might have to do with different factors, including axonal reflexes, the release of a chronic muscle spasm as well as a normal tissue response to mechanical stimulus ((Pedreira et al., 2006; Roy, Boucher et Comtois, 2008).

5.6.2 Sham group

Figure 1B shows that both the ipsilateral and the contralateral sides have similar CT for all iso-time points. Both sides warmed similar amounts after the sham treatment followed by a drop and rise in CT (t_1 to t_5), typical of a biphasic response. The ipsilateral side appears to be warmer, but this difference is not significant. Nonetheless, this could somehow be considered normalization (i.e., trending to values similar to the treatment group) after the application of the chiropractor's hand at the site of the adjustment. However, the contralateral side was not touched and also showed a normalization (warming) effect. Physiologically, as discussed in the treatment group section, there is a blanching/reddening effect. When tissues are compressed mechanically, there is a temporary lack of blood supply. When this mechanical deformation of the tissue is sustained, there is often a rebound perfusion effect to re-supply the area (reactive/ischemic hyperemia). It could also be a response from sensory receptors of the skin producing an axonal reflex associated with antidromic reaction from the cutaneous nerves (Massett et al., 2000; Sabharwal et al., 2004). Thus, the same mechanisms as discussed in the treatment group section could be involved, except for the fact that the CT response in the sham group is biphasic in contrast to the multiphasic response in the treatment group. Hence, there may be a lack of physiological cellular reactions (deep tissue blood vessels or immunological reactions) not brought about by the mock intervention in the sham group that characterised the latter CT response in the treatment group.

5.6.3 Pain free patients versus patient in pain

Comparing the present results, patients with an acute low back condition, with our previously published work (Roy, Boucher et Comtois 2008) where we studied patients without pain, we observed an opposite trend on the initial CT measurement. In the 2008 study, the ipsilateral side (subluxated side) was contacted by an

instrument (colder) and in the present study the contact was by hand (warmer), which is perhaps the reason for opposite CT responses at time 0 immediately following the intervention. This means, beyond any doubt, that a certain period of time is needed before making a post intervention evaluation, possibly 3 to 5 minutes.

As well, in the present study, CT was colder on the subluxation (ipsilateral) side in pain free patients with low back conditions necessitating support care. This raises the question that could it be possible that CT measurement may be valuable in the diagnosis of pain-free as well as painful conditions. CT monitoring throughout the entire treatment course for patients initially in pain to the later part of the treatment when patients are pain-free, but still subluxated, may indicate the possible need for care without the presence of pain while providing the diagnostic clues to pursue treatment. This is an interesting point of view, but firstly physiological mechanisms involved in CT changes must be identified. At the moment, more research is needed to observe changes over time associated with clinical correlations.

5.7 Limitations

This type of speculation, as discussed above, is an observation that cutaneous thermometry lacks sufficient research to understand all the underlying principles. In addition, since little is known about normal values for pain free subjects, it cannot be assumed at the moment that rewarming is neither beneficial nor detrimental. As well, a previously unmentioned objective in this study was an attempt to caution on the overuse, underuse or misuse of thermometry. Currently, research is being pursued to establish various CT parameters, including a paraspinal CT index that hopefully could be useful for any individual using thermometry.

5.7.1 Thermal measurements study limitations

There were no attempts to blind the assessor from the thermal assessment since the data were recorded directly into the computer after each measurement and the assessor needed to insure settling of the recording before depressing the recording pedal. Only one recording was taken at each measurement or time marker. The assessor could not know the value during measurement. The risk of influencing thermal estimation was minimized to nil by insuring outmost rigor of the measurement protocol by the assessor.

5.7.2 Subject cohort

The BMI (Table 1) for the sham group was significantly greater and could have been a factor for the lower initial pre-intervention CT, even though and as mentioned earlier, the average pre-intervention CT at L-5 was not significantly different between both groups (see results section). The sham group was also significantly older. This significance is important but perplexing, since according to Dufour et Candas (2007) older subjects and middle aged subjects should have a higher CT than younger individuals. Yet according to Wilson et al. (2004), a greater heat loss in older subjects could also indicate a possible cutaneous vasoconstrictor dysfunction resulting from an inability to prevent heat loss via skin that is typically associated with older subjects. Yet neither seems to apply in the present study, since CT analysis suggests that both groups are not statistically different (see Table 2) even though anthropometrically they are.

5.8 Conclusion

Contacting the skin with the hand with a sustained pressure produced an initial warming immediately after the contact. A spinal manipulation produced a cooling followed by a rewarming of the CT, as it was observed between t_1 and t_5. A secondary cooling at t_5 was followed by a rewarming at t_{10}. Mechanisms are still being investigated.

5.9 Competing Interests

The authors declare that they have no competing interests.

5.10 Author's contribution

RAR carried out the conception, design and acquisition of data, analysis and interpretation of the data and was involved in the drafting of the manuscript. JPB carried out a review of the conception, design and acquisition of data, analysis and interpretation of the data and was involved in the drafting and revising of the manuscript for important intellectual content. ASC carried out a review of the conception, design and acquisition of data, analysis and interpretation of the data and was involved in the drafting and revising of the manuscript for important intellectual content and as well the supervision of physiological content.

5.11 Acknowledgements

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5.13 Tables

Table 5.1

Anthropometric measurements by groups

	Treatment group	Sham group	Differential (Absolute)
Age (years)	35.7 ± 11.73	44.7 ± 9.8	9.0 ($p = 0.04$)
Height (m)	1.64 ± 0.06	1.60 ± 0.16	0.40 (NS)
Weight (kg)	60.68 ± 12.81	78.30 ± 13.62	17.62 ($p = 0.0004$)
BMI	22.38 ± 3.63	28.52 ± 5.64	6.14 ($p = 0.002$)

Values are mean ± SD; Differential are absolute values. BMI, body mass index; NS, non-significant.

Table 5.2

Analysis of Variance Groups *Sides * Time (both groups mixed)

Between-Subjects Effects						
Source	**SS**	**DF**	**MS**	**F**	**p**	**P**
Group	4.935	1	4.935	1.493	.238	
Within-Subjects Effects						
Source	**SS**	**DF**	**MS**	**F**	**p**	**P**
Sides	**33.227**	**1**	**33.227**	**13.363**	**.002**	**.932**
Sides * Group	3.978	1	3.978	1.600	.222	
Times	**8.351**	**5**	**1.670**	**3.238**	**.010**	**.872**
Times * Group	3.366	5	.673	1.305	.269	
Sides * Times	**3.249**	**5**	**.650**	**2.970**	**.016**	**.838**
Sides * Times * Group	1.903	5	.381	1.740	.134	

Bold characters indicate significant interactions. SS, sum of squares; DF, degree of freedom; MS, mean of squares; F, F-value; *p*, probability; P, power

Table 5.3

Analysis of Variance Treatment group only

Source	SS	DF	MS	F	p	P
sides	**30.100**	**1**	**30.100**	**10.961**	**.009**	**.837**
time	4.234	5	0.847	1.933	.107	
sides * time	**4.144**	**5**	**0.829**	**3.427**	**.010**	**.871**

Bold characters indicate significant interactions. SS, sum of squares; DF, degree of freedom; MS, mean of squares; F, F-value; *p*, probability; P, power

Table 5.4

Analysis of Variance Sham Group only

Source	SS	DF	MS	F	p	P
sides	7.105	1	7.105	3.191	.108	
time	**7.483**	**5**	**1.497**	**2.521**	**.043**	**.733**
sides * time	1.008	5	0.202	1.030	.412	

Bold characters indicate significant interactions. SS, sum of squares; DF, degree of freedom; MS, mean of squares; F, F-value; *p*, probability; P, power

5.14 Figure Legends

Figure 5.1 Cutaneous temperature (CT) measurements (°F) over time (t-2, t0, t1, t3, t5 and t10) following the 8 min acclimation period. Average contralateral and ipsilateral temperatures at L-5 for the treatment (1-A) and sham (1-B) groups. The asterisks are in the time slots that correspond to the significant sides*times interactions for the treatment group only. Filled symbols indicate treatment side CT measurements (Ipsi, ipsilateral side); Empty symbols indicate opposite to treatment side CT measurements (Contra, contralateral side). CTL, control period of 2 min before the chiropractic or sham intervention (t_{-2}).

Figure 5.2 CT measurements expressed as differential of temperature in relation to t-2, (°F) over time (t-2, t0, t1, t3, t5 and t10) following the 8 min acclimation period for the treatment (2-A) and sham (2-B) groups. The asterisks are in the time slots that correspond to the significant sides*times interactions for the treatment group only. Filled symbols indicate treatment side CT measurements (Ipsi, ipsilateral side); Empty symbols indicate opposite to treatment side CT measurements (Contra, contralateral side). CTL, control period of 2 min before the chiropractic or sham intervention (t_{-2}).

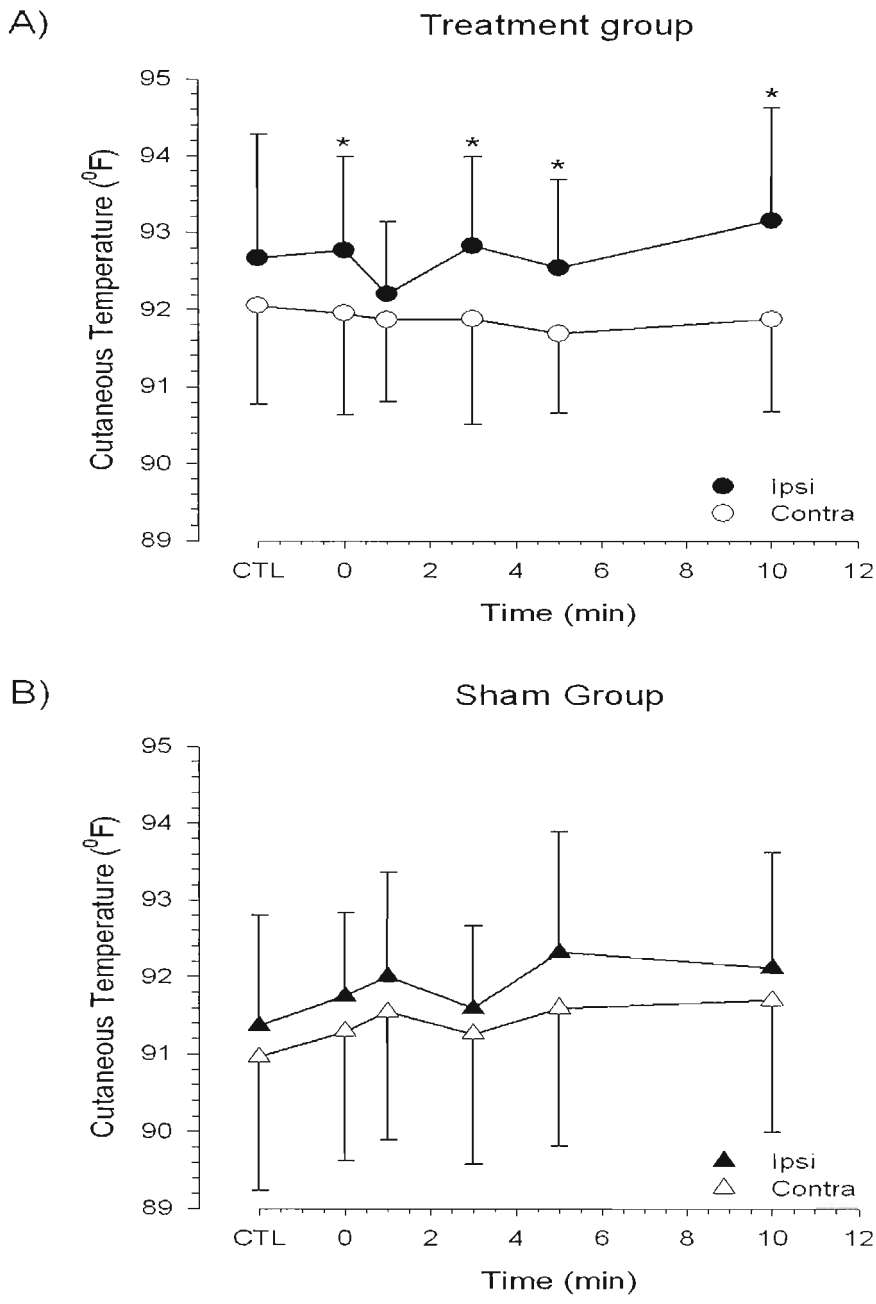
A)
Treatment group
Cutaneous Temperature (°F)
95
94
93
92
91
90
89
*
*
*
*
Ipsi
Contra
CTL
0
2
4
6
8
10
12
Time (min)
B)
Sham Group
Cutaneous Temperature (°F)
95
94
93
92
91
90
89
Ipsi
Contra
CTL
0
2
4
6
8
10
12
Time (min)

Figure 5.1

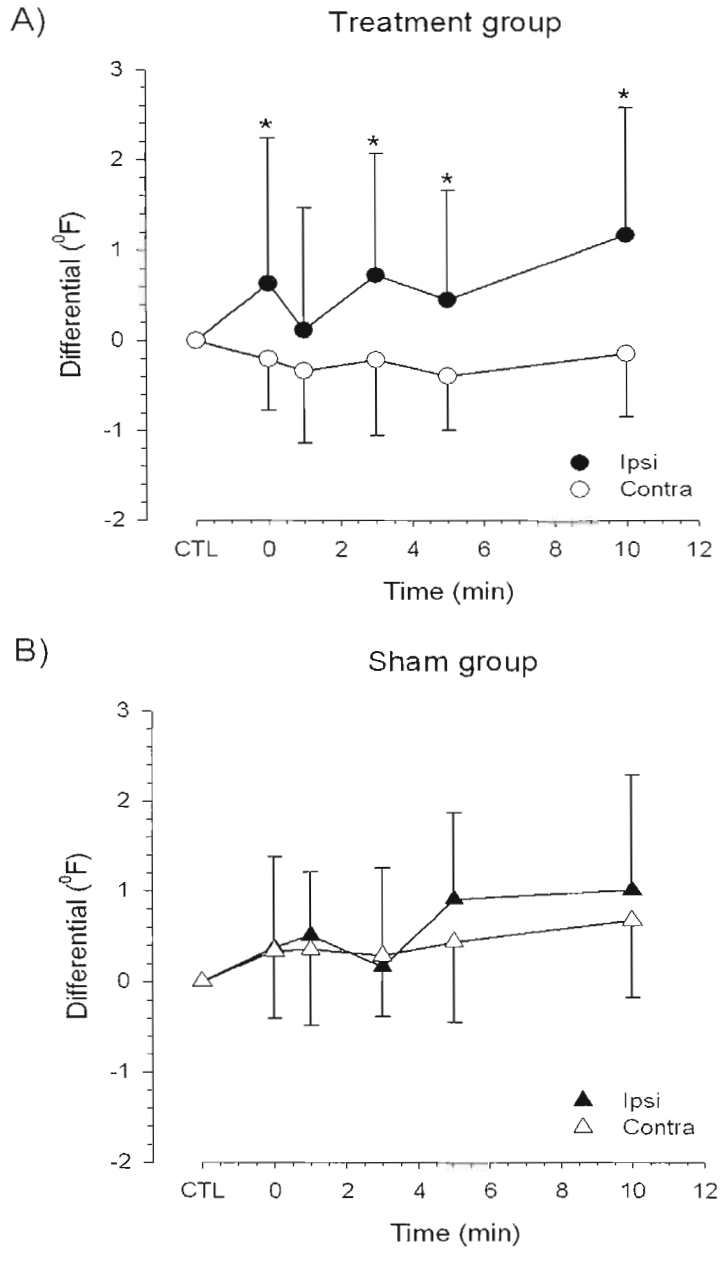
A)
Treatment group
Differential (°F)
3
2
1
0
-1
-2
*
*
*
*
Ipsi
Contra
CTL
0
2
4
6
8
10
12
Time (min)
B)
Sham group
Differential (°F)
3
2
1
0
-1
-2
Ipsi
Contra
CTL
0
2
4
6
8
10
12
Time (min)

Figure 5.2

CHAPITRE VI

MANUSCRIT PUBLIÉ

HEART RATE VARIABILITY MODULATION FOLLOWING MANIPULATION IN PAIN FREE PATIENTS VERSUS PATIENTS IN PAIN

Ce chapitre est la version publiée de l'article mentionné dans le titre du chapitre.

Le projet consistait à évaluer l'effet d'un traitement chiropratique sur la VRC sur deux groupes de patients: un groupe avec douleurs et un groupe sans douleur. Les deux groupes étaient évalués sur la même période d'adaptation. Les périodes d'adaptation à la température de la pièce étaient une période de trois minutes et une période d'enregistrement de cinq minutes suivies du traitement et d'une autre période d'enregistrement de cinq minutes. Ceci nous permettait d'évaluer les différentes mesures de la VRC sur les deux groupes et de comparer l'effet de traitements chiropratiques sur les groupes. Nos conclusions sont que le traitement chiropratique lombaire a créé une augmentation de la basse fréquence et une diminution de la haute fréquence de la VRC de patients. La réaction des deux groupes peut être considérée un réflexe supraspinal.

6.1 Lettre de présentation

September 9th, 2008

Journal of Manipulative and Physiological Therapeutics

Manuscript Processing Department

Dear Dr. Johnson:

Please find enclosed the manuscript entitled *"Heart rate variability modulation followinga manipulation in pain free patients versus patients in pain"*

The manuscript has not been submitted elsewhere while it is being reviewed by the editorial board of your journal. It is the resultant amalgamation of the two previous manuscript we submitted in July 2008.

Thank you in advance for considering the manuscript for publication in JMPT.

Kindest regards,

Dr Richard Roy, Dc, MSc, PhD (c)

6.2 Page couverture du manuscrit

Heart rate variability modulation following manipulation in pain free patients versus patients in pain

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Disclaimer: Nothing of value related to this research was received from a commercial entity.

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PRACTICAL APPLICATIONS

- Patients in pain and pain free patients may react differently to chiropractic care
- Touch may be an ingredient that alters heart rate variability
- Heart rate variability is still limited in its chiropractic clinical use

6.3 Résumé du manuscrit

ABSTRACT

Background: The purpose of this study was to examine heart rate variability (HRV) in the presence or the absence of pain in the lower back, while receiving one chiropractic treatment at L5 from either a manually assisted mechanical force (Activator) or a traditional diversified technique spinal manipulation.

Methods: A total of 51participants were randomly assigned to a control (n=11), 2 treatment or 2 sham groups (n = 10 per group). Participants underwent an eight-minute acclimatizing period. The HRV tachygram (RR interval) data were recorded directly into a Suunto watch (model T6). We analyzed the five minute pre-treatment and post treatments intervals. The spectral analysis of the tachygram was performed with Kubios software.

Results: All groups decreased in value except the control group which reacted in the opposite direction, when comparing the pre and post tests for the high frequency component. The very low frequency increased in all groups except the control group. The low frequency decreased in all groups except the sham pain free group. The low frequency/hi frequency ratio decreased in the treatment pain group by 0.46 and in the sham pain free group by 0.26. The low frequency/high frequency ratio increase was 0.13 for the sham pain group, 0.04 for the control group and 0.34 for the treatment pain free group. The mean R-R increased by 11.89 ms in the sham pain free group, 18.65 ms in the treatment pain group and 13.14 ms in the control group. The Mean R-R decreased in the treatment pain free group by 1.75 ms and by 0.01 ms in the sham pain group.

Conclusion: Adjusting the lumbar vertebrae affected the parasympathetic nervous system output for this group of participants. The output was reflected by a lowering of the high frequency and an increase of the low frequency, this output differences found in the modulation of the HRV would seem to be related to the presence or absence of pain. The autonomic nervous system response may be specific and sensitive to its effectors organ.

Key indexing term: Chiropractic; Heart Rate; Manipulation, Spinal.

Roy RA, Boucher JP and Comtois.

Heart rate variability modulation in pain-free patients vs patients in pain. J Manipulative Physiol Ther 2009:32:277-286.

6.4 Corps du texte du manuscrit

6.4.1 Introduction

In the past, the chiropractic profession has utilized research results from other fields of research (Windsor, 1921; Ussher, 1933) on the autonomic nervous system and extrapolated them into its science and clinical interpretation (Windsor, 1921; Ussher, 1933; Wiles, 1989). More recently, chiropractic researchers looked into autonomic nervous system (ANS) adaptations in an animal model following a mechanical stress to the spinal column (Sato et Swenson, 1984), a noxious mechanical stimulation (Sato et Neru, 1976) or a spinal manipulation (DeBoer, Schultz et McKnight, 1988).

In the human model, several investigations have been done to measure modifications of heart rate variability (HRV) following cervical (Budgell et Hirano, 2001) and thoracic manipulations (Budgell et Polus, 2006) or in a multisite clinical study (Zhang et al., 2006) where details of the manipulation site were not provided. In these studies (Budgell et Hirano, 2001; Budgell et Polus, 2006; Zhang et al., 2006), changes were observed in various HRV variables, while in two of those studies (Budgell et Hirano, 2001; Budgell et Polus, 2006), where sham groups were included; the sham conditions did not demonstrate any changes in the reported HRV parameters. There are strong indications that HRV is a good marker of ANS activity (Kitney et Rompelman, 1980; Bonaduce et al., 1994; Fishman, Turkheimer et De Good , 1995; Taylor et al., 1998; Martinma et al., 2006). Thus, in the three above mentioned studies, it appears that chiropractic interventions have an effect on the ANS. At present, however, no studies to evaluate whether a lumbar spinal manipulation would produce a change in the HRV have been reported. Thus, the purpose of the present study was to measure the effect of a lumbar adjustment, with a manually assisted mechanical force, producing a chiropractic adjustment, in participants without lumbar pain or a diversified technique lumbar roll traditional adjustment in participants with lumbar pain on HRV. The hypothesis being that a lumbar intervention would have an acute effect on the ANS and demonstrate changes in the modulation of HRV variables.

6.4.2 Methods

6.4.2.1 Participants

A total of 51 participants were recruited between the period of February 2006 and May 2006. For sample size determination, we considered alterations in physiological responses (Fuhr et al., 1997); where it was established in nine participants.

Therefore we established our cohort at 20 participants, ten participants per sub group and ten participants in the control group. Anthropometric characteristics of the participants are shown in Table 6.1. The research protocols for the evaluation and adjustment were approved by the Université du Québec à Montréal ethics committee. This study was registered with clinicaltrials.gov, registration number NCT00740558. Written informed consent was obtained from all participants. None of the participants received a chiropractic adjustment one week prior to this study. None of the participants were students from the University.

