

Collected Scientific Research Relating to the Use of Osteopathy with Autonomic nervous system activity

Important:

1) Osteopathy involves helping people's own self-healing abilities to work better, rather than focussing primarily on particular conditions.

2) Each person is different, and osteopathy treats them differently.

Therefore people respond to osteopathic treatment in different ways. Treatments that work for one person cannot be guaranteed to work for another person in the same way. The fact that there is scientific research supporting a treatment in a group of people does not mean that it will always work in the same way (which is probably true of all research).

A number of things make research into osteopathy challenging. These include the two aspects of osteopathy mentioned above, and also the lack of major commercial interests to provide funding in expectation of financial returns. At the same time, there is an emerging body of research demonstrating the usefulness of osteopathic treatment.

Please note: there is room for debate about the classifications used for these studies. Please let John Smartt know if you believe that any of these classifications are incorrect.

The "autonomic", or "automatic" part of the nervous system controls things that we don't control consciously. It is highly relevant to stress, distress, and health, because one aspect of this system (the "sympathetic" part) takes more control when we are either excited or frightened, and another aspect (the "parasympathetic" part) takes more control when we are relaxed, and our body focusses on repairing and digesting. The evidence (and our clinical experience) suggests that osteopathy can help people's autonomic nervous systems to be better-regulated.

These studies are from peer-reviewed journals

Number
of studies:
32

Clinically and statistically significant results

Number
of studies:
31

Systematic reviews

Number of studies: 1

Luis B, Borgesa A, Luiz G, Hugo B, Netoab P 2018 **Effects of spinal manipulation and myofascial techniques on heart rate variability: A systematic review** Journal of Bodywork and Movement Therapies Volume 22, Issue 1, January , Pages 203-208 <https://www.ncbi.nlm.nih.gov/pubmed/29332747>

"Background: The analysis of heart rate variability is important to the investigation of stimuli from the autonomic nervous system. Osteopathy is a form of treatment that can influence this system in healthy individuals as well as those with a disorder or disease.

Objectives: The aim of the present study was to perform a systematic review of the literature regarding the effect of spinal manipulation and myofascial techniques on heart rate variability.

Methods: Searches were performed of the Pubmed, Scielo, Lilacs, PEDro, Ibesco, Cochrane and Scopus databases for relevant studies. The PEDro scale was used to assess the methodological quality of each study selected.

Results: A total of 505 articles were retrieved during the initial search. After an analysis of the abstracts, nine studies were selected for the present review.

Conclusion: Based on the findings, osteopathy exerts an influence on the autonomic nervous system depending on the stimulation site and type. A greater parasympathetic response was found when stimulation was performed in the cervical and lumbar regions, whereas a greater sympathetic response was found when stimulation was performed in the thoracic region."

Kovanur Sampath K, Mani R, Cotter JD, Tumilty S 2015 **Measureable changes in the neuro-endocrinal mechanism following spinal manipulation**. Med Hypotheses Dec;85(6):819-24
<http://www.medical-hypotheses.com/article/S0306-9877%2815%2900374-6/abstract#>.
VkwyqRZHQQM.facebook

"The autonomic nervous system and the hypothalamic–pituitary–adrenal axis have been shown to be dysfunctional in a number of chronic pain disorders. Spinal manipulation is a therapeutic technique used by manual therapists, which may have widespread neuro-physiological effects. The autonomic nervous system has been implicated to modulate these effects. A theory is proposed that spinal manipulation has the potential to be used as a tool in restoring the autonomic nervous system balance. Further, it is also hypothesised that through its anatomical and physiological connections, the autonomic nervous system activity following a thoracic spinal manipulation may have an effect on the hypothalamic–pituitary–adrenal axis and therefore pain and healing via modulation of endocrine and physiological processes. To substantiate our hypothesis we provide evidence from manual therapy studies, basic science and animal studies. According to the proposed theory, there will be measurable changes in the neuro-endocrinal mechanisms following a thoracic spinal manipulation. This has far-reaching implications for manual therapy practice and research and in the integration of spinal manipulation in the treatment of a wide array of disorders."

Fornari M, Carnevali L, Sgoifo A 2017 **Single Osteopathic Manipulative Therapy Session Dampens Acute Autonomic and Neuroendocrine Responses to Mental Stress in Healthy Male Participants.** *J Am Osteopath Assoc* Sep 1;117(9):559-567 <http://jaoa.org/article.aspx?articleid=2652668>

"Context: The efficacy of osteopathic manipulative therapy (OMTh; manipulative care provided by foreign-trained osteopaths) is supported by observational data and patient feedback, but there is still a need for objective, quantitative biomarkers that allow measurement of the underlying mechanisms. No study exploring the protective potential of OMTh for mental stress has been published, to the authors' knowledge.

Objectives: To explore the modulating effect of OMTh on autonomic neural regulation of the heart and verify its ability to influence the activity of the hypothalamic-pituitary-adrenocortical axis.

Methods: Healthy young adult men who had never received OMTh were exposed to either a brief protocol using craniosacral techniques or sham therapy (control) involving the same anatomical areas. A laboratory stress episode consisting of a 5-minute arithmetic task participants were required to perform in front of a committee preceded the therapy sessions. Continuous electrocardiograph recordings were done before, during, and after the stress episode. Heart rate and frequency-domain parameters of heart rate variability (specifically, high-frequency component power in normalized units and the ratio of low-frequency to high-frequency power) were measured to quantify the activity of the parasympathetic nervous system and the state of sympathovagal balance at the level of the heart, respectively. Saliva samples were also collected at points throughout the study to determine cortisol levels.

Results: Osteopathic manipulative therapy reduced the overall chronotropic effect of the stressor ($t=-2.9$, $P<.05$) and counteracted the vagal withdrawal and the shift of autonomic balance toward sympathetic prevalence ($t=-2.8$, $P<.05$) that were observed in control participants. Moreover, OMTh participants had a much lower overall cortisol level during the mental stressor compared with control participants ($t=-2.3$, $P<.05$). Participants in the OMTh group did not show the statistically significant reduction in the amplitude of the cortisol awakening response observed in their control counterparts after the stress episode (control: $t=2.7$, $P<.05$; OMT: $P=.83$).

Conclusion: The application of a single OMTh session to healthy participants induced a faster recovery of heart rate and sympathovagal balance after an acute mental stressor by substantially dampening parasympathetic withdrawal and sympathetic prevalence. The OMTh session also prevented the typical increase in cortisol levels observed immediately after a brief mental challenge."

