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Effect of two consecutive spinal manipulations in a single session on myofascial pain pressure sensitivity: a randomized controlled trial

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Objective: *To investigate the summative effect of two consecutive spinal manipulative therapy (SMT) interventions within the same session on the pain pressure sensitivity of neurosegmentally linked myofascial tissues.*

Methods: *26 participants were recruited and assessed for the presence of a clinically identifiable myofascial trigger point in the right infraspinatus muscle. Participants were randomly assigned to test or control group. Test group received two consecutive real cervical SMT interventions to C5-C6 segment while controls received one real SMT followed by one validated sham SMT intervention to C5-C6 segment. Participants received the two consecutive SMT interventions 30 minutes apart. Pain pressure threshold (PPT) readings were recorded at pre-SMT1 and 5, 10, 15, 20 and 25 minutes post-SMT1 and post-SMT2. PPT readings were normalized to pre-SMT1 values and averaged.*

Objectif : Étudier l'effet sommatif de deux interventions consécutives de manipulation vertébrale (MV) dans la même session sur la sensibilité à la pression douloureuse des tissus myofasciaux liés par des neurosegments.

Méthodologie : *26 participants ont été recrutés, chez qui on a étudié la présence d'un point de déclenchement myofascial cliniquement identifiable dans le muscle infraépineux droit. Les participants ont été répartis au hasard au groupe expérimental ou au groupe témoin. Le groupe expérimental a subi deux interventions consécutives réelles de MV cervicales au niveau de C5-C6, tandis que le groupe témoin a subi une MV réelle suivie d'une manipulation factice confirmée, au niveau de C5-C6. Les participants ont subi les deux interventions consécutives de MV à un intervalle de 30 minutes. Les seuils de pression douloureuse (PPT) ont été enregistrés avant les MV-1 et 5, 10, 15, 20 et 25 minutes après la MV-1 et après la MV-2. Les PPT ont été normalisés et ramenés à la moyenne, sur les valeurs pré-MV-1.*

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Results: *Repeated measures ANOVA demonstrated a significant main effect of SMT intervention [F(1,24)=8.60, p<0.05] but not group [F(1.24)=0.01] (p=0.91). Post-hoc comparisons demonstrated a statistically significant (p<0.05) increase in SMT2 versus SMT1 (18%) in the test group but not in controls (4%) (p=0.82).*

Conclusions: *Two consecutive SMT interventions evoke significant decreases in mechanical pressure sensitivity (increased PPT) within neurosegmentally linked myofascial tissues. The antinociceptive effects of SMT may be summative and governed by a dose-response relationship in myofascial tissues.*

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KEY WORDS: chiropractic, spinal manipulation, myofascial pain, pressure thresholds

Résultats : *Les mesures répétées ANOVA ont montré un effet principal significatif de l'intervention MV [F (1,24) = 8,60, p <0,05], mais pas du groupe [F (1,24) = 0,01] (p = 0,91). Des comparaisons subséquentes ont montré une augmentation statistiquement significative (p <0,05) dans MV-2 par rapport au MV-1 (18 %) chez le groupe expérimental, mais pas chez le groupe témoin (4 %) (p = 0,82).*

Conclusions : *Deux interventions consécutives de MV évoquent une diminution significative de la sensibilité à la pression mécanique (augmentation de la PPT) dans les tissus myofasciaux liés par des neurosegments. Les effets antinociceptifs de la MV peuvent être sommatifs et régis par une relation de « réponse à la dose » dans les tissus myofasciaux.*

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MOTS CLÉS : chiropratique, manipulation vertébrale, douleur myofasciale, seuils de pression

Introduction

Chronic musculoskeletal diseases rank amongst the leading burdens of illness on the Canadian economy[1]. Myofascial pain (MPS) is the most common form of musculoskeletal pain and is characterized by chronic regional pain associated with the clinical manifestation of myofascial trigger points (MTrP) within the affected muscles[2]. Its prevalence in the general Canadian population has been reported as high as 20%[3] and up to 85%[4] in the elderly (>65 years) population segment. MTrP are recognized as palpable hyperirritable nodules located within taut bands of skeletal muscle[5]. Given that the ratio of over-65 to under-65 population is expected to double in Canada by 2050[6], chronic MPS is poised to become one of the greatest challenges to Canada's health delivery system. For this reason, advancing cost-effective therapies for the management of MPS is important to the sustainability of our health delivery system.

