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RESEARCH ARTICLE

A Comparison of the Immediate Effects of Chiropractic Thoracic High-Velocity Low-Amplitude Manipulation Applied Supine and Prone on the Autonomic Nervous System

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Abstract
Thoracic manipulation is one of the spinal manipulative treatment methods frequently used by clinicians. However, when carrying out this task, several methods could be preferred. This study aimed to compare the immediate effects of supine and prone thoracic high-velocity-low-amplitude chiropractic manipulations on the autonomic nervous system. The study included 62 healthy and volunteer participants aged 18-45 years. Participants were randomly assigned to supine and prone manipulation groups. Both groups, heart rate variability data were obtained with the Elite HRV CorSense device for 1 minute before the application, systolic and diastolic blood pressures were measured, pulse and saturation values were recorded. After the measurement, supine chiropractic manipulation was applied to the mid-thoracic region and the same measurements were repeated. Heart rate variability data were analyzed with Elite HRV application, pulse rate, saturation, systolic and diastolic blood pressure values were recorded, and the results were statistically evaluated. In the intra-group comparison, LF/HF ratio increased in the prone group (p=0.025). When the difference between the groups was analyzed, the change in LF/HF ratio was found to be statistically significant between the two groups (p=0.008). The effect of prone application on the autonomic nervous system was found to be higher than supine application. This study revealed that prone and supine thoracic chiropractic HVLA application was effective on OSS in healthy individuals and that the efficiency of prone manipulation was significantly higher.

Keywords
Chiropractic, Autonomic Nervous System, Spinal Manipulation, Parasympathetic Nervous System

INTRODUCTION

Thoracic manipulation techniques are frequently applied with a chiropractic focus all over the world. Understanding the mechanisms and effects of these techniques is important for proper patient selection and correct technique selection (**Erdem et al.2021; Sener et al. 2021**). There are few studies in the literature investigating the effects of prone and supine thoracic manipulation (**Cakir et al. 2019; Tsegay et al. 2022**). Several studies show that thoracic manipulation has several neurophysiological effects. These effects include excitation of the sympathetic chain, mechanical hypoalgesia, decreased neural mechanosensitivity, increased pain tolerance and normalization of muscle activity (**Lascurain-Aguirrebena et al., 2016**).

Throughout the history of chiropractic, the treatment of visceral disorders has been adopted as a field of study, with an emphasis on the autonomic nervous system (**Gatterman, 2005**). From the earliest studies of chiropractic to the present day, there has been increasing evidence that manipulation of specific spinal segments can reduce the symptoms of visceral disorders. There are

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studies indicating that the autonomic nervous system (ANS) is affected in various ways by thoracic manipulation (**Sillevis et al., 2011; Sillevis et al., 2021**). Studies have shown increased parasympathetic activity, decreased heart rate and blood pressure, and increased proprioceptive input as a result of lumbar and lower thoracic spinal manipulations. In addition, thoracic manipulation has been reported to cause changes in blood pressure, skin temperature, heart rate, pupil diameter on the ANS (**McDevitt et al., 2022; Ward et al., 2015; Jowsey et al., 2010**). Results have also shown that the immune and endocrine systems are also affected by spinal manipulation (**Carnevali et al., 2020; Sampath et al., 2017**).

Although studies have shown that thoracic manipulations have an effect on the autonomic nervous system, it is not known whether the technique of application makes a difference. Therefore, we conducted this study to compare the immediate effects of prone and supine chiropractic HVLA thoracic manipulation on the ANS.

MATERIALS AND METHODS

This study followed to all relevant sections of the Declaration of Helsinki and was carried out in accordance with ethical standards. Ethics committee approval numbered 2022-186 was obtained from Bandırma Onyedi Eylül University Health Sciences Non-Interventional Research Ethics Committee on 12.01.2023. Our study was registered with the number NCT05850910. The research strictly adhered to the ethical principles of the Declaration of Helsinki, prioritizing participant's rights and well-being in design, procedures, and confidentiality measures. Participants were informed about the study and provided written informed consent.

Participants

The study included 62 healthy volunteers. Participants were divided into two groups by simple randomization method via random.org website. Thoracic manipulation was applied to both groups, the first group prone and the second group supine. The G Power 5.1.9.4 program was used to determine the sample size and the Type 1 error (alpha) was calculated as 0.05 and the power of the test (1-beta) was calculated as 0.8. A total of 58 people were calculated for each group, 29 in total. photoplethysmography. This program allows for the quick collection of RMSSD, SDNN, LN, In case of dropout, 31 in each group and 62 in total were included in the study (**Sener et al. 2021**).