Yung EY, Oh C, Wong MS, Grimes JK, Barton EM, Ali MI, Cameron D 2017 **The immediate cardiovascular response to joint mobilization of the neck - A randomized, placebo-controlled trial in pain-free adults.** *Musculoskelet Sci Pract* Apr;28:71-78 <https://www.ncbi.nlm.nih.gov/pubmed/28219804>

"Some normotensive patients can have a spike in resting systolic blood pressure (SBP) in response to acute neck pain. Applying the typical dosage of mobilization may potentially result in a sympatho-excitatory response, further increasing resting SBP. Therefore, there is a need to explore other dosage regimens that could result in a decrease in SBP.

OBJECTIVES: To compare the blood pressure (BP) and heart rate (HR) response of pain-free, normotensive adults when receiving unilateral posterior-to-anterior mobilization (PA) applied to the neck versus its corresponding placebo (PA-P).

STUDY DESIGN: Double-Blind, Randomized Clinical Trial.

METHODS: 44 (18 females) healthy, pain-free participants (mean age, 23.8 ± 3.04 years) were randomly allocated to 1 of 2 groups. Group 1 received a PA-P in which light touch was applied to the right 6th cervical vertebra. Group 2 received a PA to the same location. BP and HR were measured prior to, during, and after the application of PA or PA-P. A mixed-effect model of repeated measure analysis was used for statistical analysis.

RESULTS: During-intervention, the PA group had a significant reduction in SBP, while the placebo group had an increase in SBP. The change in SBP during-intervention was significantly different between the PA and the placebo group (p-value = 0.003). There were no significant between-group differences found for HR and diastolic BP (DBP). The overall group-by-time interaction was statistically significant for SBP (p-value = 0.01).

CONCLUSIONS: When compared to placebo, the dosage of applied PA resulted in a small, short-lived drop in SBP not exceeding the minimal detectable change"

Giles PD, Hensel KL, Pacchia CF, Smith ML, 2013 **Suboccipital Decompression Enhances Heart Rate Variability Indices of Cardiac Control in Healthy Subjects** The Journal of Alternative and Complementary Medicine. February, 19(2): 92-96 <http://online.liebertpub.com/doi/abs/10.1089/acm.2011.0031>

"Osteopathic manipulative treatment (OMT) focused on the upper cervical spine is theorized to affect the function of the vagus nerve and thereby influence the parasympathetic branch of the autonomic nervous system. This study was designed to determine the acute effect of upper cervical spine manipulation on cardiac autonomic control as measured by heart rate variability."

"Nineteen healthy, young adult subjects underwent three different experimental interventions administered in random order: cervical OMT, sham manipulation, and time control. Six minutes of electrocardiographic data were collected before and after each intervention, and heart rate variability was assessed by both time-domain and frequency-domain measures."

"The OMT protocol resulted in an increase in the standard deviation of the normal-to-normal intervals (0.12 ± 0.082 seconds, $p < 0.01$), an increase in the high frequency spectral power ($p = 0.03$), and a decrease in the low/high frequency spectral ratio ($p = 0.01$) relative to the sham and time control conditions. No significant differences between sham and time control were observed ($p > 0.11$ for all variables)."

"These data support the hypothesis that upper cervical spine manipulation can acutely affect measures of heart rate variability in healthy individuals."

Henderson AT, Fisher JF, Blair J, Shea C, Li TS, Bridges KG. 2010 **Effects of rib raising on the autonomic nervous system: a pilot study using noninvasive biomarkers.** J Am Osteopath Assoc Jun;110(6):324-30 <http://www.ncbi.nlm.nih.gov/pubmed/20606239>

"Changes in salivary biomarkers after rib raising were investigated using a pretest-posttest, placebo-controlled design. Healthy adult participants were recruited and randomly assigned to rib raising or placebo (light touch) groups. All participants provided baseline saliva samples and samples immediately and 10 minutes after receiving the rib raising or placebo procedure. Salivary flow rate, alpha-amylase activity, and cortisol levels were measured for each sample."

"Twenty-three participants were recruited, of whom 14 completed the study (7 in each group). Subjects who received rib raising had a statistically significant decrease in alpha-amylase activity both immediately after ($P = .014$) and 10 minutes after ($P = .008$) the procedure. A statistically significant change in alpha-amylase activity was not seen in the placebo group at either time point. Changes in salivary cortisol levels and flow rate were not statistically significant in either group."

"The results of the present pilot study suggest that SNS activity may decrease immediately after rib raising, but the hypothalamic-pituitary-adrenal axis and parasympathetic activity are not altered by this technique. Salivary alpha-amylase may be a useful biomarker for investigating manipulative treatments targeting the SNS. Additional studies with a greater number of subjects are needed to expand on these results."

Kim SJ, Kwon OY, Yi CH. 2009 **Effects of manual lymph drainage on cardiac autonomic tone in healthy subjects.** Int J Neurosci 119(8):1105-17. <http://www.ncbi.nlm.nih.gov/pubmed/19922342>

"This study was designed to investigate the effects of manual lymph drainage on the cardiac autonomic tone. Thirty-two healthy male subjects were randomly assigned to manual lymph drainage (MLD) (experimental) and rest (control) groups. Electrocardiogram (ECG) parameters

were recorded with bipolar electrocardiography using standard limb lead positions. The pressure-pain threshold (PPT) was quantitatively measured using an algometer. Heart rate variability differed significantly between the experimental and control groups ($p < 0.05$), but the PPT in the upper trapezius muscle did not ($p > 0.05$). These findings indicate that the application of MLD was effective in reducing the activity of the sympathetic nervous system."

Roy RA, Boucher JP, Comtois AS 2009 **Heart rate variability modulation after manipulation in pain-free patients vs patients in pain.** *J Manipulative Physiol Ther* May;32(4):277-86 <https://www.ncbi.nlm.nih.gov/pubmed/19447264?dopt=Abstract>

"BACKGROUND:

The purpose of this study was to examine heart rate variability (HRV) in the presence or the absence of pain in the lower back, while receiving one chiropractic treatment at L5 from either a manually assisted mechanical force (Activator) or a traditional diversified technique spinal manipulation.

METHODS:

A total of 51 participants were randomly assigned to a control ($n = 11$), 2 treatment, or 2 sham groups ($n = 10$ per group). Participants underwent an 8-minute acclimatizing period. The HRV tachygram (RR interval) data were recorded directly into a Suunto watch (model T6; FitzWright Company Ltd, Langley, British Columbia, Canada). We analyzed the 5-minute pretreatment and posttreatment intervals. The spectral analysis of the tachygram was performed with Kubios software.

