BJCMR Brazilian Journal of Clinical Medicine and Review

PCAA PUBLICAÇÕES CIENTÍFICAS DE ACESSO ABERTO

Original Research

Acute Effect of Vertebral Manipulation Technique on the Autonomic Nervous System

Ana Paula de Oliveira Marques [1], Carlos Eduardo Damasceno Lima [1], Lidiane Gomes da Silva [1], Lucivana de Sena Alves [1], Jose Evaldo Gonçalves Lopes Junior [1], Edfranck de Sousa Vanderlei [1], Eduardo de Almeida e Neves [1,*]

[1] Centro Universitário Ateneu - UNIATENEU, Fortaleza, CE, Brazil.

* Correspondence: eduardo.neves@professor.uniateneu.edu.br.

Abstract: The term "stress" refers to the state induced by perceiving stimuli that trigger emotional and hormonal responses in the body's balance. In acute stress situations, adrenaline, neurotransmitters, and cortisol are released, causing systemic changes and physiological disruptions, keeping the body alert. Heart rate variability assesses the autonomic nervous system. Joint manipulation, involving high-speed, low-amplitude movements, was chosen based on the patient's dysfunction. The study aimed to assess the immediate effects of this technique on the sympathetic and parasympathetic systems, analyzing heart rate variability in university students in Fortaleza. This cross-sectional, randomized, quantitative study at the Ateneu University Center involved 20 participants divided into two groups: G1 – vertebral manipulation application and G2 – a control group with positioning only. Autonomic nervous system evaluation used a sensor connected to the earlobe and the Inner Balance app. Data was processed by Em Wave and Kubios software before and after manipulation. Range of motion was assessed using Kinovea software. Both groups experienced increased range of motion, with greater improvement in the manipulation group. Both groups showed increased parasympathetic activity and reduced sympathetic stress levels, possibly influenced by manipulation and touch, providing either nerve decompression or direct autonomic nervous system stimulation through touch.

Keywords: Vertebral manipulation; Stress; Autonomic Nervous System; Thermography.

Citation: Marques APO, Lima CED, Silva LG, Alves LS, Lopes-Junior JEG, Vanderlei ES, Neves EA. Acute Effect of Vertebral Manipulation Technique on the Autonomic Nervous System. Brazilian Journal of Clinical Medicine and Review. 2024 Jul-Sep;02(3):3-11.

Received: 2 November 2023
Accepted: 1 December 2023
Published: 1 January 2024

1. Introduction

The term "stress" refers to the state caused by the perception of stimuli that provoke emotional and hormonal agitation in the process of the body's balance. In acute cases, there is an increase in the secretion of adrenaline and other neurotransmitters, as well as the hormone cortisol, leading to systemic changes, with physiological and psychological disturbances. Thus, stress situations generally result in an overall increase in the activation of the body, so that the individual can react to the aggressor [1, 2].

Initially, it was believed that this physiological activation was generic and undifferentiated for any stressor. However, it is now assumed that different neural and endocrine systems are involved in responding to stress and can indeed be activated. The neuroendocrine axis takes longer to activate and requires more prolonged stress conditions. Its activation triggers the adrenal medulla, leading to the secretion of catecholamines (adrenaline and noradrenaline), which helps to increase and maintain somatic adrenergic activity, producing effects like those generated by sympathetic activation [3].

Generally, this imbalance occurs due to an individual's inability to respond to environmental demands. It manifests through a variety of responses, whether physical, psychological, environmental, or emotional. Chronic and intense exposure to stressors stimulates changes in stress-responsive systems, phenomena closely linked to the pathophysiology of numerous diseases. One of the most studied systems is the cardiovascular system, as it is one of the leading causes of death worldwide, and it is subject to significant changes in response to acute and chronic stress [4].

The complexity of the cardiovascular system is regulated by neural and neuro-hormonal mechanisms that respond to stimuli from afferent receptors through efferent innervations of the autonomic nervous system (ANS). Commonly, an increase in heart rate (HR) is considered a result of greater sympathetic pathway activity or decreased parasympathetic activity (PSN), i.e., vagal inhibition, while its decrease is primarily dependent on the dominance of vagal activity [5].