Spinal manipulative therapy (SMT) is a cost-effective and commonly employed therapeutic modality used in the clinical setting for the treatment and management of chronic pain of myofascial origin.[7,8] SMT is characterized by the application of a high-velocity, low amplitude manual thrust to the joints of the spine. Despite the widespread use of SMT in the rehabilitation setting, its physiologic mechanisms and dose-response effect in the treatment of myofascial pain are poorly understood.

A limited number of studies have been published addressing the dose-response physiologic effect(s) of SMT. A dose-dependent reduction in the frequency and intensity of cervicogenic headache has been reported with SMT for up to 8 treatments.[9] Similarly, increasing the frequency of chiropractic treatments from one to four sessions per week over a four week period has also been shown to reduce pain and disability outcomes in a dose-dependent manner within a chronic low back pain population.[10]

The body of research investigating the mechanisms of SMT has also consistently shown that SMT evokes regional physiologic effects. Significant decreases in regional paraspinal muscle tenderness have been observed post-SMT[11] and more recent research has suggested that these antinociceptive effects may be mediated via neurosegmental mechanisms[7]. A neurosegmental mechanism refers to an effect following an intervention

delivered to a specific intersegmental functional spinal unit on a tissue innervated by its corresponding spinal nerve root, an example of this would be an intervention delivered to the C5-C6 functional spinal segment having an effect on the infraspinatus muscle, which is innervated by the suprascapular nerve (origins of the C5 and C6 spinal nerve roots).[29] Very few studies to date, however, have explored the summative (dose-response) antinociceptive effect of SMT. In particular, no studies have investigated the summative antinociceptive effect of two consecutive SMT interventions in myofascial tissues using a randomized controlled design.

The purpose of this study is to investigate the summative effect of two consecutive SMT interventions within the same session on the pain pressure sensitivity (PPT) in neurosegmentally linked myofascial tissues. We set out to test the hypothesis that two consecutive SMT interventions applied to the C5 spinal segment evokes greater increases in PPT at a MTrP site within a neurosegmentally linked muscle (infraspinatus, C5-C6) as compared to a single SMT intervention. The findings of this study will provide insight into the temporal summative effect(s) of two consecutive SMT interventions and inform future research investigating the summative and dose-response relationship of SMT for therapeutic applications in the management of MPS.

Methods

This randomized controlled intervention study was approved by the Ethics Board at the Canadian Memorial Chiropractic College and the University of Guelph and was conducted in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki, 2000) for experiments with humans. This manuscript conforms with the consort guidelines for reporting randomized trials (http://www.consort-statement.org/). All participants provided written informed consent prior to participating and none of the participants withdrew from the study.

A power analysis using previously published data determined that a sample size of 13 participants per group (n=26) was needed to provide 90 percent power to detect an effect size of d=1.33 standard deviation at an alpha of 0.05 using a two-tailed test for significance.[12] A total of 26 prospective participants were recruited via convenience sampling from the Canadian Memorial Chiropractic College (CMCC, Toronto, Ontario, Canada) student population. Participants were either male or female between the ages of 21-40 years from the CMCC main campus and/or campus clinic. Each prospective participant was assessed for eligibility by completing a confidential health history questionnaire and undergoing a brief physical assessment conducted by the primary investigator, a licensed chiropractor in the Province of Ontario, Canada.