Patients between the ages of 18 and 45 who were without mechanical limitations as determined by an examination of the thoracic region and without palpable discomfort, as well as those who had tumors, infections, injuries, inflammatory disorders, neurological and vascular issues, were included.

Design

Patients with tumors, infections, traumas, inflammatory illnesses, neurological and vascular problems, as well as those who were between the ages of 18 and 45 and were without mechanical restricts as determined by an examination of the thoracic region and without palpable discomfort, were included.

The supine application group (Group 1) was asked to cross their arms in front of their torso while the participant was lying on their back. The arm of the practitioner was placed in a half fist on the opposite side of the individual's torso in the mid-thoracic region. In this position, the spinous process coincided with the space in the center of the half fist, while the thoracic processes coincided with the fingertips and the tenar region. With the other hand of the practitioner supporting the patient's elbows, HVLA thrust is applied from front to back.

In the prone application group (Group 2); the participant positions his/her hands freely from the side of the treatment table while lying prone. The practitioner is positioned next to the patient with the hypothenar part of the hands over the thoracic processes in the mid-thoracic segment. From this point, a high-speed, low-amplitude thrust is applied from the back to the front.

Blood pressure, heart rate, and 1-minute HRV were all monitored following the intervention, and the findings of each measurement were recorded. Using an Omron M2 (HEM-7121-E) model sphygmomanometer, blood pressure and pulse were measured before and after the application. Systolic and diastolic blood pressures were recorded.

Before and after the thoracic manipulation, each subject conducted 1-min HRV measurements using the Elite CorSense equipment (Figure 3.3). The Elite HRV app was used to evaluate the measurements. The data is monitored by the Elite CorSense HRV program using a technique called

PNN50, and LF/HF ratio data on a single screen, making it easy to use (Chhetri et al., 2022).

Statistical Analyses

Statistical Package for Social Sciences (SPSS) Version 20.0 (SPSS inc. Chicago, IL, USA) was used for data analysis. Data expressed in numbers were expressed as n (%) and data expressed in measurements were expressed as arithmetic mean ± standard deviation (X±SD). Statistical significance level was accepted as $p<0.05$ in all analyses. Depending on the properties of the data, several methodologies were used to conduct statistical analysis. Student's t-tests were used to compare means between two groups for normally distributed variables. Additionally, correlation analysis using the Pearson and Spearman coefficients were carried out to look at the connections between continuous variables. In cases where the data did not meet the assumptions of normality, non-parametric tests like the Mann Whitney-U test were used to compare group differences.

RESULTS

There were 31 individuals total in both groups: 20 women and 11 men in the prone group and 21 women and 10 men in the group that was supine (Figure 1). When demographic information was compared between the groups, there was no significant difference ($p>0.05$) (Table 1).

Table 1: Compares the demographic data of the different groups.

	Group1 (n=31)	Group2 (n=31)	P
Age	26.00±5.66	23.96±3.61	0.097
BMI(kg/cm^2)	22.69±3.25	22.48±3.30	0.800
Gender	21 Female / 10 Male	20 Female / 11 Male	**0.011**

Kg: kilogram, cm: centimeters, p<0,05

Pulse rate, systolic and diastolic pressure decreased in both groups after the application but were not statistically significant. The values of HRV values before and after supine and prone thoracic manipulation are given in the table. RMSSD and LF values increased after both supine and prone manipulations. However, this increase was not statistically significant ($p>0.05$). There was not a significant difference between the groups in RMSSD, LF and HF variables ($p>0.05$). While there was not a significant change in the LF/HF ratio in the supine group ($p>0.05$), a significant increase was observed in the prone group ($p<0.05$). There was a significant difference in the LF/HF ratio between the groups ($p<0.05$).

