Effect of spinal manipulation on thalamic neuron somatic activation thresholds

William R. Reed, Randall Sozio, Amanda Hussman

Palmer Center for Chiropractic Research, Palmer College of Chiropractic, Davenport, Iowa 52803

No. 266.04

Introduction

High velocity low amplitude spinal manipulation (HVLA-SM) is commonly used in clinical practice to alleviate both neck and low back pain. Although the underlying neurophysiological mechanisms remain unknown, spinal manipulation has been clinically shown to reduce mechanical pain thresholds (PPT) in both symptomatic and asymptomatic subjects.[1-3] The hypoalgesic affects of manual therapy have been attributed to alterations in nociceptive peripheral perception, central pain processing and/or stimulation of descending pain inhibitory systems.[4-5] The thalamus is a collection of medial and lateral subnuclei involved with receiving and processing convergent somatic innocuous and nociceptive stimuli destined to reach the cortex. In this study we determined whether the magnitude of a simulated spinal manipulation (55% or 85% body weight) affected the mechanical response threshold of thalamic neurons to trunk stimuli in an animal model.

Methods

- Electrophysiological recordings of 93 thalamic neurons were obtained from 18 male Wistar rats (330-540g).
- Rats were anesthetized with an i.p. injection of 50% urethane (1.2g/kg) and maintained with supplements of 5% urethane administered i.v. as needed.
- The rat's head was clamped into a stereotaxic device and the thalamus exposed through an opening in the skull 1.5 to 4.5mm caudal to bregma. Thalamic neurons were recorded extracellularly with DiI (1,1'-dioctabecyl-3,3,3'3'-tetramethyl-indocarbocyanine perchlorate) coated tungsten microelectrodes (6-8MΩ) impedence . The location of electrode tracks were verified post-mortem via histological reconstructions.
- Thalamic threshold response to mechanical trunk stimuli (Electro-vonFrey -rigid tip applied in dorsal-ventral, 45º cranialward, and 45º caudalward directions; 400g maximum) was recorded prior to and following a simulated HVLA-SM .
- Both the order of mechanical trunk testing and the magnitude of the manipulative thrust were randomized.

- Manually-delivered spinal manipulation to the lumbar spine in a prone position was simulated:
  - using a small, motor-driven forceps rigidly attached to the rat L_5 spinous process
  - by applying forces (0%- time control, 55% and 85% body weight) which encompassed values reported in the clinical literature
  - delivered in a dorsal-ventral direction at the L_5 spinous process

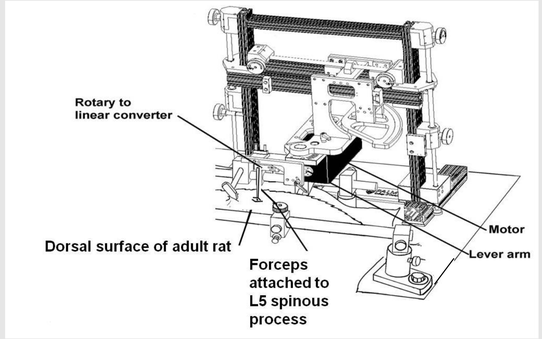

Figure 1. Schematic of preparation

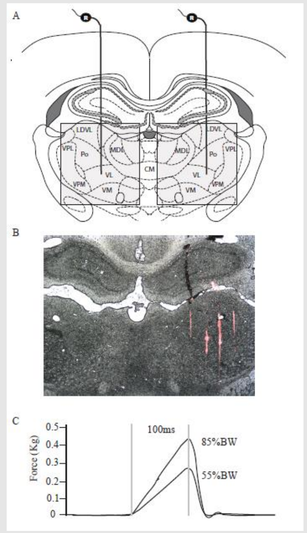

Figure 2. A) diagram illustrating setup for thalamic recordings. Shading indicates the potential search area. CM, centromedial; LDVL, lateral dorsal ventrolateral, MDL, mediodorsal lateral; VM, ventrolmedial; VL ventrolateral; Po, posterior, VPM, ventroposteromedial; VPL, ventroposterolateral. B) Example of a single row of DiI-coated electrode tracks through the thalamus (X40). C). Example of L_5 spinal manipulation at 55% and 85% rat body weight and 100ms thrust duration.

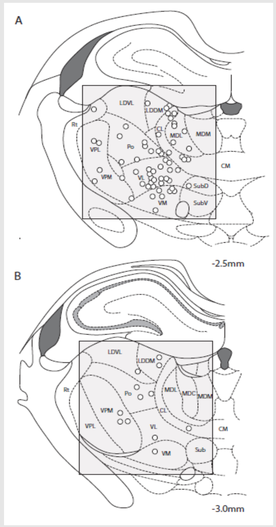

Figure 3. Summary showing the location of medial and lateral thalamic neurons responding to mechanical stimuli applied to the trunk. Only the -2.5mm (A) and -3.0mm (B) from bregma levels are shown. Shading indicates the potential search area.