All patients were screened for current/recent episodes of neck pain. The primary inclusion criterion was the presence of a clinically identifiable MTrP locus (experimental unit) within the right infraspinatus muscle. The diagnostic features of a MTrP used in this study have been previously reported and include a palpable hyperirritable nodule located within a taut band of skeletal muscle, pain recognition on palpation of the trigger point, pain referral to the lateral aspect of the affected shoulder and/or local twitch response in the muscle[13]. To improve the reliability of detection, we only accepted clinically identifiable MTrP loci with a baseline PPT value less than 35 N (Newtons).[14]

A computer generated random allocation sequence was used to randomize qualifying participants into two groups. Each group received two SMT interventions (SMT1, SMT2) 30 minutes apart. The test group received two real cervical spinal manipulative therapy interventions (rcSMT) while controls received one rcSMT and then one sham cervical spinal manipulative therapy intervention (scSMT). The statistician held the randomization scheme and, in order to ensure concealment, the statistician was not involved in the experiment. The individual group allocations were printed by the research assistant and placed into blank white opaque numbered envelopes. The assessing clinician was blinded but the treating clinician was exposed to allocation codes. The same research assistant was responsible for recording all PPT values during the course of the study and was also blinded to the participants' group status.

One licensed clinician with over 34 years of clinical experience in SMT provided all cervical spine interventions to the participants. All testing was conducted at the Canadian Memorial Chiropractic College (CMCC) main campus clinic in Toronto, Ontario, Canada. The treating clinician was responsible for administering all SMT interventions (real and sham). The assessing clinician was responsible for performing the history and physical

assessment on all prospective participants and for clinically identifying MTrP within the infraspinatus muscle. The assessing clinician was blinded to participants' group allocation while the treating clinician was not.

The primary outcome used to quantify the pressure sensitivity at the infraspinatus MTrP site was the pressure pain threshold (PPT) measure. A Chatillon DFE Series Force Gauge (AMETEK TCI, Florida, USA) with a gauge tip contact area of 285mm^2 (19x15mm) was used for all PPT recordings. For this study, we defined the PPT as the magnitude of force (Newtons) applied to the MTrP locus at the infraspinatus muscle which elicited the onset of a self-reported deep dull achy pain, local discomfort and/or referred pain down the posterior lateral aspect of the ipsilateral arm. To quantify the pressure sensitivity of the infraspinatus MTrP, the algometer tip was placed perpendicular to the skin surface and a progressively increasing force was applied by the force gauge at a constant rate of 5N/s[15] until the participant verbally indicated the onset of the local and/or referred deep, dull, or achy sensation in the area of the infraspinatus. The maximum reading on the force gauge at that point was recorded as the raw PPT reading. Three consecutive raw PPT readings were taken from the MTrP point locus at each measurement and the average of the three raw PPT readings was used as the raw PPT measure for analysis. All raw PPT values for each time point were normalized to baseline (pre-SMT1) during the analysis to allow for between subject comparisons.

Participants were asked to lay prone while the assessing clinician identified a MTrP in the infraspinatus muscle. The MTrP locus was identified and marked with a non-toxic marker directly on the skin to allow for easy identification and consistency throughout the study. All PPT readings were taken from the right side. Prior to the SMT1 intervention, participants were trained to consistently identify the PPT threshold using the contralateral infraspinatus MTrP. Baseline (pre-SMT1) PPT values were taken with the pressure gauge by the assessing clinician from the right infraspinatus. The assessing clinician was not present in the room while the treating clinician performed the SMT intervention to the cervical spine.

After the baseline PPT values were recorded, participants were asked by the assessing clinician to lie supine on the chiropractic table with the head resting on the drop headpiece which is designed to increase acceleration of the thrust during the cervical manipulative procedure. The participants that were assigned to the test group received each of the two rcSMT interventions 30 minutes apart with PPT measurements taken every 5 minutes (5, 10, 15, 20 and 25 minutes) after each of the rcSMT interventions. The rcSMT was performed by manually contacting the C5-C6 segment. The participant's head was supported by the treating clinician's forearm while the contact hand of the treating clinician contacted the C5-C6 spinal segment. A thrust maneuver was then applied to the C5-C6 segment with the supportive hand resting on the zygoma of the participant. A rotational inferior drop thrust maneuver was delivered with a high velocity low amplitude thrust. The head and neck was then returned to the neutral position.[19] Immediately after the first rcSMT (SMT1) intervention, test participants were placed in the prone position for PPT measurements at 5-minute intervals (5, 10, 15, 20 and 25 minutes). A second rcSMT (SMT2) was then performed 5 minutes after the last PPT reading (ie., 25 minutes post-SMT1) and participants once again assumed the prone position for PPT measurements at 5-minute intervals (5, 10, 15, 20 and 25 min) for up to 25 minutes post-SMT2.