RESULTS:

All groups decreased in value except the control group that reacted in the opposite direction, when comparing the pretests and posttests for the high-frequency component. The very low frequency increased in all groups except the control group. The low frequency decreased in all groups except the sham pain-free group. The low frequency-high frequency ratio decreased in the treatment pain group by 0.46 and in the sham pain-free group by 0.26. The low frequency-high frequency ratio increase was 0.13 for the sham pain group, 0.04 for the control group, and 0.34 for the treatment pain-free group. The mean RR increased by 11.89 milliseconds in the sham pain-free group, 18.65 milliseconds in the treatment pain group, and 13.14 milliseconds in the control group. The mean RR decreased in the treatment pain-free group by 1.75 milliseconds and by 0.01 milliseconds in the sham pain group.

CONCLUSION:

Adjusting the lumbar vertebrae affected the lumbar parasympathetic nervous system output for this group of participants. Adaptation in the parasympathetic output, reflected by changes in high frequency, low frequency, and very low frequency, may be independent of type of adjustment. Therefore, the group differences found in the modulation of the HRV would seem to be related to the presence or absence of pain. The autonomic nervous system response may be specific and sensitive to its effectors organ."

Arroyo-Morales M, Olea N, Martinez M, Moreno-Lorenzo C, Díaz-Rodríguez L, Hidalgo-Lozano A 2008 **Effects of myofascial release after high-intensity exercise: a randomized clinical trial.** *J Manipulative Physiol Ther* Mar;31(3):217-23 [https://www.jmptonline.org/article/S0161-4754\(08\)00032-8/fulltext](https://www.jmptonline.org/article/S0161-4754(08)00032-8/fulltext)

"Objective

The usefulness of massage as a recovery method after high-intensity exercise has yet to be established. We aimed to investigate the effects of whole-body massage on heart rate variability (HRV) and blood pressure (BP) after repeated high-intensity cycling exercise under controlled and standardized pretest conditions.

Methods

The study included 62 healthy active individuals. After baseline measurements, the subjects performed standardized warm-up exercises followed by three 30-second Wingate tests. After completing the exercise protocol, the subjects were randomly assigned to a massage (myofascial release) or placebo (sham treatment with disconnected ultrasound and magnetotherapy equipment) group for a 40-minute recovery period. Holter recording and BP measurements were taken after exercise protocol and after the intervention.

Results

After the exercise protocol, both groups showed a significant decrease in normal-to-normal interval, HRV index, diastolic BP ($P > .001$), and low-frequency domain values ($P = .006$). After the recovery period, HRV index ($P = .42$) and high-frequency (HF) ($P = .94$) values were similar to baseline levels in the massage group, whereas the HRV index tended ($P = .05$) to be lower and the HF was significantly ($P < .01$) lower vs baseline values in the placebo group, which also showed a tendency ($P = .06$) for HF to be lower than after the exercise. Likewise, diastolic BP returned to baseline levels in the massage group ($P = .45$) but remained lower in the placebo group ($P = .02$).

Conclusion

Myofascial release massage favors the recovery of HRV and diastolic BP after high-intensity exercise (3 Wingate tests) to preexercise levels."

Cutler MJ, Holland BS, Stupski BA, Gamber RG, Smith ML 2005 **Cranial manipulation can alter sleep latency and sympathetic nerve activity in humans: a pilot study.** The Journal of Alternative and Complementary Medicine Feb;11(1):103-8. <http://www.ncbi.nlm.nih.gov/pubmed/15750368>

"The current study is the first to demonstrate that cranial manipulation, specifically the CV4 [compression of the 4th ventricle] technique, can alter sleep latency [more rapid onset of sleep] and directly measured MSNA [muscle sympathetic nerve activity] in healthy humans. These findings provide important insight into the possible physiologic effects of cranial manipulation."

Sergueef N, Nelson KE, Glonek T 2002 **The effect of cranial manipulation on the Traube-Hering-Mayer oscillation as measured by laser-Doppler flowmetry.** Altern Ther Health Med. Nov-Dec;8(6):74-6. <http://www.ncbi.nlm.nih.gov/pubmed/12440842>

"Immediately following the procedures, a 5-min posttreatment laser-Doppler recording was acquired. For each cranial treatment subject, the 4 major components of the blood-flow velocity record, the thermal (Mayer) signal, the baro (Traube-Hering) signal, the respiratory signal, and the cardiac signal, were analyzed, and the pretreatment and post treatment data were compared."

"Cranial manipulation affects the blood-flow velocity oscillation in its low-frequency Traube-Hering-Mayer components. Because these low-frequency oscillations are mediated through parasympathetic and sympathetic activity, it is concluded that cranial manipulation affects the autonomic nervous system."

Delaney JP, Leong KS, Watkins A, Brodie D 2002 **The short-term effects of myofascial trigger point massage therapy on cardiac autonomic tone in healthy subjects.** J Adv Nurs Feb;37(4):364-71 <https://www.ncbi.nlm.nih.gov/pubmed/11872106?dopt=Abstract>

"AIM OF THE STUDY:

To investigate the effects of myofascial trigger-point massage therapy to the head, neck and shoulder areas on cardiac autonomic tone. Background. No studies have reported on the effect of back massage on autonomic tone as measured by heart rate variability. This is especially relevant to the nursing profession, as massage is increasingly available as a therapy complementary to conventional nursing practice.

DESIGN/METHODS:

An experimental study in which subjects were initially placed in age- and sex-matched groups and then randomized to treatment or control by alternate allocation. The study involved 30 healthy subjects (16 female and 14 male, aged 32.47 +/- 1.55 years, mean +/- standard error). A 5-minute cardiac interbeat interval recording, systolic and diastolic blood pressure and subjective self-evaluations of muscle tension and emotional state were taken before and after intervention. Autonomic function was measured using time and frequency domain analysis of heart rate variability.

RESULTS:

Following myofascial trigger-point massage therapy there was a significant decrease in heart rate ($P < 0.01$), systolic blood pressure ($P=0.02$) and diastolic blood pressure ($P < 0.01$).

Analysis of heart rate variability revealed a significant increase in parasympathetic activity ($P < 0.01$) following myofascial trigger-point massage therapy. Additionally both muscle tension and emotional state, showed significant improvement ($P < 0.01$).

CONCLUSIONS:

In normal healthy subjects myofascial trigger-point massage therapy to the head, neck and shoulder areas is effective in increasing cardiac parasympathetic activity and improving measures of relaxation."

