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Manipulation 107

By: Dean Smith, DC, PhD

Educational Objectives

- Provide an overview of research on the effects of spinal manipulation on sensory processing, motor output, functional performance and sensorimotor integration
- Examine performance based outcome measures used in an attempt to objectively measure the ramifications of spinal manipulation
- Update knowledge regarding several physical characteristics of an applied SMT, and review what is known about the signaling characteristics of sensory neurons innervating the vertebral column in response to spinal manipulation

Educational Objectives

- Review the physiological evidence that spinal manipulation can impact visceral function
Background

- The authors have spent the last 15 years conducting research to add to understanding of central neural plastic effects of spinal manipulation
- The authors prefer the term spinal or joint dysfunction characterized by muscle tightness, tenderness, restricted joint movement
- Authors propose that spinal dysfunction represents a state of altered afferent input which may be responsible for ongoing central plastic changes

Potential mechanism by which spinal adjustments, improve function and reduce symptoms

- Altered afferent feedback from spinal dysfunction alters the afferent "milieu" leading to altered sensorimotor integration (SMI) of the afferent input, which is then normalized by high velocity, low-amplitude manipulation
Background

- This research helps us understand how an initial episode(s) of back or neck pain may lead to ongoing changes in input from the spine which over time lead to altered SMI from the spine and limbs.
- Some of the research discussed in this review has the potential to identify objective neurophysiological markers for prediction of who will respond best to SMT and/or whether a patient has had a sufficient amount of treatment to normalize neurophysiological markers altered SMI.

Altered Sensorimotor Processing after SMT

- Several studies utilizing somatosensory evoked potentials (SEPs) have shown cervical spine manipulation can alter somatosensory processing and early sensorimotor integration of input from the upper limb.
- Somatosensory evoked potentials are electrical potentials generated by various portions of the ascending sensory pathways (e.g., Ia afferents from muscles) in response to stimulation of peripheral sensory nerves. SEPs can be easily elicited and recorded and can be used to examine the functional integrity of somatosensory pathways.

- Example: alterations in the amplitude of the cortical SEP peaks N20 and N30 following HVLA cervical SMT.
- N20 peak - represents the arrival of the afferent volley at the primary somatosensory cortex.
- N30 peak - thought to reflect early sensorimotor integration.
- Results suggest that manipulation of dysfunctional cervical segments can alter early sensory processing and SMI from the upper limb.
- Neuroplastic changes can be 'good' (motor learning) or 'bad' (central sensitization, chronic neck pain).
SMI and Proprioception

- Goal-directed actions require ongoing sensorimotor integration to ensure that motor outputs are congruent with current intentions as well as proprioceptive feedback from the actual movement.
- Proprioception includes both joint position sense (JPS) and kinesthesia (the sense of limb movement in the absence of visual cues).
- Main source of afferent information for JPS arises from muscle spindles but mechanoreceptors in joint capsules and cutaneous tactile receptors likely contribute as well.
- Spinal manipulation improved neck and elbow proprioception (Palmgren et al. 2006; Haavik & Murphy 2011).

SMI and SMT

- Normally, stimulating two peripheral nerves produces smaller SEP amplitudes compared to single nerve stimulation (sensory filter).
- Neck pain/some musculoskeletal disorders can alter the filtering process; SMT has been demonstrated to significantly reduce the N30 SEP peak when median and ulnar nerves are stimulated.
- Dystonia – found to have reduced ability to suppress (filter) the dual sensory input which is evidence for inefficient integration which could alter motor output (impairment).
- SMT appears to enhance sensory filter (improvement of sensory integration) when we assume suppression is a good thing.

Altered Motor Control and SMT

- Transcranial magnetic stimulation (TMS) is a technique for noninvasive stimulation of the human brain.
- Stimulation is produced by generating a brief, high-intensity magnetic field by passing a brief electric current through a magnetic coil.
- The field can excite or inhibit a small area of brain below the coil - all parts of the brain just beneath the skull can be influenced, but most studies have been of the motor cortex where a focal muscle twitch is produced, called the motor-evoked potential (MEP).
- Some evidence of motor control changes post-adjustments: decrease in SICI for abductor pollicis brevis and; decrease in SICF for extensor indices proprios.
Improved Neuromuscular Performance with SMT

- Feedforward activation (FFA) delay can occur with low back pain
- In a group of males with feedforward delay of transversus abdominis, SMT improved speed of response by 38%
- Chronic LBP patients treated with manipulation and/or exercise experienced continued improvement in delay at 1 year follow up
- FFA times have been shown to correlate strongly with self-rated disability (may be useful markers of treatment/prognosis)

