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THE MECHANISM OF BACK PAIN RELIEF BY SPINAL MANIPULATION RELIES ON DECREASED TEMPORAL SUMMATION OF PAIN

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Abstract—The aim of the present study was to determine whether thoracic spinal manipulation (SM) decreases temporal summation of back pain. The study comprised two controlled experiments including 16 and 15 healthy participants, respectively. Each study included six sessions during which painful or non-painful electrical stimulations were delivered in three conditions: (1) control (2) light mechanical stimulus (MS) or (3) SM. Electrical stimulation was applied on the thoracic spine (T4), in the area where SM and MS were performed. In Experiment 1, electrical stimulation consisted in a single 1-ms pulse while a single or repeated train of ten 1-ms pulses was used in Experiment 2. SM involved articular cavitation while MS was a calibrated force of 25 N applied manually for 2 s. For the single pulse, changes in pain or tactile sensation in the SM or MS sessions compared with the CTL session were not significantly different (all *p*'s > 0.05). In contrast, temporal summation of pain was decreased in the SM session compared with the CTL session for both the single and repeated train (*p*'s < 0.05). Changes were not significant for the MS sessions (all *p*'s > 0.05) and no effect was observed for the tactile sensation (all *p*'s > 0.1). These results indicate that SM produces specific inhibitory effects on temporal summation of back pain, consistent with the involvement of a spinal anti-nociceptive mechanism in clinical pain relief by SM. This provides the first mechanistic evidence of back pain relief by spinal manipulation.

Key words: spine, vertebral, manual therapy, back pain, chiropractic.

INTRODUCTION

Back pain is highly prevalent, leading to significant economical and societal costs (Manchikanti et al., 2009). The diagnosis and treatment of chronic back pain remains challenging. However, acute episodes of back pain can be addressed successfully by a number of interventions, including spinal manipulation (SM) (Lin et al., 2011; Pillastrini et al., 2012; Hooten and Cohen, 2015). SM consists in a high-velocity, low-amplitude thrust applied on the spine that elicits audible release (intra-articular cavitation of facet joints) (Herzog, 2010; Kawchuk et al., 2015). Several studies have examined the effects of SM on pain perception (Bialosky et al., 2008, 2009b, 2012, 2014; Coronado et al., 2012; Millan et al., 2012). Overall, these studies indicate that SM produces hypoalgesic effects on both experimental and clinical pain. However, there is limited evidence on the underlying mechanisms of these hypoalgesic effects, which could further support the use of SM for the treatment of back pain.

One possibility is that SM may act on spinal mechanisms underlying temporal summation of pain and central sensitization, which leads to chronic pain. Accordingly, cutaneous noxious heat applied on a lumbar-innervated region of the lower limb (calf) was shown to be unaffected by SM, but pain produced by the same stimulus repeated at a frequency that induces temporal summation was significantly decreased following SM in healthy controls and patients with back pain (George et al., 2006; Bialosky et al., 2009b). These effects were not observed in upper limb dermatomes and no effect was observed on temporal summation of pain when SM was applied in the cervical region (George et al., 2006). This suggests that a segmental (spinal) mechanism is involved in the hypoalgesic effects of SM. In these studies, cutaneous noxious heat was applied on the lower limb because temporal summation of pain cannot be assessed in the back with this type of stimulus, as reported earlier (George et al., 2006). However, considering the relevance of temporal summation

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Abbreviations: CTL, control; MS, mechanical stimulus; SM, spinal manipulation; SMT, spinal manipulative therapy; T4, 4th thoracic vertebra.

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in acute and chronic back pain, it is critical to examine whether temporal summation of back pain itself is affected by SM. The present experiment was designed accordingly and takes advantage of electrical stimulation properties to induce temporal summation of pain in the back.

It is challenging to take into account every confounding effect in experiments involving SM, although some significant factors such as non specific temporal or perceptual effects can be measured and controlled for. The aim of the present study was to provide evidence of specific hypoalgesic effects of thoracic SM on temporal summation of back pain. Thus, the experimental design included control sessions during which non-specific temporal effects could be measured and controlled for. Moreover, a control test stimulus (non-painful electrical stimulation) was used in order to exclude non-specific perceptual effects of SM. Finally, a light mechanical stimulus was used to determine whether low-threshold mechanoreceptors contribute to SM-induced hypoalgesia or whether hypoalgesia is induced specifically when high-threshold mechanoreceptors are activated. Based on the existing literature and on results from previous studies (George et al., 2006; Bialosky et al., 2009b; Bishop et al., 2011), we hypothesized that SM would specifically decrease pain evoked by a pulse train or a repeated stimulus (inducing temporal summation) but not by a single stimulus, while no effect would be observed on tactile sensation induced by single or repeated non painful stimuli.

EXPERIMENTAL PROCEDURES

Ethics approval

All experimental procedures conformed to the standards set by the latest revision of the Declaration of Helsinki and were approved by the Research Ethics Board of "Université du Québec à Trois-Rivières". All participants gave written informed consent, acknowledging their right to withdraw from the experiment without prejudice and received compensation for their travel expenses, time and commitment. For both experiments, participation consisted in six sessions of 90 min., including the determination of pain threshold and the evaluation of pain or tactile sensation induced by electrical stimulation, in addition to SM or MS in four out of the six sessions.