The participants were blinded to the intervention but considering that they were already chiropractic patients, the patients in the sham groups would mention that the treatment felt different. The Activator Methods sham treatment was only the application of the instrument on the skin while in the other hand another instrument was fired by the chiropractor. In the case of the lumbar roll, the patient was in the side posture and the chiropractor applied pressure with his treatment hand but no thrust was generated.

Those administering the intervention were not blinded to the group assignment. The researchers were not blinded to which group patients belonged when measuring outcomes. Data from the pain free group were collected at one location and the pain group data were collected at a different location, both in the same city.

6.4.2.1.1 Pain Free Group

A total of 33 healthy participants, 18 females and 15 males, were recruited from a chiropractic clinic between February 2006 and May 2006. The inclusion criterion was that all participants were receiving maintenance chiropractic care and were pain free. Exclusions criteria were any patients with pain. All participants had been previously examined and radiographed.

Participants were also pre-selected according to the Activator Methods Chiropractic Technique protocol (AMCT) 16 for the presence of an L-5 spinal dysfunction. They were divided in 3 groups, control, sham and treatment.

6.4.2.1.2 Control Group

The control group was formed from the participants of the pain-free group, as described above. The participants of the control group were receiving maintenance chiropractic care and were pain free.

6.4.2.1.3 Pain Group

Twenty participants were recruited, 12 females and eight males, were recruited from a different chiropractic clinic between February 2006 and May 2006. The inclusion criteria were that all participants were suffering from an acute low back pain and were receiving chiropractic care. Exclusions criteria were any patients without pain.

The definition of acute low back pain was as defined by the North American Spine Society as, "Low back pain present for up to six weeks. It may be experienced as aching, burning, stabbing, sharp or dull, well-defined, or vague. The intensity may range from mild to severe and may fluctuate. The pain may radiate into one or both buttocks or even into the thigh/hip area." All participants had been previously examined and radiographed. Participants were also pre-selected for the presence of an L-5 spinal dysfunction. The evaluating chiropractor used static and dynamic palpation, range of motion, physical, neurological, orthopaedic and chiropractic examinations in conjunction with radiographs. They were divided in a sham and treatment group.

6.4.2.2 Subject Group Assignment

In the pain-free group, participants were randomly assigned into three subgroups (n=11 per subgroup): treatment, sham and control groups. In the pain group, participants were randomly assigned into two subgroups (n=10 per subgroup): treatment and sham groups. For all participants, there was no need for a follow-up.

The randomization was done by having each subject pick a number from a closed envelop and they were assigned to a specific group according to the number they picked. Each number was discarded after it had been picked by a subject. The participants were blinded to the intervention. Those administering the intervention were not blinded to the group assignment.

6.4.3 Spinal Dysfunction Assessment

The spinal dysfunction assessments were determined by the Activator Methods evaluation (Fuhr et al, 1997) by the treating clinician for the pain free group. The assessments for the pain group receiving the diversified technique lumbar roll traditional manipulation (Esposito et Philipson, 2005) was assessed by motion palpation by the treating clinician. These assessments were completed prior to the adjustment on the day of treatment, but after the other examinations mentioned previously.

6.4.4 Chiropractic Techniques

In the pain free group we utilized the Activator Methods protocol, by determining the pelvic deficiency side and evaluating the patient for the presence of an L-5 spinal dysfunction. The treatment was executed using an Activator Adjusting Instrument, namely the Activator IV (Activator Methods, Phoenix, AZ) at the number four setting, representing an average force of 174.75 Newton (N) (Fuhr et al. 1997).

In the pain group the chiropractor used the diversified technique type lumbar roll as demonstrated in Esposito, 17 from the traditional chiropractic style manipulation. The chiropractor determined the area to be treated by motion palpation, static palpation and prior evaluations as mentioned above. The adjustment force as been described and averages 264 N (Kawchuk et al, 2006).

6.4.5 HRV Measurement and Analysis

A commercially available heart rate monitor (Suunto watch, model T6, Fitz Wright Company Ltd., Langley, BC, Canada) was used since R-R measurements obtained with that type of monitor were compared against a "Holter" recorder and were shown to be in good agreement (Kingsley, Lewis et Marson, 2005; Gamelin, Berthoin et Bosquet, 2006; Gamelin et al., 2008). The recordings obtained from the heart rate monitor were analyzed for the five minute pre-treatment and post treatments intervals.

The analysis was performed with a personal computer using custom software (Kubios, Biosignal Analysis and Medical Imaging Group, Department of Physics, University of Kuopio, Kuopio, Finland) (Tarvainen et Niskanen; 2006) for several HRV parameters, as described below.

Furthermore, as mentioned above, there were no attempts to blind the assessors since the data were recorded directly into the heart rate monitor. The risk of influencing HRV was kept to a minimum by insuring that

the interaction, between the subject and the examiner, was limited to the intervention in the treatment and sham groups and to no intervention in the control group.

6.4.5.1 Variables

The following variables were evaluated for both groupings: for the time domain analysis we have the mean R-R interval (Mean RR), the R-R intervals standard deviation (SDNN), the number of pairs of adjacent NN intervals differing by more than 50 ms (NN 50 Count), and the proportion of NN intervals differing by more than 50 ms (pNN 50% = NN50 divided by total number of NN intervals).

For the frequency domain analysis, we have the very low frequency (VLF) band of the R-R interval recording that was also quantified by normalizing the spectral components between 0 and 0.04 Hz and adding them. Similarly, the normalized spectral components between 0.04 and 0.15 Hz were summed and referred to as the low frequency (LF) band. For the high frequency (HF), the normalized spectral power components were summed between 0.15 and 0.4 Hz. Then, the LF/HF (Gamelin, Berthoin et Bosquet; 2006) ratio was calculated. The HF band is known to be related to the parasympathetic nervous system efferent activity22 and is synchronized with respiratory rhythms (Gamelin, Berthoin et Bosquet; 2006). The LF band is related to both the sympathetic nervous system and parasympathetic nervous system efferent activity 10 and the cardiac sympathetic and parasympathetic nerve activity (Gamelin, Berthoin and Bosquet; 2006). The VLF band is not well defined, but appears to be related to thermoregulation (Fishman, Turkheimer et De Good , 1995; Taylor et al., 1998; Gamelin, Berthoin and Bosquet; 2006) renin-angiotensinaldosterone system (Bonaduce et al., 1994, Fishman, Turkheimer et De Good , 1995), and parasympathetic mechanisms (Taylor et al., 1998). Furthermore, both the parasympathetic (Taylor et al., 1998) and sympathetic branches of ANS affect the VLF (Martinma et al., 2006) band and the humoral system (Lombardi et al., 1996; Park et al., 2008).

Finally, the LF/HF ratio is used to reflect the balance between the sympathetic nervous system and parasympathetic nervous system efferent tones (Zhang et al., 2006). Thus, a change in this score may indicate either a parasympathetic nervous system or a sympathetic nervous system tonal change.

6.4.6 Intervention Procedures

In the pain-free group, the participants in the treatment subgroup received a standard AMCT evaluation (Fuhr et al., 1997) and subsequently only the treatment groups received the usual treatment at L-5. The participants in the treatment group received a single thrust from the instrument and no other treatment.

The manually assisted mechanical force was produced using an Activator Instrument IV, at the indicated level #4 for the lumbar adjustment. The attending chiropractor held an advanced proficiency rating in AMCT (Fuhr et Pavia, 2006). The treatment protocol followed the AMCT protocol for clinical application of the instrument (Fuhr et al., 1997). The instrument was loaded to engage the stylus, producing minimal tissue pull, and the handle was pressed to release the hammer and produce the adjustment for the treatment group.

In the pain-free group, the participants in the sham subgroup only received application of the instrument loaded to engage the stylus producing minimal tissue pull or pressure. The AMCT instrument was placed on the evaluated site, producing a skin fold without the thrust or adjustment.

The sham groups were included in this experiment to distinguish the effects of the pressure component, without adjustment, on HRV. Participants in the sham subgroup were told that they had received no adjustment only after the recording session had been completed. In the pain group, the participants of the treatment subgroup received the pre-mentioned chiropractic evaluation and received a chiropractic adjustment at L-5 in side posture. The technique utilized was a traditional lumbar roll, with a pisiform contact on the ipsilateral mamillary of L-5 (Esposito et Philipson, 2005). High velocity, low-amplitude manipulation that produced joint cavitations was used.

In the pain group, the sham subgroup participants received a standard chiropractic evaluation and subsequently were administered a five second pressure with the chiropractor's hand without the thrust or adjustment.

Sham group participants also lied in side posture for the sham treatment. A sham group was included in this experiment to distinguish the effect of a simple pressure from that of an adjustment on HRV. The sham group was told that they had received no adjustment or a sham treatment only after the recording session had been completed.

Participants in the control group proceeded to lie prone on an activator chiropractic table and did not receive any treatment. A control group was included to isolate the effect of the sham procedure and the treatment for both pain-free and pain groups.

In both pain-free and pain groups, the heart rate recording for the duration of the manipulation period was excluded from the data analysis. The time duration of the period of manipulation varied from one participant to the next and was noted.

6.4.7 Experimental procedures

When the participants arrived for a recording session, they were asked to remove their clothing except for their underwear. They were provided with a cotton gown that had an open slit in the back. They then proceeded to install the chest strap of the heart rate monitor and then the heart rate recording watch was placed on their right wrist. The chest strap and the watch were verified to insure that the signal from the chest strap was properly received by the watch.

In the pain-free group, the participants then proceeded to lie prone on an activator chiropractic table. The pelvic deficiency (PD) side and the side of the lumbar spinal dysfunction were both noted.

In the pain group, the participants then proceeded to lie prone on a chiropractic table. The side of the lumbar spinal dysfunction was previously established and noted.

In both pain-free and pain groups, the participants remained in a prone position for 8 minutes before the intervention for the treatment and the sham groups, and all groups remained in the prone position for another 8 minutes after the intervention. The control group participants stayed on the table for 16 minutes without disturbances.

At the end of the recording session, participants were instructed to get up, get dressed and were thanked for participating in the experiment. There was no protocol deviation and there were no adverse events for all participants throughout the experiment.

6.4.8 Statistical analysis

First, descriptive statistics (mean ± SD) were computed for all conditions. Then, groups by tests factorial ANOVA model with repeated measures on the last factor (Kirk, 1982) was used to compare all main effects and interactions. When the level of significant difference of 0.05 was obtained, Tukey's HSD post-hoc test was performed to identify specific significant differences.

The results are provided by giving the obtained levels of type I error (p) and statistical power (P). The standardized effect size (Cohen's *d*) (Cohen, 1992) was used to measure the effect size, where *d* is defined as the difference between two means divided by the pooled standard deviation for those means (see formula below). Thus, in the case where both samples are the same size, d = mean1 – mean2 /√(SD1 2 + SD2 2/2 where mean and SD*s* are the mean and standard deviation for group i, for i = 1, 2. We used the mean of the treatment group as mean1 and the mean of the sham group as mean2 with their respective standard deviation. The following scale of interpretation for Cohen's d was considered: $0.0 < d < 0.2$: trivial effect size, $0.2 < d < 0.5$: small effect size, $0.5 < d < 0.8$: moderate effect size and $0.8 < d$: strong effect size (Cohen, 1992).

6.5 Results

We evaluated the following variables for both the pain-free and pain groups: Mean R-R, SDNN, NN 50 Count, pNN 50%, reflecting the time-domain analysis and the VLF, LF, HF and LF/HF representing the frequency domain analysis. The homogeneity of the variance between all groups was similar for each variable (Levene Test).

The following repeated measures ANOVA results were obtained in the pain-free and pain groups, as indicated in Table 6.2.

In Table 6.2, only the variables that show significant differences are presented. In the pain groups, no variable showed statistically significant differences for the Within-Subjects effects and two variables showed statistically significant differences for the Between-Participants effects: the HF Groups effect (p= 0.002, P= 0.925) and the VLF Groups effect (p=0.001, P= 0.951) (See Table 6.2). As illustrated in Tables 6.3 to 6.7, we show changes for the Mean R-R, VLF, HF, LF and the LF/HF frequencies for both the sham and treatment groups, alongside the respective effect size (ES).

In the pain-free groups, two variables showed a statistically significant change for the Within-Participants effects: the mean RR with Times at p=0.041 with a P= 0.541 and the HF with the interaction of Times* Groups at p= 0.049, P= 0.588. No other HRV variables showed a statistically significant change for the Between-Subjects effects. As illustrated in Tables 6.3 to 6.7, we show changes for the Mean R-R, VLF, HF, LF and the LF/HF frequencies for the control, sham and treatment groups, alongside the respective effect size (ES).

Our results revealed treatment effects on the HRV in both groups (pain-free and pain). The mean R-R increased in treatment pain, control Sham pain free but decreased in Sham pain and treatment pain free. The VLF increased in the pain and pain free groups but decreased in the control group. The HF decreased in the sham pain, treatment pain, sham pain free pain-free group and increase the control group. The LF decreased in the sham pain, treatment pain, control and treatment pain free but increased in the sham pain free. The LF/HF ratio increased for the sham pain, control and treatment pain free and decreased for treatment pain and sham pain free.

6.5.1 Time Domain Analysis

Mean R-R modulation

The Mean R-R (Table 6.3) increased by 11.89 ms in the sham pain free group (*d: 0.17)*, 18.65 ms in the treatment pain group (*d*: 0.16) and 13.14 ms in the control group (*d: 0.07)*. The Mean R-R decreased in the treatment pain free group by 1.75 ms (*d: 0.02)* and by 0.01 ms in the sham pain group (*d: 0.00)*.

6.5.2 Frequency Domain Analysis

VLF modulation

The VLF frequency (Table 6.4) increased in all groups except the control group. The increase was 4.29 % of the total power in the FFT spectrum (TPFFT) for the sham pain group (*d*: *0.34*), 8.6% TPFFT for the treatment pain group (*d: 0.36)*, 3.36% TPFFT for the sham pain free group (*d: 0.15)* and 14.14% for the treatment pain free group (*d: 0.59)*. The control group decrease by 4.07% (*d: 0.19)*.

HF modulation

All groups decreased in value except the control group which reacted in the opposite direction (Table 6.5), when comparing the pre and post tests for the HF component. The sham pain group decreased by 2.41% TPFFT (*d:*

0.21), the treatment pain group by 0.76% TPFFT (*d: 0.06)*, the sham pain free group by 9.59% (*d: 0.66)* and the treatment pain free group 10.36% TPFFT (*d: 0.66)*. The control group HF increased by 5.15% TPFFT (*d: 0.25)*.

LF Modulation

The LF frequency decreased in all groups except the sham pain free group. The decrease was 1.99 % TPFFT for the sham pain group (*d: 0.22)*, 7.82% TPFFT for the treatment pain group (*d: 0.46)*, 1.1% TPFFT for the control group (*d: 0.07)* and 3.79% for the treatment pain free group (*d: 0.23)*. The sham pain free group increase by 6.29% (*d: 0.41)*.

The LF/HF ratio modulation

The LF/HF ratio decreased in the treatment pain group by 0.46 (*d*: 0.20) and in the sham pain free group by 0.26 (*d: 0.05)*. The LF/HF ratio increase was 0.13 for the sham pain group (*d: 0.06)*, 0.04 for the control group (*d: 0.02)* and 0.34 for the treatment pain free group (*d: 0.09)*.

6.6 Discussion

The HF variable, which decreases in all groups except the control group, is representative of the parasympathetic activity (Lombardi et al., 1996) that is also linked to respiratory activity. The VLF variable increased in all groups except the control group, the exact physiological meaning of VLF still remains in debate (Berntson et al., 1997) thus it is difficult to assign a specific factor to this change even though the changes were in all groups except the control group. The LF, decreased in all groups except the sham pain free, which is representative of sympathetic activity (Berntson et al., 1997) and is related to vasomotor activity (Berntson et al., 1997). In all the groups except the control group, we have a prevalence of HF over LF, suggesting a shift of sympatho-vagal balance towards parasympathetic predominance (Berntson et al., 1997). Since we were treating the lumbar spine we were expecting an increase of the HF activity resulting from the chiropractic adjustment. This result was not uniform. We did not expect a decrease of the LF since it is more related to the sympathetic activity. Budgell et Hirano (2001) reported "an increase in the ratio of low-frequency LF-to-high-frequency HF (LF/HF) components of the power spectrum of heart-rate variability, which may reflect a shift in balance between sympathetic and parasympathetic output to the heart..." While Budgell et Polus (2006) reported that "the ratio of the powers of the low-frequency and high-frequency components [LF/HF] increased." Driscoll et Hall (2000) also

found some changes in different variables of the HRV and their experiment included cervical, thoracic as well as lumbar manipulations. Budgell's experiments (2001, 2006) reflected changes happening after a manipulation respectively in the cervical spine (Budgell et Hirano, 2001) and in the dorsal spine (Budgell et Polus, 2006). In our experiment, LF/HF increased by 0.13 in the sham pain group, 0.34 in the treatment pain free group and 0.04 in the control group. The LF/HF decreased in the treatment pain group by 0.46 and 0.26 in the sham pain free group. A change in the LF/HF ratio is dependent on the numerator and the denominator values. When there is an increase of the LF/HF ratio, it can be due to a decrease of the denominator or an increase of the numerator. All our groups except the control group had a decrease activity of the HF. As mentioned previously the reaction was strongest in the pain free groups. This alone should be reflected by and increase of the LF/HF ratio due to the diminish value of HF. But we also had a decrease of the LF value in all groups except the sham pain free group; the diminution was the strongest for the treatment pain group. Thus this combination of reduced activity of both the numerator and the denominator of the LF/HF ratio reflects changes in the parasympathetic-sympathetic activity and modulation and the reflection of the ratio demonstrates that the equilibrium reacts accordingly but not consistently for all groups. We treated the lumbar spine with two different chiropractic adjusting techniques. We assumed that the autonomic nervous system equilibrium between the sympathetic and the parasympathetic nervous systems would maintain itself; the parasympathetic system reacted affecting the overall equilibrium in opposite direction for the treatment pain and treatment pain free groups as reflected by the change in the LF/HF ratio. Three studies (Driscoll et Hall, 2000; Budgell et Hirano, 2001; Budgell et Polus, 2006) demonstrated an effect of the spinal adjustment on the LF/HF (Budgell et Hirano, 2001; Budgell et Polus, 2006) or other variables of the HRV (Driscoll et Hall, 2000). However, this study seems to demonstrate that pain and pain free participants react to a parasympathetic lumbar adjustment in a different fashion. But the overall effect when we look at the standardized effect size for the LF/HF ratio is to low to take into consideration.

6.6.1 Time domain analysis

6.6.1.1 Mean R-R modulation

The R-R-interval length is known to be related to the vagal nerve-firing rate in an essentially linear manner (Martinma et al., 2006). Even if our results demonstrate a statistically significant change, it cannot be explained. In the ANOVA analysis of all the data, the probability ($p=0.041$) and the power ($P= 0.541$) are weak. It

is difficult to draw a specific conclusion. The measured effect is from the pre and post measurements for the participants within the pain free groups. The sham pain free group, the treatment pain group and the control group reacted in a similar order of magnitude. We have presence and absence of pain as well as presence and absence of treatment and even a group not being touched at all (control group). The overall standardized effect size for the R-R interval is to low to take into consideration The R-R interval results are considered inconclusive. However, according to Fishman et al. (1995) a cardiovascular response to touch does not represent a stable trait for individuals.

6.6.1.2 Frequency Domain Analysis

According to Tarvainen et Niskanen (2006) in his handbook for the Kubios software: "The continuous modulation of the sympathetic and parasympathetic innervations results in variations in heart rate. The most conspicuous periodic component of HRV is the so-called *respiratory sinus arrhythmia* (RSA) which is considered to range from 0.15 to 0.4 Hz. In addition to the physiological influence of breathing on HRV, this *high frequency* (HF) component is generally believed to be of parasympathetic origin. Another widely studied component of HRV is the *low frequency* (LF) component usually ranging from 0.04 to 0.15 Hz including the component referred to as the 10-second rhythm or the Mayer wave. The rhythms within the LF band have been thought to be of both sympathetic and parasympathetic origin even though some researchers have suggested them to be mainly of sympathetic origin."

6.6.1.2.1 HF modulation

Can this variable modulation be linked to the status of the participants? As mentioned earlier, the HF band is known to be related to the parasympathetic nervous system efferent activity (Malliani et al., 1991; Lombardi et al., 1996; Berntson et al., 1997; Tarvainen et Niskanen, 2006; Yilmaz et al., 2007) and is synchronized with respiratory rhythms (Seely et Macklem, 2004). Since all our groups, rested the same amount of time and there was no intervention other than the chiropractic treatment, we could consider the respiratory factor to be similar. However, in the pain group the patients had to turn to their side during the course of the adjustment delivery. In addition, pressure was applied to the rib cage to stabilize the dorsal spine in order to give an effective treatment to the lumbar area. This action could affect the patient's breathing and create changes in the HF frequency producing a greater decrease in the pain-free group versus the pain group. Could it be a reflection of the

parasympathetic system reacting to position changes in the participants? When in pain, we are in the presence of an excitable neuron pool. Doing an adjustment in the painful area creates a slight temporary increase in the inflammation, as demonstrated by cutaneous temperature evaluation (Roy, Boucher et Comtois, 2008). On the other hand, the pain-free group received stimulation in a neutral area without tension on the dorsal spine or changes in position affecting breathing. In both conditions, we found a decrease of the HF activity; can this be reflecting a normalization of the parasympathetic activity? The ANOVA does reflect this reaction for both the pain (p= 0.002, P=925) and the pain free (p=0.49, P=.588) groups. The control group received no intervention and remained prone for the same duration of time as the other groups and it presented an opposite reaction. It could be thought that the treatment or the touching of the participant creates a change that the control group did not receive. The overall standardized effect size of the HF frequency reveals quite an effect for the pain free groups, namely the sham pain free (*d: 0.66)* and the treatment pain free groups (*d*: 0.66) as well. This is a medium effect versus no effect (*d*: 0.06 for the treatment pain group) to little effect (*d*: 0.21 for the sham pain group) for the pain groups. This outcome is more representative of the cohort than of the treatment used.

6.6.1.2.2 VLF modulation

As mentioned earlier, the factors affecting a change in VLF are numerous. A variation in sympathetic nervous system activity reflected in the Mean R-R, in addition to the subject's movement to receive the adjustment affecting his thermoregulation, the modifications in breathing due to changing the position, and the stabilization of the dorsal spine for the adjustment, are all sufficient to affect the pain groups and pain free groups. This variable is the second one, with the HF modulation, where the control group is alone in the direction of its variation, a variation opposite to the other groups. Since the exact physiological meaning of VLF still remains in debate 24 many factors could have an effect. The overall standardized effect size of the VLF frequency reveals a medium effect for the treatment pain free group (*d*: 0.59), a low effect size for the pain groups, namely the sham pain (*d: 0.34)* and the treatment pain group (*d*: 0.36) and for the sham pain free (*d*: 0.15) and the control group (*d*: 0.19).