In contrast to the test group, controls received a rcSMT intervention first (SMT1) and scSMT intervention second (SMT2). The sham SMT intervention used in this study has been previously validated[16] and involves an identical preloading of the cervical spine tissues as the rcSMT protocol. In the scSMT intervention, however, the participant's head is supported by the treating clinician's forearm, which rests directly on the headpiece. The treating clinician thrusts downward into the headpiece with the supporting arm to produce the sensation of a rapid manual thrust to the neck, however, no thrust is made by the contact hand and no segmental cSMT is applied to the C5-C6 segments. In order to assess for group bias, at the end of the study all participants were asked which intervention they believed they received.

All raw PPT measures were normalized to baseline (pre-SMT1) values prior to statistical analysis. The dependent variable was the mean normalized PPT which was calculated for each 25-minute epoch post-SMT intervention (SMT1 and SMT2) for each intervention group (test and control). We tested for equality of variance using Brown Forsythe test. A repeated measures two-way

Table 1.
Demographic profile of participants (n=26) in this study.
Data presented as mean (SD).
SD=standard deviation

Group	Height (m)	Weight (kg)	Age (yr)	BMI (kg/m^2)	Male:Female
Control	1.74 (0.10)	75.05 (11.86)	25.08 (2.22)	23.93 (2.00)	9:4
Test	1.77 (0.09)	77.77 (20.53)	24.77 (1.69)	24.59 (4.72)	6:7
P-value	0.534	0.682	0.694	0.647	

Table 2.
Average normalized (to baseline pre-SMT1) pain pressure threshold (PPT) readings at the right infraspinatus muscle at each time point after SMT interventions (SMT1, SMT2) on both test and control groups.
Data expressed as mean (SD).

		Control	**Test**
	SMT 1		
Min Post-SMT1	5	1.28 (0.20)	1.20 (0.27)
	10	1.42 (0.44)	1.30 (0.42)
	15	1.45 (0.48)	1.45 (0.54)
	20	1.52 (0.63)	1.48 (0.50)
	25	1.53 (0.57)	1.42 (0.36)
	SMT 2		
Min Post-SMT2	5	1.48 (0.47)	1.55 (0.49)
	10	1.54 (0.68)	1.63 (0.54)
	15	1.51 (0.71)	1.63 (0.61)
	20	1.51 (0.53)	1.61 (0.56)
	25	1.46 (0.56)	1.64 (0.62)

ANOVA was performed using SMT intervention (SMT1, SMT2) and group (test, control) as the independent factors and normalized PPT as the dependent variable. Post-hoc comparisons of SMT interventions for each group were performed using the Bonferroni test. Multiple t-tests were used to compare baseline demographics between groups. Statistical analysis was performed with SPSS Statistical Software (Version 11.0, SPSS Ins., Chicago, USA). Level of significance was set at 0.05.

Results

A total of 26 participants (13 test, 13 control, mean age 24.9 ± 1.9 yr) were analyzed and no one withdrew from the study nor was excluded from the analysis. No statistical differences in baseline demographics including height, weight, age and BMI were observed between groups (Table 1).

The average normalized PPT reading after each SMT intervention (SMT1, SMT2) at each time point for each group is listed in Table 2. Brown Forsythe test did not reveal any differences in the variance between groups (p=0.21). The results of the two-way ANOVA demonstrated a significant main effect of SMT intervention [$F(1,24)=8.60$, $p<0.05$] but not group [$F(1.24)=0.01$] (p=0.91). SMT intervention*group interaction approached significance [$F(1,24)=3.10$](p=0.09). Post-hoc individual comparisons demonstrated statistically significant increases in SMT2 versus SMT1 in the test group [-0.24, CI -0.41,-0.07](p<0.05) but not controls [-0.06, CI -0.23,0.11](p=0.82). Our data also demonstrates a significant 18% increase in PPT after SMT2 in the test group