Study participants

Thirty-two healthy volunteers participated in the study, 16 in Experiment 1 (8 women and 8 men; range 23–47 years old; mean ± SD 26.3 ± 5.8 years old) and 16 in Experiment 2, from which one participant dropped out for a final sample of 15 participants (8 women and 7 men; range 21–27 years old; mean ± SD: 23.4 ± 1.8 years old). They were recruited by advertisement on the campus of "Université du Québec à Trois-Rivières". Participants were included in the study if they were between 18 and 50 years old and were excluded from the study during the recruitment interview if they had taken any medication within 2 weeks prior to the experiment, if they had a history of acute or chronic pain, acute or chronic illness, or a diagnosed psychiatric disorder.

Experimental design

This study relies on two experiments based on a within-subject design to examine the effects of SM and MS on tactile sensation and pain induced by a single-pulse electrical stimulation (Experiment 1) as well as effects of SM and MS on a single or repeated electrical pulse train that induces temporal summation (Experiment 2). This was examined within six counter-balanced experimental sessions to avoid sequence order effects. In order to assess whether SM effects on perception are transient or may last several minutes, the post-SM period included two stimulus blocks (see Fig. 1 for illustration of sessions and conditions).

Painful and non-painful electrical stimulation

Transcutaneous electrical stimulation was delivered with an isolated DS7A constant current stimulator (Digitimer Ltd., Welwyn Garden City, Hertfordshire, UK) triggered by a Grass S88 train generator (Grass Medical Instruments, Quincy, MA, USA) and controlled by a computer with a stimulus presentation program (E-Prime2, Psychology Software Tools, Sharpsburg, PA, USA). Degreased skin over the T4 segment of the thoracic spine was stimulated by a pair of custom-made surface electrodes (1 cm^2; 2 cm inter-electrode distance) oriented from left to right over the spinous process of T4. Pain threshold was determined using the staircase method as in our previous studies (Piche et al., 2011; Ladouceur et al., 2012), including three series of stimuli of increasing intensity with steps of 1 mA. Pain threshold was defined as the lowest stimulus intensity that evoked pain. The intensity of stimulation was adjusted individually to 60% of the pain threshold (non-painful stimulation) or to 120% of the pain threshold (painful stimulation) and was constant for the remaining of the experiment.

The electrical stimulation protocol is illustrated in Fig. 2. In Experiment 1, a total of 90 stimuli were delivered as a single 1-ms pulse with a constant inter-stimulus interval of 6 s, except for a short pause to perform SM or MS when required. In Experiment 2, stimuli consisted in a train of ten 1-ms pulses delivered at 333 Hz applied as a single- or repeated train stimulation. The repeated train stimulation consisted in five of these trains applied with an interval of 500 ms. The stimulation regularly alternated between single and repeated trains with an interval of 10 s, except for a short pause to perform SM or MS when required. A total of 15 single-train and 15 repeated train stimuli were delivered.

Repeated noxious stimulation is well-known to produce wind-up in spinal neurons and temporal summation of pain (Price et al., 1978). Single trains of electrical pulses at high frequency also produce temporal summation and higher pain ratings compared with a single pulse (Mouraux et al., 2014). Thus, the pulse train in Experiment 2 was purposefully used to produce temporal