The ANS is divided into two parts, the parasympathetic, which generally relaxes the body, and the sympathetic, which has an antagonistic action, exciting the individual. Despite their differences, the parasympathetic has localized action to an organ or part of the body, and the sympathetic tends to have diffuse actions, affecting several organs or sectors; both assist and work harmoniously in coordinating visceral activity. The ANS plays a fundamental role in controlling blood pressure and heart rate and can be related as a significant pathophysiological factor in the development of hypertension. Thus, some dysfunctions along the spinal column can cause changes in the Autonomic Nervous System, leading a person to exhibit signs not related to any diagnosed pathology [6, 7].

Heart rate variability (HRV) is a tool often used to measure independent positioning. HRV explains the variations in intervals between heartbeats in continuous RR space, which are associated with the effects of the ANS on the sinus node. As a non-invasive measure used to identify symptoms related to comfort in both individuals with dysfunction and healthy athletes or not, thoracic manipulations can stimulate the cardiac sympathetic system, increasing heart rate, stroke volume, and cardiac output, while some authors find changes in the parasympathetic system related to cervical myofascial release and targeted cervical use to present the positioning of the vagus nerve [8, 9].

Joint use is a recognized method involving a rapid, high-acceleration, and small-displacement movement, usually performed at the end of the range of motion. The point of application is marked according to the change exhibited by the patient, designated, and examined. It is considered that not all patients are comfortable with the use or achieve the necessary relaxation for it. The method can be applied as an oscillatory strategy at some points of the range of motion, or as a high velocity thrust (HVT) at the end of the joint range of motion. It is believed that after spinal manipulation there is a creation of analgesia and sympathetic excitation, but the mechanisms by which this occurs are not fully understood [10, 11].

The accepted model is that the analgesia resulting from use (and association) is a natural neurophysiological response to the stimulation of the pain pathway generated by descending inhibitory pain services, with an indispensable role provided by the lateral column of the periaqueductal gray matter (PAG). This hypothesis is supported by animal studies where stimulation of the dorsal/dorsolateral PAG leads to analgesia, motor facilitation, and sympathetic excitation [12]. Several studies show changes in the activation of the peripheral and central sympathetic nervous system after spinal manipulation, with most researchers observing resolutions in the SNS following a decrease in agility. The execution of a lateral glide of the spine and a postero-anterior movement C5/6 are examples of central sympathetic-excitatory consequences, as evidenced by changes in the cardiovascular and respiratory systems [13].

The neurophysiological implications of association and handling are similar. They refer to hypoalgesia, inhibition of muscle contraction by influencing motoneuron irritability, improvement in motor command, and reproduction in the autonomic nervous system. Although it is not yet precise, the principle allowing for analgesia is established due to mechanical peri-articular receptors, which inhibit the later mechanical receptors. This constitutes an assertive conclusion of the mechanisms proposing pain inhibition [11].

This study aims to evaluate the acute effects of spinal manipulation on the autonomic nervous system in students at a university center in Fortaleza, Brazil.

2. Methodology

2.1 Research Design

This is an analytical, interventional, quantitative, and cross-sectional study.

2.2 Location and Participants of the Research

The research was conducted at the Ateneu University Center, São Vicente campus at the address: Rua São Vicente de Paula, 300 – Antônio Bezerra, Fortaleza – CE, 60860-528, from September to December 2019, with students regularly enrolled in the 2019.2 semester, in any undergraduate course at the Ateneu University Center. The students were randomly chosen and allocated into groups. The inclusion criteria for this study were Ateneu University Center students aged between 20 and 40 years, of both sexes, who reported some discomfort in the spine. The exclusion criteria for this study were students with skin diseases, burns, joint hypermobility, vertebral fractures, protrusion and disc herniation, severe osteoporosis, spondylolisthesis, or those who were afraid of undergoing manipulations. The students were divided into two groups: G1, where high-velocity and low-amplitude spinal manipulation was performed, and G2, where the students were only positioned in the manipulation posture, without performing the maneuver.

2.3 Data Collection and Analysis

Approved by the Ethics and Research Committee and after signing the Free and Informed Consent Form (TCLE), the data collection and analysis began.