Table 2: Before and after intra- and inter-group manipulation application

	Group1			**Group2**			
	Pre-Application	Post-Application	P	Pre-Application	Post-Application	p	p
Pulse	82.32±12.92	81.77±13.84	0.546	86.51±11.88	85.41±10.07	0.373	0.717
SBB	112.96±13.71	111.67±15.45	0.314	117.74±13.07	111.93±13.38	0.010	0.072
DBB	75.41±10.07	73.83±10.46	0.212	78.32±10.52	73.58±9.43	0.032	0.231
RMSSD	54.57±22.85	61.04±28.56	0.134	52.04±22.19	55.73±26.71	0.364	0.634
LF/HF	2.80±2.68	2.05±1.74	0.106	2.05±1.42	2.86±2.36	**0.025**	**0.008**
LF	2479.37±2353.89	2999.32±3855.65	0.891	1855.15±1575.67	2475.37±2455.22	0.153	0.307
HF	1445.94±1847.48	1943.37±2322.15	0.299	1422.72±1466.40	1179.06±1214.24	0.710	0.877

p<0,05.
RMSSD:Root mean square of successive differences SDNN: Standart deviation of normal normal intervals LN:Natural logaritm PNN50:Percantage of normal normal intervals LF: Low frekans HF: High Frekans, *SBB: Sistolik Blood Pressure DBB: Diastolic Blood Pressure,*

DISCUSSION

In this study, the impacts of thoracic chiropractic HVLA in the prone and supine positions on the ANS in healthy participants were examined. Data collected at the conclusion of the study demonstrated that the prone group had higher LF/HF ratios and lower systolic and diastolic blood pressures. These outcomes, however, lacked statistical significance. The LF/HF ratio indicated a significant difference between the two groups when the change between the groups was evaluated. **Wirth and et. al** (**2019**) investigated the neurophysiological effects of spinal manipulative therapy with HVLA thrust in their systematic study. They discovered that stimulation of the upper or lower thoracic or lower cervical segments increased the sympathetic to parasympathetic ratio (LF/HF ratio). This can be associated to the segment used because the T5 segment's effects on the lumbar segments were insignificant. We came to the conclusion that modification of the middle and lower thoracic segments may not have an impact on HRV because the preganglionic fibers of the cardiac plexus largely branch from the T3-T4 spinal segments. In our research, we found that while there was no significant change in the supine group, the LF/HF ratio increased significantly in the prone group with mid-thoracic manipulation (**Wirth et al., 2019**).

The effects of a single spinal manipulation on cardiovascular autonomic activity and pressure pain threshold were studied by **Picchiottino et al**. (**2020**) According to the study of 41 participants, a single spinal manipulation of the thoracic spine had no appreciable impact on autonomic activity. **Picchiottino et al.** (**2019**) [17] investigated at the acute effects in ANS activity of spinal manipulation therapy given to spinal or peripheral joints in their systematic study. This study, which included 29 investigations, found that several forms of mobilization significantly increased sympathetic nerve activity both immediately and shortly. HVLA procedures, on the other hand, have no noticeable impact on the ANS. Results for a particular sector, however, were not recorded. Systolic and diastolic blood pressure, indicators of parasympathetic nervous system activity, were reduced in our study by prone application at the T6-T7 level, but the results were not statistically significant (**Picchiottino et al. 2020**).

Araujo et al. (**2019**) investigated the effects of spinal manipulative therapy on the ANS in their systematic review. Including 18 studies, it was reported that vertebral mobilization caused an increase in sympathetic activity regardless of the region of application (cervical, thoracic or lumbar spine). Continuous natural apophyseal shifts were reported to have no effect on the ANS, and manipulation practices were found to give conflicting results. It was stated that the inclusion of studies with low level of evidence may cause this contradiction. We applied mid-thoracic chiropractic HVLA manipulation in healthy subjects and found that ANS was affected in favor of parasympathetic activity. The reason for this difference may be that a specific level was not studied, or symptomatic individuals were included in the study (**Araujo et al., 2019**).

Roura et al. (**2021**) evaluated the effect of manual therapy interventions on the ANS in their systematic review. In the study, which included 12 systematic reviews, the findings showed that manual therapy can be effective on both sympathetic and parasympathetic systems. However, the results obtained from the included studies were found to be inconsistent due to their methodological rigor and differences in how they were measured. In a systematic review, Navarro-**Santana et al**. (**2020**) evaluated the effects of joint mobilization on changes in clinical signs of sympathetic nervous system activity. As a result, moderate clinical evidence was found indicating a sympathetic stimulating effect of joint mobilization (**Roura et al., 2021**). In our study, we found a significant change in the LF/HF ratio from HRV values as a result of prone mid-thoracic chiropractic manipulation. This change indicates that it causes an immediate effect in the direction of increased activity of the parasympathetic nervous system.