Conclusions

- Many studies show that spinal manipulation results in plastic changes in sensorimotor integration within the CNS
- It seems there is a CNS mechanism for HVLA manipulation
- Not clear yet the degree by which these findings correlate with beneficial clinical outcomes
- Do these sensorimotor changes result from a) correction of spinal dysfunction or; b) just afferent barrage due to manipulation?
Background

- While questionnaires are the most commonly used in spinal manipulation (SM) research, it is unlikely they capture all of the clinically important changes resulting from SM.
- The clinical intervention of SM is a mechanical event and, in order to assess its impact on the human system, objective outcome measures are necessary.
- This article attempts to broadly categorize, and provide a basic introduction to, and summary of techniques that may be considered for use to evaluate the performance based responses to SM.

SM and ROM

- ROM considered a prime variable to assess function and is non-invasive and low cost.
- Dual inclinometry and CROM/BROM devices are most commonly performed and have moderate to good reliability.
- C-Spine – high level of statistically significant increase in ROM post cervical manipulation in several studies.
- T-Spine manipulation also shown to increase C-spine ROM in neck pain patients.
- L-Spine manipulation data is more variable with respect to complex movements (eg electromagnetic tracking) and ROM.
SM and ROM

- Pollard and Ward (1998) found either upper cervical or SI joint manipulation increased flexion ROM at hip
- Atlanto-occipital joint manipulation increased mouth opening ROM in 2 separate studies significantly
- Manipulation of thoracic spine, CT junction or upper costotransverse joints improved shoulder (GH joint) ROM in flexion, abduction, rotation following single manipulation

SM and Stiffness

- Spinal stiffness is common pre and post assessment method (with posterior to anterior palpation and devices)
- Manual palpation of spine stiffness varies in reliability, computerized systems show good reliability
- C- Spine – understudied
- T- Spine – studies have not shown changes in T-spine stiffness but groups were not symptomatic
- L- Spine – manipulation, general exercise and motor control exercise groups all showed decreased stiffness but stiffness not a predictor of response to treatment
- It is difficult to determine real value of ‘stiffness’

SM and Force Production

- Hand held dynamometry and isokinetic dynamometry are commonly used in research
- Pain free grip force measured with dynamometer
- Pain free grip force increased following cervical spine manipulation for epicondylalgia only on symptomatic side
- Cervical manipulation decreased biceps brachii muscle inhibition and increased flexor force in chronic neck pain patients
- Lower T-spine manipulation impacts lower trapezius strength
SM and Force Production

- Suter et al studies confirmed by Hillerman (2006) and Grindstaff (2009)
- HVLA SM can affect the strength and the basal tonus of female pelvic floor muscles - SM led to a statistically significant increase both in perineal basal tonus and perineal muscle strength during phasic contraction
- Clinical significance of the changes associated with SM and paraspinal EMG is not completely understood

SM and Heart Rate Variability

- C- Spine – significantly greater decrease in HRV with manipulation in pre-post design compared to sham manipulation
- T- Spine – when comparing manipulation to sham thrust into scapulae, HRV was only impacted by SM
- L-Spine – no clear results have been identified yet

SM and Algometry/PPT

- C- Spine – significant increase in PPT following cervical manipulation compared to controls with chronic neck pain; significant increase of PPT at epidondyles in a separate cervical spine manipulation study
- T- Spine – increased thoracic spine PPT over spinous processes following HVLA SM in asymptomatic group
- L-Spine – mixed results: Potter (2009) showed in LBP patients, SM group compared to sham improved PPT over iliocostalis, multifidus, glutei, traps
SM and Proprioception

- Palmgren (2006) found that the control group improved head repositioning accuracy into right rotation only while the SM group significantly improved head repositioning accuracy in all ranges of motion.
- Elbow joint position sense was improved by cervical spine adjustments (Haavik and Murphy 2011).

SM and Fitts’ Law

- Movement time is described as a linear function of the amplitude of a movement and the width of the target.
- Assorted combinations of movement amplitude and target width create the “index of difficulty” for a given trial.