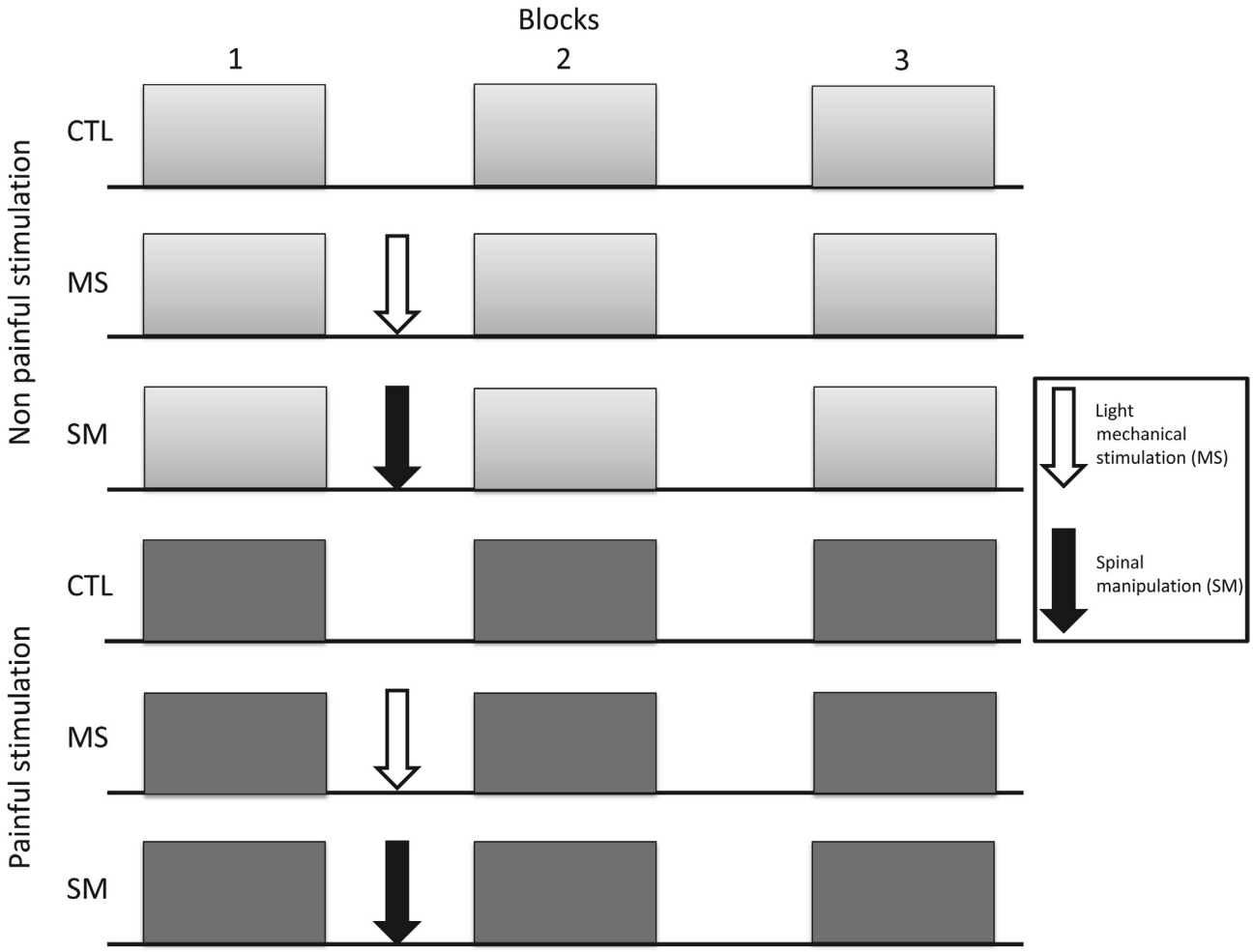

Fig. 1. Experimental paradigm. A within-subject design containing six counter-balanced experimental sessions was used to examine how spinal manipulation (SM) and light mechanical stimulation (MS) may modulate tactile sensation and pain induced by electrical stimulation, accounting for non-specific temporal changes measured in a control session (CTL). This paradigm was used in two separate experiments each including these six sessions. In experiment 1, electrical stimulation consisted in 1-ms single-pulse stimuli while in experiment 2, it consisted in single train and repeated train stimuli to induce temporal summation (see Fig. 2 for a detailed description and illustration of electrical stimuli).

summation. Indeed, when adjusting stimulus intensity individually, the same stimulus intensity produces stronger pain for the single train compared with the single pulse, as confirmed in our laboratory (unpublished observation). In addition, the same stimulus repeated five times at an interval of 500 ms was used successfully to produce robust temporal summation of spinal nociceptive activity and pain (Marouf et al., 2015).

Spinal manipulation and light mechanical stimulation

Spinal manipulation was performed by two licensed chiropractors and consisted in a short-duration, high-velocity thrust applied on the spine to generate audible release (cavitation). The spine was manipulated using a bilateral hypothenar contact over transverse processes of the T4 vertebrae, after which the chiropractor rapidly applied a posterior to anterior force to the spinal segment. This type of manipulation typically lasts less than 200 ms and involves a force of approximately 500 Newtons (Herzog, 2000; Triano et al., 2015). MS consisted in a calibrated force of 25 N applied for 2 s on the same region with a contact over the spinous process, using a hand-held dynamometer (Hoggan scientific LLC, model Micro FET2, Salt Lake City, UT, USA).

Subjective ratings

A numerical rating scale was used for the evaluation of the tactile sensation or pain caused by electrical stimulation. Participants were instructed to rate tactile sensation or pain where 0 indicated no sensation or no pain and 100 for pain threshold or the worst pain imaginable for the tactile and pain rating scales, respectively. Employing these scales, participants were asked to rate electrical stimulation after each block of 30 stimuli in Experiment 1 and after each single or repeated train in Experiment 2. For the ratings of repeated trains, participants were instructed to rate the strongest sensation felt during the stimulation.

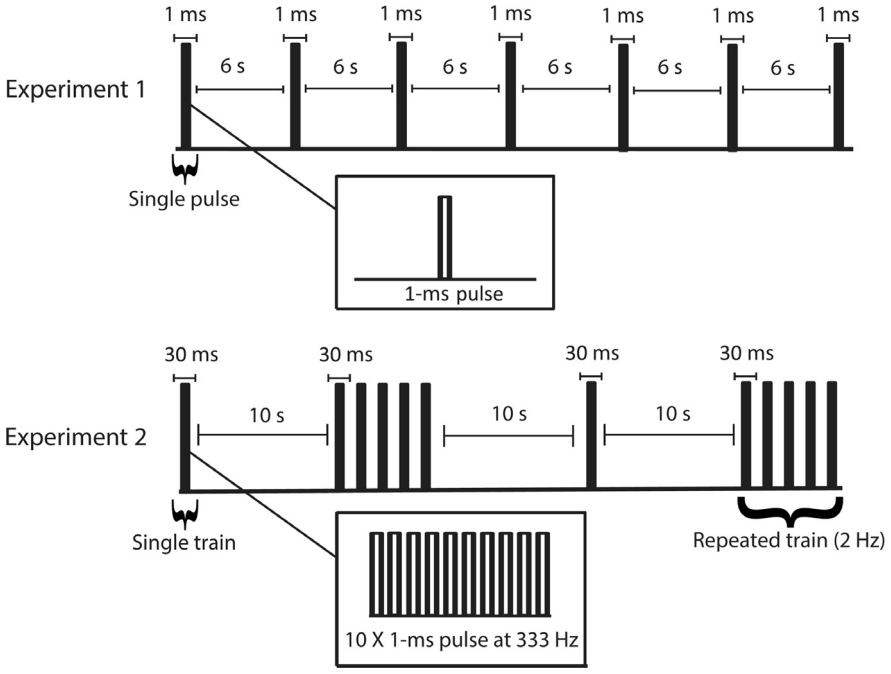

Fig. 2. Electrical stimulation protocol. In Experiment 1, electrical stimulation was applied as a single 1-ms pulse with a constant inter-stimulus interval of 6 s and included 90 stimuli distributed equally in three blocks. In experiment 2, electrical stimuli consisted in a train of ten 1-ms pulses delivered at 333 Hz applied as a single or repeated train. The repeated train consisted in five of these trains with an interval of 500 ms (2 Hz). The stimulation regularly alternated between single and repeated trains with an interval of 10 s, for a total of 15 single and 15 repeated trains distributed equally in three blocks.