6.6.1.2.3 LF Modulation

This frequency has two masters, sympathetic activity and vasomotor activity (Lombardi et al., 1996). Yet its reaction in the different groups is not consistent with the HF and VLF frequency. For example the standardized effect size for the treatment pain group is *d:* 0.46 a medium effect where the LF frequency decreases

from 34.29 % ± 18.83TPFFT to 26.47% ± 14.62 TPFFT while the Sham pain free group is *d*: 0.41 a medium effect as well but the LF frequency increases from 27.54% ± 12.64 TPFFT to 33.83% ± 17.66 TPFFT. We obtain an opposite reaction with a similar effect for different cohort and sham versus treatment. This frequency seems to be either too unstable or too dependant on other variables outside our control at the moment.

6.6.1.2.4 The LF/HF ratio modulation

By definition, the change in the LF/HF ratio is mathematically determined by modifications in either or both the HF and LF bands. Group differences in these HF and LF bands will be reflected in the LF/HF ratio. In our project, when comparing the groups on the basis of the LF/HF ratio, no specific conclusions can be drawn. The overall standardized effect size for all the groups vary from *d*: 0.02 to *d*: 0.09 for all the groups except the treatment pain group which is at *d*: 0.20, a minimal effect.

6.6.2 Pain and HRV

Cain et al. (2007) concluded that "the relationship between pain and HRV is not simple and may depend whether the pain is chronic, acute or if other factors are present". Petelenz et al. (2004) concluded that when anesthesia is used during colonoscopy the HRV increases mainly from an increase of the LF component; but no correlation between the "non sedated" group versus the sedated groups are established. Finally, Appelhans et Luecken (2008) suggest that the HRV analysis could also be a reflection of the emotionality of the subjects. In cases of migraine, according to Yildiz et al (2008), there is an asymmetric sympathetic hypofunction on the symptomatic side in attack and interictal periods, whereas there is a hyperfunction in the post-attack period. Thus the hyperfunction of the sympathetic nervous system after a chiropractic adjustment, which could be similar to a post attack period of a migraine because the patient receives some relief, could inhibit the HRV reaction and would seem to inhibit the parasympathetic reaction from the adjustment and a possible reaction that perhaps occurred in our pain free group. Schattschneider et al (2008) concluded that, "The sympathetic–afferent interaction does not play a major role in pain generation due to nerve entrapment." Nevertheless, in a subgroup of patients, nociceptive afferents shows sensitivity to physiological and pharmacological sympathetic stimulation. This finding is important because it emphasizes that despite there is no clinical detectable effect on pain, sympathetic afferent interaction can be found. In other words the sympathetic nervous system interacts at every

level were there is pain. Therefore, taking this information in consideration we must be cautious with our conclusion.

6.6.3 Chiropractic Techniques

We have some effect on the HRV, regardless of the chiropractic techniques utilized. Different studies (Herzog, 1991; Herzog et al., 1993; Symons et al., 2000; Wood, Colloca et Matthews, 2001; Herzog, Kats et Symons, 2001; Shearar, Colloca et White, 2005; Kawchuk et al., 2006; Roy, Boucher et Comtois, 2008) have been done in the past to evaluate and compare the relative effect of he MAMF versus the traditional chiropractic adjustment (Wood, Colloca et Matthews, 2001). According to Wood, Colloca and Matthews, (2001) they were both producing beneficial effects. Synzons et al. (200) reported that the EMG recordings from a previous study on dogs (Synzons et al., 2000) for the MAMF and on humans (Herzog, 1993) for traditional chiropractic and their study supported these previous studies were the sEMG were of the same latency of 2.2 ms and duration of 30ms. In another study, Shearar, Colloca et White (2005) showed that neither mechanical force manually assisted nor high velocity, low amplitude adjustments were found to be more effective than the other in the treatment of the patient population. Roy, Boucher et Comtois (2008) demonstrated a similar reaction of the spinal cutaneous temperature to an adjustment produced by either approaches. In addition, Kawchuk et al., (2006) and Herzog (1991, 1993) demonstrated that there was less variation between an experimented and a novice practionner utilizing the instrument-based adjusting versus experimented and a novice practionner utilizing the manual manipulation technique. Finally Herzog (2001) demonstrated that the end result forces are the same on average between instruments and traditional spinal manipulation. We therefore used a chiropractor with twelve years experience for the traditional adjusting technique and a chiropractor with seventeen years experience for the MAMF. Considering these previous explanations we do not consider the treatment approaches different and we therefore consider that the effect on the HRV modulation from the two groups is related to the presence or absence of pain.

6.7 Limitations

Two different chiropractic techniques and two different cohorts were utilized in this project. It is not possible at this time to draw conclusion on the effectiveness of one technical approach over another. Conclusions are drawn on the cohorts, but a more extensive cohort reflecting the pain cohort with only one adjusting technique

will be used in future projects to further validate some of our findings. As mentioned in the pain and HRV section, further research needs to take into consideration the emotional aspect of the patient. As well, since our results are not as strong a Budgell (Budgell ct Hirano, 2001; Budgell et Polus, 2006) using respectively the cervical and thoracic spine as mode of intervention and Zhang et al., (2006) using a multimodal treatment in different chiropractic clinics, we are suggesting that the autonomic nervous system may be specific and sensitive to the origin of the preganglionic/postganglionic innervations to the effectors organs. In other words, had we evaluated effectors organs connected more directly to the lumbar parasympathetic innervations we might have found results respectively similar to Budgell (Budgell et Hirano, 2001; Budgell et Polus, 2006) and Zhang et al. (2006). Even though, investigators in the present study were not blinded, outmost care was taken to maintain objectivity and eliminate any unwarranted bias during data analysis and interpretation.

6.8 Conclusion

Adjusting the lumbar vertebrae seems to affect the lumbar parasympathetic nervous system output. The evidence demonstrates that the adaptation in the parasympathetic output, reflected by changes in HF, LF, VLF and LF/HF, is independent of the type of adjustment. Therefore, the group differences found in the modulation of the HRV would seem to be related to the presence or absence of pain. In our experiments, the parasympathetic reaction was stronger in the pain free groups. However, caution is warranted, since this was a onetime intervention and that more research is needed to establish the effect of a longer treatment period.

6.9 Author's contribution

RAR carried out the conception, design and acquisition of data, analysis and interpretation of the data and was involved in the drafting of the manuscript. JPB carried out a review of the conception, design and acquisition of data, analysis and interpretation of the data and was involved in the drafting and revising of the manuscript for important intellectual content. ASC carried out a review of the conception, design and acquisition of data, analysis and interpretation of the data and was involved in the drafting and revising of the manuscript for important intellectual content and as well the supervision of physiological content.

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6.12 Tables

Table 6.1

Anthropometric measurements of participants

	Pain free group			Pain group	
	Control (n=11)	Sham (n=11)	Treatment (n=11)	Sham (n=10)	Treatment (n=10)
Age (years)	37.4 ± 10.7	33.28 ± 9.2	25.1± 4.0	44.7 ± 9.8	35.7 ± 11.7
Height (m)	1.66 ± 0.05	1.71 ± 0.1	1.70 ± 0.1	1.60 ± 0.16	1.64 ± 0.06
Weight (kg)	69.3 ± 14.8	69.9 ± 16.2	68.1 ± 1.1	78.3 ± 13.6	60.7 ± 12.8
BMI	25.0 ± 5.1	23.6 ± 3.4	23.5 ± 3.0	28.5 ± 5.6	22.4 ± 3.6

Values are mean ± SD.

Table 6.2

ANOVA compiled and summarized for Between-Subjects effects and Within-Subjects effects for both grouping (Pain free and Pain).

Variables	No Pain (Within)	No Pain(Between)	Pain (Within)	Pain (Between)
Mean R-R	Times	N.S.	N.S.	N.S.
	p=0.041, P= 0.541			
VLF	N.S.	N.S.	N.S.	Groups
				p=0.001, P= 0.951
HF	Times* Groups	N.S.	N.S.	Groups
	p=0.049, P =0.588			p= 0.002, P=0.925

N.S. = not significant, p= probability and P= Power.

Table 6.3 A

Mean R-R (ms) all groups pre and post measurement with effect size.

Groups	Pre	Post	Standardized Effect size
Sham Pain	808.11 ± 111.42	808.10 ± 94.15	0.00
Treatment Pain	800.97 ± 116.41	819.62 ± 115.83	0.16
Control	866.11 ± 186.85	879.25 ± 186.68	0.07
Sham Pain Free	793.22 ± 71.43	805.11 ± 69.77	0.17
Treatment Pain Free	803.24 ± 80.13	801.49 ± 79.5	0.02

Table 6.3 B

VLF (n.u.) all groups pre and post measurement with effect size.

Groups	Pre	Post	Standardized Effect size
Sham Pain	58.59 ± 14.60	62.88 ± 9.87	0.34
Treatment Pain	48.45 ± 26.85	57.05 ± 20.74	0.36
Control	34.34 ± 22.00	30.27 ± 20.21	0.19
Sham Pain Free	46.76 ± 19.27	50.12 ± 25.18	0.15
Treatment Pain Free	31.08 ± 17.84	45.22 ± 28.67	0.59

Table 6.3 C

HF (n.u.) all groups pre and post measurement with effect size.

Groups	Pre	Post	Standardized Effect size
Sham Pain	16.26 ± 12.93	13.85 ± 10.03	0.21
Treatment Pain	17.24 ± 11.85	16.48 ± 11.77	0.06
Control	33.90 ± 18.73	39.05 ± 22.59	0.25
Sham Pain Free	25.67 ± 16.69	16.08 ± 11.78	0.66
Treatment Pain Free	23.60 ± 16.64	19.24 ± 14.62	0.66

Table 6.3 D

LF (n.u.) all groups pre and post measurement with effect size.

Groups	Pre	Post	Standardized Effect size
Sham Pain	23.63 ± 10.58	21.64 ± 6.83	0.22
Treatment Pain	34.29 ± 18.83	26.47 ± 14.62	0.46
Control	31.77 ± 14.87	30.67 ± 18.7	0.07
Sham Pain Free	27.54 ± 12.64	33.83 ± 17.66	0.41
Treatment Pain Free	39.32 ± 14.57	35.53 ± 18.38	0.23

Table 6.3 E

LF/HF ratios all groups pre and post measurement with effect size.

Groups	Pre	Post	Standardized Effect size
Sham Pain	2.71 ± 2.39	2.84 ± 2.26	0.06
Treatment Pain	3.11 ± 2.19	2.65 ± 2.46	0.20
Control	1.54 ± 1.76	1.58 ± 2.44	0.02
Sham Pain Free	3.70 ± 6.47	3.44 ± 2.42	0.05
Treatment Pain Free	2.74 ± 3.01	3.08 ± 4.13	0.09

CHAPITRE VII

MANUSCRIT SOUMIS

INFLAMMATORY, HEART RATE VARIABILITY, AND PARASPINAL CUTANEOUS TEMPERATURE RESPONSES FOLLOWING A SHORT TERM TREATMENT COURSE IN SUBJECTS WITH AND WITHOUT CHRONIC LOW BACK CONDITION

Ce chapitre est la version soumise de l'article mentionné dans le titre du chapitre.

Le projet consistait à évaluer l'effet d'un traitement chiropratique d'une durée de neuf traitements sur la TC, la VRC et l'IL-6 et la PRC chez des participants qui souffraient de douleurs lombaires chroniques. Nous avions un groupe témoin sain. Les deux groupes étaient évalués à deux semaines d'intervalles pour toutes les variables. Ceci nous permettait de répondre aux questions suivantes:

1- Est-ce qu'il y a un effet du traitement chiropratique sur la TC sur une période de neuf traitements?

2- Comment se compare le groupe traitement au groupe témoin?

3- Est-ce qu'il y a un changement de la VRC et comment se compare le groupe traitement au groupe témoin?

4- Est-ce qu'il y a un changement de l'Il-6 et de la PRC et comment se compare le groupe traitement au groupe témoin?

Nos conclusions sont que le traitement chiropratique à un effet sur chacune des variables et que les valeurs de variables du groupe traitement ont tendance à se déplacer vers les valeurs du groupe témoin.

7.1 Lettre de présentation

November 19th, 2009

Journal of Chiropractic Medicine Manuscript Processing Department
To whom it may concern:

Please find enclosed the manuscript entitled *"**Inflammatory, heart rate variability, and paraspinal cutaneous temperature responses following a short term treatment course in subjects with and without chronic low back condition.**"*

The manuscript has not been submitted elsewhere while it is being reviewed by the editorial board of your journal.

Thank you in advance for considering the manuscript for publication in Journal of Chiropractic Medicine.

Kindest regards,

Dr Richard Roy, Dc, MSc, PhD (c)

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7.2 Page couverture du manuscrit

Inflammatory, heart rate variability, and paraspinal cutaneous temperature responses following a short term treatment course in subjects with and without chronic low back condition.

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Disclaimer: Nothing of value related to this research was received from a commercial entity.

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7.3 Résumé du manuscrit

Abstract

Background Many outcome measures are used to monitor or validate a chiropractic adjustment. Some of these outcome measures, however, have never been evaluated and compared under a same course of treatment.

Methods Twenty one participants were non-randomly assigned to a treatment (chronic low back pain) or a control group (healthy no low back pain). All participants took part for a 2 week period. Only the treatment group received 9 chiropractic interventions. Pre and post intervention measures were recorded as follows: Oswestry questionnaire; paraspinal cutaneous temperature (CT) in the prone position after an 8 minute acclimation period; instantaneous heart rate for heart rate variability (HRV) analysis; blood samples for detection of pro-inflammatory cytokines IL-6 and hsCRP.

Results The Oswestry index in the treatment group was reduced following treatment. The paraspinal CT was warmer for the control group. The treatment group surprisingly showed a warmer CT on the non-injured side and a cooler overall paraspinal CT. However, the treatment group paraspinal CT warmed up after nine treatments despite remaining colder than the control group. Both HRV and mediators of inflammation (IL-6 and hsCRP) were modified by the intervention received by the treatment group.

Conclusion A total of 9 chiropractic lower back interventions caused marked differences in paraspinal CT and the Oswestry index. HRV and mediators of inflammation presented a normalisation response in individuals suffering from chronic low back pain.

Key indexing term: Manipulation; Diagnostic technique; Thermography; IL-6; hsCRP; Heart rate variability.

7.4 Corps du texte du manuscrit

7.4.1 Introduction

The chiropractic profession has investigated many different outcome measures as a means of monitoring the treatment course of chiropractic adjustments (Gregory, Hayek et Hayek, 1998; French, Green et Forbes, 2000; Fryer, Morris et Gibbons, 2004; Owens et al., 2004; DeVocht, Pickar et Wilder, 2005; Zhang et al., 2006; Roy, Boucher et Comtois, 2008). Outcome measures, however, such as Oswestry disability index, heart rate variability (HRV), paraspinal cutaneous temperature (CT) and inflammation markers have never been compared to each other during the same course of treatment. Thus, the scientific relationship that may exist between them is at the moment unknown, and at best empiric.

The Oswestry disability index is recognized as an effective tool to evaluate the activities of daily living for patients suffering from low back pain. One aspect though that may contribute to lower back discomfort is the inflammatory process that is typically accompanied by various expressions of plasma cytokines. In fact, different disease states exhibit unique cytokine profiles (Heney et al., 1993). Inflammation is often associated with the like of several pro-inflammatory cytokines that include interleukin-6 (IL-6) and the hepatocyte derived C-reactive protein (CRP). IL-6 is the main mediator of the acute phase inflammatory response (Bartalena et al., 1993). In humans, IL-6 causes a dramatic increase in hepatocyte derived CRP synthesis (Thorn, Lu et Whitehead, 2004). However, in non acute phase inflammatory status, Meir-Ewert et al, (2001) have shown no diurnal effects of CRP plasma concentrations over a 24 hour period. Nonetheless, several authors (Jain et Misra 1967; Danesh et al., 2000; Rifai et Ridker 2001; Macy, Hayes et Tracy, 1997) have found that CRP is a sensitive marker of inflammation and that it has emerged as a powerful predictor of cardiovascular diseases (Jain et Misra, 1967; Danesh et al, 2000; Rifai et Ridker, 2001).

The availability of high sensitivity assays for CRP has also enabled the detection of even low-grade inflammatory responses that have previously been regarded as clinically non meaningful (Koenig, 2001). In fact, high sensitivity assays have been shown to differentiate between inflammatory and non inflammatory conditions, in measuring responses to therapeutic interventions, and in estimating disease prognosis (Van Leeuwen et al., 1994; Macy, Hayes et Tracy, 1997). Recently, it has been reported (Teodorczyk-Injeyan, Injeyan et Rugg, 2006, Teodorczyk-Injeyan et al., 2008) that the chiropractic treatment does indeed affect the level of circulating

cytokines but not that of substance-P and IL-2. Therefore, the objective of this report consisted in evaluating several outcome measures that included the Oswestry disability index, pro-inflammatory markers (IL-6 and CRP), HRV (temporal and spectral analysis) and paraspinal CT following a 9 lumbar spine treatment course.

Lumbar spine was considered from the T-12 to L-5 level for the chiropractic intervention, and as proposed by Maigne (1972, 1980), "The most frequent manifestation of this thoracolumbar junction syndrome is low back pain, which is exactly like low back pain of lumbosacral or sacroiliac origin" (Maigne 1972, 1980). Thus, spinal interventions were performed using a manually assisted mechanical force lumbar spine protocol (Fuhr et Fischer 2009), while HRV measurements and paraspinal CT were taken in the prone position as previously described (Owens et al., 2004; Roy, Boucher et Comtois, 2006, 2008, 2009). The overall objective and essence of this report is best summarized by Wirtz et al. (2000) as follows "Therapeutically, conservative, minimal-invasive and operative procedures are not rival but rather complementary".

7.4.2 Methods

7.4.2.1 Participants

Anthropometric characteristics of the participants are shown in Table 1. The research protocol for the evaluation and adjustment was approved by the Université du Québec à Montréal ethics committee. Written informed consent was obtained from all participants. This study was registered with clinicaltrials.gov, registration number NCT00739570. All participants received a physical examination, spinal radiographs and completed the Oswestry questionnaire.

7.4.2.1.1 Control group

A total of ten participants were recruited, four females and six males at the beginning of June 2008 from a chiropractic clinic, located at LaSalle, Quebec. The inclusion criterion was that all participants were pain free and receiving maintenance chiropractic care and would not receive any other treatment during the two week span of the research project. All participants were evaluated for all the same outcome measures as the treatment group.

7.4.2.1.2 Treatment group

All treatment group participants were recruited via an announcement in the newspaper, Le Messager de LaSalle, during the period from July 6th to the 20th 2008. Forty five subjects responded to the telephone number at

the university and left a message indicating their interest in the project. Eleven participants that met the criteria were selected while the others were thanked for their interest. The eleven retained participants were four females and seven males. The participants were suffering from a chronic low back condition of at least three months in duration. Chronic lower back pain usually has a more insidious onset, occurring over a long period of time. Chronic back pain can be described as:

> "Low back pain that comes and goes over weeks to months. The severity of the pain is always the same. The character of the pain is always the same, cramping pain, sharp or stabbing pain, burning pain and pain that travels to the back" (Schueler 2008).

One participant (female) did not come for the final evaluation. Our treatment group was thus 10 participants, three females and seven males. Those administering the intervention were not blinded to the group assignment. The final evaluation comprised the same tests as the initial examination.

7.4.3 Outcome measures

7.4.3.1 Oswestry disability index

The modified Oswestry disability index was utilized to evaluate lower back functional disability. It is comprised of ten self-rated items on an A to F scale that evaluate the capacity of an individual to function during daily activities. The value of A=0, and each subsequent letter has an ascending numerical value, B=1 to F=5. The maximum total score for all ten items is 50. The total for all the answers is tabulated and multiplied by two to give a percentage of dysfunction due to lumbar pain.

7.4.3.2 Paraspinal Cutaneous Temperature (CT)

The thermal scan was calibrated according to the calibration report- for the thermoglide/Tytron C-4000 ™ [42150] provided by the distributor (Myovision system, Precision Biometrics Inc., San Carlos, California, USA. 94070). The thermal scan was performed as previously described by Roy, Boucher et Comtois. (2006). The data were recorded directly into the computer software that was afterwards exported as a text file in order to gather the raw data. Then a spinal length ratio for the number of recordings was attributed to each spinal segment. The thermal scan software records a value for a certain distance that covers 50 centimetres, which is typically the length of the spine being measured. The correction factor that was attributed for each spinal section was a

thickness value of one unit for the cervical spine vertebrae, 1.5 units for the thoracic spine vertebrae and 2 units for the lumbar spine vertebrae. This yielded 7 units for the cervical spine, 18 units for the thoracic spine, and 10 units for the lumbar spine. Thus a total of 35 units for the entire spine was determined and amounted to 320 recordings or to mention differently, ~9 paraspinal CT recordings per unit. Therefore, roughly 9, 14 and 18 recordings per segment were obtained for the cervical, thoracic and lumbar spine, respectively over the entire length of paraspinal CT recording. In order to obtain the absolute paraspinal CT in degrees Celsius, 30 was added to the raw value of the recorded averaged numerical value for each segment, as recommended by the manufacturer. Thus, the absolute paraspinal CT in degrees Celsius was determined for every patient.

7.4.3.3 HRV measurement and analysis

Heart rate was recorded using a commercially available heart rate monitor (Suunto watch, model T6, Fitz Wright Company Ltd., Langley, BC, Canada) as previously described (Roy, Boucher et Comtois, 2009). A five minute period of stable resting heart rate was analyzed that was typically located between the 80-380 sec marks, in order to eliminate movement artifact during the initial positioning of the subject on the table. The HRV analysis was performed with a personal computer using custom software (Kubios, ver 2.0, beta 3, Tarvainen et Niskanen 2006) for several HRV parameters, as described below. There were no attempts to blind the assessment since the data were recorded directly into the heart rate monitor. The risk of influencing HRV was kept to a minimum by insuring that the interaction, between the subject and the examiner, limited itself to the installation and removal of the recording apparatus.