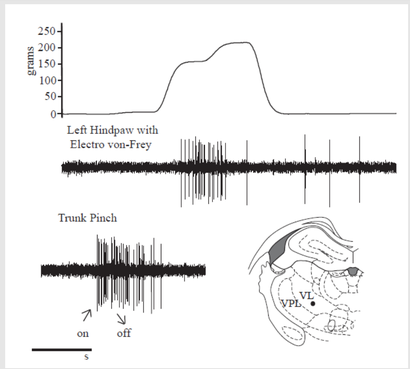

Figure 4. Example of raw recordings of somatic responses of a thalamic neuron located in the ventrolateral (VL) nucleus. The onset of neural response to dorsal-ventral applied mechanical stimulus (Electro-vonFrey rigid tip) occurred at 161 grams. The response to trunk pinch is also shown.

Results

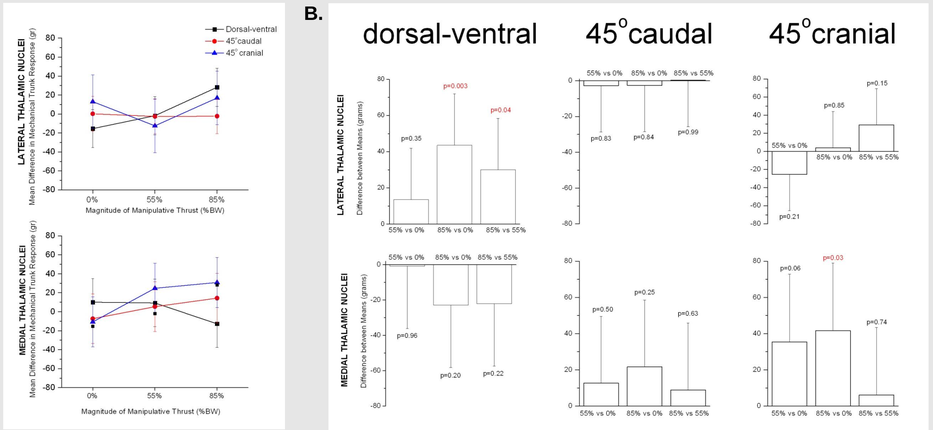

Figure 5. A) The mean difference in pre- and post spinal manipulation (0%-time control, 55%BW, 85%BW) mechanical trunk thresholds (Electro vonFrey–rigid tip) in lateral (top panel) and medial (lower panel) thalamic nuclei neurons. B) Comparisons between the effects of thrust magnitude (0%-time control, 55%BW, and 85% BW) and the direction (dorsal-ventral, 45º caudalward, 45º cranialward) of applied mechanical trunk stimuli pre-and post spinal manipulation. Data are reported as means and 95% confidence intervals.

Conclusions

- Lumbar HVLA spinal manipulation with higher thrust magnitudes (85%BW) increased the dorsal-ventral mechanical trunk activation thresholds for neurons located in the lateral but not medial thalamic subnuclei.
- Lumbar HVLA spinal manipulation with higher thrust magnitudes (85%BW) increased the 45º cranial mechanical trunk activation thresholds for neurons located in the medial but not lateral thalamic subnuclei.
- Lumbar HVLA spinal manipulation of any magnitude failed to change 45º caudal mechanical trunk activation thresholds for neurons located in either the lateral or medial thalamic subnuclei.
- Magnitude of thrust may be a physical parameter of high velocity low amplitude spinal manipulation that contributes to the overall hypoalgesic effect reported to occur with this type of clinical treatment.
- The thalamus may be one of several supraspinal structures involved in the nociceptive central processing responsible for the clinical hypoalgesic effects associated with various forms of manual therapy intervention.

References

1) Maduro deCamargo V, Alburquerque-Sendin F, Berzin F et al. Immediate effects on electromyographic activity and pressure pain thresholds after a cervical manipulation in mechanical neck pain: a randomized controlled trial. *J Manipulative Physiol Ther* 2011;34:211-20.
2) Vicenzino B, Paungmali A, Buratowski S et al. Specific manipulative therapy treatment for chronic lateral epicondylalgia produces uniquely characteristic hypoalgesia. *Man.Ther.* 2001;6:205-12.
3) Vernon H. Qualitative review of studies of manipulation-induced hypoalgesia. *J.Manipulative Physiol Ther.* 2000;23:134-8.
4) Skyba DA, Radhakrishnan R, et al. Joint manipulation reduces hyperalgesia by activation of monoamine receptors but not opioid or GABA receptors in the spinal cord. *Pain* 2003;106:159-68.
5) Wright A. Hypoalgesia post-manipulative therapy: a review of a potential neurophysiological mechanism. *Man.Ther.* 1995;1:11-6.

Acknowledgements

The authors thank Dr. Cyndy Long for statistical consultation and Ying Cao for statistical assistance.

This work was supported by a grant from the Australian Spinal Research Foundation to WRR.