Statistical analyses

All results are expressed as mean ± SEM unless specified. The data were analyzed by Statistica v10.0 (Statsoft Inc., Tulsa, OK, USA) with significance thresholds set to $p \leq 0.05$ (2-tailed). Data distribution was assessed for normality with the Kolmogorov–Smirnov test and statistics were performed with the Greenhouse-Geisser-corrected ANOVAs. Changes in subjective ratings were compared between blocks of stimuli (3) and between sessions (3) for each type of stimulation (single pulse, single train and repeated train) with two-way repeated-measures ANOVA, for both tactile sensation and pain separately. The Bonferroni-corrected planned contrasts were used to test a priori hypotheses and decompose significant effects. Effect sizes are reported based on partial eta-squared (η_p^2).

RESULTS

Experiment 1: Single pulse

For the single-pulse stimulation, pain was significantly different between conditions across blocks ($F_{4,60} = 2.7$; $p = 0.04$; $\eta_p^2 = 0.15$; see Fig. 3). However, the Bonferroni-corrected planned contrasts revealed that changes in pain during block 2 or 3 relative to block 1 in the SM or MS sessions compared with the CTL session were not significantly different (all p's > 0.1). For the non-painful stimulus, tactile sensation was not significantly different between conditions across blocks ($F_{4,60} = 0.9$; $p = 0.5$; $\eta_p^2 = 0.06$; see Table 1).

Experiment 2: Single train, repeated train and temporal summation

For the single train, pain was significantly different between conditions across blocks ($F_{4,56} = 2.9$; $p = 0.03$; $\eta_p^2 = 0.17$; see Fig. 4). The Bonferroni-corrected planned contrasts revealed that pain was decreased by SM compared with the control session during block 2 compared with block 1 ($p < 0.01$). However, this effect did not persist over 5 min (block 3 vs block 1; $p = 0.5$). In contrast, temporal summation of pain was not significantly attenuated by MS compared with the control session during block 2 ($p = 0.06$) or block 3 ($p = 0.6$) compared with block 1. For the non-painful train, tactile sensation was not significantly different between conditions across blocks ($F_{4,56} = 0.9$; $p = 0.5$; $\eta_p^2 = 0.06$; see Table 1).

The effect of stimulus repetition was examined in the baseline condition of each session to confirm that temporal summation of pain could be evoked effectively, by comparing single and repeated trains. Pain was stronger during the repeated train compared with the single-train stimulation (main effect: $F_{1,14} = 38.7$; $p < 0.001$; $\eta_p^2 = 0.73$) and the effect was not significantly different across sessions (interaction: $F_{2,28} = 0.3$; $p = 0.72$; $\eta_p^2 = 0.02$). This indicates that temporal summation of pain was evoked effectively and that it was comparable between sessions at baseline, therefore allowing the assessment of inhibitory effects produced by SM.

Changes in temporal summation between sessions across blocks were then examined. Pain evoked by the repeated train was not significantly different between sessions across blocks, although graphical and statistical results indicated a trend ($F_{4,56} = 2.1$; $p = 0.086$; $\eta_p^2 = 0.13$; see Fig. 5). The Bonferroni-corrected planned contrasts revealed that temporal summation of pain was attenuated by SM compared with the control session for block 2 relative to block 1 ($p = 0.036$). However, this effect did not persist over 5 min (block 3 vs block 1; $p = 0.6$). In contrast, temporal summation of pain was not significantly attenuated by MS compared with the control session for block 2 ($p = 0.18$) or block 3 ($p = 0.6$) relative to block 1. Tactile sensation evoked by the non-painful repeated train stimulation was not significantly different between sessions across blocks ($F_{4,56} = 1.6$; $p = 0.2$; $\eta_p^2 = 0.10$; see Table 1).