Heart rate variability was collected using a sensor placed on the earlobe and connected to a smartphone. The collection was done 5 minutes before and 5 minutes after the manipulation or just positioning. The app used was Inner Balance, available for free. The data obtained by the app were transferred to a computer as a text file and the RR interval signals processed to calculate HRV using the Kubios HRV Analysis software (MATLAB, version 2 beta, Kuopio, Finland). The cardiac variability system (data collection with the EmWave system / data processing with the Kubios system), HRV Cardiac variability (autonomic nervous system) performed before and after the manipulation. The variables collected were SNP index (parasympathetic nervous system) and SNS index (sympathetic nervous system).

The assessment of joint range of motion was performed using Kinovea software, obtained for free from its website. Reference points, marked with a skin marking pen (dermatograph), were placed on specific points, depending on the joint to be assessed.

2.4 Evaluation of range of motion

2.4.1 Cervical

Flexion and extension: the patient was seated and the evaluator standing beside them. Fixed arm of the goniometer: placed at the level of the acromion and parallel to the ground, in the same transverse plane as the spinous process of the seventh cervical vertebra. Movable arm of the goniometer: At the end of the movement, placed towards the earlobe.

Lateral flexion: The patient was seated, and the evaluator stood behind the patient. Fixed arm of the goniometer: parallel to the ground in the same transverse plane as the spinous process of the seventh cervical vertebra. Movable arm of the goniometer: at the end of the movement, it was placed along the midline of the cervical spine, directed towards the external occipital protuberance.

Rotation: The patient was seated, and the evaluator stood behind the patient. Fixed arm of the goniometer: in the center of the head, on the sagittal suture. Movable arm of the goniometer: at the end of the movement, placed on the sagittal suture.

2.4.2 Hip

Flexion (lasègue): The patient was in the supine position, and the evaluator beside them. Fixed arm of the goniometer: placed along the mid-axillary line of the trunk. Movable arm: the goniometer was placed parallel and over the lateral surface of the thigh, towards the lateral condyle of the femur.

The patients' assessments were carried out by measuring the range of motion using Kinovea software (before and after manipulation or positioning), as shown in figure 1, and Heart Rate Variability using the Inner Balance app before and after the technique, and later analyzed by Kubius software.

2.5 Experimental Procedure

2.5.1 Lumbar

Participants allocated to G1 received a high-velocity and low-amplitude (HVLA) manipulative technique in the lumbar region. The HVLA manipulation was unspecific, not manipulating a single vertebra but the entire segment under study. In performing the lumbar manipulation technique, the patient was positioned in a lateral decubitus position. The therapist positioned themselves at the height of the patient's abdomen, with their caudal hand in the suprajacent interspinous cavity, pulling the lower arm and rotating their trunk until tension was assessed in the mentioned region. Then, the leg on the top was positioned in hip and knee flexion, with the latter off the table, leaving the lumbar spine in maximum rotation (Figure 1). In a quick movement, a rotation of low amplitude was performed.

2.5.2 Thoracic

The patient was positioned in prone position on a low table with the upper limbs close to the body. The physiotherapist positioned themselves at the patient's side with the hypothenar area of their hands touching the transverse processes, applying a small force in a postero-anterior and caudo-cephalic direction along the entire length of the thoracic spine, as shown in figure 2.

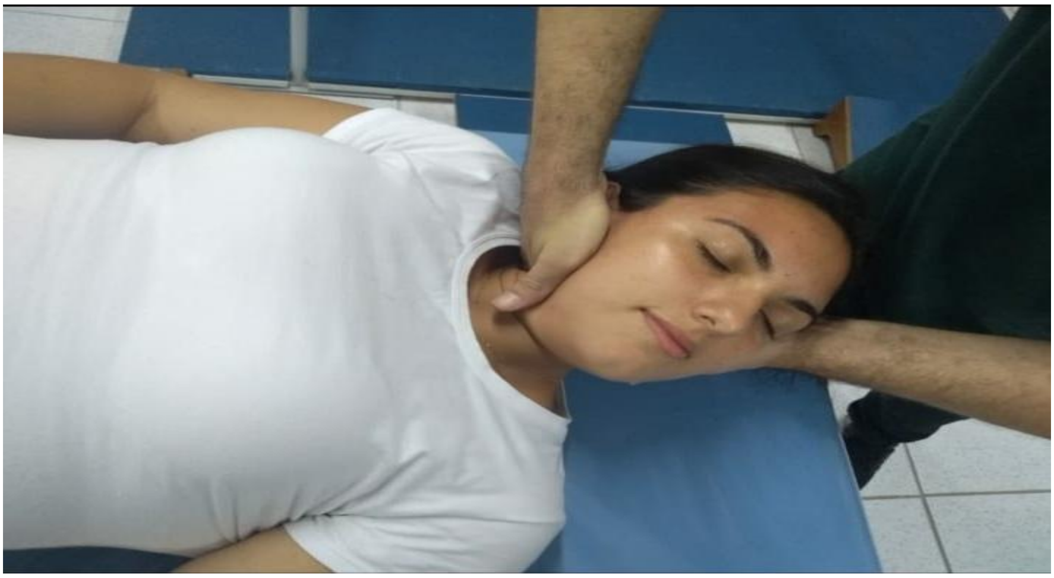
Figure 1: Initial Position for Lumbar Manipulation of Patients Allocated to G1.