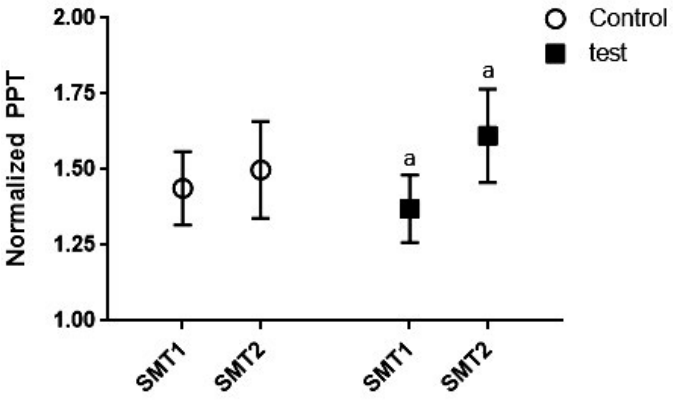

Figure 1.
Normalized mean(SEM) pain pressure threshold (PPT) reading over the 25-minute recording period following each intervention (SMT1, SMT2) for each group (test, control). Common lettering denotes significant difference (alpha = 0.05). SEM = standard error of mean; SMT = spinal manipulative therapy; PPT = pain pressure threshold.

while controls demonstrate a 4% increase in PPT after the SMT2 intervention (Figure 1).

Subjects were asked what group (test,control) they thought they were assigned to. Our results demonstrate a specificity of 85% and sensitivity of 77% for participants correctly guessing their group assignment.

Discussion

The results of this study support our hypothesis that two consecutive, SMT interventions evoke greater decreases in mechanical pressure sensitivity within neurosegmentally linked myofascial tissues versus a single SMT intervention. Our data shows a statistically significant increase in PPT from SMT1 to SMT2 in the test group; in contrast, no difference was observed from SMT1 to SMT2 in controls. Test participants demonstrated an average of 18% increase in PPT after SMT2 compared with only a 4% increase in controls, who received a rcSMT followed by a scSMT intervention. These collective observations suggest that the effects of two SMT interventions are summative (temporal summation) and support the hypothesis that a dose-response relationship may exist between SMT and its antinociceptive effect in myofascial tissues.

A significant body of research has previously demonstrated regional changes in mechanical pressure sensitivity (PPT) after spinal manipulation in both healthy and clinical cohorts. SMT applied to the spine has been shown to evoke significant reductions in local mechanical pressure sensitivity in both asymptomatics[7;17;18] as well as a chronic neck pain population[19-21]. In contrast, only two studies have failed to demonstrate changes in local pressure sensitivity after an SMT intervention. One of these findings was reported in the lumbar spine after lumbar SMT in healthy asymptomatics[22], while another study reported no difference in mechanical pressure sensitivity in the low back, gluteal and sacroiliac regions following lumbosacral SMT in a chronic low back pain group[23]. Two additional studies reported similar decreases in mechanical pressure sensitivity in the extremities after cervical SMT; bilateral decreases in PPT were measured at the lateral epicondyles of asymptomatics[24] as well as patients with lateral epicondylalgia[25] post-cervical SMT. Similarly, regional decreases in PPT have also been observed in cranial structures including the masseter and temporalis muscles[26] of asymptomatics as well as over the sphenoid bone in chronic neck pain patients[27] after SMT to the atlanto-occipital joint.

Despite the extensive research studying the effects of SMT, very little research to date has been done to investigate the dose-response effects of SMT. Two studies have examined dose response effects of multiple session SMT protocols in chronic LBP patients. The first demonstrated a positive clinically important effect for the number of chiropractic treatments on chronic low back pain intensity and disability outcomes after 4 weeks of treatment[10] while a follow-up study examining the effect of four different treatment doses and found a mild dose-response effect to the total number of SMT treatments, peaking at 12 treatments; this study employed outcomes of pain intensity, functional disability and medication use[9]. Positive dose-response effects have also been reported after a six-week course of cervical SMT in a chronic cervicogenic headache cohort.[28]

In contrast to the existing literature examining the dose-response of SMT in multiple sessions, our study is the first to examine the summative effect of consecutive SMT within a single session. Our findings show that two

SMT interventions lead to greater reductions in mechanical pressure sensitivity (temporal summation), adding evidence to support the hypothesis that a dose-response relationship may exist between SMT and antinociceptive effects in myofascial tissues.