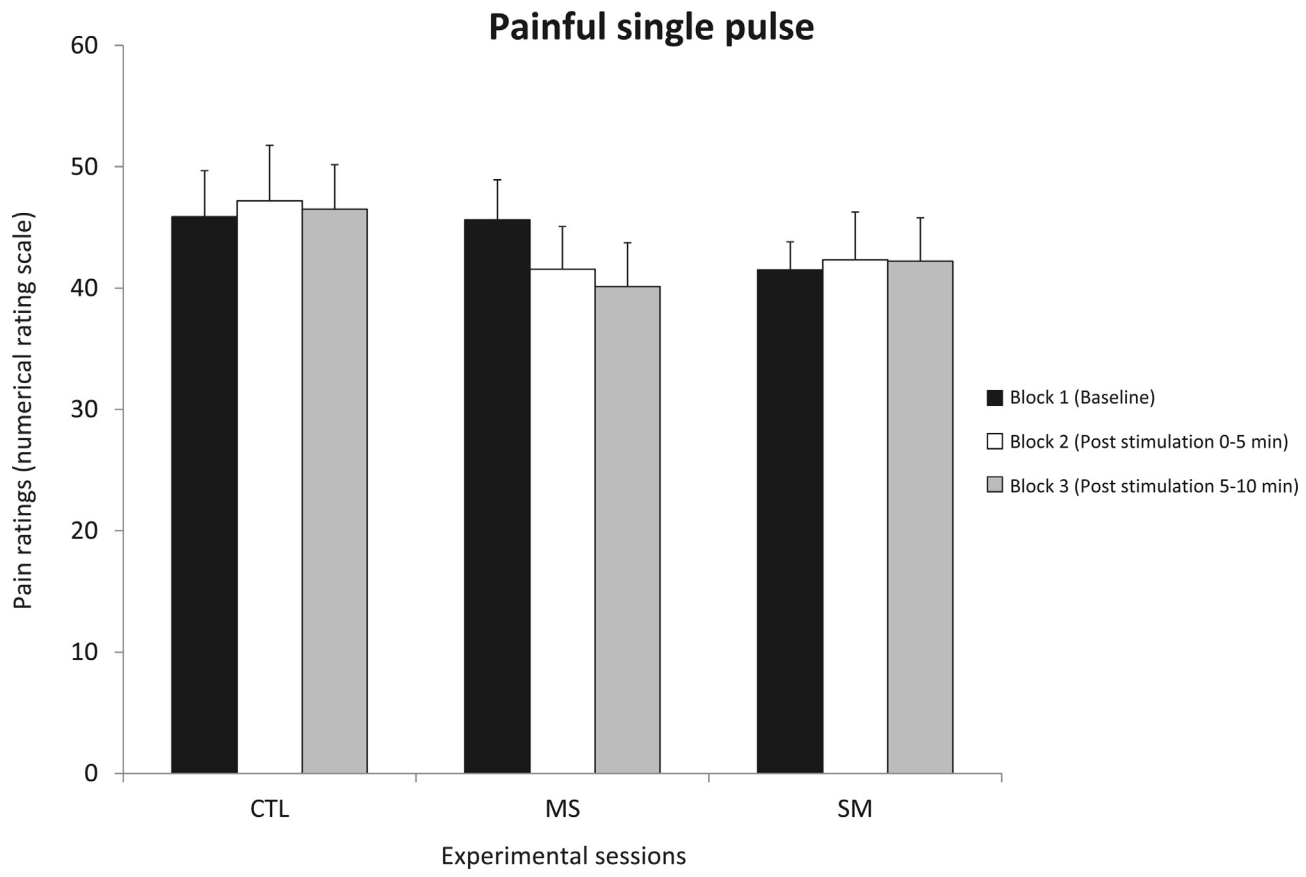

Fig. 3. Pain ratings for the single-pulse stimulation. Ratings are reported for the three sessions that included painful single-pulse stimuli (mean ± SEM). The Bonferroni-corrected planned contrasts revealed that changes in pain ratings during block 2 or 3 (post-stimulation) relative to block 1 (baseline) in the SM or MS sessions compared with the CTL session were not significantly different.

Table 1. Ratings of non-painful stimuli: tactile sensation

Session block	Control			Light mechanical stimulus			Spinal manipulation		
	1	2	3	1	2	3	1	2	3
Single pulse	48.4 ± 4.5	45.6 ± 5.1	39.1 ± 5.4	53.6 ± 5.6	48.4 ± 5.4	48.8 ± 5.2	48.9 ± 5.3	42.2 ± 5.2	40.7 ± 5.6
Single train	14.8 ± 2.3	14.5 ± 2.6	11.15 ± 2.4	18.4 ± 2.3	14.4 ± 1.8	12.3 ± 2	16.6 ± 1.6	11.7 ± 1.8	11.6 ± 2.4
Repeated train	25.7 ± 3.8	24.6 ± 4.6	21.1 ± 3.7	34.0 ± 3.3	30.3 ± 3.5	28.2 ± 3.6	26.5 ± 2.3	24.0 ± 3.9	21.6 ± 3.6

DISCUSSION

This is the first study that provides evidence for SM-induced inhibition of temporal summation of back pain. Moreover, the study shows that SM does not change pain induced by a single electrical pulse or tactile sensation induced by a single or a repeated electrical stimulus. In addition, a light mechanical stimulus could not elicit significant hypoalgesic effects, in contrast to SM. These findings are consistent with a specific effect of SM on temporal summation of back pain and a lack of effect on processes related to sensory transmission of tactile information. This extends results from previous studies showing that the relief of back pain by SM partly relies, at least in part, on specific hypoalgesic or anti-nociceptive processes within the spinal cord (George et al., 2006; Bialosky et al., 2009b).