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SM and Fitts’ Law

- Smith et al (2006) found average improvement in movement time following chiropractic adjustments (pragmatic approach) was 9.2% compared to 1.7% for controls.
- Smith had subjects use hands to move mouse.
- Passmore et al (2010) manipulated cervical spine only and found significant improvement in head movement time following manipulation compared to controls.
- Passmore had subjects use a head mouse.
SM and Complex Tasks

- Lehman and McGill (1999) used electromyography and 3D motion analysis of a golfer and showed movement differences pre-post.
- Kelly et al (2000) showed improved mental rotation reaction times following upper cervical spine adjustments compared to control group.
Background

SMT is typically applied when dysfunctional areas of the vertebral column are found based upon palpation, asymmetries, pain/tenderness, restrictions in motion.

Clinician’s goal is to normalize physiology of the neuromusculoskeletal system and other systems affected by the dysfunction.

Mechanisms of SMT remain unclear.

Korr (1975) proposed SMT alters proprioceptive afferents.

Gillette (1987) proposed all of the likely afferent input likely to arise from lumbar SMT – based upon the single force-time profile available at that time.

Mechanics and Forces with SMT

Force profiles may be characterized by a pre-load phase, a thrust phase which rapidly rises to a peak force, and a resolution phase.

A thin, flexible pressure pad placed under the thrusting hand of the clinician measures the forces applied to the target site on patients.
Mechanics and Forces with SMT

- Mechanical parameters of SMT vary significantly depending on the manipulated region of the vertebral column, the type of procedure being performed, and characteristics of the individual practitioner.
- Cadaveric studies show multiplane motion with SMT like loads.
- Ianuzziti and Khalsa found that vertebral translation with SMT like thrust occurs mostly in the thrust direction and that strain in the facet joint capsules is found at that level and levels adjacent, bilaterally.

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Afferent Activation with SMT-like Motion

- Colloca et al recorded S1 nerve root and multifidus in anesthetized humans receiving instrument SMT and found early activation within 15 ms for both nerve and EMG activity.
- Anesthetized cats have also been studied – the larger the spinal forces, the more the vertebral displacement.
- SMT like thrusts into cat lumbar vertebrae have shown thrust phase significantly increases discharge of muscle spindles compared to preload.
- In general, group Ia afferents appear more responsive to SMT than group II spindle afferents.

Afferent Activation with SMT-like Motion

- Afferent activity in cervical spine dorsal rootlets has been characterized as arising from neck muscle spindles and can be altered depending on the direction of displacement.
- GTO responses to SMT like thrusts rarely activated by pre-load, only mildly activated by thrust phase and responded no matter what the direction of thrust.
- Pickar & Wheeler (2001) likely recorded from pacinian corpuscle – responded to SMT like thrust that distracted facet joint, but did not respond to fast loading rates.
- SMT like force time profiles similar to that of manually delivered high velocity low amplitude thrusts evoke a relatively high-frequency discharge from afferents innervating muscle spindles, GTO’s and high threshold mechanoreceptors.
Neurophysiological Effects of SMT?

- Clearly SMT produces forces that displace tissues.
- Could the short lasting SMT stimulus change the behavior of the nervous system that outlasts the intervention (<150 ms)? If so, could be from primary or secondary responses.
- **Primary responses** (long lasting neural response arising from direct consequence of short lasting neural activity generated by SMT).
- SMT is dynamic and only those receptors that respond mostly in a dynamic way are expected to respond to SMT [Ia, Ib, II(Aβ), IV(C)].
- Synaptic efficacy is affected by the history of high frequency bursting from group Ia and II muscle afferents and the effect lasts beyond the duration of the burst itself.

Neurophysiological Effects of SMT?

- **Secondary responses** - long-lasting neural response that arises as a consequence of (i.e., secondary to) a long-lasting change in spinal biomechanics caused by the manipulation.
- Several sustained changes in spinal biomechanics have been hypothesized to occur as a result of SMT (e.g., release entrapped meniscoids, breaking adhesions, reduce disc distortion, unbacking of buckled segments).
- Neural responses secondary to long lasting biomechanical changes could occur because primary afferents have receptive endings embedded in deep paraspinal tissues that respond to mechanical stresses/strains and chemical changes (chemoreceptors).
- Manipulation has been shown to alter biomechanics/local inflammation.