7.4.3.3.1 HRV Variables

The following variables were analyzed, mean R-R interval (Mean RR), the standard deviation between normal to normal r-r intervals (SDNN), the number of NN intervals differing by more than 50 ms was divided by the total number of NN intervals to yield the percent number of intervals (pNN 50), the low frequency (LF) with its normalized spectral components between 0.04 and 0.15 Hz; the high frequency (HF) with its normalised spectral power components between 0.15 and 0.4 Hz and the LF/HF ratio (Seely and Macklem, 2004). Spectral analysis was conducted in order to gather information on autonomic nervous system response following treatment. Briefly, the LF band is related to both the sympathetic and parasympathetic nervous system efferent activity (Seely et Macklem 2004, Zhang et al., 2006). The HF band is related to the parasympathetic nervous system

efferent activity (Yilmaz 2007) and is synchronized to respiratory rhythms (Seely et Macklem 2004). The LF/HF ratio is used to indicate balance between the sympathetic and parasympathetic nervous system efferent tone (Zhang et al., 2006), which may indicate either a parasympathetic or sympathetic nervous system tonal change.

7.4.3.4 Analysis of Inflammatory markers

Blood samples were collected by a trained licensed nurse from the province of Quebec. For every subject, the IL-6 blood sample was collected in a properly coded lavender tube (4.0 ml, BD Vacutainer, K2 EDTA, lot 7344830, BD, Franklin Lakes, New Jersey, USA). Similarly, CRP blood samples were collected in properly coded yellow tubes for every subject (5.0 ml, BD Vacutainer, SST, lot 8032322, BD, Franklin Lakes, New Jersey, USA). All samples remained at room temperature for 15 minutes before being centrifuged for 15 minutes at 1000g. Afterwards, they were immediately decanted and the plasma or serum (IL-6 and CRP analysis, respectively) was transferred via disposable transfer pipettes (Category number 13-711-7 Fisher Scientific, Pittsburgh, Pennsylvania, USA) into clearly coded Eppendorf tubes (Sarstedt, Nümbrecth, Germany). The eppendorf tubes were then closed and stored on dry ice until delivered to Hôpital St-Luc's clinical laboratory in Montréal at the end of the day. All sample collecting needles were disposed after single use in a biohazard container (BD, Sharps collector, reference number 305648, lot 7103001, BD Medical, Oakville, Ontario) provided by the Centre Local de Services de Santé, an organism from the Quebec Ministry of Health. The IL-6 and CRP quantification was performed under the supervision of Dr. Line Labrecque, PhD (biochemistry). The results were provided by electronic means identified only by the patient's code.

7.5 Experimental procedures

7.5.1 Control and treatment group interventions

The participants of the control group received no treatment only the evaluation of the outcome measures at the pre and post 2 weeks intervention interval and the assisted mechanical (AM) evaluation to determine their pelvic deficient side (PD). A PD is explained as follows:

> "Traditionally, the short leg has been designated the Pelvic Deficient, or PD leg. It is referred to as the reactive leg because of its tendency to appear shorter or longer during different

testing procedures. The PD leg is visually observed during the initial leg check following placement of the patient in the prone position on the adjusting table (Fuhr and Fischer 2009)."

In the treatment group, the participants received the above mentioned chiropractic evaluation and using the AM basic scan protocol for the lumbar spine. They received a chiropractic adjustment with the AM instrument, which was a manual AM adjusting instrument (Activator AAI, IV signature) set at number four (176 N) for all patients (Fuhr and Fischer 2009), only the lumbar area from T-12 to L-5 was treated according to the PD side. The treating clinician held an advanced proficiency rating in the AM (Fuhr and Pavia 2008). The duration of the treatment schedule was two weeks (Barbuto 1984). As mentioned above for the control group, all participants in the treatment group had outcome measures taken at the pre and post 2 weeks intervention interval.

7.5.2 Experimental protocol

When the participants arrived for a recording session, they were asked to dress with a hospital type cotton gown that had an open slit in the back while keeping only their underclothing. They then proceeded to the room were blood samples were taken by the licensed nurse. Following the collection of blood samples the patient went to the evaluation room. They then installed the chest strap for the heart rate monitor and then the data recording watch was placed on their right wrist. The participants then proceeded to lie prone on an AM table. The participants remained in a prone position for 8 minutes and then the paraspinal thermal scan evaluation was performed. For the control group, this was the end of the recording session and the participants were instructed to get dressed and make an appointment for the next evaluation in two weeks. The participants in the treatment group proceeded to make nine appointments to receive AM treatments for the next two weeks (Barbuto 1984). Subsequently, when the treatment group subjects would arrive for a treatment session, they were shown to the treatment room and were treated according to the AM basic scan for the lumbar spine (Fuhr et Fischer 2009). After the treatment they would confirm their reservation for the following day. The participants were treated from Monday July 28th to August 1st and then from Monday August 4th to Thursday August 7th. The Friday of August 8th was the last visit and consisted of the complete re-evaluation where the initial evaluation procedure was repeated. Participant 2109 did not come for the re-evaluation; the participant had travel plans for that day. Thus, the final count for participants in the treatment group was 10. On the day of the re-evaluations, participant 2005 did not want to have blood drawn that day but permitted to do all other tests. These were the only two protocol

deviation and there were no adverse events for all participants throughout the entire length of the experiment. The final count for participants in the treatment group was n = 10 except for the blood samples were n = 9 samples. On the last day of recording, all the participants were thanked for their participation and received a $30.00 payment for their travel expenses.

7.6 Statistical analysis

Descriptive statistics (mean ± SD unless stated otherwise) were computed for all independent and dependent variables for all conditions. Significant differences were determined by using either Student's unpaired t-test (between subjects) or paired t-test (within subjects). Standardized effect size (Cohen's *d*) calculation was performed to estimate the power of group differences (control vs treatment) where $d \leq 0.2$, $d > 0.2$ and ≤ 0.5, and $d > 0.5$ and ≤ 0.8 are considered, respectively, small, medium and large effect sizes (Cohen 1969, Cohen 1988).

7.7 Results

There were no significant differences for the anthropometric characteristics of the subjects between both groups (Table 1).

7.7.1 Oswestry Index

The overall average Oswestry disability index score upon initial evaluation and at re-evaluation two weeks later (pre and post) for the control group was 10.2% ± 10.6% vs 8.6% ± 10.8% (data not shown). For the treatment group, the overall average Oswestry disability index score pre- and post-treatment was 29.8% ± 11.8% vs 14.20% ± 11.5% disability (data not shown). The pre Oswestry disability index was significantly different for the treatment group (29.8% ± 11.8%) when compared to the control group (10.2% ± 10.6%). The pre and post standardized effect size is 0.15 for the control group and 1.34 for the treatment group.

7.7.2 Paraspinal CT

Paraspinal CT modifications between pre and post intervention for both groups (within subjects) are listed in Table 2. As indicated, paraspinal CT in the treatment (Tx) group was modified by nearly 1 ^{0}C (significant at $p < 0.10$) following 2 weeks of daily intervention. This increase in Paraspinal CT was measured on the non deficient pelvic (Non PD) side and ranged from 0.67 ± 1.12 ^{0}C at T12 to 0.79 ± 1.19 ^{0}C at L5, while the paraspinal

CT on the pelvic deficient (PD) side was not modified. On the other hand, the paraspinal CT in the control (CTL) group on either side of the spine (PD vs NonPD) was not significantly modified after 2 weeks.

The paraspinal CT changes in absolute values are illustrated in Fig. 1. It can be seen overall that paraspinal CT pre intervention is lower in the treatment group when compared to the control group for both PD and NonPD sides (between subjects). This difference is indicated in Table 3, where the effect size of the difference is large (Cohen's *d* statistic in Table 3, see methods above). The post intervention paraspinal CT variation, also shown in Fig. 1, is largely similar to the pre intervention paraspinal CT. However, in the treatment group on the NonPD side only a medium to small effect size difference (Cohen's *d* statistic in Table 3) is observed for all lumbar spine levels (T12 to L5).

7.7.3 HRV parameters

Figure 2 illustrates the HRV parameters for both treatment and control groups pre and post intervention. When comparing treatment to control group pre intervention (between subjects) all HRV parameters differ little, except for SDNN, pNN50 and LF/HF ratio where a medium effect size difference is noticeable (see Cohen's *d* statistic in Table 4). Post intervention HRV parameters, however, are not different between groups, where only a small to medium effect size difference is observed for mean RR interval and pNN50 (see Cohen's *d* statistic in Table 4).

7.7.4 Markers of inflammation

Inflammation mediator response for both treatment and control groups pre and post intervention is illustrated in Fig. 3. There is a large effect size difference for both hsCRP and IL-6 between the treatment and control groups pre intervention (2.50 ± 0.79 vs 1.05 ± 0.34 g/dl and 3.97 ± 0.44 vs 3.12 ± 0.00 ng/L, respectively). A medium effect size difference for post intervention is noticeable between groups (Tx vs CTL) for both hsCRP and IL-6 (1.94 ± 0.49 vs 1.38 ± 0.51 g/dl and 2.98 ± 0.34 vs 3.24 ± 0.12 ng/L, respectively).

7.8 Discussion

7.8.1 Oswestry disability index and outcome measures

The changes observed with the Oswestry questionnaire appear to indicate that the treatment group score was tending towards the control group on the disability scale (14.20% ± 11.5% vs 8.6% ± 10.8%, respectively, d = 0.24, small effect size). The improvement on the Oswestry index score demonstrated in the current report is similar to the results obtained by Quon et al. (1989) upon treating patients with side posture manipulation. They reported that "the patients improved considerably during only two weeks of treatment," and "it is emphasized that manipulation has been shown to be an effective treatment for some patients with lumbar disc herniation" (Quon et al., 1989). While it is difficult to show clearly a reduction of the inflammatory processes, we can nonetheless speculate on the Oswestry index score and the relationship with the different physiological variables measured in this current report. As indicated for the treatment group participants, the Oswestry index score, and changes in some HRV variables and for both cytokines, tended towards reaching the control group values. In addition, there was an increase of the CT indicating that the score of the treatment group participants was moving towards the control group score. Thus, it is plausible to consider that the inflammation processes were being reversed but that complete healing was not achieved following 2 weeks of treatment. Perhaps, a longer treatment period would help to gain better knowledge on the relation between inflammatory processes and the Oswestry index score.

7.8.2 Paraspinal CT

The paraspinal CT results are partly similar to results previously obtained using a single punctual treatment (Roy, Boucher et Comtois, 2008). In these experiments (Roy, Boucher et Comtois, 2008), the CT on the treatment side warmed up, while on the opposite side the CT remained level or without any significant changes when immediately measured after the treatment. According to Menger et al (2003), post-ischemic reperfusion provokes an inflammatory response in post-capillary venules. This could be one of the possibilities for the on-going rewarming in the aforementioned study by Roy, Boucher et Comtois (2008). The present results, following a course of nine treatments, revealed a greater paraspinal CT increase on the opposite side of the treatment (NonPD side) in contrast to a small paraspinal CT increase on the treatment side (PD side). According to Ganong, (Ganong, 2005) impulses from the sensory nerves are relayed antidromically along other branches of sensory nerve fibers (Guénard 1996). This could be a reaction of the skin as it receives a potent mechanical stimulus. This

explanation is perhaps correct to explain a pre-post punctual change but is probably not the case in the present study, since 24 hours passed between the last adjustment and the measurement (see methods). The initial paraspinal CT measurement (pre intervention) is typical of what has been previously reported Roy, Boucher et Comtois, 2008), where the treatment side (PD side) is warmer than the non treatment side (NonPD side). However, the pre and post measurements gathered under punctual circumstances could possibly differ when collected over a timeline, such as in the present study. As well, in the present study, the control group was without pain and did not receive any care during the two week experimental protocol. On the other hand, the treatment group participants had lower back pain for at least three months. The possible underlying inflammation in the lumbar area would suggest that the treatment group's CT should be warmer. In contrast, however, it was cooler than the control group. Nonetheless, at the end of the treatment period the treated area (PD side) appeared to have moderately warmed up (see Fig. 1), while the side opposite to treatment (NonPD side) warmed up even more nearing paraspinal CT values similar to the control group.

This observation was in striking contrast to what was expected. The paraspinal CT is in direct relationship with thermoregulation functions (Guénard 1996). It has previously been proposed by Roy, Boucher et Comtois (2008) that CT adaptations of the cutaneous temperature are directly related to thermoregulation functions (Guénard 1996, Ganong 2005). It should be noted that that the muscle mass (thermogenesis) provide 80% of the heat CT (Hobbins and Ammer 1996) and that thermoregulation functions are controlled by the optic nucleus of the hypothalamus (Tortora 2001). Also, the neurological influx from thermogenesis centers stimulates the sympathetic nerves connected to blood vessels (Tortora 2001). According to Michikami et al (Michikami 2001) the human thermoregulation function is dependent on the vasoconstriction or vasodilatation of the subcutaneous arterio-venous plexus (mostly responsible for CT changes) that is under sympathetic control and it is known that a vasodilator mediated responses within the blood vessels plays a very limited role but it is rather a reduced activity of the sympathetic system that is primordial.

In the present study, it is possible that the initial deeper inflammation had a wider and multi level vasodilatation effect and was counter-acted upon by a vasoconstriction of the more superficial blood vessels. A situation that is later reversed when deep tissue inflammation subsides, thereby reducing the pro-inflammatory blood flow response, and leads to a vasodilatation of the superficial blood vessels. Effectively, Menger et al (2003), in their experimental studies have provided convincing evidence that microcirculatory dysfunction plays a pivotal role in

the manifestation of tissue injury in ischemia-reperfusion and vascular hyperpermeability, which results in interstitial oedema formation and perhaps blood flow congestion because of the increased interstitial pressure.

Thus, the above mentioned cascade of events is certainly useful in understanding the physiological CT response that can be observed over time. Since thermoregulation varies according to the environment and inflammatory processes, both the internal (deeper tissues) and cutaneous blood flow temperature, and muscle activity (thermogenesis) all contribute to regulate the human body temperature and eventual return to the healthy range of 37-39 ^{0}C (Ganong, 2005).

7.8.3 HRV parameters and inflammatory mediators

Several HRV parameters were analysed and are presented in Fig.2 and in Table 4. It has recently been proposed that the activity of the two branches of the autonomic nervous system, i.e. the parasympathetic and sympathetic branches, can be monitored non-invasively via HRV analysis (Seely et Macklem 2004). In the present study, HRV parameter changes were detected and the results indicate, even though modest (medium effect size, see Table 4), that modifications in HRV spectral components, namely the LF/HF ratio, shifted in favour of an improved sympatico/parasymaptico equilibrium (see Fig. 2F pre vs post in the Tx group). In addition, the feature of interest was that in the treatment group most of the parameters were converging towards those measured in the control group. Therefore, it appears that a course of 9 treatments was able to prompt a normalisation process. This observation is quite attractive and possible since the control group in this study was a healthy pain free group, thus providing limited in size but nonetheless eloquent normative baseline values. It would certainly have been interesting to continue the treatment with additional treatment periods, such has two other weeks. Perhaps the contrasts seen here would have been even greater.

Mediators of inflammation were also shown to respond to a treatment course of 9 interventions (see Fig. 3A and 3B). What is noticeable is that both hsCRP and IL-6 were observed to trend towards the control group values. The effect size differences measured indicate that both groups were highly different at pre intervention (large effect size), but at post intervention the effect size difference (medium) was much smaller for both hsCRP and IL-6. IL-6 has been shown to be an acute phase pro-inflammatory cytokine (von Haehling et al., 2009). IL-6 is responsible for the synthesis of CRP from the liver (Ho et Lipman, 2009). Thus, to observe in the treatment group

a post intervention reduction in hsCRP is not surprising, since IL-6 was also reduced, suggesting that 9 interventions are capable of attenuating the inflammatory response.

The inflammatory response attenuation is in sequence with the changes observed in paraspinal CT. In fact, prior to treatment the inflammatory state may represent a level of subcutaneous oedema that may have prevented the transfer of heat from deep tissues to the skin (Menger et al, 2003). Oedema may have compressed tissues to the level of preventing adequate blood flow to more superficial vessels, such as the subcutaneous arterio-venous complex responsible for heat transfer (Menger et al, 2003). Menger et al. (2003), then mentions that recent investigations have demonstrated that ischemia-reperfusion is associated with capillary perfusion failure, mediated by intravascular hemoconcentration, endothelial swelling and endothelia microvascular constriction. The results are reflected in Fig 1 where post intervention paraspinal CT in the treatment group trends towards the healthy control group. An indication that perhaps 9 treatments are capable of reducing deep tissue oedema in order to relieve blood vessel compression and improve deep tissue heat transfer at the skin surface.

7.9 Author's contribution

RAR carried out the conception, design and acquisition of data, analysis and interpretation of the data and was involved in the drafting of the manuscript. JPB carried out a review of the conception, design and acquisition of data, analysis and interpretation of the data and was involved in the drafting and revising of the manuscript for important intellectual content. ASC carried out a review of the conception, design and acquisition of data, analysis and interpretation of the data and was involved in the drafting and revising of the manuscript for important intellectual content and as well the supervision of physiological content.

7.10 Limitations

The major limitation in this study was group size. Initially, cohort size based on previous studies (Roy, Boucher et Comtois, 2006) indicated that 7 subjects per group would be sufficient. However, as observed in Tables 2 to 4, many dependant variables were near reaching the set level of significance set at $p < 0.05$. Nonetheless, differences in the results were reported as effect size (Cohen's d statistic) and lend strength to the conclusions raised by this study. Future investigations will warrant larger cohorts for this type of research on paraspinal CT.

Another limitation is the choice of cytokines use for analysis or perhaps the treatment group population. The cytokines IL-6 or IL-1a are acute phase pro-inflammatory mediators (Feghali and Wright, 1997). The treatment cohort in this study was chronic lower back pain individuals (for at least three months). For this cohort type, may be a chronic inflammation cytokine, such as TNF-β, would have been more appropriate and yielded different outcome results. Nonetheless, modulations of IL-6 and hsCRP in the anticipated directions were observed and the present results give some form of credence to the raised conclusions. On the other hand, an acute lower back pain cohort would have perhaps been a better choice for the inflammatory markers retained for this study. These comments and limitations are certainly matter for future investigations.

7.11 Conclusion

Paraspinal CT monitoring appears to be relevant as an objective reevaluation tool following nine visits in a clinical setting. As well, other physiological markers appear promising, but are more cumbersome to control in a clinical setting, especially mediators of inflammation. These could be useful when treatment course progression is not clearly defined. The HRV analysis shows potential and certainly warrants more research in a setting where pain is predominant. These physiological results are in agreement with Oswestry index scores. Finally, a paraspinal CT index (pathological condition to normal condition) should be created to increase clinical validity of this technology. Surely, more research is needed to better understand the relationship between inflammation and cutaneous temperature regulation.

7.12 References

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7.13 Tables

Table 7.1

Anthropometric characteristics of the subjects.

Variables	Control Group	Treatment Group
Weight (Kg)	74.9 ± 16.9	80.3 ± 16.5
Height (M)	1.7 ± 0.1	1.7 ± 0.1
BMI	25.3 ± 3.6	28.0 ± 3.7
Age (Years)	47.5 ± 16.2	45.6 ± 8.9

Values are mean ± SD.

Table 7.2 Differences in pre-post paraspinal cutaneous temperature (CT ^{O}C) for both groups (within subjects) according to lumbar spine levels.

Lumbar Spine levels	T12	L1	L2	L3	L4	L5
Tx PD	0.05 ± 1.28	0.04 ± 1.29	0.04 ± 1.31	0.05 ± 1.33	0.06 ± 1.35	0.06 ± 1.36
(pre vs post)	(p=0.91)	(p=0.92)	(p=0.92)	(p=0.90)	(p=0.89)	(p=0.88)
Tx Non PD	0.67 ± 1.12	0.70 ± 1.13	0.72 ± 1.15	0.75 ± 1.16	0.77 ± 1.17	0.79 ± 1.19
(pre vs post)	(p=0.09)	(p=0.08)	(p=0.08)	(p=0.07)	(p=0.07)	(p=0.07)
CTL PD	0.12 ± 0.66	0.11 ± 0.67	0.09 ± 0.68	0.06 ± 0.71	0.04 ± 0.74	0.01 ± 0.78
(pre vs post)	(p=0.59)	(p=0.63)	(p=0.69)	(p=0.78)	(p=0.88)	(p=0.96)
CTL Non PD	0.04 ± 0.77	0.05 ± 0.79	0.05 ± 0.82	0.05 ± 0.85	0.03 ± 0.88	0.01 ± 0.91
(pre vs post)	(p=0.87)	(p=0.85)	(p=0.85)	(p=0.87)	(p=0.91)	(p=0.98)

All values are mean ± S.D. and are expressed in degrees Celsius. Numbers in parentheses represent the significance level (α error). A positive number indicates a warming of the paraspinal CT at post measurement. Tx PD, treatment group pelvic deficient side; Tx Non PD, treatment group non deficient pelvic side; CTL PD, control group pelvic deficient side; CTL Non PD, control group non deficient pelvic side.

Table 7.3 Differences in paraspinal cutaneous temperature (CT ^{o}C) between both groups (between subjects) according to lumbar spine levels.

Lumbar Spine Level	T12	L1	L2	L3	L4	L5
PD Pre	0.97 ± 0.56	0.94 ± 0.55	0.91 ± 0.55	0.89 ± 0.54	0.88 ± 0.54	0.84 ± 0.53
(CTL vs Tx)	(p=0.10; d=0.77)	(p=0.11; d=0.76)	(p=0.11; d=0.76)	(p=0.12; d=0.74)	(p=0.12; d=0.72)	(p=0.13; d=0.71)
PD Post	1.04 ± 0.54	1.00 ± 0.54	0.96 ± 0.55	0.90 ± 0.56	0.85 ± 0.56	0.79 ± 0.57
(CTL vs Tx)	(p=0.07; d=0.86)	(p=0.08; d=0.82)	(p=0.10; d=0.78)	(p=0.12; d=0.72)	(p=0.15; d=0.67)	(p=0.18; d=0.62)
Non PD Pre	1.05 ± 0.58	1.05 ± 0.58	1.04 ± 0.57	1.03 ± 0.56	1.03 ± 0.56	1.03 ± 0.56
(CTL vs Tx)	(p=0.09; d=0.81)	(p=0.09; d=0.81)	(p=0.08; d=0.82)	(p=0.08; d=0.82)	(p=0.08; d=0.82)	(p=0.08; d=0.83)
Non PD Post	0.42 ± 0.55	0.40 ± 0.55	0.37 ± 0.56	0.33 ± 0.57	0.29 ± 0.57	0.24 ± 0.57
(CTL vs Tx)	(p=0.45; d=0.35)	(p=0.48; d=0.32)	(p=0.52; d=0.30)	(p=0.57; d=0.26)	(p=0.62; d=0.23)	(p=0.68; d=0.19)

All values are mean ± S.D. and are expressed in degrees Celsius. Numbers in parentheses represent the significance level (p, α error) and Cohen's effect size factor (d coefficient, see statistical analysis section in methods). A positive number indicates paraspinal CT of control group is warmer than treatment group. CTL, control group; Tx, treatment group; PD Pre, pelvic deficient side before intervention; PD Post, pelvic deficient side after intervention; Non PD Pre, non deficient pelvic side before intervention; Non PD Post, non deficient pelvic side after intervention.