Perceptual changes induced by spinal manipulation

Previous studies investigating the modulation of experimental pain by SM used various stimulation modalities, including electrical, thermal and mechanical stimuli (reviewed in (Coronado et al., 2012; Millan et al., 2012)). Electrical stimulation is not a natural stimulus and does not activate sensory receptors or fibers selectively. However, it was chosen over other modalities in the present study because it allows for a direct comparison of painful and non-painful stimuli within the same modality and more importantly, it is effective to evoke temporal summation of pain in the back when the electrical pulse is repeated, as shown in Experiment 2. Using the same experimental design in two separate experiments with different stimulation parameters, results from the present study indicate that SM modulates pain evoked by a

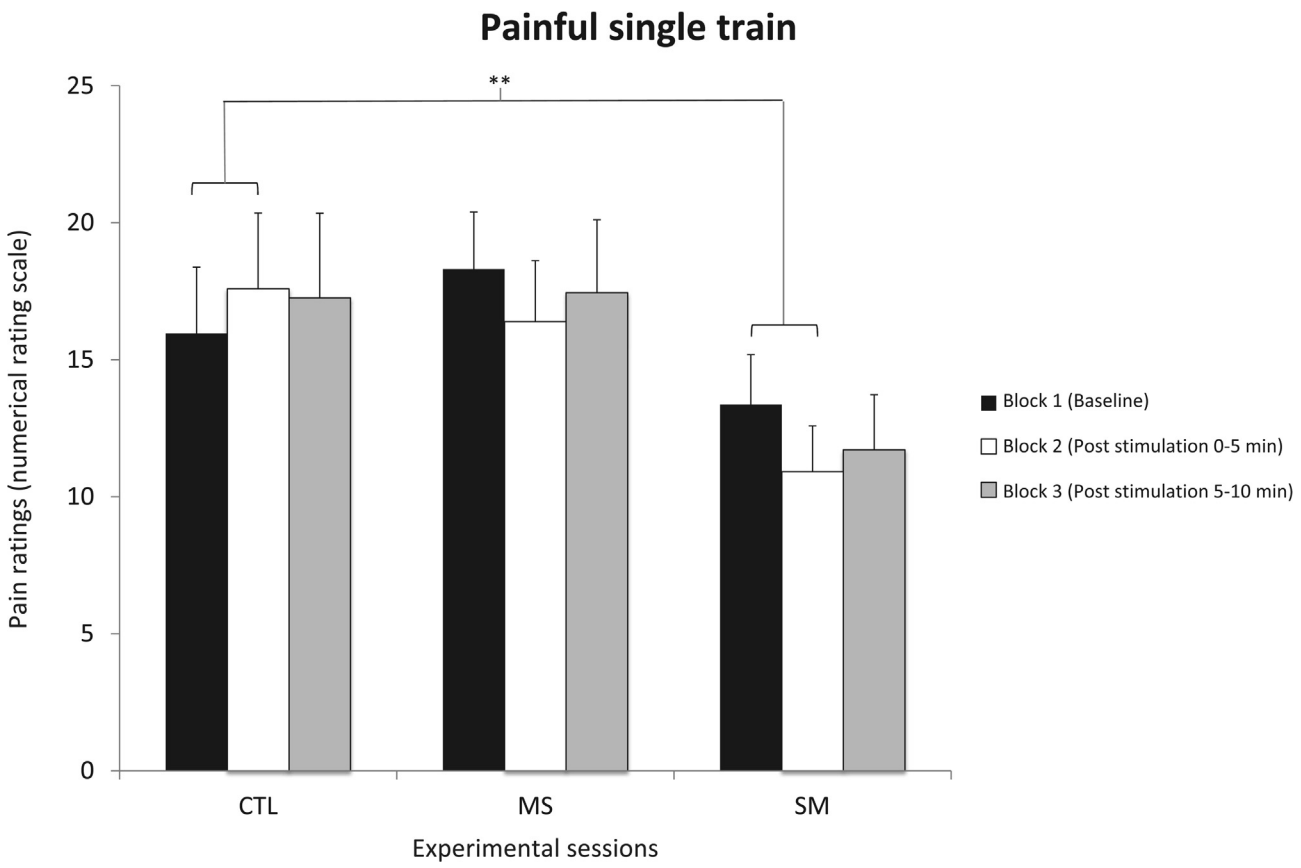

Fig. 4. Pain ratings for the single-train stimulation. Ratings are reported for the three sessions that included painful single-train stimuli (mean ± SEM). The Bonferroni-corrected planned contrasts revealed that pain was decreased by SM compared with the control session during block 2 relative to block 1 ($p < 0.01$). However, this effect did not persist over time (block 3 vs block 1: $p = 0.5$). $^{**}p < 0.01$.

repeated pulse (train) or a repeated train (as in Experiment 2) but not by a single pulse (as in Experiment 1). This suggests that SM may have stronger or more specific effects on wind-up, the spinal mechanism underlying temporal summation of pain, rather than an effect on transmission of nociceptive information from the spinal cord to the brain. This is consistent with previous studies using thermal stimulation that showed no specific effect of SM on pain evoked by A-delta fiber activation by a heat pulse, but a specific decrease in temporal summation of pain when the heat pulse was repeated, which is associated with C-fiber activation (George et al., 2006; Bialosky et al., 2009b).