Perrin RN, Edwards J, Hartley P 1998 **An evaluation of the effectiveness of osteopathic treatment on symptoms associated with Myalgic Encephalomyelitis. A preliminary report** Journal of Medical Engineering & Technology January/February

"The term Myalgic Encephalomyelitis (ME) was initially used in the 1950s. ME describes a syndrome where there is general muscle pain associated with evidence of a disturbed nervous system. ME, commonly referred to as Chronic Fatigue Syndrome (CFS), or post-viral fatigue syndrome is a condition in which mental and physical fatigue predominate. It is characterized by gross abnormal muscle fatigue which occurs after relatively mild activity. Other symptoms regularly complained of include sleep disturbance, headaches, cognitive dysfunction, feeling depressed, bouts of low grade fever (not exceeding 38.6C), increased sensitivity to light, back and neck pain, sore throat, irritable bowel and bladder. The symptoms of ME typically become apparent following a viral infection"

"There has been a long-standing debate over the naming of this disorder. Some have expressed the opinion that ME is a highly specific disease, whereas CFS is an umbrella term covering many conditions which exhibit fatigue."

"The treatment of each ME patient consisted of the following techniques:

- (1) Soft tissue massage of the paravertebral muscles, the trapezii, levator scapulae, rhomboids and muscles of respiration.
- (2) High and low velocity manipulation of the thoracic and upper lumbar spinal segments using supine and side-lying combined leverage and thrust techniques.
- (3) Gentle articulation of thoracic and upper lumbar spine, plus the ribs. This was achieved by both long and short lever techniques.
- (4) Functional techniques to the suboccipital region and the sacrum.
- (5) Stimulation of the cranio-sacral rhythm by functional-cranial techniques.
- (6) Efflourage to aid drainage in thoracic and cervical lymphatic vessels.
- (7) Exercises to improve the mobility of the thoracic spine, and to improve the physical coordination."

"Our hypothesis, based on clinical evidence, is that following osteopathic treatment the symptoms are reduced due to stabilizing nffment sympathetic flow. It is believed by the authors that this equilibrium may be achieved due to relaxation of soft tissue and an improvement in visceral function plus increased blood and lymph circulation."

"This present study has revealed a demonstrable improvement in ME symptoms as a result of osteopathic treatment."

Hoyt WH, Shaffer F, Bard DA, Benesler JS, Blankenhorn GD, Gray JH, Hartman WT, Hughes LC. 1979 **Osteopathic manipulation in the treatment of muscle-contraction headache.** J Am Osteopath Assoc Jan;78(5):322-5 <http://jaoa.org/article.aspx?articleid=2097399>

"Although there are not reliable objective criteria for the measurement of pain, an attempt has been made to evaluate the effects of osteopathic manipulative procedures on muscle-tension headaches in a group of patient with a history of such headaches over months or years. There was a statistically significant difference in subjective ratings of pain relief between groups of patients treated by palpatory examination and osteopathic manipulation and by other measures. Data from this study and those reported elsewhere suggest that the central mechanism in muscle-contraction headache may involve modulation of autonomic reactivity by a cortical-limbic process."

"The twenty-two subjects... had a history of dull, non-throbbing bilateral headaches recurring over months or years with posterior cervical discomfort."

"The experimental data suggested that osteopathic manipulation can reduce the severity of muscle-contraction headache."

Ruffini N, D'Alessandro G, Mariani N, Pollastrelli A, Cardinali L, Cerritelli F, 2015 **Variations of high frequency parameter of heart rate variability following osteopathic manipulative treatment in healthy subjects compared to control group and sham therapy: randomized controlled trial** Front Neurosci 9: 272 <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4523739/>

"Methods: Sixty-six healthy subjects, both male and female, were included in the present 3-armed randomized placebo controlled within subject cross-over single blinded study. Participants were asymptomatic adults (26.7 ± 8.4 y, 51% male, BMI 18.5 ± 4.8), both smokers and non-smokers and not on medications. At enrollment subjects were randomized in three groups: A, B, C. Standardized structural evaluation followed by a patient need-based osteopathic treatment was performed in the first session of group A and in the second session of group B. Standardized evaluation followed by a protocolized sham treatment was provided in the second session of group A and in the first session of group B. No intervention was performed in the two sessions of group C, acting as a time-control. The trial was registered on clinicaltrials.gov identifier: NCT01908920.

Main Outcomes Measures: HRV was calculated from electrocardiography before, during and after the intervention, for a total amount time of 25 min and considering frequency domain as well as linear and non-linear methods as outcome measures.

Results: OMT engendered a statistically significant increase of parasympathetic activity, as shown by High Frequency power ($p < 0.001$), expressed in normalized and absolute unit, and possibly decrease of sympathetic activity, as revealed by Low Frequency power ($p < 0.01$); results also showed a reduction of Low Frequency/High Frequency ratio ($p < 0.001$) and Detrended fluctuation scaling exponent ($p < 0.05$).

Conclusions: Findings suggested that OMT can influence ANS activity increasing parasympathetic function and decreasing sympathetic activity, compared to sham therapy and control group."

"The OMT intervention consisted in a patient's need based treatment, thus no pre-determined protocol was applied. Osteopathic session lasted 25 min, 10 min for evaluation and 15 min for treatment. Techniques used in the present study were left at the discretion of the operator but limited to balance ligamentous techniques, balance membranous techniques and cranio-sacral techniques"

Moutzouri M, Perry J, Billis E 2012 **Investigation of the effects of a centrally applied lumbar sustained natural apophyseal glide mobilization on lower limb sympathetic nervous system activity in asymptomatic subjects.** Journal of Manipulative and Physiological Therapeutics May;35(4):286-94 <https://www.ncbi.nlm.nih.gov/pubmed/22632588>

"Forty-five healthy volunteers participated in this randomized, single-blinded, parallel-group 3-arm design (experimental, sham [placebo], and control group), comprising 15 subjects each. For the experimental group, lumbar mobilization involving an active movement, the Mulligan sustained natural apophyseal glide (SNAG), was applied on L4 spinous process by an experienced manual therapist. Sustained natural apophyseal glides were performed in sitting with active flexion (6 times \times 3 sets). The sham technique simulated the SNAG without applying any force. In the control group, participants were placed in a static sitting position throughout the experiment. Measures of skin conductance in the lower limbs (L4 dermatome) were recorded to reflect sympathetic nervous system activity in the preintervention, periintervention, and postintervention periods. Differences in percentage change of skin conductance were analyzed with analysis of variance and post hoc tests.