Table 7.4 Differences in heart rate variability (HRV) parameters (temporal and spectral) between both groups (between subjects) according to lumbar spine levels.

	Temporal HRV parameters			Spectral HRV parameters		
	Mean RR interval (msec)	SDNN (msec)	pNN50 (%)	LF (%)	HF (%)	LF/HF Ratio
Pre	-33.08 ± 55.74	20.21 ± 15.12	6.47 ± 5.75	-1.58 ± 6.25	-1.17 ± 7.64	-1.21 ± 0.91
(CTL vs Tx)	(p=0.56; d=0.28)	(p=0.20; d=0.63)	(p=0.28; d=0.53)	(p=0.80; d=0.12)	(p=0.80; d=0.12)	(p=0.20; d=0.63)
Post	-53.24 ± 68.84	4.31 ± 8.53	5.47 ± 5.80	-1.80 ± 6.78	3.29 ± 7.31	-0.24 ± 0.85
(CTL vs Tx)	(p=0.45; d=0.36)	(p=0.62; d=0.24)	(p=0.36; d=0.45)	(p=0.79; d=0.13)	(p=0.66; d=0.21)	(p=0.78; d=0.13)

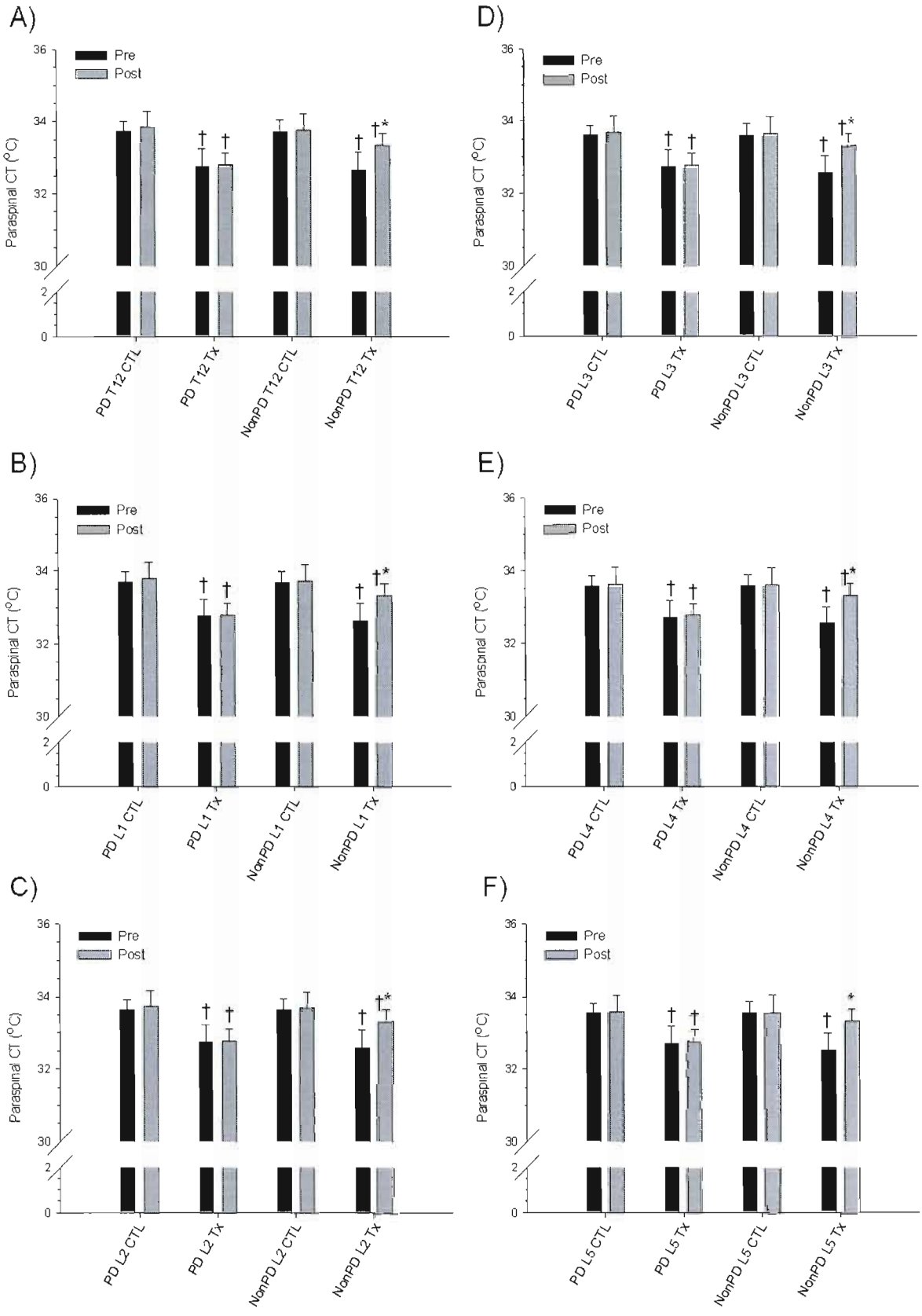
All values are mean ± S.D. Numbers in parentheses represent the significance level (p, α error) and Cohen's effect size factor (d coefficient, see statistical analysis section in methods). A positive number indicates HRV parameter of control (CTL) group is larger than treatment (Tx) group. See methods section for HRV parameter definitions. Pre, before intervention; Post, after intervention.

7.14 Figure Legends

Figure 7.1. Paraspinal CT for all lumbar spinal levels for both treatment (Tx) and control (CTL) groups. Error bars represent S.E.M. A) Spinal level T12; B) Spinal level L1; C) Spinal level L2; D) Spinal level L3; E) Spinal level L4; and F) Spinal level L5. Dark bars represent pre intervention (before treatment period). Grey bars represent post intervention (after treatment period). PD, pelvic deficient side; NonPD, non deficient pelvic side. * within subject noteworthy difference (see Table 2); † between subject noteworthy effect size (see Table 3).

Figure 7.2. HRV parameters for both treatment (Tx) and control (CTL) groups. Error bars represent S.E.M. A) Mean RR interval; B) Standard deviation of Normal to Normal RR interval (SDNN); C) pNN50, percent successive intervals differing by more than 50 msec; D) LF, low frequency spectral component (see methods); E) HF, high frequency spectral component (see methods); F) LF/HF ratio. Pre, before treatment period; Post, after treatment period. Dark bars represent CTL. Grey bars represent Tx. † between subject noteworthy effect size (see Table 4).

Figure 7.3. Inflammatory mediator response for both treatment (Tx) and control (CTL) groups. Error bars represent S.E.M. for sake of clarity. hsCRP, high sensitivity C-Reactive Protein; IL-6, pro-inflammatory marker interleukin-6; Pre, before treatment period; Post, after treatment period. Dark bars represent CTL. Grey bars represent Tx. Numbers above bars represent the significance level (p, α error) and Cohen's effect size factor (d coefficient, see statistical analysis section in methods) based on between subject differences (CTL vs Tx).


A)
B)
C)
D)
E)
F)
Pre
Post
Paraspinal CT (°C)
36
34
32
30
2
0
†
†*
*
PD T12 CTL
PD T12 Tx
NonPD T12 CTL
NonPD T12 Tx
PD L1 CTL
PD L1 Tx
NonPD L1 CTL
NonPD L1 Tx
PD L2 CTL
PD L2 Tx
NonPD L2 CTL
NonPD L2 Tx
PD L3 CTL
PD L3 Tx
NonPD L3 CTL
NonPD L3 Tx
PD L4 CTL
PD L4 Tx
NonPD L4 CTL
NonPD L4 Tx
PD L5 CTL
PD L5 Tx
NonPD L5 CTL
NonPD L5 Tx

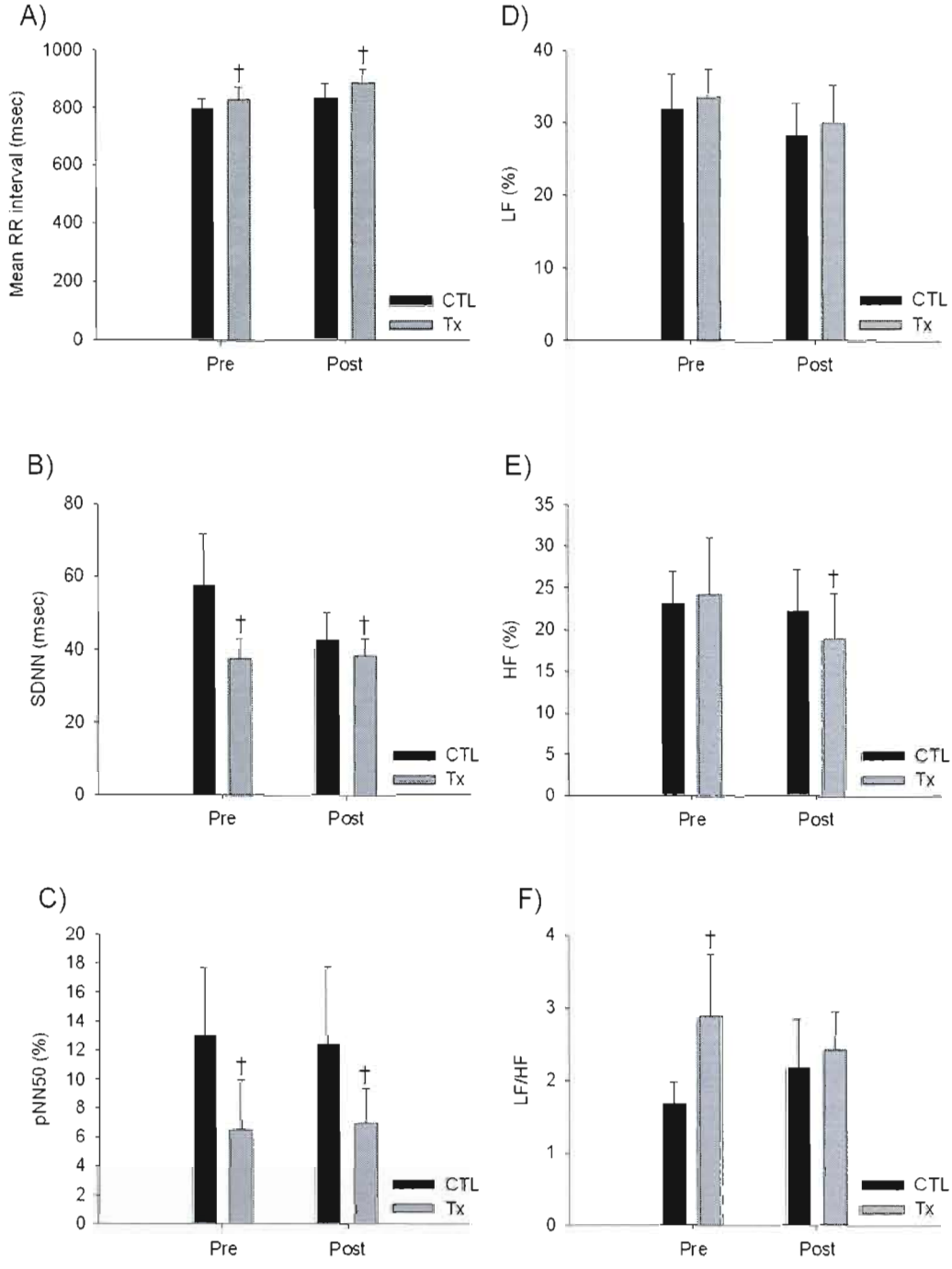

A)
Mean RR interval (msec)
1000
800
600
400
200
0
†
†
CTL
Tx
Pre
Post
D)
LF (%)
40
30
20
10
0
CTL
Tx
Pre
Post
B)
SDNN (msec)
80
60
40
20
0
†
†
CTL
Tx
Pre
Post
E)
HF (%)
35
30
25
20
15
10
5
0
†
CTL
Tx
Pre
Post
C)
pNN50 (%)
20
18
16
14
12
10
8
6
4
2
0
†
†
CTL
Tx
Pre
Post
F)
LF/HF
4
3
2
1
0
†
CTL
Tx
Pre
Post

Figure 7.2

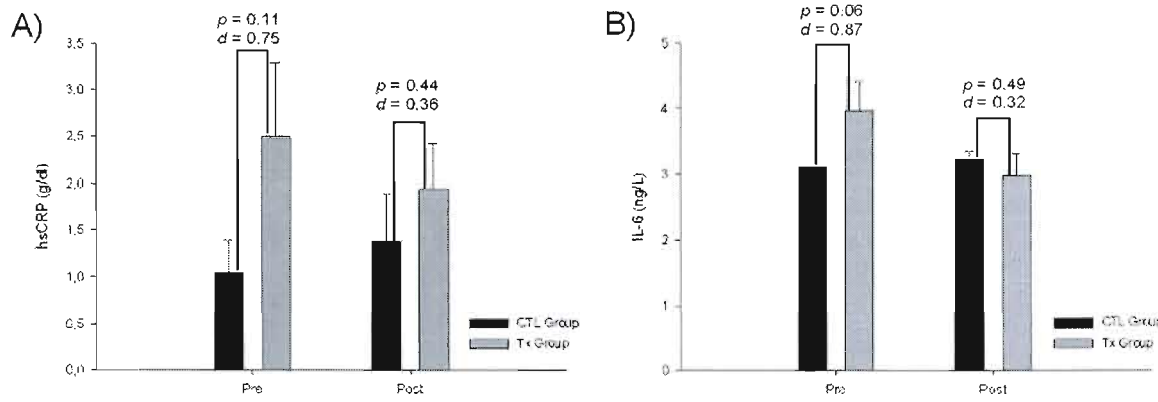

A)
p = 0.11
d = 0.75
p = 0.44
d = 0.36
hsCRP (g/dl)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Pre
Post
CTL Group
Tx Group
B)
p = 0.06
d = 0.87
p = 0.49
d = 0.32
IL-6 (ng/L)
5
4
3
2
1
0
Pre
Post
CTL Group
Tx Group

Figure 7.3

CHAPITRE VIII

DISCUSSION GÉNÉRALE

8.1 L'effet de la manipulation vertébrale

En rappel, dans l'introduction, nous avons présenté les réflexes somato-viscéraux et viscéro-somatiques. Ces réflexes ne furent pas mesurés. Toutefois, une explication est nécessaire pour comprendre ce que nous avons fait en utilisant la TC et la VRC.

Tel que mentionné, en ce qui concerne la TC et les effets somato-viscéraux; les récepteurs sensoriels cutanés et sous-cutanés soient les mécanorécepteurs et les thermorécepteurs et les récepteurs associés à la proprioception, font partie du système somato-sensoriel qui modulent le sens du toucher, les sensations de proprioception musculaires (contraction ou étirement) et le sens du positionnement articulaire. Les informations des mécanorécepteurs et des propriocepteurs passent par le corps cellulaire d'un neurone sensitif et ces derniers produisent des potentiels d'action rapides. Lors d'une manipulation vertébrale, les tissus reçoivent une stimulation mécanique qui influence les différents récepteurs sensoriels cutanés et sous-cutanés. Ces réactions, selon Sato, Sato et Schmidt, (1997), peuvent crées des réactions locales, spinales ou supraspinales. Selon Korr (1974, 1975), il y a des réactions neuromécaniques et neurotrophiques quand un nerf est irrité ou enflammé. Ces réactions peuvent affectées la TC de façon locale ou réflexogène.

Suite à ce qui fut démontré dans nos projets soit un changement de la TC suite à une manipulation vertébrale tant dans une situation ponctuelle que temporelle. Il serait intéressant de connaître les mécanismes de ces réactions qui étaient possiblement locales ou réflexogènes. Toutefois, la constatation d'une différence entre les groupes pour la température paraspinale initiale lors de projet 4, laisse croire qu'il y a plus qu'une simple réaction circulatoire locale. En effet notre la TC du groupe traitement était plus froide que la Tc du groupe témoin. Si nous avions sous la main une base de données normative, nous pourrions des lors concentrer nos efforts sur des variables plus représentatives de l'effet de la manipulation vertébrale.

Cela est essentiel car récemment, Ernst et Gilbey (2010), ont recensé plusieurs sites web chiropratique à travers le monde anglophone et leurs conclusions sont que la majorité des chiropraticiens et leurs associations semblent faire des affirmations qui ne sont pas supportées par des évidences tangibles. Alors que Bronfort et al (2010), concluent, après avoir révisé 49 articles de révision systématiques et 16 guides cliniques bases sur des évidences, qu'il n'y a pas d'évidences qui démontrent que les manipulations vertébrales sont efficaces pour l'asthme, la dysménorrhée, les otites moyennes, l'énurésie ou les coliques. Donc, tout le discours et les recherches animales ne se traduisent pas encore en des résultats tangibles ou une

meilleure connaissance des mécanismes impliqués lors de manipulations vertébrales. La discussion continue avec la présentation des effets ponctuels et temporels des recherches de cette thèse.

8.1.1 L'effet à court terme (ponctuel) de l'ajustement chiropratique sur la température cutanée

La TC fut évaluée dans deux projets portant sur l'effet à court terme de l'ajustement chiropratique. La validité et la fidélité de la technologie utilisée dans ces projets furent démontrées (Roy 2005; Roy, Boucher et Comtois, 2006a). Les fenêtres adéquates de mesures furent aussi démontrées (Roy 2005).

Dans le premier projet, il a été observé que la fenêtre ayant la meilleure applicabilité clinique correspond à la période allant de huit à 16 minutes.

Il était important de commencer avec un appareil qui ne transmet pas de chaleur, afin d'établir les meilleurs paramètres de réaction ou d'absence de réaction. La méthode *Activator* a été sélectionnée dans le premier projet. Car l'appareil avec embout caoutchouté ne transmet ni ne soustrait de chaleur à la peau lors du contact et la friction entre la peau et l'appareil est négligeable. On peut dire que cet instrument est thermiquement neutre. Pour le deuxième projet, la méthode *Diversified* a été utilisée. Cette technique utilise le contact avec la paume de la main du clinicien. La paume de la main du clinicien fut mesurée et elle était plus chaude que la température ambiante et aussi plus chaude que la TC des sujets. Donc cette technique produisait un apport de chaleur à la TC locale a'l'endroit ou le contact du traitement se produisait. Les résultats nous démontrèrent, sauf en un point, que les deux traitements réagissent de façon similaire (Figure 8.1), outre la première mesure immédiatement après l'ajustement traditionnel qui est plus élevée, cela est du au transfert de chaleur de la main du clinicien. Par la suite, toutes les autres mesures montrent un patron de variabilité similaire.

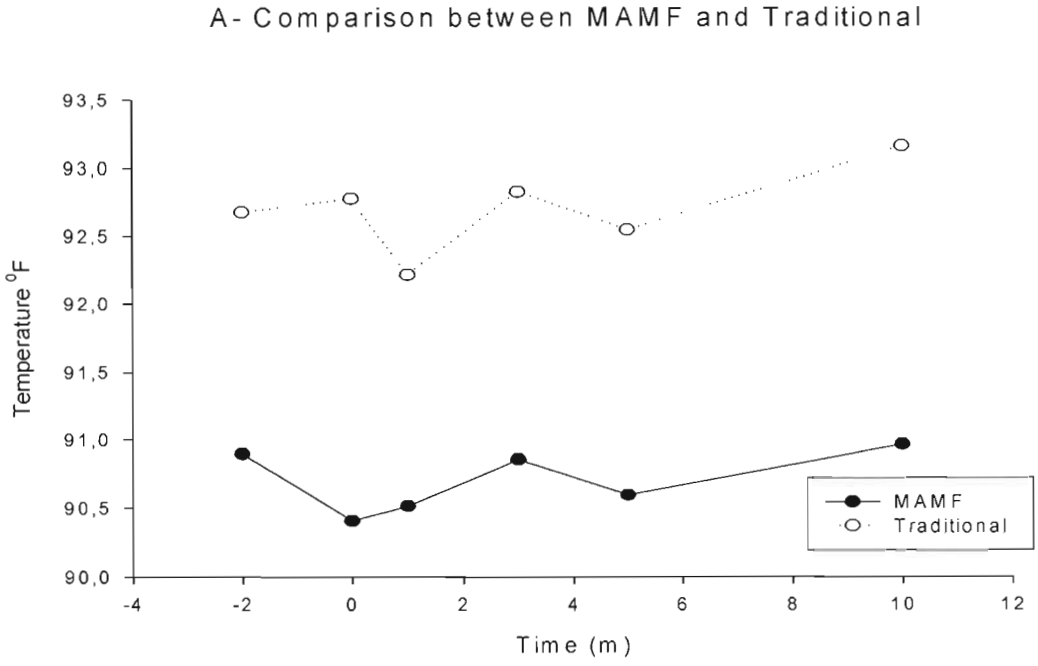


Figure 8.1 Comparaison entre les températures des projets 1 et 2, suite à l'utilisation de deux techniques différentes. (MAMF = *Activator* et Traditional = *Diversified*)

Cette différence de la première mesure après l'intervention, entre les deux techniques au temps <0>, est encore plus évidente à la figure 8.2. Sur ce graphique la valeur de la première lecture est utilisée comme référence pour chacune des deux courbes.