In the current literature on SM-induced hypoalgesia, the only study using electrical stimulation to evoke pain was conducted by Terrett and Vernon (1984). Consistent with results from our second experiment, they observed a significant increase of pain tolerance after SM. In their study, processes underlying temporal summation of pain were likely involved since the electrical stimulation consisted in a high-frequency stimulation (60 Hz) applied for several seconds. Together with the present findings, these results suggest that the non-specific or weaker effects of SM on nociceptive transmission, compared with those on temporal summation of pain, may explain the lack of effect in Experiment 1 and some of the discrepancies between studies using stimuli that do not evoke temporal summation. Indeed, previous studies on SM hypoalgesia using different stimulus modalities to produce pain yielded conflicting results. For instance, an increase in the pressure pain threshold assessed with mechanical stimuli, i.e. the minimal amount of pressure required to induce a change in sensation from pressure to pain, was observed in 19 of the 27 studies that were included in a recent systematic review (Millan et al., 2012). As for thermal pain thresholds, three studies reported a significant increase (hypoalgesia) (Bialosky et al., 2009b, 2010; Bishop et al., 2011) whereas one study reported no significant effect (Fernandez-Carnero et al., 2008). Collectively, combining all stimulus modalities together, these studies and the present one generally support favorable effects of SM on pain perception, although the effects are sometimes small and not always reproducible. In contrast, a series of studies assessing temporal summation of pain all yielded positive results (George et al., 2006; Bialosky et al., 2008, 2009b; Bishop et al., 2011), consistent with findings from Experiment 2, as discussed below.

Neurophysiological mechanisms of hypoalgesia induced by spinal manipulation

At least three types of mechanisms may contribute to the hypoalgesic effects of SM. Firstly, segmental (spinal)

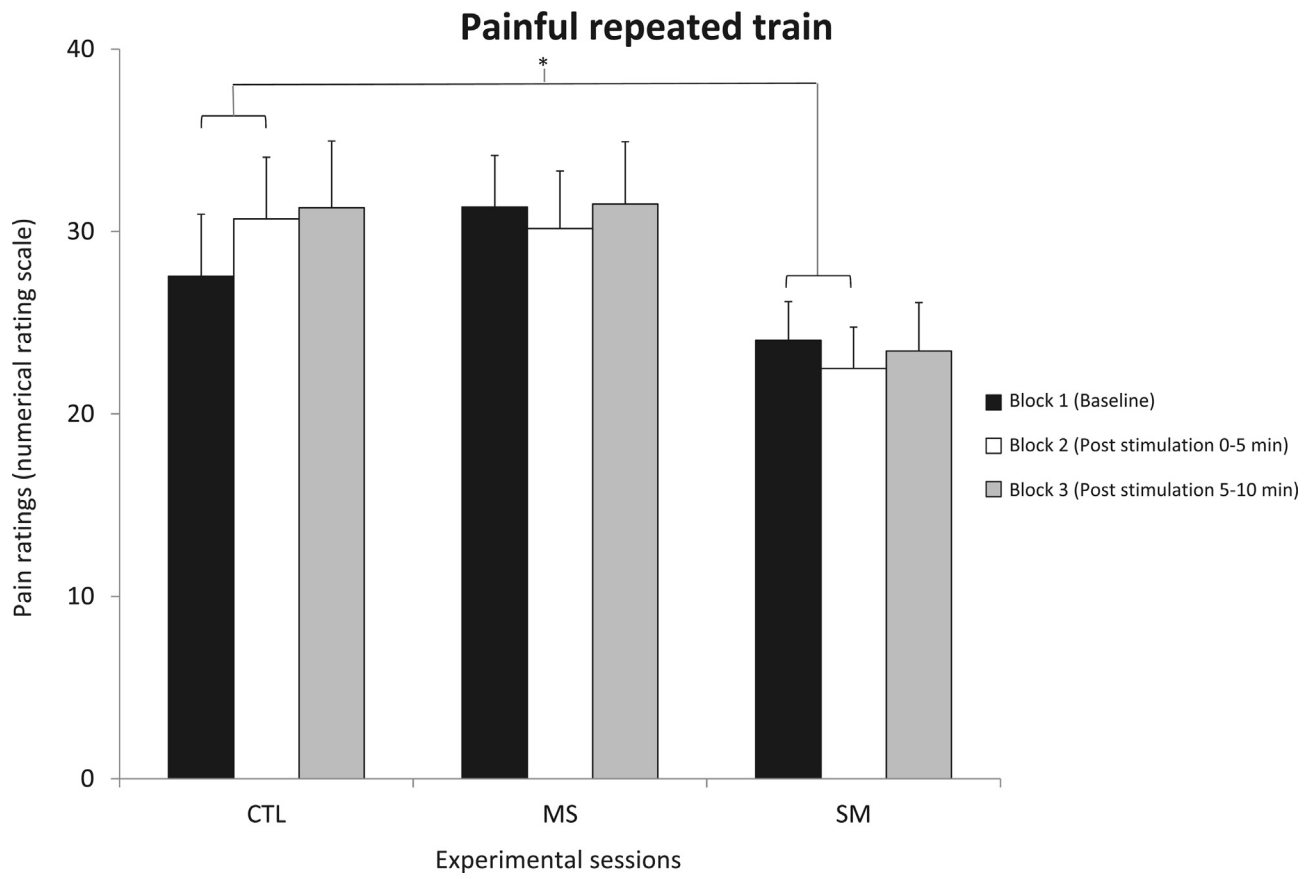

Fig. 5. Pain ratings for repeated train stimulation. Ratings are reported for the three sessions that included painful repeated train stimuli (mean ± SEM). The Bonferroni-corrected planned contrasts revealed that temporal summation of pain was attenuated by SM compared with the control session during block 2 relative to block 1 ($p = 0.036$). However, this effect did not persist over time (block 3 vs block 1: $p = 0.6$). $^{*}p < 0.05$.