Consistent with much of the existing research in this area, the primary outcome measure in this study was the PPT. The PPT was defined in our study as the least amount of force applied perpendicularly to the MTrP site in which the subject experienced a change from pressure sensation to a dull ache.[29] Pressure algometry has been experimentally validated as a reliable technique for quantifying MTrP sensitivity; extensive research exists to validate its high inter and intra-examiner reliability[30-34] and studies have demonstrated that the PPT measure is strongly correlated to pain perception[32].

The results of this study should be interpreted in light of several limitations. The primary consideration is the potential for subject group bias given that each participant had previous experience with cSMT which may have enabled them to identify their assigned intervention group. At the completion of the trials, we asked all participants which group they felt they were in. In spite of the fact that we employed a previously validated sham SMT procedure[19]; our results show a specificity of 85% and sensitivity of 77% for participants guessing their group assignment. Over the course of this study, however, we recorded 33 PPT readings from each of the 26 participants, for a total of 858 PPT readings. The mean coefficient of variation for all PPT readings was 0.05, suggesting that subject bias likely did not meaningfully impact our primary outcome measure.

Another limitation is the potential for modulating the sensitivity of a MTrP over time with repetitive pressure testing. We recorded three PPT measurements from the infraspinatus MTrP at each of the 5 time intervals post-SMT1 and SMT2, respectively, for a total of 30 readings over a one-hour period. However, previous research reports that repeated pressure algometry to a MTrP site over a one-hour duration does not impact the PPT reading.[29]

We observed significant increases in the mean normalized PPT after the second test SMT intervention (SMT2); however, the clinical significance of these differences is unknown. The minimally clinically important difference (MCID) of pressure algometry in myofascial tissues has not been established. Fuentes[34] estimated that a clinically relevant change in the lumbar paraspinals of healthy volunteers would approximate 114 kPa; this pressure represents a raw difference of 33N from baseline in our study, given that our algometer probe head area measured 285mm^2. In contrast, Walton suggests a clinically relevant range of 50-220 kPa, the equivalent of 14-63N in our study. The average raw PPT increase from baseline in the test group was 19.0N (60kPa) while the maximum recorded increase from baseline was 54.1N (189kPa). Only 2 of 13 test participants (15%) demonstrated PPT changes above Fuentes' 33N (114kPa) threshold. In contrast, 7 of 13 (54%) participants fell above Walton's minimum threshold of 14N (50kPa) and the average raw difference in our study was 19.0N. These collective observations suggest that the decrease in myofascial pressure sensitivity observed in our study post SMT2 for test subjects may not have been clinically meaningful, however, more research is needed to establish reliable MCID thresholds for use in the evaluation of myofascial trigger points.

Our study demonstrates that two, consecutive SMT interventions reduces pain pressure sensitivity in neurosegmentally linked myofascial tissues in young healthy subjects. Future research should advance this line of inquiry by investigating the effects of multiple (>2) SMT interventions on pressure sensitivity in myofascial tissues to assess for saturation effects of treatment. Furthermore, we only assessed PPT changes for up to 25 minutes post-intervention in this study; future studies should investigate the duration of antinociceptive response in myofascial tissues with increasing SMT exposures in order to assess whether multiple SMT interventions enhance effect duration. In addition, the effects of multiple SMT interventions in non-segmentally linked tissues should be evaluated to assess for non-segmental (systemic) effects.

Our findings show that two SMT interventions enhance the antinociceptive effect (temporal summation) in myofascial tissues when compared to only one. These findings also support the hypothesis that a dose-response relationship exists between SMT and the antinociceptive effects in myofascial tissues and informs future research investigating the therapeutic applications of SMT in the management of myofascial pain.

Conflicts of interest

The authors of this study report no conflicts of interest. This study was not externally funded.

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