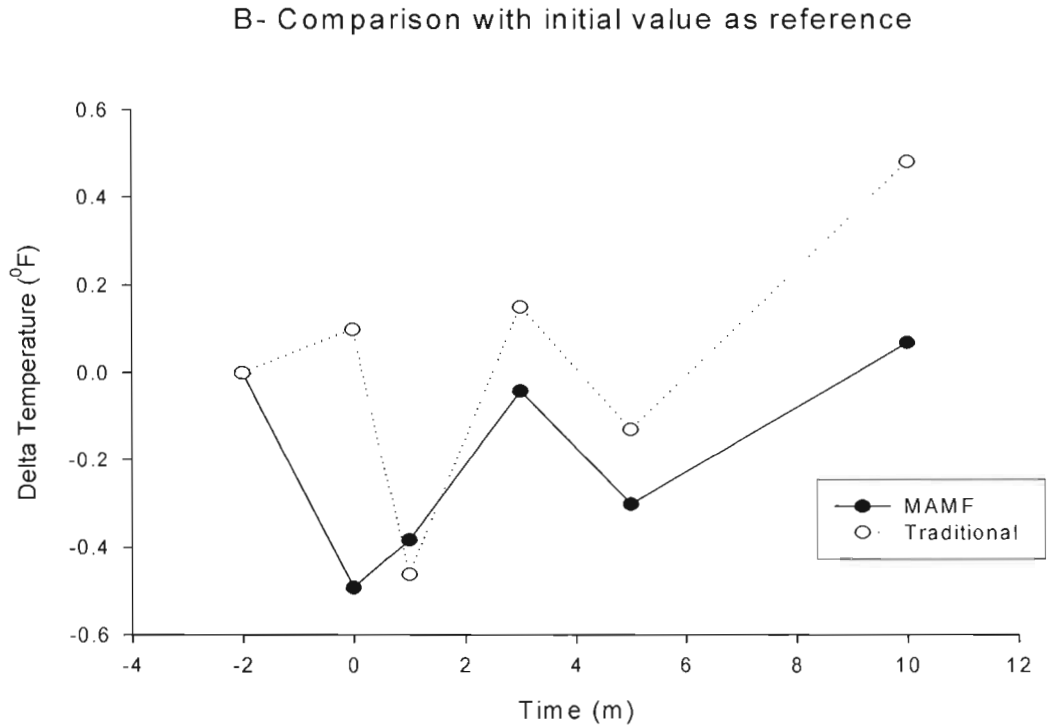


Figure 8.2 Comparaison entre les températures des projets 1 et 2, avec le temps -2 comme référence, pour un même niveau, pour les deux techniques différentes. (MAMF = *Activator* et Traditional = *Diversified*)

Pour ces projets, les analyses étaient des mesures ponctuelles pré et post traitement. La figure 8.2., nous permet d'observer la présence d'une double réaction de la TC avec réchauffement continuel, pour une période de dix minutes. Mais cela soulève plus de questions que de réponses, pour lesquelles des spéculations sur les mécanismes physiologiques possibles ont été formulées dans nos manuscrits publié (Roy, Boucher Comtois, 2008; Roy, Boucher Comtois, 2010a). Entre autres, une des spéculations est inspirée des travaux de Menger et al (2003), selon lesquels une perfusion post ischémique provoque une réponse inflammatoire dans les veinules post-capillaires. Il serait donc possible que suite à un traitement, la circulation sanguine serait rétablie, ce qui entraînerait une réponse inflammatoire, et par le fait même, le réchauffement observé post intervention, d'une durée d'au moins dix minutes (Roy, Boucher et Comtois, 2008). Voir la section 8.2.1 pour l'explication plus détaillée des changements ischémiques associés au changement de la TC.

Malheureusement, malgré ces résultats, il n'est pas possible de tirer des conclusions permettant de supporter l'utilisation clinique de cette technologie d'évaluation. Les mécanismes associés aux changements de la TC, suite à une manipulation vertébrale, sont encore méconnus.

8.1.2 L'effet à court terme (ponctuel) de la manipulation vertébrale sur la VRC

En fait, que ce soit au niveau de l'analyse temporelle ou spectrale, il serait tentant de croire que les manipulations vertébrales lombaires ne font pas réagir la VRC.

Toutefois, des études (Budgell et Hirano 2001; Zhang et al., 2001) démontrent une réaction de la VRC lors de manipulations vertébrales cervicales et dorsales. Ces réactions sont une augmentation de la BF et de la HF (Zhang et al., 2001) et une augmentation du ratio LF/HF (Budgell et Hirano, 2001). Ce qu'il est possible de conclure à la lumière du présent projet, en tenant compte de la documentation existante en arrière plan (Budgell, 2005, Zhang et al.,2001), c'est que les signaux efférents autonomiques sont sensibles et spécifiques aux organes effecteurs. Par exemple, les régions cervicales et dorsales ont des connecteurs post-ganglioniques autonomes reliés directement au cœur, ce qui n'est pas le cas pour les neurones post-ganglioniques lombaires. Une réponse de la VRC n'était donc pas attendue, suite à une manipulation vertébrale lombaire.

Une manipulation vertébrale lombaire semble affectée la réponse du système nerveux parasympathique. Les résultats démontrent que l'adaptation de la réponse parasympathique est reflétée par des changements des HF, LF, VLF et LF/HF. Cette réponse est indépendante du type d'intervention utilisée. Par conséquent, les différences entre les groupes pour la modulation de la VRC semblent plus reliées à l'absence ou la présence de la douleur. Dans le présent projet, la réaction parasympathique semble plus forte chez le groupe sain. Toutefois, il faut faire attention, puis que ce projet ne représente qu'une intervention unique Il serait essentiel d'évaluer cette variable sur un traitement à plus long terme.

Puisqu'il est clair que ces réactions autonomiques existent et que les manipulations vertébrales lombaires semblent affecter la VRC, il serait alors important, pour les prochains projets de recherche portant sur l'effet des manipulations vertébrales sur le système autonome des régions lombaire et basse dorsale, d'évaluer les organes qui leur sont directement rattachés via les neurones post-ganglioniques de ces mêmes régions du rachis.

Il a également été observé que la présence ou l'absence de douleur est une variable qui peut affecter les résultats des mesures de la VRC, lorsqu'un ajustement chiropratique est utilisé. Les chercheurs qui continueront dans cette veine de recherche, sur la VRC devront tenir compte de la douleur comme variable (Roy, Boucher et Comtois, 2009).

8.2. L'effet de la manipulation vertébrale lombaire sur une période de neuf traitements (temporelle)

8.2.1 L'effet de la manipulation vertébrale sur la TC, pour une période de traitement de neuf traitements

Le dernier projet proposait une composante temporelle et s'échelonnait sur une période de neuf traitements en deux semaines. La douleur est une variable que nous retrouvons dans le projet 4. Avec la douleur, il y a présence d'inflammation. En rappel, l'inflammation dans sa phase vasculaire crée une vasodilatation locale qui a pour but d'augmenter la circulation du sang afin d'évacuer les cellules mortes et les toxines, et d'apporter les éléments nécessaires à la guérison, notamment des globules blancs (lymphocytes) pour combattre les corps étrangers. Ce gonflement local des vaisseaux sanguins provoque la rougeur et la sensation de chaleur, ainsi qu'un épanchement de l'eau du plasma sanguin par osmose vers les

tissus, ce qui provoque l'œdème. L'œdème comprime les nerfs et provoque une sensation douloureuse et des démangeaisons. Cette compression par l'œdème fut démontrée par Menger et al (2003), qui démontra que la dysfonction de la microcirculation est un pivot essentiel qui résulte en la formation d'œdème interstitiel et une congestion possible du débit sanguin qui peut engendrer une augmentation de la pression interstitielle. Cette section se rapporte aussi à la section 8.1.1.

A cause de la vasodilatation crée dans la phase vasculaire de l'inflammation, nous nous attendons à ce que le groupe en douleurs ait un TC initiale plus élevée que le groupe contrôle. Ce que nous avons constaté est tout autre. La première constatation fut d'observer que les patients du groupe témoin avaient une TC plus chaude que le groupe traitement, pour la région complète de D-12 à L-5 (Figure 7.1). Chez le groupe traitement, le coté en douleur ou se situe l'inflammation est plus chaud que le coté opposé. Ce qui représente la réaction physiologique que nous attendions. Toutefois, lors de la mesure initiale de la TC, le groupe contrôle est plus chaud dans l'ensemble et de façon bilatérale ce pour tous les niveaux vertébraux mesurés.

Ce fut une surprise, puisque lorsqu'il est question d'inflammation (Scott, 2004), la chaleur est toujours mentionnée comme étant l'une des cinq composantes du processus inflammatoire. L'évaluation du groupe traitement a permis d'observer que le côté de la blessure est plus chaud que le côté opposé à la blessure. Donc, lorsqu'il y a un processus inflammatoire, le coté blessé est effectivement plus chaud, mais un refroidissement global de la TC lombaire est également observé.

Mais qu'en est-il du groupe contrôle qui présente une TC lombaire plus chaude, sans avoir de processus inflammatoire, tel que démontré par les radiographies lombaires en dynamique et le questionnaire de fonctionnalité Oswestry pour la région lombaire?

Pour un aperçu de ce qui se passe, il faut regarder les valeurs de la TC observée à la fin des traitements, lors de la réévaluation. En effet, nous constatons que le côté non-traité du groupe traitement se réchauffe de 0.8°C alors que le coté du traitement se réchauffe de seulement 0.06 °C. Donc, le côté non traité du groupe traitement semble vouloir se réchauffer plus rapidement pour se rapprocher du groupe contrôle, ce qui correspond à une normalisation de la TC. Alors que le côté enflammé réagit beaucoup plus lentement. Cette réaction plus lente pourrait associer à une réaction plus lente des tissus.

En effet, la présence d'une blessure réchauffe une région très spécifique et locale, ce qui ajoute une problématique additionnelle au cerveau pour maintenir l'homéostasie. Alors, le cerveau, grâce au contrôle hypothalamique et ses efférents sympathiques, maintient une vasoconstriction de la peau de la région superposée à la région enflammée. Il est possible que l'inflammation initiale profonde ait un effet de vasodilatation et ce à plusieurs niveaux de tissus locaux profonds et que par la suite, il y ait eu une contre-réaction, produisant une contraction des vaisseaux sanguins superficiels. Cette situation se transformerait lorsque l'inflammation des tissus profonds diminuerait, réduisant la réponse pro-inflammatoire sanguine et conduisant à une vasodilatation des vaisseaux sanguins superficiels. Effectivement, Menger et al (2003) fournissent des évidences convaincantes qu'une dysfonction de la microcirculation joue un rôle important dans la manifestation d'une blessure tissulaire d'ischémie-perfusion et dans l'hyperperméabilité vasculaire, ce qui résultent en la formation d'œdème interstitiel et possiblement dans la congestion de la circulation à cause de l'augmentation de la pression interstitielle.

Cette cascade d'évènements est certainement utile pour mieux comprendre la réponse physiologique de la TC. Dans ce projet (#4), il a été constaté que les valeurs de nos variables associées à la douleur et la fonctionnalité diminuent. Cette augmentation de la fonctionnalité est accompagnée d'un nouveau niveau d'activité musculaire localisé au niveau de la région qui guérit. Cette augmentation d'activité musculaire des tissus locaux génère aussi une chaleur accrue et la circulation locale est aussi améliorée (Cannon et Querido, 1924; Hobbins et Ammer, 1996). Le côté non enflammé retourne plus rapidement à son niveau d'activité et se réchauffe donc plus rapidement que le côté enflammé, tel que l'indique nos résultats concernant la TC. La TC locale augmente, le corps n'ayant plus à prévenir la perte de chaleur causée par l'inflammation.

Cela renforce la nécessité de conduire un projet qui établirait une base de données de valeurs normatives et un indice de la TC normale chez des sujets sains pour valider l'utilisation de cette technologie comme mesure d'évaluation/réévaluation en lien étroit avec les facteurs cliniques; pour éventuellement en faire un outil clinique viable. Cette démarche a été faite par le passé pour certaines maladies inflammatoires (Diakides et Bronzino, 2008), mais pas pour la TC.

8.2.2 L'effet de la manipulation vertébrale sur la VRC, pour une période de neuf traitements

Il est intéressant de constater que les manifestations de la HF de l'analyse spectrale de la VRC, observées lors du quatrième projet, révèlent un processus de normalisation des valeurs de la HF de la part des sujets en douleurs vers les valeurs de la HF des sujets sans douleurs. Cette information est attirante puisque le groupe témoin était sans douleur. En effet, une réponse sur un petit groupe a été obtenue, ce qui permet de penser qu'il est important d'établir des valeurs normatives pour une échelle de base. Si l'intervention avait été d'une plus longue durée ou si l'échantillon avait été plus grand, il est possible que des contrastes plus grands ou plus éloquents auraient été observés (voir Fig. 7.2).

8.2.3 L'effet de la manipulation vertébrale sur les cytokines PRC et IL-6

L'utilisation du questionnaire Oswestry, en début d'expérimentation et à la fin, a servi à démontrer que les conditions de douleurs et de fonctionnalité des participants du groupe traitement du projet 4 se rapprochait de celle des participants du groupe témoin, en ce qui concerne leurs douleurs et leur niveau d'incapacité. Cette amélioration est similaire aux résultats obtenus par Quon et al., (1989). Ils rapportent que [...la condition des patients s'améliore considérablement durant deux semaines de traitement.]. De plus, ils mettent l'emphase sur le fait que la manipulation vertébrale fut démontrée efficace pour soulager les patients qui souffrent d'hernie discale (Quon et al., 1989).

Les marqueurs inflammatoires ont aussi démontré une réponse à la série de neuf traitements (voir Fig. 7.3). Ce qui est notable est de constater que les valeurs des deux cytokines CRP_{hs} et IL-6 ont une tendance à se diriger vers les valeurs du groupe témoin. Les différences de la grandeur de l'effet indiquent que les deux groupes étaient très différents au stade de pré-intervention (grandeur de l'effet large), mais lors

de la post-intervention la grandeur de l'effet (moyenne) est devenue beaucoup plus faible pour les deux cytokines CRP_{hs} et IL-6. L'IL-6 fut démontrée comme étant une cytokine pro-inflammatoire de phase aigue (Von Haehling et al., 2009) et l'IL-6 est responsable de la synthèse de la PRC provenant du foie (Ho and Lipman, 2009). Conséquemment, comme la présence de l'IL-6 était réduite, il n'est pas surprenant d'observer une réduction de la présence de la CRP_{hs} lors de la post intervention chez le groupe traitement, suggérant qu'une intervention de neuf traitements est capable d'atténuer une certaine réponse inflammatoire.

L'atténuation de la réponse inflammatoire est parallèle aux changements observés sur la TC. En fait, avant le traitement, le stade inflammatoire peut représenter un niveau d'œdème sous-cutané qui peut prévenir le transfert de la chaleur des tissus profonds vers la peau (Menger et al, 2003). L'œdème pourrait créer une compression des tissus au point d'empêcher une circulation adéquate vers les tissus superficiels, tel que le complexe artério-veineux sous-cutané, responsable de l'échange de la chaleur (Menger et al, 2003). Menger et al. (2003) mentionne aussi que des recherches récentes ont démontré que l'ischémie-perfusion est associée à une défaillance de la perfusion capillaire, le tout étant modulé par l'hémoconcentration intravasculaire, l'œdème endothélial et la constriction endothéliale microvasculaire. Ces résultats sont reflétés à la figure 7.1. En effet, les valeurs de la mesure post-intervention de la TC dans le groupe traitement a tendance à se diriger vers les valeurs de la mesure post-intervention de la TC le groupe témoin, c'est-à-dire que la TC se réchauffe suite aux neuf traitements. Les résultats indiquent que neuf traitements sont peut-être capables de réduire l'œdème des tissus profonds, de réduire les compressions sur les vaisseaux sanguins et d'améliorer le transfert de chaleur des tissus profonds vers la surface. Nous ne pouvons toutefois conclure à une corrélation TC-cytokines

8.3 Hypothèses

Avons-nous répondu à nos hypothèses?

La grande question était la suivante:

« Est-ce que la manipulation vertébrale lombaire produit un changement des variables suivantes: la TC, la VRC et les cytokines: PRC_{hs} et IL-6? »

Ce qui nous a conduits à notre hypothèse générale:

$H_{générale}$: La manipulation vertébrale lombaire produit un effet mesurable sur les composantes suivantes: la TC, la VRC et les cytokines: PRC_{hs} et IL-6.

Avant de d'accepter ou rejeter notre hypothèse globale, révisons les hypothèses spécifiques à chaque projet.

8.3.1 Discussions sur les hypothèses spécifiques

8.3.1.1 Projet 1

Hypothèse spécifique au projet 1.

P1-H_1: La manipulation d'une dysfonction articulaire vertébrale par Activator crée un réchauffement significatif de la TC.

La réponse est oui pour l'effet à court terme. L'hypothèse alternative est acceptée.

8.3.1.2 Projet 2

Hypothèse spécifique au projet 2.

P2-H_2: La manipulation par la méthode traditionnelle crée un réchauffement significatif de la TC et l'influence de la chaleur de la main du praticien est négligeable.

La réponse est oui pour l'effet à court terme. L'hypothèse alternative est acceptée.

8.3.1.3 Projet 3

Hypothèses spécifiques au projet 3.

P3-H_1: La manipulation vertébrale lombaire par *Activator* produit une diminution significative des différentes fréquences de la VRC.

P3-H_2: La manipulation vertébrale lombaire par *Diversified* produit une diminution significative des différentes fréquences de la VRC.

La réponse est non. L'hypothèse nulle est acceptée, c'est-à-dire:

$H_{3\,0}$: Il y a des changements, mais les résultats sont mitigés et bidirectionnels puisque certaines valeurs augmentent alors que d'autres diminuent.

8.3.1.4 Projet 4

Hypothèses spécifiques au projet 4.

P4-H_1: La manipulation vertébrale par *Activator* augmente de façon significative la mesure de la TC.

La réponse est oui. L'hypothèse alternative est acceptée.

P4-H_2: La manipulation vertébrale par *Activator* réduit l'activité des différentes fréquences la VRC.

La réponse est non, car les résultats sont mitigés, c'est-à-dire que certaines valeurs augmentent alors que d'autres diminuent. L'hypothèse nulle est acceptée.

P4-H_3: La manipulation vertébrale par *Activator* réduit la présence de l'une et/ou de l'autre des cytokines IL-6 et PRC.

La réponse est oui. L'hypothèse alternative est acceptée.

Nous concluons qu'il est acceptable d'accepter nos hypothèses.

Il faut toutefois identifier la problématique reliée à l'utilisation clinique de la thermométrie:

Quelle est la valeur normative de la TC chez un groupe de sujets sains, sans dysfonction vertébrale?

Comme il n'y a aucune base de données normative qui existe, nos projets ont démontré qu'avant d'introduire la thermométrie en milieu clinique, il faut d'abord établir un indice de la TC pour le rachis. Par la suite, il devrait y avoir des projets de recherches pour corroborer les informations cliniques des patients avec les évaluations de la TC, afin d'établir des paramètres de réévaluation et d'introduire la possibilité de diagnostique complémentaire par l'évaluation de la TC.

En conclusion, notre hypothèse générale est acceptée:

$H_{générale}$: Le traitement chiropratique produit un effet mesurable sur les composantes suivantes: la TC, la VRC et les cytokines: PRC_{hs} et IL-6.

Graphiquement, (Fig. 8.3) cela donne la représentation suivante:

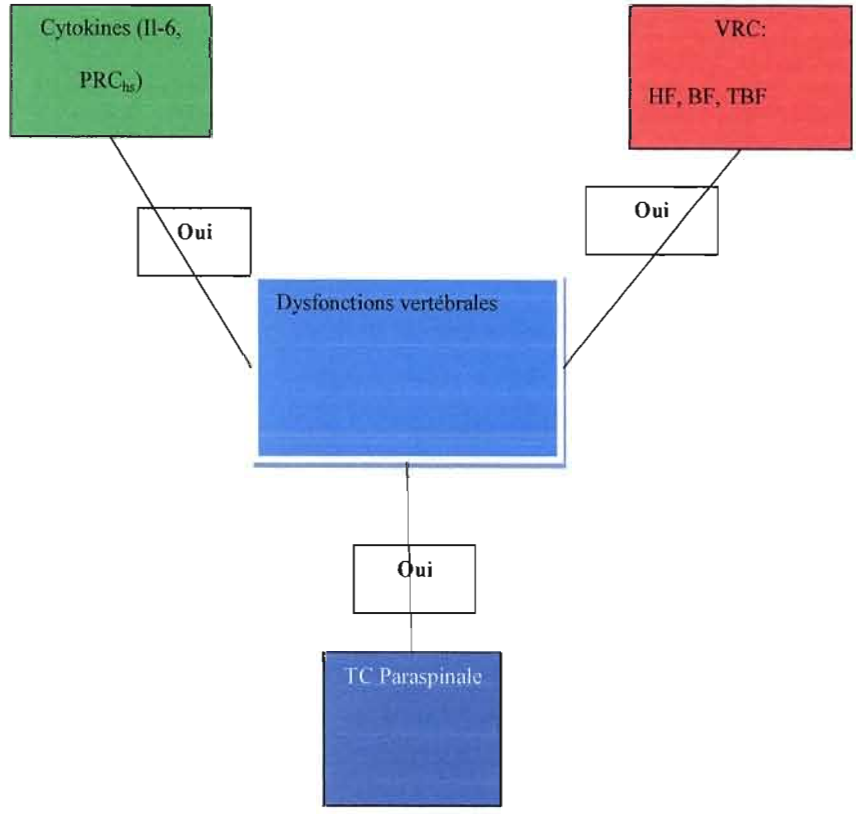


Figure 8.3 Graphique représentant les hypothèses qui furent acceptées.

8.4 Conclusion

La manipulation vertébrale par, *Activator* ou *Diversified*, produit des changements des valeurs de la TC. Toutefois, des études plus approfondies, visant à produire un indice de la TC pour l'ensemble du rachis, sont nécessaires avant de pouvoir passer à l'utilisation de la thermométrie en milieu clinique. De même, des études cliniques sur des périodes prolongées sont essentielles afin de mesurer le nombre de visites

nécessaires, après la disparition de la douleur; pour que la TC, des sujets malades, revienne vers l'indice normal.

De plus, il a été constaté que la VRC change suite à des traitements à la région lombaire. Il semble toutefois que cela soit moins évident que pour les régions cervicale et dorsale. Des études à plus long terme sont requises pour mesurer les effets sur la VRC, lors de manipulations vertébrales à la grandeur du rachis.

Finalement, la manipulation vertébrale par *Activator* réduit la présence de l'IL-6 et de la PRC. La tendance vers une normalisation de ces cytokines pourrait devenir un outil pour mesurer l'effet des traitements de la région cervicale sur ces mêmes cytokines. En effet, tel que mentionné plus tôt, cela pourrait apporter une réponse aux critiques sur les risques possibles associés aux manipulations cervicales et aux blessures vasculaires, entre autres, les blessures résultant en des attaques ischémiques transitoires.

CHAPITRE IX

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APPENDICES

APPENDICE A

Réponse aux arbitres pour l'article 1

Elsevier Editorial System(tm) for Journal of Manipulative and Physiological Therapeutics

Manuscript Draft

Manuscript Number: JMPT-D-07-00071R1

Title: Effects of a manually-assisted mechanical force on cutaneous temperature.