Figure 2: Initial Position for Thoracic Manipulation of Patients Allocated to G1.

2.5.2 Thoracic

For the cervical spine, the patient was positioned in a supine position. The therapist stood at the back of the patient's head. They performed a lateral flexion of the cervical spine and rotated it towards the side opposite the lateral flexion (Figure 3). At the end of the range, a high-speed and low-amplitude displacement was performed. A crepitation may be felt, indicating that a manipulation has occurred.

Figure 3: Initial Position for Cervical Manipulation of Patients Allocated to G1.



3. Results and discussion

Spinal manipulation often results in a sensation of comfort and muscle relaxation in many patients, due to postural correction and activation of the autonomic nervous system (Maitland, 2006; Ianuzzi et al., 2005). After the spinal manipulation, an increase in the range of motion and parasympathetic action was observed in the tested students. However, it was also noted that simply positioning the student stimulated the ANS, which may have contributed to the increased range of motion measured.

Table 1: Degrees (°) values of the range of motion before and after spinal manipulation for the movements of flexion, hyperextension, rotation, and lateral flexion of the cervical spine, and hip flexion. The student's "t" test was applied with $p < 0.05$.

Positioning	Before	After	Reference Value
Cervical flexion	49.4	58	65
Cervical hyperextension	40	45.9	50
Hip flexion	80.3	97.2	125

Cervical rotation to the right	77.4	85.4	90
Cervical rotation to the left	75.8	85.1	90
Cervical lateral flexion to the right	36.1	41.2	45
Cervical lateral flexion to the left	37.2	41.8	45

According to Table 1, there was a significant difference for $p < 0.05$ between the parameters evaluated before and after spinal manipulation for the movements of cervical flexion, hyperextension, and hip flexion. After the procedure, the values were closer to the reference standards. Based on the Student's "t" test, there was no significant difference in right rotation, while there was a significant difference in left rotation compared to before and after the manipulation. This is attributed to the fact that the mean amplitude to the left was much lower than to the right. No questionnaire was conducted to identify if the dominant side of the students could have any interference.

There was an increase in amplitude in the movement of lateral flexion to the right and left when comparing before and after, which demonstrates the efficacy of the technique in these students. Scharples [14] assessed the results of cervical range of motion after thoracic spine manipulation, observing significant results in all movements when comparing the assessment before the first intervention with the assessment after the second intervention. In cervical tilting movements, the increase in range of motion was significant immediately after the first intervention. Similar results were found after a single intervention, however, the increase in amplitude was significant for rotation movements. Peñas [15], despite observing an increase in range of motion, did not find the results to be significant.

After manipulation, the students reported muscle relaxation or a sensation of bodily comfort. No one presented algic symptoms immediately after. This study did not aim to confirm changes in the degree of pain and posture, but the results suggest that the reduction of range of motion (ROM) is related to the presence of vertebral somatic dysfunction and muscle tensions. Manipulations lead to significant improvement in pain, mobility, and functional capacity [16]. Spinal manipulation indicates that the aspects that mark the immediate results on discomfort and reduction of movements at the level of the joint and proportion of the intervertebral joint level [17]. The combination of movements in the spinal column on stress zones in the spine and the displacement of the position of the vertebrae can dominate and move various structures of the body in space, altering normal functions.

According to Table 2, it can be observed that there was a significant increase, albeit smaller compared to manipulation, in the range of motion of the parameters used. It is believed that even the touch on the patient influences the autonomic nervous system, modifying levels of cortisol and oxytocin, altering the bio-psycho-social environment, and thus, stimulating the parasympathetic system [18].