processes may decrease pain perception through inhibition of dorsal horn neurons' activity. Secondly, descending pathways originating from various brain structures, including the brainstem, may be activated by SM and modulate spinal neurons' activity. Thirdly, non-specific cerebral processes that modulate pain perception without a spinal involvement could decrease nociceptive activity and pain perception. The first two mechanisms can be partly teased apart by applying pain stimuli in different body regions, including areas innervated by the same spinal levels as the manipulated vertebral segments (ex: L4-L5 manipulation with pain stimuli applied on the low back or corresponding leg dermatomes) and areas remote from the manipulated spinal segment that are not innervated by the same spinal cord levels (ex: L4-L5 manipulation with pain stimuli applied on the forearm). As summarized in a previous systematic review, a majority but not all studies included in the review reported a segmental hypoalgesic effect of SM or a hypoalgesic effect in a remote site (Millan et al., 2012). This argues for a segmental mechanism with a contribution from supraspinal pathways. However, the potential contribution of non-specific processes including expectations, which may decrease pain perceived in any region of the body, cannot be ruled out (Bialosky et al., 2009a). To our knowledge, only two studies specifically examined this issue (Bialosky et al., 2008, 2014). Results from these studies indicate that SM has greater effects than expectations of hypoalgesia, supporting a specific effect of SM on pain perception. Nevertheless, the contribution of segmental or descending pain modulatory pathways to these effects remains to be clarified.

Another approach to distinguish spinal from supraspinal mechanisms is to examine specific pain regulation processes. Temporal summation of pain is a commonly studied perceptual phenomenon that relies, at least in part, on a spinal mechanism (Price et al., 1978). Temporal summation of pain represents a progressively increasing pain perception evoked by a repeated stimulus of constant intensity. It is the perceptual correlate of and occurs due to wind-up in spinal dorsal horn neurons, which response increases with the summation of peripheral inputs (Price et al., 1978). A short pulse train, although perceived as a single stimulus, can also produce temporal summation, increased nociceptive brain activity and increased pain perception compared with a single pulse at the same intensity (Mouraux et al., 2014). Although temporal summation terminates after stimulus application, it is a clinically relevant form of pain amplification because it shares some mechanisms with pathological pain processes such as central sensitization. Therefore, it constitutes an interesting experimental model to study the spinal mechanisms of SM hypoalge-

sia. In the present study, temporal summation of pain was induced by a repeated electrical stimulus applied in the same area as the spinal manipulation. SM decreased temporal summation of pain compared with the control session, in which a trend toward a progressively increasing pain was observed. This is coherent with previous studies in which temporal summation was examined with cutaneous heat applied on the skin of the limbs (George et al., 2006; Bialosky et al., 2008, 2009b; Bishop et al., 2011), but not in the back. Therefore, the present results extend and strengthen these findings providing more direct evidence showing that temporal summation of back pain is decreased by SM.

In order to examine the potential contribution of low-threshold mechanoreceptors to SM-induced hypoalgesia, we included sessions during which a light mechanical stimulus was applied instead of SM. Results indicate that MS did not significantly decrease pain compared with the control session, suggesting that SM-induced hypoalgesia results, at least in part, from deep high-threshold mechanoreceptors' activation. However, the trend for MS was somewhat similar to SM and results should be interpreted with caution. Indeed, the MS was used as a control stimulus and more clinically relevant stimulation such as mobilization could be more effective and produce effects similar to those evoked by SM. Therefore, the present results do not exclude the possibility that mobilization, using higher levels of force, is also effective to decrease temporal summation of pain.

Limitations and future directions

In the present study, SM was effective to decrease temporal summation of back pain. However, effects were transient and electrical pain inhibition may not translate into clinical back pain decrease. Moreover, although temporal summation of pain likely relies on wind-up in spinal projecting neurons, an objective measure of spinal nociceptive transmission is needed to confirm that the observed effects depend on a spinal mechanism. This could be assessed with the spinal nociceptive flexion reflex, as an index of spinal nociception. In addition, future studies should determine if the present anti-nociceptive effects apply to central sensitization, which is relevant to clinical states such as acute and chronic back pain. Whether spinal manipulative therapy may prevent or reverse central sensitization by decreasing spinal mechanisms also remains to be determined. The present study also has limitations that are inherent to all pain studies. For instance, we could not control for the time of the day at which experiments were conducted and the day of the menstrual cycle in female participants. Also, placebo effects cannot be completely ruled out. However, MS was chosen as a control condition because it is a standardized force, it controls for the activation of low-threshold mechanoreceptors and it was applied for about the same duration as SM with the preload (2 s.). Of course, participants noticed that MS an SM were different (force and cavitation). However, the lack of effect of SM on sensation produced by non-painful stimuli and on pain produced by a single pulse suggests that placebo effects unlikely explain the results. A selective effect of SM on pain perception only when it is caused by a stimulus that produces temporal summation (single or repeated train) certainly brings support to this interpretation. Lastly, a different chiropractor performed SM for Experiments 1 and 2, which could bring variability in SM procedures. However, SM was performed in a controlled experimental set-up and both chiropractors performed the exact same type of manipulation with the same positioning and procedures. Although this bias cannot be completely ruled out, the specific effects observed in this study, in line with previous findings and the study hypothesis are unlikely explained by this limitation.

CONCLUSION

The present study provides evidence for a transient but specific inhibition of temporal summation of back pain by SM. Future studies should explore the long-term effects of spinal manipulative therapy on temporal summation of pain and on central sensitization (experimental and clinical pain) and whether inhibition of these processes is associated with more effective management of acute and chronic back pain.

CONFLICT OF INTEREST

The authors have no conflict of interest in relation to this work.

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