Article Type: Clinical Trial

Keywords: Chiropractic Adjustment, Diagnostic Technique, Thermography Prevention.

Corresponding Author: Alain Steve Comtois, PhD

Corresponding Author's Institution: Université du Québec à Montréal

First Author: Richard A Roy, DC, MSc, PhD (candidate)

Order of Authors: Richard A Roy, DC, MSc, PhD (candidate); Jean P Boucher, PhD; Alain Steve Comtois, PhD

Manuscript Region of Origin:

To: Claire Johnson, MSEd, DC

Editor-in-Chief

Journal of Manipulative and Physiological Therapeutics

cjohnson@nuhs.edu >

Dear Dr Johnson,

We want to sincerely thank you for the effort and the time you provided us with your analysis of our submission, we hope that the corrections and modifications will satisfy you and the two reviewers.

Ms. Ref. No.: JMPT-D-07-00071

New Title: *Effects of a manually assisted mechanical force on cutaneous temperature.*

Required items:

1. Have your paper edited for English spelling and grammar by primary English speaker prior to submitting your revision.

The paper was edited by Bioscience writers at www.biosciencewriters.com

2. Assignment of copyright - Please fax completed assignment of copyright form for Drs. Comtois and Boucher to (630) 839-1792. This form can be downloaded from www.mosby.com/jmpt

*** Response to Editor &/or Reviewers - without author details**

The assignment of copyright form for Dr Comtois and Boucher has been faxed.

3. Ethics approval - Please provide documentation that this study was approved by an IRB/ethic review board and include this information in the methods section (as per instructions for authors). On page 5, we wrote "The research protocols for the evaluation and adjustment were approved by the Université du Québec à Montréal ethics committee. Written informed consent was obtained from all subjects."

4. Funding source - Please provide the information about the funding source for this project.

On page 18, we wrote "Acknowledgements

The authors acknowledge the Fondation Chiropratique du Québec (Subvention à la recherche 2005-2006) for their financial support. No other financial support or consideration was received from any organization or commercial entity.

Competing Interests

The authors declare that they have no competing interests.

5. Figures- The bar graph shades are indistinguishable in black and white. Please use patterns, rather than colors, for each bar, or label the x axis instead of using a legend. All figures were changed according to your recommendations.

6. Key Indexing Terms - Please select words that describe your study from the MeSH Database in PubMed (as per instructions for authors) and enter them into the Key Indexing Term field during submission of the revision.

Key Indexing Term field have been changed and reflect the MeSH Database in PubMed and they are

"**Key Indexing Terms:** Chiropractic Adjustment, Diagnostic Technique, Thermography"

7. Order of references - Please list references/citations in order of appearance in text.

The order of the references in the text was reviewed and corrected

8. Reference formatting - Please make sure that all references are formatted as per Vancouver style (http://www.nlm.nih.gov/bsd/uniform_requirements.html). Please provide the volume and issue number for reference 5 (Unable to, it did not have any, we discarded it). Please cite references 9 and 10 as required in the Vancouver style for conference proceedings (they were changed to reflect a single reference and we used a publication instead which reflected more current information. It is now reference 9). Please provide the first 6 authors for reference 20 and the appropriate abbreviation for the periodical (Done). Please remove reference 21 (was removed), as it is not a citable source. Please provide the appropriate periodical abbreviation for reference 23 (Done), 25 (Done). Please provide the first 6 authors for reference 26 (Done).

9. Key learning points - Please include in the title page up to 5 short phrases in bullet form that emphasize the key learning points of the article. We wrote as recommended:

"Learning Points:

- Use of infrared thermometry in the proper recording time period
- Effects of a chiropractic adjustment on cutaneous temperature
- Clinical relevance of differences in cutaneous temperature in patients under maintenance care

10. Short description - Please include in the title page a short description of the manuscript to appear in the JMPT Highlights, consisting of approximately two sentences and of no more than 40 words.

We wrote as recommended:

"Short Description:

This article presents the use of digital infrared segmental thermometry in the evaluation of cutaneous temperature after a chiropractic adjustment. This tool could possibly be used to assist the chiropractor in being more precise in their intervention.

11. Device information - In parentheses following the mentioning of each device or software program, please provide the full name of any devices or software programs used, the name of the manufacturer, and the city where that company is located. This was done as recommended: on page 6 "the Subluxation Station Insight

7000□ (Chiropractic Leadership Alliance, Crossroads Corporate Center, One International Boulevard, Suite 750, Mahwah, New Jersey 07495).

Reviewers' comments:

Dear Reviewer #1: We thank you very much for your comments and detailed work, we also thank you for having worked at rewriting. Unfortunately, by the time this electronic reply is sent, we have not yet received your hard copy form the Editor; snail mail can be slow especially when it crosses the border and customs. Thank you again for your time and devotion to editing research material.

The design of this study is quite straightforward, but I have some questions about choices made in the methods section. I would strongly suggest you reword the title to make it more clear (done) and redesign your graphs for clarity (done). I understand that English is not the first language of the authors and thus I appreciate the effort that it takes to write a scientific paper in another language (English editing done). I took the time (several hours) to rewrite parts of the paper to make it clear (at least to me) and to eliminate writing in the first person (Where it was present it was corrected by the English language editor). Because there are so many corrections, I will be sending a hard copy to the editor to see if she would like to return it to you. That would be the easiest thing to do from my perspective. The clinical relevance of these small temperature changes is not addressed.

Additionally, I question the validity of using the Activator as a determinant of the 'subluxation'.

The reviewer is mistaken, we did not use the Activator instrument but the Activator Methods. As you know there has been numerous research validating the use of the instrument. The Activator Methods Chiropractic Technique, like many chiropractic technique which are taught in chiropractic colleges and used universally; are still under the scrutiny of researcher to validate them. This is part of our research program at the UQAM and it is intrinsically related to future projects.

What about the reliability of selecting the L4 and L5 vertebral levels? Why different levels for each group? (We selected different levels to compare within the methods of Activator if it would show a difference and we selected L5 for the next study for the traditional chiropractic adjustment)

What about the patient with 4 or 6 lumbars and this is usually not known?

(There were no patients with 4 or 6 lumbars; they all had previous radiographs available).

The Discussion seems to include some large leaps of logic as well. (The discussion presents three

different hypotheses and the conclusion states that more research needs to be done) All

of these points are indicated in red ink on the hard copy.

Dear Reviewer #2: We thank you very much for your comments and detailed work, and your suggestions. Thank you again for your time and devotion to editing research material.

This is an interesting paper and certainly an area where we need research. The design was quite innovative with a sophisticated statistical analysis. I think you may have overextended the conclusion however. I have a number of suggestions for improvement of the manuscript.

1. Please shorten the title, and do not use acronyms in the title. The main thesis of the paper is that there will be short-term skin temperature changes in response to an instrument delivered thrust.

Done as recommended

2. Please renumber the references. In the introduction, the citations jump from 15 to 22. It looks like just 22 & 23 are out of order.

Done as recommended

3. In "Measurements" please list the manufacturer and location for the Insight 7000.

This was done as recommended: on page 6 "the Subluxation Station Insight

7000 (Chiropractic Leadership Alliance, Crossroads Corporate Center, One

International Boulevard, Suite 750, Mahwah, New Jersey 07495).

4. At the beginning of the methods section you state that a power analysis was done, based on previous data.

This was clarified, on page 4 "The required number of subjects was calculated

using the results from a previous study12. Based on an effect size of 0.25°F, a type I error

of 0.05, a Power of 80% and according to Cohen's table17, eight subjects per group were

required. We elected to have 11 subjects per group. It seems that you're working hard to satisfy a CONSORT recommendation here. However, the CONSORT is for clinical trials, which this study is not (We agree it will be resubmitted amended as an outcome study).

It's a good idea to do a power analysis, but you would need to be more specific about the basis for the analysis. In particular, the power analysis is set up to satisfy the needs of a hypothesis. You would need to state that you expect to find a certain amount of change in skin temperature (what would a significant change be: 0.5 degrees, 2 degrees?) and that you would need X number of patients in 3 groups to detect such a difference. (See above)

5. I was left confused about the relationship between the adjusted side (IPSI), the colder side and the Activator methods examination. In one place, you say that all TRP30 subjects would be adjusted at L4, and all TRP8s would be adjusted at L5. Then, you discuss the use of the Activator assessment. Was the

adjustment site determined "a priori" or by the assessment? So, perhaps the clinical assessment was only used to determine the side of adjustment. It's startling to me that all patients just happened to be in need of adjustment at the prescribed segment. Also strange is that all the patients had a colder temperature on the side of the adjustment. That correlation is surprising. Please clear this up for me.

We hoped to have clarified this on page 4-5 that now reads as follows: "A total of 66 healthy subjects (36 women and 30 men) were recruited between July 2004 and July 2006 from a chiropractic clinic. The inclusion criterion was that all subjects were receiving maintenance chiropractic care and were pain free. In addition, all subjects were free of any underlying conditions (acute or chronic diseases, cold, menses, and/or any thermogenic disease) that could have affected their CT. Subjects were also instructed not to drink any coffee or any other beverages containing caffeine (e.g.: caffeinated soft drinks, tea) and not to smoke or chew tobacco at least two hours prior to the recording session. Compliance with the instructions was verified on the recording day. All subjects had been previously examined and x-rayed. All subjects had five lumbar vertebrae. Subjects were also pre-selected according to the Activator Methods Chiropractic Technique protocol (AMCT) 18 for the presence of either an L-4 or L-5 subluxation. Subjects were randomly assigned to one of two groups based on the recording period: (L-5) TRP8 or (L-4) TRP30. Each recording period group was divided into three subgroups (n=11 per group): treatment, sham and control groups.

6. I'd like to know how often the adjustment was given (and the cold side occurred) on the left versus right side. There may have been some hidden biases in the measurements. Each subject (in the treatment group) received only one adjustment according to their listing as they had been previously pre-selected. Other groups received the sham treatment as it is described and the control group did not receive any treatment or sham.

7. How did you determine ipsi vs contralateral sides in the control group? These subjects were apparently not examined for clinical indications. The control group subjects were examined for the presence of an L-4 or L-5 subluxation according to the AMCT protocol and they were assigned to their respective groups and they were then randomly assigned to their respective groups,. They had been evaluated and demonstrated a positive listing for their group according to the AMCT protocol, the side where they would have been adjusted was considered the ipsilateral side.

8. You mention that patients were blinded to group assignment (at least the sham vs adjusted groups). Was there any attempt to blind the thermal assessment? This is important if there is any way that the examiner could influence the readings. If the examiner was not blinded to group assignment, you need to mention this as a limitation. We do mention it on page 6 "**Limitations in the thermal measurements.** There were no attempts to blind the thermal assessment since the data were recorded directly into the computer after each measurement. At each test or time marker only one recording was taken. The examiner could not know the value during measurement. The risk of influencing thermal assessment was kept to a minimum by insuring that the measurement protocol was respected by the examiner.

9. Figures 2 & 3: The first time point on the TRP8 data should be T(0.5), not T2. These figures should also include error bars to show the standard error (or confidence intervals) around the means. The figures might be clearer if you split out the ipsilateral and contralateral data into separate charts.

This was corrected as you recommend

10. I agree with your discussion that the main point of interest was seen in the diffcrent responses to the adjustment versus the sham in the TRP8 group only. However, it is a short-term effect, correct? It seems to wash out in about 1 minute. Incorrect, the effect of tissue compression seems to wash out but there is another rebound between t3 to t10 that rebound is not yet explainable. Our discussion and conclusion reflect the need for more research.

11. Be careful about discounting the findings of the TRP30 group. You discuss the effect as if it is real in the manuscript, but it seems to be discounted in the abstract as not being clinically useful. (The starting point is not as clear as TRP8). The curious thing is that the sham group seemed to show a greater change than the treatment group at TRP30. It suggests that the temperature change is a local phenomenon due to pressure on the skin. (Yes it does reflect the intense pressure and the lengthy duration of the pressure for both the treatment and sham group which we used to try and mimic the pressure produced by a traditional adjustment) Why would acclimation time affect the skin response?

This was demonstrated in our paper "Roy RA, Boucher JP and Comtois AS. 2006a Digitized Infrared Segmental Thermometry (DIST™): Time requirements for stable recordings. J Manipulative Physiol Ther. 2006 August;29: 468.e1-468.e10"

If you saw the temperature change at remote points, that might actually be evidence that there was an organized response by the sympathetic nervous system. We wish to thank reviewer #2 for his suggestion and we certainly will apply the suggestion in our future research

12. I would use caution in discussing clinical importance of this data. Your patients were asymptomatic, and the clinical evaluation for subluxation seems forced (see #5 above). (Answer see # 5 above)

13. You talk about DIST as having a use in prevention. That statement is unsupportable with this data. Your data show that temperature asymmetries can exist, and, magically, correlate with Activator findings. There's no way of knowing that folks with these kinds of temperature asymmetries (or Activator findings) are at risk for any kind of health problem in the future. I would totally get rid of that discussion point.

As recommended, this part of the discussion was removed

14. I don't understand this statement: "In our experiment, the Activator adjusting instrument has been calibrated to work within a certain frequency range. The frequency range of 30 to 50 Hz can be considered within normal in the lumbar spine A-P direction 19, 21, 29." Keller et al described the vibrational behavior of the spine in the AP direction and have measured a resonance at about 40 Hz. The activator isn't particularly tuned to that frequency, though. That statement slipped through the crack. It was supposed to have been removed, we apologize about this mistake. It has been removed from the resubmitted version.

15. The conclusion should be simply that compression of the skin in the area of thrusts with the activator instrument produces a short-lived increase in temperature. Contacting the skin with the head, without a thrust also produces a temperature change.

This was changed on page 16 **"Conclusion**

Contacting the skin with the instrument with (Treatment group TRP30) or without (Sham group TRP30) a thrust with a sustained pressure stronger than the loading principle taught in the Activator Methods

Chiropractic Technique protocol or a thrust respecting the standard loading principle (Treatment group TRP8) of the instrument produced a CT cooling immediately after the adjustment. Furthermore, we observed that when contacting the skin with the instrument with a thrust respecting the standard loading principle (Treatment group TRP8) of the instrument it produced a secondary cooling at t5 followed by a rewarming at t10. Finally, contacting the skin with the instrument without a thrust and respecting the standard loading principle (Sham TRP8) of the instrument did not produce a CT.

APPENDICE B

Réponse aux arbitres pour l'article 2

Ms. Ref. No.: JMPT-D-09-00104
Title: Cutaneous temperature modification after a spinal manipulation
Journal of Manipulative and Physiological Therapeutics
Dear Dr Johnson, MSEd, DC
Editor-in-Chief
Journal of Manipulative and Physiological Therapeutics
cjohnson@nuhs.edu
This is the reply too the revision requirements for JMPT-D-09-00104
Revision requirements:
1. Assignment of copyright - Please fax completed assignment of copyright form for Drs. Comtois and Boucher to (630) 839-1792. This form can be downloaded from www.mosby.com/jmpt

These were faxed on September 18th 2009.

2. Key Indexing Terms – These were modified accordingly

3. Structured abstract - The abstract is at the beginning of the text

4. Tables - The tables are at the end of the manuscript

5. Figure Legends - The figure legends are in the main manuscript document, following the tables.

6. Please expand title to be more descriptive of the study. The new title is

"Paraspinal lumbar cutaneous temperature modification following a single lumbar spinal manipulation"

7. Please clarify/expand on the goal/purpose statement in both the abstract and at the end of the Introduction section.

The new goal/purpose statement in both the abstract and the introduction now reads as follows:

"The purpose of this paper was to investigate local paraspinal cutaneous temperature (CT) modifications following spinal manipulative therapy at L-5."
Reviewers' comments:
Reviewer #2: The Introduction requires some expansion. The validity / reliability of CT measurement should be discussed more in depth, how reproducible and valid are results in clinical conditions (i.e. less controlled than in an experiment)? Do we even know at this point? There is mention of validity and reliability under adequate conditions - what does this entail? The authors mention only one study for reliability, can we be positive of the reliability of this technology/technique based on one study?

The introduction has been revamped and reads as follow:

"The application of thermometry principles has been proposed as potentially useful in chiropractic medicine (Ebrall, 2004). It has recently been shown that paraspinal cutaneous temperature (CT) can be reliably measured clinically by thermometry under controlled conditions (Hart et Owens, 2004; Roy, Boucher et Comtois 2006a; Roy, Boucher et Comtois 2006b). Recently, a study, using a handheld thermographic scanner, evaluated the interexaminer and intraexaminer reliability where it was found to be very high (Owens et al., 2004). In another study (Roy, Boucher et Comtois 2006a), fifteen subjects were evaluated with 30 spot-shot repeated measures per day of recording (15 in the lumbar area at L-5 and 15 in the cervical area at C-5) on five different occasions and at different times of day, for a total of 2,250 recordings. The total of these recordings was used to establish infrared camera CT validity and reliability, were strong significant correlations between skin thermistors and infrared camera recordings at L-5 were established.

Optimal time period for CT measurement has also been a subject of interest. Hart et Owens (2004) have shown that a 16 minute acclimation period is necessary for the purpose of pattern analysis of paraspinal CT. In another study conducted by Roy, Boucher et Comtois (2006b), two stabilisation periods were identified as acceptable for adequate CT recordings, one occurring between minute 8 and 16 and a second between minute 30 and 45. Roy, Boucher et Comtois (2006b) proposed that for a clinical setting the 8 to 16 minute stabilisation period is more practical, but a controlled environment (stable room temperature, ~22 ± 1.0 C) is necessary to obtain valid and reliable recordings.

Thermometry based on paraspinal differences at the same segmental level has been proposed by several authors that it may be indicative of somatospinal inconsistencies requiring a chiropractic adjustment (Ebrall, 2004; Hart et Owens, 2004; Roy, Boucher and Comtois 2006a; Roy, Boucher et Comtois 2008). Several studies using CT thermography recordings have shown that there are temperature gradients along the length of the spine (Uematsu et al., 1988a, Uematsu et al., 1988b; Herry et Frize, 2002). However, to the best of our knowledge, there is one scientific study done with humans that have evaluated the effect of a spinal manipulative therapy on paraspinal CT. The study measured the effect of a manually assisted mechanical force on lumbar paraspinal CT using an instrument in order to limit the possible heat transfer from the clinician's hand unto the patient CT (Roy, Boucher et Comtois, 2008). CT was modified following the intervention but mechanisms involved at this time are entirely speculative. In addition, a study by Harris et Wagnon (1987) has shown that a chiropractic adjustment can modify fingertip CT depending on the specific region of spine adjustment (C1-C7 and/or L4-L5). Thus, it appears that spinal manipulations can alter CT; however, the effects of these spinal manipulations are still unknown on lumbar paraspinal CT.

To this day new emerging technologies are being explored, such as visible and infrared light, microwaves, terahertz rays, and intrinsic and applied electric and magnetic fields (Wolbarst et Hendee, 2006). Also, the utilization of handheld thermometric equipment is well advertised and its use is empirical at best. In spite of this and as mentioned earlier, there is still a lack of concrete objective data in the scientific literature on changes to paraspinal CT procured by spinal manipulative therapy.

Nevertheless and as stated by Plaugher (1992), continued investigation is needed in the area of thermographic research. It has been proposed that future research should focus on thermography as a non-invasive outcome measure and improved interpreter reliability (Plaugher, 1992). Thus, based on the above

succinct review of CT measurements in the field of chiropractic practice, the goal of the current study was to investigate the local CT modifications following spinal manipulative therapy at L-5. We hypothesized that spinal manipulation at the level of L-5 would modify the paraspinal CT."

There is a fair amount of repetition in the Methods that could be eliminated and I would like to see the methods re-structured to facilitate this.

We have streamlined it and we have included the details of the calculation used, to establish subject number, as more details were requested by reviewer #3, for reproducibility purposes.

I was distressed by the lack of blinding involved,

The text has been rewritten to make it clearer about the blinding and non blinding process.

"The assessor (person setting the equipment and doing the recordings) was blinded to the allocation of the patients to the different groups and he did not interact with the patients or the clinician. The person administering the adjustment was not blinded to the group assignment."

Overall there are some issues with grammar and syntax that would lead one to believe that another read through by the authors is warranted.

An English journalist/reviewer was hired to help with the latest version submitted.

I would like to see elucidation as to how these results fit in with their previous work in the Discussion.

This section was added as requested at the end of the discussion

"Pain free patients versus patient in pain.

Comparing the present results, patients with an acute low back condition, with our previously published work (Roy, Boucher et Comtois 2008) where we studied patients without pain, we observed an opposite trend on the initial CT measurement. In the 2008 study, the ipsilateral side (subluxated side) was contacted by an instrument (colder) and in the present study the contact was by hand (warmer), which is perhaps the reason for opposite CT responses at time 0 immediately following the intervention. This means, beyond any doubt, that a certain period of time is needed before making a post intervention evaluation, possibly 3 to 5 minutes.

As well, in the present study, CT was colder on the subluxation (ipsilateral) side in pain free patients with low back conditions necessitating support care. This raises the question that could it be possible that CT measurement may be valuable in the diagnosis of pain-free as well as painful conditions. CT monitoring throughout the entire treatment course for patients initially in pain to the later part of the treatment when patients are pain-free, but still subluxated, may indicate the possible need for care without the presence of pain while providing the diagnostic clues to pursue treatment. This is an interesting point of view, but firstly physiological mechanisms involved in CT changes must be identified. At the moment, more research is needed to observe changes over time associated with clinical correlations."

Reviewer #3:

In the Major area:

A. Please explain the CT recording protocol in more detail. You want enough detail that someone could follow your methods and repeat the study. Specify that the CT was a spot-shot at L5. The subluxation station protocol usually involves a moving scan. Which Subluxation Station protocol did you use? Systems like that

typically have a little settling time and average data over a recording period. So, please describe the recording protocol in more detail. For instance, here are the steps I'd like to see described:

1. locate the target spot (How and when is it located; is it marked?),

2. position the recording head xx inches over the target spot (You mentioned the sticks, but not how long they project from the front of the scanner head. Is the head held by hand?)

3. push the trigger (How long do you hold the trigger? Do you watch the temperature stabilize? Is the recording an average of several readings?

4. I assume that all recordings were taken in the prone position, but the treatment and sham were in side posture. Describe how soon after the treatment/sham the patient was repositioned.