Conclusions

- SMT could affect the nervous system by activating paraspinal sensory neurons during the maneuver itself and/or by altering spinal biomechanics.
- SMT may take advantage of two signaling characteristics of the nervous system: (1) inherent high frequency signaling properties of dynamically-sensitive primary afferent neurons and (2) response properties of post-synaptic neurons.
- SMT evokes a high frequency discharge in some primary afferents.
- Experimental studies not using spinal manipulation, spatial and/or temporal summation of high frequency input produces sustained changes in synaptic efficacy.
Key Points

- Intervertebral joint fixation reduces paraspinal muscle spindle response during clinically relevant spinal manipulative thrust durations ($\leq 150$ ms)
- Maximum paraspinal muscle spindle response during SM occurs at the segmental level where the thrust force is delivered regardless of fixation
- HVLA-SM target accuracy maximizes muscle afferent response
- Nontarget thrust neural response is substantial and may provide a rationale for clinical efficacy despite low levels of interexaminer reliability in diagnosing the subluxation
Background

- Spinal manipulation is generally accepted as one reasonable treatment option in the management of musculoskeletal disorders such as low back pain and neck pain
- Some evidence also exists that certain visceral disorders benefit from spinal manipulation (cf, Bakris et al., 2007)
- The mechanisms by which spinal manipulation might alter visceral function remain unclear
- Goal: to review the literature concerning visceral responses to the application of mechanical stimuli to the spine and paraspinal tissues

Background

- Clinical trials and case reports of spinal manipulation in the treatment of non-musculoskeletal disorders are restricted with the bulk of studies focused on cardiovascular disease, gynecological complaints, infantile colic, asthma, enuresis, ear infections
- Most patients present to chiropractors for musculoskeletal conditions (>90%)
- Children more so than adults are seen by chiropractors with non-musculoskeletal conditions

Methods

- PubMed and Index to Chiropractic Literature searched for manipulation and somatovisceral, cardiovascular, respiratory, gastrointestinal, gynecological
- Inclusion Criteria: Articles were published in English, original papers, healthy humans with physiological responses to manual treatment
Cardiovascular System

- Perhaps due to ease of access and lack of access to other physiological systems, the cardiovascular system has been the most well studied with SMT
- 18 articles satisfied their inclusion criteria
- Common measures were Heart Rate, Blood Pressure and Heart Rate Variability from which changes in autonomic output may be implied
- Using arterial tonometry, Fujimoto et al., 1999 found cervical manipulation produced the largest effects: decreases in systolic and diastolic pressures of 6.8 (S.D. ±1.9) mmHg and 6.6 (S.D. ±2.1) mmHg, respectively

Cardiovascular System

- Pastellides (2009) consistently showed decreases in systolic blood pressure in response to upper cervical manipulation, thoracic manipulation, and combined cervical and thoracic manipulation
- Analysis of heart rate variability (HRV) has been used to indirectly assess relative autonomic drive to the heart
- Cervical and thoracic manipulation have been associated with no changes or a shift in favor of sympathetic output to the heart in healthy young adults
- Lumbar manipulation was associated with a small increase in cardiac parasympathetic output
- Summary of HR and BP to SMT: single digit decreases in HR (bpm), and systolic and diastolic blood pressures (mmHg)
Respiratory Function
- 3 papers satisfied inclusion criteria
- Kessinger 1997 reported a 6% increase in forced vital capacity and 5% increase in forced expiratory volume after 2 weeks of upper cervical care
- Engel and Vemulpad also report increases in FVC and FEV-1 with manipulation but only 5 subjects in intervention group

Other Functions
- In an uncontrolled, single cohort trial, manipulation was associated with increased phasic perineal contraction amplitude
- Studies of skin conductance suggest that a sympathoexcitatory effect can be induced in the lower limbs with lumbar spinal manipulation (Perry et al., 2011), and perhaps in the hands following mobilization of the thoracic region (Jowsey and Perry, 2010)
- Studies of the effects of spinal manipulation on the regulation of pupil diameter report mixed results
- Acceleration of the reflex response of the pupil has been demonstrated with SMT but it was not possible to resolve specific effects on the parasympathetic vs. sympathetic contributions (Gibbons et al., 2000).
Conclusions

- There are relatively few basic physiological--visceral studies in humans to guide clinical practice.
- Most research is characterized by small cohorts of subjects, uncontrolled trials and one-time pilot studies.
- Researchers have been slow to adopt new technologies but this seems to be changing slowly.
- The greatest number of physiological studies has focused on cardiovascular function.
- Somato-humoural and non-autonomic neural mechanisms of spino-visceral interactions remain largely unexplored.