RESULTS:

Lumbar SNAG produced sympathoexcitation compared with the control group in the intervention period ($P = .04$). No significant difference was found between SNAG and sham groups, and no statistically significant difference was found between groups in the final rest period.

CONCLUSION: The results of this study showed that, in asymptomatic participants, both lumbar SNAG and sham techniques performed on L4/5 intervertebral joint with active flexion induced a sympathoexcitatory response in lower limbs compared with the control group."

Jowsey P, Perry J 2010 **Sympathetic nervous system effects in the hands following a grade**

III postero-anterior rotatory mobilisation technique applied to T4: a randomised, placebo-controlled trial. *Manual Therapy* Jun;15(3):248-53 <https://www.ncbi.nlm.nih.gov/pubmed/20093065>

"Joint mobilisation to the T4 vertebra has been advocated as a treatment for T4 syndrome. To date no controlled studies have investigated the effects of thoracic spinal manual therapy (SMT) applied to T4 on sympathetic activity in the hands. This study investigated whether a grade III postero-anterior rotatory joint mobilisation technique applied to the T4 vertebra at a frequency of 0.5 Hz had demonstrably greater effects than a validated placebo intervention on skin conductance (SC) in the hands of healthy subjects. A power analysis calculation was performed and using a double blind, placebo-controlled, independent groups design, 36 healthy subjects (18-35 years) were randomly assigned to two groups (placebo intervention or treatment intervention). A BioPac unit recorded continuous SC measures before, during and after each experimental intervention. An exit questionnaire was used to validate the expectancy effects of the placebo intervention. Results demonstrated a significant difference between groups in SC in the right hand during the post-treatment rest period ($F = 4.888$, $p = 0.034$); with the treatment intervention being sympathoexcitatory in nature. A trend towards a significant difference between groups was also demonstrated in the left hand during the rest period ($F = 4.072$, $p = 0.052$). This study provides preliminary evidence that joint mobilisation applied to the T4 vertebra at a frequency of 0.5 Hz can produce sympathoexcitatory effects in the hand. Further research is recommended in a patient population."

Perry J, Green A 2008 **An investigation into the effects of a unilaterally applied lumbar mobilisation technique on peripheral sympathetic nervous system activity in the lower limbs.** *Manual Therapy* Dec;13(6):492-9 <https://www.ncbi.nlm.nih.gov/pubmed/17643340>

"Physiotherapeutic management of lumbar disorders often utilises specific segmental joint mobilisation techniques; however, there is only limited evidence of any neurophysiological effects and much of this has focused on the cervical spine and upper limbs. This study aims to extend the knowledge base underpinning the use of a unilaterally applied lumbar spinal mobilisation technique by exploring its effects on the peripheral sympathetic nervous system (SNS) of the lower limbs. Using a double blind, placebo controlled, independent groups study design and based upon power calculations, 45 normal naïve healthy males were randomly assigned to one of three experimental groups (control, placebo or treatment; a unilaterally applied postero-anterior mobilisation to the left L4/5 zygapophyseal joint). SNS activity was determined by recording skin conductance (SC) obtained from lower limb electrodes connected to a BioPac unit. Validation of the placebo technique was performed by post-intervention questionnaire. Results indicated that there was a significant change in SC from baseline levels (13.5%) that was specific to the side treated for the treatment group during the intervention period (compared to placebo and control conditions). This study provides preliminary evidence that a unilaterally applied postero-anterior mobilisation technique performed, at a rate of 2 Hz, to the left L4/5 lumbar zygapophyseal joint results in side-specific peripheral SNS changes in the lower limbs."

Sterling M, Jull G, Wright A 2001 **Cervical mobilisation: concurrent effects on pain, sympathetic nervous system activity and motor activity.** *Manual Therapy* May;6(2):72-81 <https://www.ncbi.nlm.nih.gov/pubmed/11414776>

"Recent findings that spinal manual therapy (SMT) produces concurrent hypoalgesic and sympathoexcitatory effects have led to the proposal that SMT may exert its initial effects by activating descending inhibitory pathways from the dorsal periaqueductal gray area of the midbrain (dPAG). In addition to hypoalgesic and sympathoexcitatory effects, stimulation of the dPAG in animals has been shown to have a facilitatory effect on motor activity. This study sought to further investigate the proposal regarding SMT and the PAG by including a test of motor function in addition to the variables previously investigated. Using a condition randomised, placebo-controlled, double blind, repeated measures design, 30 subjects with mid to lower cervical spine pain of insidious onset participated in the study. The results indicated that the cervical mobilisation technique produced a hypoalgesic effect as revealed by increased

pressure pain thresholds on the side of treatment ($P=0.0001$) and decreased resting visual analogue scale scores ($P=0.049$). The treatment technique also produced a sympathoexcitatory effect with an increase in skin conductance ($P<0.002$) and a decrease in skin temperature ($P=<0.02$). There was a decrease in superficial neck flexor muscle activity ($P<0.0002$) at the lower levels of a staged cranio-cervical flexion test. This could imply facilitation of the deep neck flexor muscles with a decreased need for co-activation of the superficial neck flexors. The combination of all findings would support the proposal that SMT may, at least initially, exert part of its influence via activation of the PAG."

McGuiness J, Vicenzino B, Wright A 1997 **Influence of a cervical mobilization technique on respiratory and cardiovascular function.** *Manual Therapy* Nov;2(4):216-220 <https://www.ncbi.nlm.nih.gov/pubmed/11440535>

"SUMMARY. Spinal manipulative therapy techniques are frequently applied by physiotherapists to relieve pain of musculo-skeletal origin and to improve the quality of joint movement in a variety of musculo-skeletal conditions. However, there has been little research into the physiological effects of these techniques, or the mechanisms responsible for these effects. The aim of this study was to establish whether a grade III posteroanterior mobilization technique applied centrally to the cervical spine would affect respiratory and cardiovascular indicators of sympathetic nervous system function in pain-free, normal volunteers. A significant increase in respiratory rate, heart rate, systolic and diastolic blood pressure occurred during application of the technique to C5/6, when compared to the control and placebo conditions. There was little change in any of the measured variables during the placebo condition. This study provides objective evidence that application of this mobilization technique elicits changes in sympathetic nervous system activity distinct from placebo in pain-free individuals. These results provide a basis for further research into the physiological effects of manipulative procedures, and in particular, exploration of the mechanisms responsible for analgesia produced by this method. "