Table 2: Degrees (°) values of the range of motion before and after positioning for the movements of flexion, hyperextension, rotation, and lateral flexion of the cervical spine, and hip flexion. The student’s "t" test was applied with $p < 0.05$.

Positioning	Before	After	Reference Value
Cervical flexion	48.42	52.57	65
Cervical hyperextension	39	42.14	50
Hip flexion	80.85	90.14	125
Cervical rotation to the right	76.57	79.85	90
Cervical rotation to the left	77.57	79.28	90
Cervical lateral flexion to the right	38	41.57	45

Cervical lateral flexion to the left	39.25	41.28	45

It is known that the activity of the parasympathetic nervous system (PNS) (vagal stimulation) decreases heart rate and increases heart rate variability. The activity of the sympathetic nervous system (SNS) has the opposite effect on heart rate and heart rate variability, that is, it increases the HR and decreases the HRV. Therefore, the HR is lower and the HRV is higher when we are at rest and fully recovered. During stressful situations, when sympathetic nerve activity increases, the resting heart rate is elevated and heart rate variability decreases [19].

In a randomized study with 100 patients suffering from chronic neck pain, Galaasen Bakken et al. [20] investigated the immediate effect of a spinal manipulation at T3-T4 on the autonomic nervous system activity in individuals with chronic neck pain. The manipulation did not result in a change in sympathetic activity. Furthermore, there was no significant difference in the subjects' perception of pain (p=0.961) when comparing the effects of the manipulation to a placebo intervention within this group of individuals with chronic neck pain. The interpretation of PNS and SNS indices is straightforward [20].

A PNS (or SNS) index value of zero means that the parameters reflecting parasympathetic (or sympathetic) activity are, on average, equal to the normal population mean. Correspondingly, PNS index values different from zero describe how these values are below or above the reference. This reference is given with the population at rest. However, during stress or during high-intensity exercises, very low PNS indices and much higher SNS values can be observed. A tabela 3 mostra a média do percentual dos alunos. Inicialmente, se apresentaram mais simpáticos. Após a manipulação vertebral, os níveis de simpático diminuíram e o parassimpático aumentou. Essa diferença foi significativa estatisticamente, pelo teste "t" de Student, com p < 0,05.

Table 3: Result of the Kubios HRV Analysis on the Sympathetic and Parasympathetic Systems Before and After Spinal Manipulation.

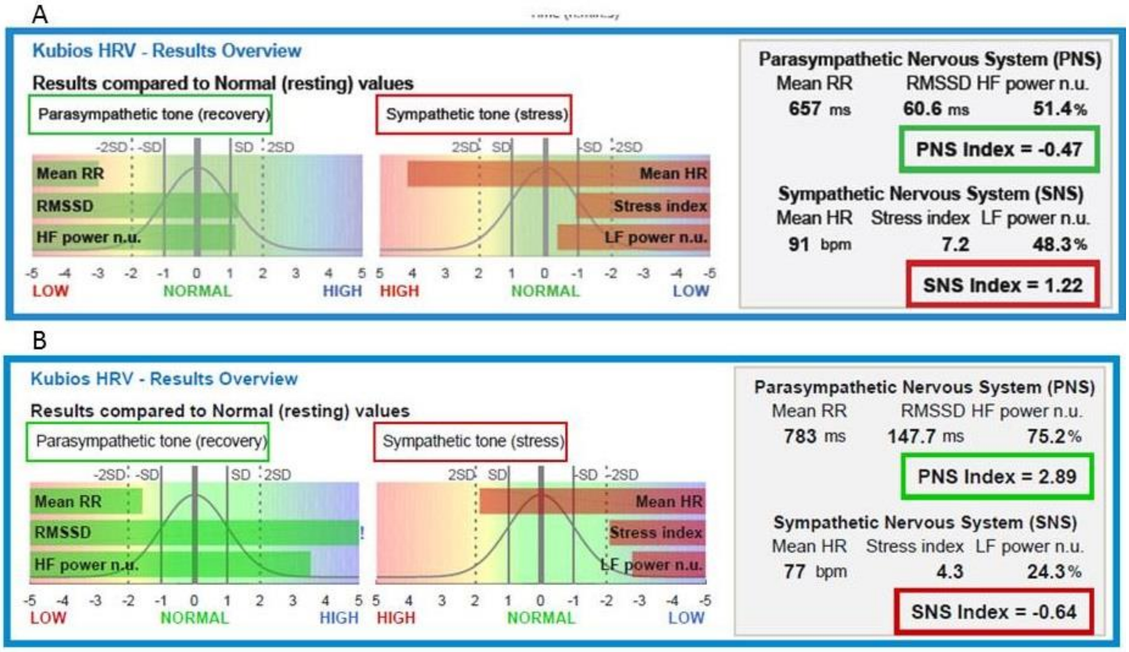
	Index	**Percentage**
Sympathetic before	0.6	53.46
Sympathetic after	-0.065	45.76
Parasympathetic before	0.973	46.26
Parasympathetic after	2.332	53.82