This section was changed and reads as follow:

« **Measurements.**

The CT measurements were obtained with infra red cameras (Roy, Boucher and Comtois, 2006a). All temperatures were recorded in degrees Fahrenheit (°F). The infra red cameras were calibrated on site using the manufacturer's recommendations. The cameras used were not the rolling type cameras but the hand held square box like cameras. To introduce a constant half-inch distance between the infra red cameras lens and the skin surface, wooden sticks (Popsicle style) were secured to the side of each infra red camera casing. When the end tip on the Popsicle stick touched the skin the camera lens were half-inch away from the skin. This was a spot-shot at L-5. The subluxation protocol used was for the hand held non rolling instrument. The technician waited until the recording settled, as seen on the computer screen when the CT recording was done. That period of settling varied between five to 10 seconds. When the temperature settled on the screen the technician would then depress the recording pedal. The hand held units were held on the sides over the wooden sticks, in order to avoid heat transfer from the technician and affect the recordings. The target area was identified by the clinicians with two felt pen markings four inches lateral to the spinous process of L-5, outside the recording area of the lenses. The recordings were all done in the prone position and the treatment was in the side posture, it took less than 30 seconds for the subjects to return to the prone position form the side posture. CT was measured at the following six specific time points: before the spinal manipulation (t_{-2}) that served as a control (CTL) period, at the time immediately after the spinal manipulation (t_0), and 1, 3, 5, and 10 min after the spinal manipulation (t_1, t_3, t_5 and t_{10}, respectively).

Infrared cameras recorded directly into the Subluxation Station Insight 7000™ (Chiropractic Leadership Alliance, Mahwah, New Jersey, USA). All data were collected at a room temperature of 21.95 ± 1.0 °C (data not shown)."

B. I'm a little confused by the statistical analysis: In the results and in Table 2 you show no difference between groups. There is a Side*Time difference, however. To me this suggests that you cannot attribute the Side*Time changes to treatment group, it happened in both groups. Yet, you conclude that the different treatments produced different temperature changes. Perhaps you need to (or already did) analyze the Side*Time differences in the 2 treatment groups separately. Either way, the statistical analysis seems to conflict with the conclusion.

This was changed and reads as follow:

"The results are provided by giving the F ratio along with the obtained levels of type I error (p) and observed power (P). Subsequent to our initial analysis we performed a within subject ANOVA for each group, see Table 3 and 4."

And follows later in the results with:

"Tables 3 and 4 respectively illustrate the results of the ANOVA for the treatment and sham groups. Only the treatment group had significant side and side * time differences. Figure 1 presents the initial measurement at t_{-2} for each group and side. The side ipsilateral to the spinal manipulation, or subluxated side, was warmer than the non-subluxated side for both groups, but the difference was not statistically significant. The sides are identified as ipsilateral and contralateral in relation to the side of subluxation. The sham group is cooler than the treatment group. The average CT at L-5 was 33.7 ± 0.90 °C for the treatment group and 32.98 ± 0.80 °C for the sham group (data not shown), but this difference was not statistically significant. Similarly, the response to the intervention seems non significant between groups, as demonstrated in Table 2. However, when we analyze each group separately, we can observe in Tables 3 and 4 the significant differences seen in the for the treatment group, but not in the sham group."

Minor corrections:
C. Please check the text describing who was blinded. You say that the assessor was _not_ blinded to treatment, and that he did not interact with the patient or clinician. The second part of the sentence makes it look like there was some attempt to blind the assessor.

This was corrected and also mentioned in answering reviewer #2.

The text has been rewritten to make it clearer about the blinding and non blinding process. It now reads as follows:

"The assessor (person setting the equipment and doing the recordings) was blinded to the allocations of the patients to the different groups and he did not interact with the patients or the clinician. The person administering the adjustment was not blinded to the group assignment."
D. The paper needs to be edited again for grammar. Aside from trivial typos, the best-written section is the discussion. The introduction, though, needs more work to improve readability. The sentences there are choppy and terse, with little information linking the concepts.

As mentioned to reviewer #2: An English journalist/reviewer was hired to review the manuscript.
E. Indicate the meaning of astrices in figure 1A. It is mentioned in the text, but should also be in the figure legend.

This was changed and reads as follows:

Figure 1: Cutaneous temperature (CT) measurements (°F) over time (t-2, t0, t1, t3, t5 and t10) following the 8 min acclimation period. Average contralateral and ipsilateral temperatures at L-5 for the treatment (1-A) and sham (1-B) groups. The asterisks are in the time slots that correspond to the significant sides*times interactions for the treatment group only. Ipsi = ipsilateral; Contra = contralateral. Filled symbols indicate treatment side CT measurements (Ipsi, ipsilateral side); Empty symbols indicate opposite to treatment side

CT measurements (Contra, contralateral side). CTL, control period of 2 min before the chiropractic or sham intervention (t_{-2}).

Figure 2: CT measurements expressed as differential of temperature in relation to t-2, (°F) over time (t-2, t0, t1, t3, t5 and t10) following the 8 min acclimation period for the treatment (2-A) and sham (2-B) groups. The asterisks are in the time slots that correspond to the significant sides*times interactions for the treatment group only. Filled symbols indicate treatment side CT measurements (Ipsi, ipsilateral side); Empty symbols indicate opposite to treatment side CT measurements (Contra, contralateral side). CTL, control period of 2 min before the chiropractic or sham intervention (t_{-2}).

APPENDICE C

Réponse aux arbitres pour l'article 3

Date: Nov 12, 2008 To: "Alain Steve Comtois" comtois.alain-steve@uqam.ca cc: bgreen@nuhs.edu From: cjohnson@nuhs.edu Subject: Your Submission

Ms. Ref. No.: JMPT-D-08-00069R1
Title: Heart rate variability modulation following a manipulation in pain free patients versus patients in pain
Journal of Manipulative and Physiological Therapeutics
Dear Alain Steve Comtois,
This letter is in regard to your paper "Heart rate variability modulation following a manipulation in pain free patients versus patients in pain". Members of the Editorial Board have reviewed the paper and on the basis of these reviews, I feel that revision of this manuscript is in order.
Please make appropriate changes in the manuscript as listed below. Publication is contingent on revision. Request for revision does not promise future acceptance. Further review and revision may be necessary before a final decision can be reached.
Please supply your revised draft and a cover letter with a list of itemized changes made in your manuscript addressing each of the reviewer comments/concerns.
I look forward to receiving your revisions so that we can move forward toward publication. Please feel free to contact me if you have any questions.
To submit a revision, you will first need to make the changes to your manuscript from your file on your computer, and then save it. When you are ready to submit the revised manuscript via EES, please go to http://ees.elsevier.com/jmpt/ and login as an Author.
Your username is: ******
Your password is: ******
On your Main Menu page is a folder entitled "Submissions Needing Revision". You will find your submission record there.

Thank you, again, for your submission to the JMPT.

Sincerely,

Claire Johnson, MSEd, DC
Editor-in-Chief
Journal of Manipulative and Physiological Therapeutics
cjohnson@nuhs.edu
Still need the following items:
1. Assignment of copyright - Please fax completed assignment of copyright form for Drs. Roy and Boucher to (630) 839-1792. This form can be downloaded from www.mosby.com/jmpt

Dr Roy and Boucher were advised to do so. Dr Roy's form accompanies this Fax

2. Order of references - Please list references/citations in order of appearance in text. References skip from 21 to 24 in the text, 22 and 23 are shown later, 29 is not cited in the text. Please make these corrections. The reference list has been revised in the text and modified accordingly.

Revision items:

ABSTRACT

1. Please be more descriptive with the types of chiropractic treatments used

Introduction. The purpose of this study was to examine the heart rate variability (HRV) in the presence or the absence of pain in the lower back, while receiving one chiropractic treatment at L5 from either a manually assisted mechanical force (Activator) or a traditional Diversified spinal manipulation.

And

Conclusion Adjusting the lumbar vertebrae affects the lumbar parasympathetic nervous system output. The evidence demonstrates that the adaptation in the parasympathetic output, reflected by changes in HF, LF and VLF, is independent of type of adjustment. Therefore, the group differences found in the modulation of the HRV would seem to be related to the presence or absence of pain. In addition the autonomic nervous system response may be specific and sensitive to its effector organ. This was a one time intervention. More research is needed to see the effect for a longer treatment period.

INTRODUCTION

1. Please clarify your hypothesis/purpose statement

Page 3. Thus, the purpose of the present study was to measure the effect of a lumbar adjustment, with a manually assisted mechanical force, producing a chiropractic adjustment, in participants without lumbar pain or a Diversified lumbar roll traditional adjustment in participants with lumbar pain on HRV. The hypothesis being that a lumbar intervention would have an acute effect on the ANS and demonstrate changes in the modulation of HRV variables.

METHODS

1. Please choose an alternate word for "subluxation" for what is being adjusted - since in standard medical terminology "subluxation" means partial dislocation, and this is most likely not accurately describing the patients in your study

Page 6 spinal dysfunction.

2. Please clarify how the "subluxations" were found for all patients

New paragraph page 7

Spinal Dysfunction assesment

The spinal dysfunction assesment was determined by the Activator Methods evaluation [17] by the treating clinician for the pain free group. The assesment for the pain group receiving the Diversified lumbar roll traditional manipulation [18] was assessed by motion palpation by the treating clinician. These assessments were completed prior to the adjustment on the day of treatment, but after the other examinations mentioned previously.

3. Please provide the inclusion and exclusion criteria that were used in recruiting patients for this study.

Page 6

Pain free group

A total of 33 healthy participants, 18 females and 15 males, were recruited from a chiropractic clinic between July 2004 and July 2006. The inclusion criterion was that all participants were receiving maintenance chiropractic care and were pain free. Exclusions criteria were any patients with pain.

And page 6

Pain group

Twenty participants were recruited, 12 females and eight males, were recruited from a different chiropractic clinic between July 2004 and July 2006. The inclusion criterion was that all participants were suffering from an acute low back pain and were receiving chiropractic care. Exclusion criteria were any patients without pain. Definition of acute low back pain was as defined by the North American Spine Society (**NASS Headquarters,** 7075 Veterans Blvd., Burr Ridge, IL 60527) as: "low back pain present for up to six weeks. It may be experienced as aching, burning, stabbing, sharp or dull, well-defined, or vague. The intensity may range from mild to severe and may fluctuate. The pain may radiate into one or both buttocks or even into the thigh/hip area".

4. Please clarify if the subjects were students from the University

Page 5. None of the participants were students from the University.

5. Please provide more detail about each of the 2 techniques used.

Page 7-8 new paragraph

Chiropractic techniques

In the pain free group we utilized the Activator Methods protocol, by determining the pelvic deficiency side and evaluating the patient for the presence of an L-5 spinal dysfunction. The treatment was executed using an activator adjusting instrument, namely the Activator IV at the number four setting, representing an average force of 174.75 Newton (N) [19].

In the pain group the chiropractor used the Diversified type lumbar roll as demonstrated in Esposito [18], from the traditional chiropractic style manipulation. The chiropractor determined the area to be treated by motion palpation, static palpation and prior evaluations as mentioned above. The adjustment force as been described and averages 264 N. [19]

6. Please include an estimation of the forces used for each type of chiropractic adjustment

See number 5 above page 8 in the manuscript new paragraph.

7. Please provide details about how the sample size was determined

Page 5

For sample size determination, we considered alterations in physiological responses[16]; where it was established in nine participants. Therefore we established our cohort at 20 participants, ten participants per sub group and ten participants in the control group.

8. Please provide more details as to how all subjects were blinded. (eg, If they were regular chiropractic patients the sham was most likely identified as a shame treatment)

Page 5, the participants were blinded to the intervention but considering that they were already chiropractic patients; the patients in the sham groups would mention that the treatment felt different. The Activator Methods sham treatment was only the application of the instrument on the skin while in the other hand another instrument was fired by the chiropractor. In the case of the lumbar roll, the patient was in the side posture and the chiropractor applied pressure with his treatment hand but no thrust was generated. Those administering the intervention were not blinded to the group assignment. The researchers were not blinded to which group patients belonged when measuring outcomes.

9. Please provide more details about if the researchers were blinded from which group the patients were from when they were measuring their outcomes

See number 8 and page 5 in the text

10. Please provide more detail about the period of recruitment of patients

Page 4-5 in the text

A total of 51 participants were recruited between the period of February 2006 and May 2006.

Pain free group

A total of 33 healthy participants, 18 females and 15 males, were recruited from a chiropractic clinic between February 2006 and May 2006, from a poster in the waiting room informing patients of the coming research project. The poster mentioned that patients had to be under maintenance/preventative care and be pain free.

Pain group

Twenty participants were recruited, 12 females and eight males, were recruited from a different chiropractic clinic between February 2006 and May 2006, from a poster in the waiting room informing patients of the coming research project. The poster mentioned that patients had to be in pain and under initial intensive chiropractic care and in pain. The inclusion criterion was that all participants were suffering from an acute low back pain and were receiving chiropractic care. Exclusions criteria were any patients without pain. Definition of acute low back pain is defined by the North American Spine Society (**NASS Headquarters,** 7075 Veterans Blvd., Burr Ridge, IL 60527) as: "low back pain present for up to six weeks. It may be experienced as aching, burning, stabbing, sharp or dull, well-defined, or vague. The intensity may range from mild to severe and may fluctuate. The pain may radiate into one or both buttocks or even into the thigh/hip area".

DISCUSSION

1. Please expand the limitations section to include confounders for your study.
2. In the limitations section, please include alternate possible explanations for the findings
3. In the limitations section, please include other limitations which relate to bias, blinding, etc

Page 22-23 in the text

Limitations

Two different chiropractic techniques and two different cohorts were utilized in this project. It is not possible at this time to draw conclusion on the effectiveness of one technical approach over another. Conclusions are

drawn on the cohorts, but a more extensive cohort reflecting the pain cohort with only one adjusting technique will be used in future projects to further validate some of our findings. As mentioned in the pain and HRV section, further research needs to take into consideration the emotional aspect of the patient. As well, since our results are not as strong a Budgell [8, 9] using respectively the cervical and thoracic spine as mode of intervention and Zhang [10] using a multimodal treatment in different chiropractic clinics, we are suggesting that the autonomic nervous system may be specific and sensitive to the origin of the preganglionic/postganglionic innervations to the effector organs. In other words, had we evaluated effector organs connected more directly to the lumbar parasympathetic innervations we might have found results respectively similar to Budgell [8, 9] and Zhang [10]. Even though, investigators in the present study were not blinded, outmost care was taken to maintain objectivity and eliminate any unwarranted bias during data analysis and interpretation.

ACKNOWLEDGMENTS

1. Please clarify if Activator Methods donated instruments for use in this study page 25

Acknowledgements

The authors acknowledge the « Fondation de recherche chiropratique du Québec » (Subvention à la recherche 2005-2006) for its financial support. In addition the authors wish to thank Activator Methods International Inc for donating the activator adjusting instrument, namely Activator IV Signature Series instrument. No other financial support or consideration was received from any organization or commercial entity.

F. Table 1. It is a 'p' being represented not a 't', The significance is generated by Student's t-test.

Changed accordingly

APPENDICE D

Réponse à la lettre à l'éditeur pour l'article 3

Lettre à l'éditeur

Journal of Manipulative and Physiological Therapeutics

Manuscript Draft

Manuscript Number: JMPT-D-09-00145

Title: Comment on «Heart rate variability modulation after manipulation in pain-free patients vs patients in pain»

Article Type: Letter to the Editor

Keywords: autonomic; sympathetic; parasympathetic; spinal manipulation; heart rat variability; HRV

To the Editor,

In May 2009 the JMPT published a study on the modulation of heart rate variability (HRV) by lumbar spinal manipulation (Roy, Boucher et Comtois, 2009). In this letter we would like to raise several contentious issues with the aforementioned study. We will argue that it cannot be concluded that lumbar spinal manipulation affects heart rate variability or that the response of the autonomic nervous system may be specific to its effectors organs, based on that study. Rather, we suggest that the reported results reflect nonspecific effects which were not measured or controlled for. Firstly, the parasympathetic nervous system does not have a lumbar output, as the authors erroneously suggest. The parasympathetic nervous system has two major divisions, including nuclei of the brainstem and the sacral spinal cord; the origin of preganglionic fibers (Brodal, 2004). Critically, there are no anatomical connections between the lumbar spinal afferents and the heart, nor between the sacral parasympathetic neurons and the heart. Thus, the hypothesis submitted by the authors is not tenable on a purely anatomical basis. It is hardly conceivable that lumbar spinal manipulation could have any specific effect on the parasympathetic output to the heart. We find the authors' connection between the lumbar spine intervention and changes in cardiac function is quite puzzling. From the abundant literature on somato-autonomic interactions (see . Sato A, Sato Y, & Schmidt RF, 1997)

for an excellent review), no physiological mechanism for the proposed parasympathetic regulation of cardiac functions by primary afferents from the lumbar spine can be postulated.

Secondly, the authors correctly state that the so-called high frequencies of the power spectrum analysis of the tachogram are tightly coupled to respiration. Accordingly, changes in respiration significantly affect the results from HRV analyses (Stauss, 2003; Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996). To avoid this confounding factor the experimental design should have used paced respiration, as in previous studies (Budgell & Polus, 2006). Alternatively, respiration could have been recorded and controlled for in the analysis. The authors cannot infer parasympathetic modulation, based on changes in the high frequency band, unless respiration is controlled for across conditions (before vs after the intervention) and across groups. Moreover, it cannot simply be assumed that respiration was comparable between conditions or between groups as this may not be the case. This is a critical issue as the effects of interventions reported in the study by Roy et al. may simply reflect nonspecific changes in the respiration rate.

In conclusion, we hope this letter clearly conveys the major shortcomings of the Roy et al. study. We also hope that the methodological considerations raised here will be taken into account in future studies using spinal manipulation and HRV. Doing so will greatly improve experimental designs and interpretation of the results.

References

Roy,R.A., Boucher,J.P., & Comtois,A.S. Heart rate variability modulation after manipulation in pain-free patients vs patients in pain. *J. Manipulative Physiol Ther.* 32, 277-286 (2009).

Brodal,P. *The central nervous system: structure and function* (Oxford University Press, Oslo, 2004).

Sato,A., Sato,Y., & Schmidt,R.F. The impact of somatosensory input on autonomic functions. *Rev. Physiol Biochem. Pharmacol.* 130, 1-328 (1997).

Stauss,H.M. Heart rate variability. *Am. J. Physiol Regul. Integr. Comp Physiol* 285, R927-R931 (2003).

Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. Heart rate variability: standards of measurement, physiological interpretation and clinical use. *Circulation* 93, 1043-1065 (1996).

Budgell,B. & Polus,B. The effects of thoracic manipulation on heart rate variability: a controlled crossover trial. *J. Manipulative Physiol Ther.* 29,

603-610 (2006).

Réponse à la lettre à l'éditeur

To the Editor,

In response to the letter concerning the study mentioned (Roy, Boucher & Comtois, 2009), we will argue each statement.

Firstly, the parasympathetic nervous system does have a lumbar output, as Chusid (1985) clearly illustrates. In fact, post-ganglionic fibers emerge from L-5 and S-3, they merge with a postganglionic fiber originating from L-2 of the inferior mesenteric ganglion, to form the hypogastric plexus and innervate the reproductive organs. Concerning the abundant literature on somato-autonomic interactions, we assume that it was also read by your group since you provide the reference and as you well know, Sato, Sato and Schmidt (1997) stated:

Cardiovascular responses are particularly pronounced when the joint receptors are sensitized by inflammation…Since the response is abolished after severance of medial and posterior articular nerves, it is evident that the response is a reflex that is evoked by excitation of knee joints afferents…Therefore, the response of the cardiac sympathetic nerve during knee joint stimulation is elicited by knee joint afferent excitation…. The articulo-cardiovascular reflex originating in the knee joint was therefore thought to be a supraspinal reflex… Stimulation of the thoracic or lumbar region produces… small decreases in heart rate…In order to confirm that the observed responses were mediated by spinal joints afferents… the lumbar spine was examined while cutting successive dorsal roots…The observed responses were found to be due to…afferent fiber-mediated reflexes.'

Therefore, we contend that the autonomic balance could be affected by a lumbar manipulation and we do point out that the differences lies in the grouping, pain versus no pain.

Secondly, we agree that changes in respiration can significantly affect the results of HRV analysis. We knowingly designed our project in such a fashion as to not disturb the normal breathing pattern of the subject, which disturbances could in fact affect their personal HRV. In addition, subjects lying prone may have had difficulties in following a certain rhythm and the resultant probable anxiety could also affect the HRV [4]. In fact for some of them the increase respiration rate and/or resulting anxiety could have induced a shift toward sympathetic dominance (Cervantes Blásquea, Rodas Font & Capdevila Ortis, 2009). Imposed breathing patterns also modify end-tidal CO_2 that has been shown to affect HRV. Thus, we chose to eliminate those possible biases and retain the natural patterns instead. We contend that each subject's heart and respiration rate is personal and natural; to change one is to create a bias toward the other.

As you mention, it is a critical issue and if we would have induced a certain rhythm of respiration, we contend that the effects of the intervention reported would have been erroneous and biased. Maybe our results could have been more spectacular or eloquent if we had induced the subjects in producing an artificial breathing rhythm.

In conclusion, we hope that our arguments satisfy your contentious issues. We hope as well that our methodological considerations of allowing spontaneous breathing will be taken into account in future studies on HRV.

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APPENDICE E

Lettre d'acceptation pour publication du manuscrit intitulé:

Paraspinal lumbar cutaneous temperature modification following a single lumbar spinal manipulation

Date: Dec 07, 2009

To: "Alain Steve Comtois" comtois.alain-steve@uqam.ca

cc: bgreen@nuhs.edu

From: Claire Johnson cjohnson@nuhs.edu

Subject: Your Submission

Ms. Ref. No.: JMPT-D-09-00104R1
Title: Paraspinal lumbar cutaneous temperature modification following a single lumbar spinal manipulation
Journal of Manipulative and Physiological Therapeutics

Dear Alain Steve Comtois,

This acknowledges that your manuscript: "Paraspinal lumbar cutaneous temperature modification following a single lumbar spinal manipulation", has received final approval and will be scheduled for publication in the Journal of Manipulative and Physiological Therapeutics.

NOTE: All manuscripts accepted for publication are subject to routine editing for clarity, American English usage, and JMPT manuscript style. It is permissible at this time to refer to this manuscript as "accepted for publication" in a forthcoming issue of JMPT; however, it is requested that no further details of the paper, or the research on which it may have been based, be given out in consideration that abridged or inexact versions of research or scholarly work can be misleading, or even hazardous where clinical procedures are involved.

Thank you for submitting your work to the JMPT.

Please feel free to email me if you have any questions.

Sincerely,

Claire Johnson, MSEd, DC
Editor-in-Chief
Journal of Manipulative and Physiological Therapeutics
cjohnson@nuhs.edu