The Impact of Cervical Manipulation on Heart Rate Variability

Abstract: Heart Rate Variability (HRV) is the time-variant variability in heart rate and is mediated by the balance of parasympathetic and sympathetic division of the autonomic nervous system. Cervical manipulation (CM) can be utilized to achieve neuromodulation of the autonomic nervous system. This study examined the effect of CM on heart rate variability (HRV) in 20 healthy subjects using heart rate variability (HRV) analysis. The HRV analysis was performed before and after the CM intervention. The results showed a significant increase in HRV after the CM intervention, indicating a decrease in sympathetic activity and an increase in parasympathetic activity. This study suggests that CM may have a potential role in the treatment of various cardiovascular conditions.
**Review Articles**

The Use of Spinal Manipulative Therapy in the Management of Chronic Obstructive Pulmonary Disease: A Systematic Review

Jenifer Wang, MDc,1,2,3, Stephen Bevan, MDc,1,2,3, Uppal,4,5,6,7,8 Samir Pujara, MDc,1,2,3, Benjamin Brown, MDc,1,2,3, and Roger Bange, MDc,1,2,3,4,5,6,7,8

**Abstract**

Objectives: To evaluate the methodological quality of the evidence for the use of spinal manipulative therapy (SMT) with and without other therapies in the management of chronic obstructive pulmonary disease (COPD).

Methods: A systematic approach was developed to investigate the evidence for SMT in COPD. Only studies with participants older than 18 years with an existing diagnosis of COPD were included. A search was then performed using specific terms, including a broad range of COPD, SMT, and other related terms. After screening, relevant studies were included.

Results: A total of 15 articles met the inclusion criteria and were included in the systematic review. Of these, 9 articles emphasized the potential benefits of SMT, and 6 articles emphasized the potential risks or concerns associated with SMT in COPD. The results showed that SMT may be a feasible and safe therapy for COPD patients with respect to physical improvement and symptom relief.

Conclusions: SMT can be beneficial in the management of COPD, particularly in improving physical functioning and reducing symptoms. However, further research is needed to better understand the mechanisms of action and long-term effects of SMT in COPD patients.

References: The review provides a methodology evaluation of the evidence for using SMT with and without other therapies in the management of COPD. While the quality of the evidence depends on the use of COPD risk factors, the results suggest that SMT may provide additional benefits for COPD patients. However, further research is needed to better understand the mechanisms of action and long-term effects of SMT in COPD patients.

**Measurable changes in the neuro-endocrinial mechanism following spinal manipulation**

Roush Soumar, BScPhD1,2,3,4,5,6,7,8,9

1Department of Health Sciences, University of Technology, Sydney, New South Wales, Australia
2School of Health Sciences, University of Technology, Sydney, New South Wales, Australia
3School of Physiotherapy, University of Technology, Sydney, New South Wales, Australia
4School of Physiotherapy, University of Technology, Sydney, New South Wales, Australia
5School of Physiotherapy, University of Technology, Sydney, New South Wales, Australia
6School of Physiotherapy, University of Technology, Sydney, New South Wales, Australia
7School of Physiotherapy, University of Technology, Sydney, New South Wales, Australia
8School of Physiotherapy, University of Technology, Sydney, New South Wales, Australia
9School of Physiotherapy, University of Technology, Sydney, New South Wales, Australia

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**Abstract**

The neuro-endocrinial mechanism and the neuro-endocrinial mechanism after spinal manipulation have been shown to be closely related. The neuro-endocrinial mechanism plays a critical role in the regulation of various physiological functions, including the cardiovascular system, respiratory system, and protective system. Previous studies have shown that spinal manipulation can affect the neuro-endocrinial mechanism by altering the neural activity in the spinal cord and the brainstem. However, the exact mechanisms of action are not fully understood.

In this study, we aimed to investigate the measurable changes in the neuro-endocrinial mechanism following spinal manipulation. We hypothesized that spinal manipulation would affect the neuro-endocrinial mechanism and lead to measurable changes in various physiological parameters. To test this hypothesis, we performed a series of experiments in a group of healthy volunteers. The results showed that spinal manipulation led to measurable changes in the neuro-endocrinial mechanism, including changes in heart rate, respiratory rate, and blood pressure. These changes were associated with an improvement in the overall health and well-being of the participants.

The results of this study support the hypothesis that spinal manipulation can affect the neuro-endocrinial mechanism and lead to measurable changes in physiological parameters. These changes have the potential to provide additional benefits for patients with various health conditions, including musculoskeletal disorders, respiratory diseases, and cardiovascular diseases. Further research is needed to better understand the mechanisms of action and long-term effects of spinal manipulation on the neuro-endocrinial mechanism.