Chiu TW, Wright A 1996 **To compare the effects of different rates of application of a cervical mobilisation technique on sympathetic outflow to the upper limb in normal subjects.** *Manual Therapy* Sep;1(4):198-203 <https://www.ncbi.nlm.nih.gov/pubmed/11440508>

"SUMMARY. The aim of this study was to compare the effects of different rates of application of a commonly used physiotherapeutic spinal manipulative therapy technique on sympathetic function in normal pain-free volunteers. A randomized, repeated measures, double blind, controlled study design was used to investigate the effects of two different rates of a C5 grade III central postero-anterior mobilization technique on skin conductance (SC) and skin temperature (ST) in the distal C6 dermatome of asymptomatic subjects. Sixteen asymptomatic male volunteers participated in the study. Application of a C5 central postero-anterior grade III mobilization at the rate of 2Hz produced significantly greater increases in SC values than that at the rate of 0.5 Hz and control. The results of this study suggest that mobilization with the rate which is commonly used clinically causes a greater increase in sympathetic efferent activity in the upper limb of normal pain-free volunteers than a slower rate. These results may also provide a basis for further investigation into the physiological effects of different rates of mobilization and in particular exploration of the relationship between changes in sympathetic function following mobilization and manipulation-induced analgesia."

Korotkov K, Shelkov O, Shevtsov A, Mohov D, Paoletti S, Mirosnichenko D, Labkovskaya E, Robertson L 2012 **Stress reduction with osteopathy assessed with GDV electrophotonic imaging: effects of osteopathy treatment.** The Journal of Alternative and Complementary Medicine Mar;18(3):251-7 <http://www.ncbi.nlm.nih.gov/pubmed/22420738>

OBJECTIVES:

The purpose of this study is to explore how osteopathy treatments influence certain measurable aspects of the human biofield; namely, various calculated parameters of finger corona discharge patterns produced by high-voltage electrophotography.

METHODS:

The Gas Discharge Visualization camera was used to assess subjects before and after osteopathy treatment. Thirty-three (33) apparently healthy adults (20-56 years old) took part in the study. The patterns of light emitted from the subjects' fingertips were digitally recorded and computer analyzed. Parameters including normalized area, brightness, and right- and left-hand integrals were calculated and statistically compared.

RESULTS:

Most of the recipients of these osteopathic treatments experienced increase in fingertip florescence area and average intensity, reduction in stress levels, and improved blood pressure measurements. With all of these parameters simultaneously improving, the patients received a good benefit from these sessions.

CONCLUSIONS:

Virtually all subjects were in a good mood after treatment. Many of them had pain and muscle tension that disappeared. These changes were reflected in all parameters analyzed, in both psychosomatic and somatic states. Thus, osteopathic manipulations as administered in these two studies provide good, lasting relaxation. This study also provides the interesting observation that daily relaxation practices done by Dr. Paoletti enable him to work hard without additional stress.

Henley CE, Ivins D, Mills M, Wen FK, Benjamin BA. 2008 **Osteopathic manipulative treatment and its relationship to autonomic nervous system activity as demonstrated by heart rate variability: a repeated measures study.** Osteopathic medicine and primary care Jun 5;2:7 <http://www.ncbi.nlm.nih.gov/pubmed/18534024>

"The relationship between osteopathic manipulative treatment (OMT) and the autonomic nervous system has long been acknowledged, but is poorly understood. In an effort to define this relationship, cervical myofascial release was used as the OMT technique with heart rate variability (HRV) as a surrogate for autonomic activity. This study quantifies that relationship and demonstrates a cause and effect."

"Predominantly parasympathetic responses were observed with subjects in the horizontal position, while a 50-degree tilt provided a significantly different measure of maximum sympathetic tone ($p < 0.001$). Heart rate changed in all subjects with change in position; respirations remained constant. When OMT was performed in a sympathetic environment (tilt), a vagal response was produced that was strong enough to overcome the sympathetic tone. There was no HRV difference between sham and control in either the horizontal or tilt positions."

"The vagal response produced by the myofascial release procedure in the maximally stimulated sympathetic environment could only have come from the application of the OMT. This demonstrates the association between OMT and the autonomic nervous system. The lack of significance between control and sham in all positions indicates that HRV may be a useful method of developing sham controls in future studies of OMT."

Welch A, Boone R 2008 **Sympathetic and parasympathetic responses to specific diversified adjustments to chiropractic vertebral subluxations of the cervical and thoracic spine.** J Chiropr Med Sep;7(3):86-93 <http://www.ncbi.nlm.nih.gov/pubmed>

"OBJECTIVE:

The aims of this study were to investigate the response of the autonomic nervous system based upon the area of the spine adjusted and to determine if a cervical adjustment elicits a parasympathetic response and if a thoracic adjustment elicits a sympathetic response.

METHODS:

Forty patients (25-55 years old) met inclusion criteria that consisted of normal blood pressure, no history of heart disease, and being asymptomatic. Patients were evaluated pre- and post-chiropractic adjustment for the following autonomic responses: blood pressure and pulse rate. Seven patients were measured for heart rate variability. The subjects received either a diversified cervical segment adjustment or a diversified thoracic segment adjustment.

RESULTS:

Diastolic pressure (indicating a sympathetic response) dropped significantly postadjustment among those receiving cervical adjustments, accompanied by a moderate clinical effect (0.50). Pulse pressure increased significantly among those receiving cervical adjustments, accompanied by a large effect size (0.82). Although the decrease in pulse pressure for those receiving thoracic adjustments was not statistically significant, the decrease was accompanied by a moderate effect size (0.66).

CONCLUSION:

It is preliminarily suggested that cervical adjustments may result in parasympathetic responses, whereas thoracic adjustments result in sympathetic responses. Furthermore, it appears that these responses may demonstrate the relationship of autonomic responses in association to the particular segment(s) adjusted."

Milnes K, Moran RW 2007 **Physiological effects of a CV4 cranial osteopathic technique on autonomic nervous system function: A preliminary investigation** International Journal of Osteopathic Medicine 10(1):8-17 41 <http://www.sciencedirect.com/science/article/pii/S1746068907000089>

"Heart rate variability, respiration rate, galvanic skin resistance and skin temperature were measured in ten subjects (six females, four males) in an experiment consisting of five generic phases"

"On examination of heart rate variability, it became apparent that three subjects may have responded in a manner that was consistent with an increase in parasympathetic activity during the treatment phase. This identification leads to the notion that there may be both 'responders' and 'non-responders' to cranial treatment."

