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Effect of Spinal Manipulation Thrust Magnitude on Trunk Mechanical Activation Thresholds of Lateral Thalamic Neurons

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Abstract

Objectives: High-velocity low-amplitude spinal manipulation (HVLA-SM), as performed by doctors who use manual therapy (eg, doctors of chiropractic and osteopathy), results in mechanical hypoalgesia in clinical settings. This hypoalgesic effect has previously been attributed to alterations in peripheral and/or central pain processing. The objective of this study was to determine whether thrust magnitude of a simulated HVLA-SM alters mechanical trunk response thresholds in wide dynamic range (WDR) and/or nociceptive specific (NS) lateral thalamic neurons.

Methods: Extracellular recordings were carried out in the thalamus of 15 anesthetized Wistar rats. Lateral thalamic neurons having receptive fields, which included the lumbar dorsal-lateral trunk, were characterized as either WDR (n = 22) or NS (n = 25). Response thresholds to electronic von Frey (rigid tip) mechanical trunk stimuli were determined in 3 directions (dorsal-ventral, 45° caudalward, and 45° cranialward) before and immediately after the dorsal-ventral delivery of a 100-millisecond HVLA-SM at 3 thrust magnitudes (control, 55%, 85% body weight).

Results: There was a significant difference in mechanical threshold between 85% body weight manipulation and control thrust magnitudes in the dorsal-ventral direction in NS neurons ($P = .01$). No changes were found in WDR neurons at either HVLA-SM thrust magnitude.

Conclusions: This study is the first to investigate the effect of HVLA-SM thrust magnitude on WDR and NS lateral thalamic mechanical response threshold. Our data suggest that, at the single lateral thalamic neuron level, there may be a minimal spinal manipulative thrust magnitude required to elicit an increase in trunk mechanical response thresholds. (J Manipulative Physiol Ther 2014;37:277-286)

Key Indexing Term: *Spinal Manipulation; Thalamus; Nociceptive Neurons; Lumbar Vertebrae; Chiropractic*

Spinal manipulation and spinal mobilization are commonly used in clinical practice to alleviate low back pain.[1-3] Although the underlying mechanisms remain unknown, these forms of manual therapy have been clinically shown to increase mechanical pressure pain thresholds (ie, decrease sensitivity) in both symptomatic and asymptomatic subjects.[4-12] Cervical spinal manipulation has been shown to result in unilateral as well as bilateral mechanical hypoalgesia.[6,7,12,13] Compared with no manual therapy, oscillatory spinal manual therapy at T12 and L4 produced significantly higher paraspinal pain thresholds at T6, L1, and L3 in individuals with rheumatoid arthritis.[4] The immediate and widespread hypoalgesia associated with manual therapy treatments has been attributed to alterations in peripheral and/or central pain processing including activation of descending pain inhibitory systems.[7,14-16]

Increasing evidence from animal models suggests that manual therapy activates the central nervous system and, in so doing, affects areas well beyond those being treated.[14,17,18] Sluka and Wright[19] reported in rats that unilateral knee joint

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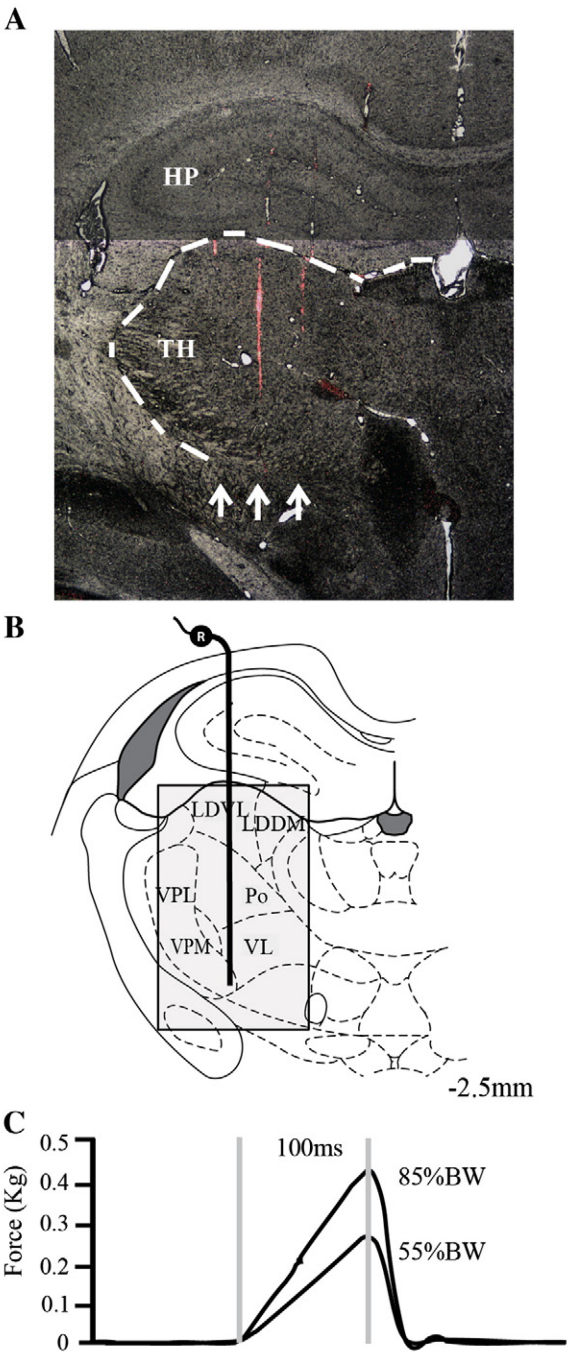