According to Table 4, it can be observed that positioning the patient, even without spinal manipulation, was statistically significant, as there was an improvement in the index and percentage, with respect to the increase in parasympathetic and decrease in sympathetic activity. Figure 4 shows the variation of the index and percentage before and after spinal manipulation. In this case, there was an increase in the index from 1.22 to -0.64 in the sympathetic system. This indicates that the student was experiencing a level of stress above that of the resting population, and after the manipulation, the stress levels decreased.

Table 4: Result of the Kubios HRV Analysis on the Sympathetic and Parasympathetic Systems Before and After Positioning.

	Index	**Percentage**
Sympathetic before	-0.18	42.56
Sympathetic after	-0.49	39.46
Parasympathetic before	3.79	56.93
Parasympathetic after	5.13	60.13

Figure 4: Graph generated by Kubios HRV showing the index values and the sympathetic and parasympathetic percentages. A) before manipulation. B) after manipulation.



4. Conclusion

Based on the presented data, it can be concluded that both spinal manipulation and simple positioning, simulating a manipulation, can affect the autonomic nervous system, thereby reducing stress levels (sympathetic) and increasing the parasympathetic system. It is believed that simple touch can interfere with the action of the autonomic nervous system, thus modifying a lifestyle and reducing stress levels.

The gain in range of motion can be related both to the reduction in sympathetic levels and to localized effects. Manipulation corrects subluxations, which in turn decompress nerve exits, thereby improving nerve supply to the muscles, tendons, and fasciae. The purpose of this study was to acutely evaluate the effects of manipulation. Further research is still needed to understand how long these effects last in the body and what other structures are affected by this procedure.

Funding: None.

Research Ethics Committee Approval: None.

Acknowledgments: None.

Conflicts of Interest: The authors declare no conflict of interest.

Supplementary Materials: None.

References

1. Patel V, Vaishnaw A, Shirbhate E, Kore R, Singh V, Veerasamy R, Rajak H. Cortisol as a Target for Treating Mental Disorders: A Promising Avenue for Therapy. Mini Rev Med Chem. 2023 Oct 10. doi: 10.2174/0113895575262104230928042150. Epub ahead of print. PMID: 37861053.
2. Reuter M. Impact of cortisol on emotions under stress and nonstress conditions: a pharmacopsychological approach. Neuropsychobiology. 2002;46(1):41-8. doi: 10.1159/000063575. PMID: 12207146.
3. Schaeuble D, Myers B. Cortical-Hypothalamic Integration of Autonomic and Endocrine Stress Responses. Front Physiol. 2022 Feb 11;13:820398. doi: 10.3389/fphys.2022.820398. PMID: 35222086; PMCID: PMC8874315.
4. Vancheri F, Longo G, Vancheri E, Henein MY. Mental Stress and Cardiovascular Health-Part I. J Clin Med. 2022 Jun 10;11(12):3353. doi: 10.3390/jcm11123353. PMID: 35743423; PMCID: PMC9225328.