Budgell B, Polus B. 2006 **The effects of thoracic manipulation on heart rate variability: a controlled crossover trial.** J Manipulative Physiol Ther Oct;29(8):603-10 <https://www.ncbi.nlm.nih.gov/pubmed/17045093>

"OBJECTIVE:

The objective of this study was to measure the effects of thoracic spinal manipulation on heart rate variability (HRV) in a cohort of healthy young adults.

METHODS:

A controlled crossover trial that was conducted on 28 healthy young adults (23 men and 5 women; age range, 18-45 years; mean age, 29 +/- 7 years) measured HRV before and after a sham procedure and a thoracic spinal manipulation.

RESULTS:

In healthy young adults, thoracic spinal manipulation was associated with changes in HRV that were not duplicated by the sham procedure. The ratio of the powers of the low-frequency and high-frequency components increased from 0.9562 +/- 0.9192 to 1.304 +/- 1.118 (P = .0030, Wilcoxon signed rank test). In subjects undergoing sham spinal manipulation, there was no statistically significant change in the low-frequency or the high-frequency component of the power spectrum; neither was there any in the ratio of the two regardless of whether the comparison was made using the paired t test or the Wilcoxon signed rank test.

CONCLUSION:

High-velocity and low-amplitude manipulation of the thoracic spine appears to be able to influence autonomic output to the heart in ways that are not duplicated by a sham procedure or by other forms of somatic/physical therapies."

Budgell B, Polus B 2006 **The Effects of Thoracic Manipulation on Heart Rate Variability: A Controlled Crossover Trial** J Manipulative Physiol Ther Volume 29, Issue 8, Pages 603–610 [https://www.jmptonline.org/article/S0161-4754\(06\)00225-9/fulltext](https://www.jmptonline.org/article/S0161-4754(06)00225-9/fulltext)

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Zhang J, Dean D, Nosco D, Strathopoulos D, Floros M 2006 **Effect of chiropractic care on heart rate variability and pain in a multisite clinical study.** J Manipulative Physiol Ther May;29(4):267-74 <http://www.ncbi.nlm.nih.gov/pubmed>

"OBJECTIVE:

The purpose of this study is to investigate the effect of chiropractic care in a multiclinic setting on sympathetic and parasympathetic nervous system activities using heart rate variability (HRV) analysis.

METHODS:

Physicians of chiropractic in private practice were provided with an HRV device to perform analysis before and after chiropractic adjustments on 10 subjects. At each site, 8 subjects were monitored before and after a single chiropractic adjustment, and 2 additional patients were followed for a 4-week period with 2 HRV recordings per week. Patient information forms and a visual analog scale (VAS) questionnaire were completed both before and after each chiropractic adjustment.

RESULTS:

Data from 96 physicians were divided into single-visit and 4-week groups. After 1 chiropractic adjustment, pain as analyzed by VAS was reduced significantly from 3.7 +/- 2.2 to 2.1 +/- 2.0 (P < .001). The mean heart rate reduced from 76.7 +/- 12.7 to 74.3 +/- 12.4 (P < .01), the SD of normal-to-normal QRS increased from a range of 55.8 to 44.6 to a range of 60.6 to 47.2 (P < .001), the high-frequency component increased from 359 +/- 968 to 444 +/- 1069 (P < .01), the low-frequency component increased from 403 +/- 753 to 465 +/- 755 (P < .05), and the total power increased from 1063 +/- 1886 to 1265 +/- 2048 (P < .01). After 4 weeks of chiropractic adjustments, pain measured by the VAS was reduced significantly before and after each visit as analyzed by t tests, but the significant changes were not found using analysis of variance analysis. The reduction of pain from each treatment was not maintained over the 4 weeks of study period. The analysis of variance on the HRV 4-week data found that changes in the SD of normal-to-normal QRS, total power, and low-frequency components reached statistically significant levels (P < .05). The heart rate and the high-frequency component did not change significantly (P > .05).

CONCLUSION:

In this study, HRV and VAS changed in patients as a result of chiropractic care."

Gosling CM, Kinross T, Gibbons P, Holmes M 2005 **The short term effect of atlanto-axial high velocity low amplitude manipulation with cavitation on Edge Light Pupil Cycle Time** International Journal of Osteopathic Medicine Volume 8, Issue 3, September , Pages 81–86 <https://www.sciencedirect.com/science/article/pii/S1746068905000519>

"Edge Light Pupil Cycle Time (ELPCT) is a measure of the pupillary light reflex mediated via the autonomic nervous system (ANS). ELPCT is a measurable constant, unaffected by eye measured (i.e. left versus right eye), gender, visual acuity, refractive error, eye colour and pupil size. Previous research suggests that spinal manipulation techniques can produce distant effects mediated in part by the ANS."

"Thirty participants (mean age = 23.8) without eye, central or autonomic nervous system pathology had their ELPCT measured in both eyes pre- and post-manipulation. The manipulation technique used was a high velocity low amplitude (HVLA) rotatory thrust, with the applicator localised to the atlanto-axial joint on the left (n = 10) or right (n = 10) determined randomly. All HVLA manipulations were associated with audible cavitation. The control group (n = 10) underwent the same protocol, including pre-positioning for the manipulation, but without the thrust."

"ELPCT measures demonstrated a significant decrease between groups (P = 0.004) and between groups according to eye measured (P = 0.022). Significant decreases between pre- and post-manipulation measures of ELPCT indicated an association between side manipulated and eyes, with right-sided manipulation producing a decrease in ELPCT in the right eye (P = 0.001) and a left-sided manipulation producing a decrease in the left eye (P = 0.013). No other significant changes were observed."

"ELPCT, mediated via the ANS, is directly influenced by HVLA manipulation with cavitation to the atlanto-axial joint. The ANS changes observed in this study demonstrated a unilateral response to HVLA manipulation."

Yu IY, Jung IG, Kang MH, Lee DK, Oh JS 2015 **Immediate effects of an end-range mobilization technique on shoulder range of motion and skin temperature in individuals with posterior shoulder tightness.** J Phys Ther Sci Jun;27(6):1723-5 <https://www.ncbi.nlm.nih.gov/pubmed/26180306>

"This study investigated the effects of an end-range mobilization technique on the range of motion of the glenohumeral internal rotation and the skin temperature of the shoulder in individuals with posterior shoulder tightness. [Subjects] Thirteen subjects with posterior shoulder tightness who had glenohumeral internal rotation deficit $\geq 15^\circ$ participated. [Methods] All subjects underwent glenohumeral joint end-range mobilization intervention. The internal rotation range of motion of the glenohumeral joint was measured by a goniometer and the shoulder skin temperature was measured by a digital infrared thermographic imaging device before and immediately after the intervention. Paired t-tests were used to analyze the differences in these parameter pre and post-intervention. [Results] The glenohumeral internal rotation range of motion and skin temperature of the posterolateral shoulder in increased significantly post-intervention. [Conclusion] The end-range mobilization technique is effective for increasing the glenohumeral internal rotation range of motion and skin temperature of the shoulder in individuals with posterior shoulder tightness."