In a randomized controlled -blind pilot investigation, **Rogan et al**. (**2019**) assessed the effects of thoracic spinal manipulation on the autonomic nervous system. In this study, 12 healthy volunteers had two days of prone and supine thoracic spinal mobilization to the T6-T12 regions. Blood pressure, heart rate, pulse, and skin perfusion were all monitored. On the majority of secondary variables, prone mobilization had a stronger impact than supine mobilization. It has been demonstrated that prone application may raise the pulse rate and HRV HF and LF/HF ratios. In our investigation, we subjected several subjects to supine and prone

manipulation of T6-T7 segments. Similar to this study, we found a greater and significant change in parasympathetic values in the prone group compared to the supine group. In our study, an increase in the LF/HF ratio was found among the

In a randomized controlled double-blind pilot investigation, **Rogan et al.** (**2019**) assessed the effects of thoracic spinal manipulation on the autonomic nervous system. In this study, 12 healthy volunteers had two days of prone and supine thoracic spinal mobilization to the T6-T12 regions. Blood pressure, heart rate, pulse, and skin perfusion were all monitored. On the majority of secondary variables, prone mobilization had a stronger impact than supine mobilization. It has been demonstrated that prone application may raise the pulse rate and HRV HF and LF/HF ratios. In our investigation, we subjected several subjects to supine and prone manipulation of T6-T7 segments (**Rogan et al., 2019**).

In a placebo-controlled trial, Rodrigues et al. examined the immediate impact of manual treatment administered to the upper thoracic spine on cardiovascular autonomic regulation. A significant increase in RMSSD and HF values, which indicate parasympathetic activity, was observed in the spinal manipulation group. Only the spinal manipulation group reported significant improvements in the sympathetic activity indicators LF and LF/HF ratio. In neither group was there a noticeable distinction in the blood pressure response. The results of the two studies are comparable in that we observed an increase in the LF/HF ratio in our study as a result of prone mid-thoracic chiropractic HVLA manipulation. The results of our blood pressure tests are comparable (**Rodrigues et al., 2021**).

Using HRV data, in their study, **Çakır et al.** (**2019**) examined the immediate impact of chiropractic thoracic manipulations on the ANS. While there were significant increases in LF power, SNS Index, and Stress Index values in the experimental group, there were significant decreases in RMSSD, HF power, PNS Index, and PNN50 values, which indicate parasympathetic nervous system activity. There was not a significant alteration in the parameters in the placebo group. In contrast, we determined that intermediate thoracic manipulation produced parasympathetic effects in our investigation. Which section they used in their HRV values. They suggested that pulse, HF and LF/HF ratio may increase. We are of the opinion that such a difference may occur due to the larger number of subjects in our study (**Rogan et al., 2019**).

investigation was not made clear. The applied section may determine how the two applications differ from one another. Again, they examined people with mechanical constraints in their study, whereas we used healthy people (**Çakır et al., 2019**).

Conclusion

As a result of the study in which we compared the immediate effects of supine and prone mid-thoracic chiropractic manipulations on the ANS, only a statistical increase in the LF/HF ratio was found after the prone manipulation. As a result, the immediate effect of prone mid-thoracic chiropractic HVLA manipulation on the ANS is higher. One of the limitations of our study is that we focused solely at immediate effects in the middle thoracic region in healthy individuals. Different outcomes may be seen with applications to the cervical, upper and lower thoracic, lumbar, and sacral regions. Spinal manipulation may have distinct impacts on the ANS in people with pain and mechanical restrictions than it does in healthy people. When it comes to the study's advantages, contrasting the results of manipulations performed in various postures and adding to the body of knowledge will help chiropractors select the most effective method.

Conflict of Interest

No conflict of interest is declared by the authors. In addition, no financial support was received.

Ethics Statement The approval of the Scientific

Research Ethics Committee of Bandırma University obtained for the study 2022186.

Author Contributions

Study Design, BEP; Data Collection, YA, and BEP; Statistical Analysis, HG; Data Interpretation, YA, HG; Manuscript Preparation, YA, BEP, HG; Literature Search, YA, BEP, HG. All authors have read and agreed to the published version of the manuscript.

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