Fig 1. *A, Example of tracks (arrows) from DiI-coated electrodes through the lateral thalamus (TH) and hippocampus (HP) in a coronal brain section at magnification X40. Of the 3 DiI electrode tracks shown, the medial and lateral DiI tracks are seen in greater detail in adjacent tissue sections. B, A diagram illustrating the experimental setup for extracellular thalamic recordings at −2.5 mm caudal to bregma. Shading indicates search area that included the laterodorsal dorsal medial (LDDM), laterodorsal ventrolateral (LDVL), posterior (Po), ventroposterolateral (VPL), ventroposteromedial (VPM), and ventrolateral (VL) nuclei. C, Force profiles for L5 spinal manipulative thrust with 100-millisecond duration at 55% and 85% BW. (Color version of figure is available online.)*

mobilization evokes bilateral hypoalgesia, suggesting a widespread centrally mediated response to joint mobilization. More recently, it was shown that Grade 2 equivalent spinal mobilizations applied manually to the L5 spinous process increases hindpaw mechanical nociceptive thresholds in the awake rat with or without acute inflammation.[17] In addition, Song et al[20] reported that instrument delivered high-velocity low-amplitude spinal manipulation (HVLA-SM) significantly reduces the severity and shortens the duration of pain and hyperalgesia caused by neural inflammation within the intervertebral foramen. These findings from animal models are consistent with the widespread hypoalgesic effects reported clinically following a manual therapeutic intervention. To what extent these hypoalgesic effects are attributable to central mechanisms is undetermined, but alterations in convergent supraspinal nociceptive processing likely play a role.

The thalamus is subcortical structure receiving convergent input from all innocuous (dorsal column pathway) and/or nociceptive (spinothalamic pathway) somatosensory receptors stimulated during delivery of a spinal manipulation. The ability of the thalamus to modulate ascending sensory input as well as interact functionally with descending pain modulating structures such as the periaqueductal gray (PAG) is not well understood despite studies showing the existence of direct projections between multiple thalamic nuclei and the PAG.[21-23] Recently, in humans, it was demonstrated that the lateral thalamus and PAG interact reciprocally at short latencies (~5 milliseconds) and that stimulation of either structure relieved pain to various degrees.[24] Although more work in this area is required, the authors suggested that the thalamus and PAG influence each other in opposite ways via a fairly direct pathway not involving spinal cord circuitry and thereby being important in pain perception.[24] Whether such a pathway could contribute to the immediate and widespread hypoalgesia after HVLA-SM is plausible but, at this point, purely speculative.

Optimization of the biomechanical features that characterize a spinal manipulation such as thrust magnitude, thrust duration, loading direction relative to the patient, tissue preload, and anatomical contact site is thought to be critical to clinical expertise.[25-28] A pilot study investigating the relationship between the magnitude of the force applied and hypoalgesia in individuals with lateral epicondylalgia suggested that the amount of applied manual force may determine the extent of hypoalgesia.[29] The purpose of the present study was to determine the relationship between HVLA-SM thrust magnitude and trunk mechanical response threshold of lateral thalamic neurons in an animal model. Determination of which (if any) biomechanical characteristics of an HVLA-SM alter neural response characteristics has been the subject of several recent basic investigations.[30-34] Together, these studies aim to provide insight into the mechanisms underlying spinal manipulation.