Case controlled studies

Number of studies: 1

Reis MS, Durigan JL, Arena R, Rossi BR, Mendes RG, Borghi-Silva A 2014 **Effects of posteroanterior thoracic mobilization on heart rate variability and pain in women with fibromyalgia**. Rehabil Res Pract 2014:898763 <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4060169/>

"Fibromyalgia (FM) has been associated with cardiac autonomic abnormalities and pain. Heart rate variability (HRV) is reduced in FM with autonomic tone dominated by sympathetic activity. The purpose of this study was to evaluate the effects of one session of a posteroanterior glide technique on both autonomic modulation and pain in woman with FM. This was a controlled trial with immediate followup; twenty premenopausal women were allocated into 2 groups: (i) women diagnosed with FM (n = 10) and (ii) healthy women (n = 10). Both groups received one session of Maitland mobilization grade III posteroanterior central pressure glide, at 2 Hz for 60 s at each vertebral segment. Autonomic modulation was assessed by HRV and pain by a numeric pain scale before and after the intervention. For HRV analyses, heart rate and RR intervals were recorded for 10 minutes. FM subjects demonstrated reduced HRV compared to controls. Although the mobilization technique did not significantly reduce pain, it was able to improve HRV quantified by an increase in rMSSD and SD1 indices, reflecting an improved autonomic profile through increased vagal activity. In conclusion, women with FM presented with impaired cardiac autonomic modulation. One session of Maitland spine mobilization was able to acutely improve HRV."

Mixed results (significant for some outcomes, not others)

Number of studies: 1

Systematic reviews

Number of studies: 1

Jäkel A, von Hauenschild P 2011 **Therapeutic effects of cranial osteopathic manipulative medicine: a systematic review**. J Am Osteopath Assoc Dec;111(12):685-93. <http://www.ncbi.nlm.nih.gov/pubmed/22182954>

"Of the 8 studies that met the inclusion criteria, 7 were randomized controlled trials and 1 was an observational study. A range of cranial OMM techniques used for the management of a variety of conditions were identified in the included studies. Positive clinical outcomes were reported for pain reduction, change in autonomic nervous system function, and improvement of sleeping patterns. Methodological Downs and Black quality scores ranged from 14 to 23 points out of a maximum of 27 points (overall median score, 16)."

It is unclear whether the following journals are peer-reviewed

Number of studies: 2

Clinically and statistically significant results

Number
of studies:
2

Randomised controlled trials

Number of studies: 1

Farthing RJ, Gosling CM, Vaughan B 2005 **The effects of slow rib raising on heart rate, blood pressure, respiration rate and pain pressure threshold** Osteopathic Medicine, School of Health Sciences, Victoria University, Melbourne (unpublished thesis) http://vuir.vu.edu.au/795/1/Farthing_et.al_2005.pdf

"Objective To determine whether rib raising over the costovertebral joints at a slow rate (0.5hz, 30/min) can affect indicators of SNS [sympathetic nervous system] function by producing changes in heart rate, respiratory rate, blood pressure and pain pressure threshold.

Design Randomized, cross-over, single blind, placebo controlled design in which participants experienced all three treatment conditions (rib raising treatment, placebo treatment and control treatment).

Subjects Thirty asymptomatic and apparently healthy participants (age 22.4 ± 2.75 yrs) were voluntarily recruited from the Victoria University Osteopathic Medicine Student Clinic.

Method Participants were randomly allocated to receive a treatment condition for three sessions with weekly intervals between treatment sessions. All treatment modalities were experienced by the participants. Baseline measures for heart rate (HR), respiratory rate (RR), systolic blood pressure (SBP), diastolic blood pressure (DBP) and pain pressure threshold (PPT) were recorded initially and repeated after two treatment interventions and after two rest periods.

Results

Analysis with five separate one way analysis of variance (ANOVA) with a priori comparisons revealed stastically significant interactions between groups for RR ($F(2,87) = 7.02, P = 0.001$), DBP ($F(2,87) = 3.51, P = 0.03$) and PPT ($F(2,87) = 3.51, P = 0.03$). Increases were also observed for HR and SBP although these results were not stastically significant.

Conclusions

Mobilization of the ribs 1-6 at a slow rate (0.5hz, 30 cycles per minute) in asymptomatic patients produced stastically significant increases in RR, DBP and PPT. These changes were compared to the control and placebo groups in which little to minimal changes were observed."

Burns L 1907 **The experimental demonstration of the osteopathic centers: the heart** Studies in the Osteopathic Sciences: Basic Principles 1 <http://www.mcmillinmedia.com/eamt/files/burns1/bur1cont.html>

"Stimulation of the tissues near the fourth thoracic spine caused an increase of as much as fifteen beats per minute in the pulse rate. In those persons in whom the rate was greatly increased, the force of each beat was somewhat lessened. The utmost efforts at stimulation were unable to increase the pulse rate at all in some individuals.

In all, when efficient stimulation was given, the blood pressure was raised. This reaction was no doubt partly due to the simultaneous reflex stimulation of the pulmonary vaso-motors, and in part to the cardiac effects. The rise of blood pressure thus produced may amount to twenty millimeters of mercury in some individuals. In others, the effects are much less pronounced. Efficient stimulation always produces some change, however in a normal person.

The effect of this stimulation upon the sphygmogram is usually very pronounced. In persons whose muscles are very heavy, and who have been of robust health for a long time, it requires a considerable amount of strength to effect the deeper muscles in sufficient degree to effect a perceptible change in the sphygmogram."

" It appears from these experiments that the action of the heart may be affected by somato-sensory impulses from the area of distribution of the fourth thoracic nerves, and that those movements are most effectual which affect the relations of the joint surfaces.

Abnormal conditions affecting the somato-sensory impulses carried over the third, fourth and fifth thoracic nerves may exert a direct influence upon the heart's action.

Any condition which affects the sensory fibers of the vagus may affect the action of the heart."