5. Siepmann M, Weidner K, Petrowski K, Siepmann T. Heart Rate Variability: A Measure of Cardiovascular Health and Possible Therapeutic Target in Dysautonomic Mental and Neurological Disorders. Appl Psychophysiol Biofeedback. 2022 Dec;47(4):273-287. doi: 10.1007/s10484-022-09572-0. Epub 2022 Nov 22. PMID: 36417141; PMCID: PMC9718704.
6. Hirooka Y. Sympathetic Activation in Hypertension: Importance of the Central Nervous System. Am J Hypertens. 2020 Oct;33(10):914-926. doi: 10.1093/ajh/hpaa074.
7. Grassi G, Dell'Oro R, Quarti-Trevano F, Vanoli J, Oparil S. Sympathetic Neural Mechanisms in Hypertension: Recent Insights. Curr Hypertens Rep. 2023 Oct;25(10):263-270. doi: 10.1007/s11906-023-01254-4. Epub 2023 Jul 14. PMID: 37450271; PMCID: PMC10505104.
8. Hayano J, Yuda E. Assessment of autonomic function by long-term heart rate variability: beyond the classical framework of LF and HF measurements. J Physiol Anthropol. 2021 Sep 21;40(1):21. doi: 10.1186/s40101-021-00272-y.
9. Ernst G. Heart-Rate Variability-More than Heart Beats? Front Public Health. 2017 Sep 11;5:240. doi: 10.3389/fpubh.2017.00240. PMID: 28955705; PMCID: PMC5600971.
10. Picchiottino M, Leboeuf-Yde C, Gagey O, Hallman DM. The acute effects of joint manipulative techniques on markers of autonomic nervous system activity: a systematic review and meta-analysis of randomized sham-controlled trials. Chiropr Man Therap. 2019 Mar 12;27:17. doi: 10.1186/s12998-019-0235-1. PMID: 30911373; PMCID: PMC6413458.
11. Aspinall SL, Leboeuf-Yde C, Etherington SJ, Walker BF. Manipulation-induced hypoalgesia in musculoskeletal pain populations: a systematic critical review and meta-analysis. Chiropr Man Therap. 2019 Jan 29;27:7. doi: 10.1186/s12998-018-0226-7. PMID: 30719281; PMCID: PMC6350309.
12. Tobaldini G, Sardi NF, Guilhen VA, Fischer L. Pain Inhibits Pain: an Ascending-Descending Pain Modulation Pathway Linking Mesolimbic and Classical Descending Mechanisms. Mol Neurobiol. 2019 Feb;56(2):1000-1013. doi: 10.1007/s12035-018-1116-7. Epub 2018 Jun 1. PMID: 29858776.
13. Picchiottino M, Honoré M, Leboeuf-Yde C, Gagey O, Cottin F, Hallman DM. The effect of a single spinal manipulation on cardiovascular autonomic activity and the relationship to pressure pain threshold: a randomized, cross-over, sham-controlled trial. Chiropr Man Therap. 2020 Jan 20;28(1):7. doi: 10.1186/s12998-019-0293-4. PMID: 31988711; PMCID: PMC6971986.
14. Sharples L. Does a single thrust manipulation of the upper thoracic spine increase neck range of motion? Unitec Institute of Technology; 2010.
15. Peñas F. Changes in Neck/Pain/Range of Motion After Thoracic Manipulation. J Manipulative Physiol Ther. 2007;38(4):312-20.
16. Roberge RJ, Roberge MR. Overcoming barriers to the use of osteopathic manipulation techniques in the emergency department. West J Emerg Med. 2009;10(3):184-9.
17. Ianuzzi A, Partapp MS, Khalsa DS. Comparison of human lumbar facet joint capsule strains during simulated high-velocity, low-amplitude spinal manipulation versus physiological motions. Spine J. 2005;5:277-90.
18. Lima JPC. Efeitos da administração nasal de ocitocina sobre parâmetros autonômicos e níveis salivares de cortisol em modelo de stress social. [Dissertation]. São Paulo: Universidade de São Paulo, Instituto de Psicologia, Programa de pós-Graduação em Neurociências e Comportamento; 2017.
19. Acharya UR, Joseph KP, Kannathal N, Lim CM, Suri JS. Heart rate variability: a review. Med Biol Eng Comput. 2006;44(12):1031-51.
20. Galaasen Bakken A, Eklund A, Hallman DM, Axén I. The effect of spinal manipulative therapy and home stretching exercises on heart rate variability in patients with persistent or recurrent neck pain: a randomized controlled trial. Chiropr Man Therap. 2021 Nov 29;29(1):48. doi: 10.1186/s12998-021-00406-0. PMID: 34844625; PMCID: PMC8628060.