Journal of Chiropractic Medicine (2008) 7, 86–93

ELSEVIER

Journal of Chiropractic Medicine

www.journalchiromed.com

Sympathetic and parasympathetic responses to specific diversified adjustments to chiropractic vertebral subluxations of the cervical and thoracic spine

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Received 2 November 2007; received in revised form 19 February 2008; accepted 10 April 2008

Key indexing terms:
Heart rate;
Chiropractic;
Autonomic nervous system;
Manipulation, chiropractic;
Manipulation, spinal

Abstract

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.

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1556-3707/$ – see front matter © 2008 National University of Health Sciences.
doi:10.1016/j.jcm.2008.04.001

Introduction

Chiropractors have suggested the positive effects of chiropractic adjustments on musculoskeletal and visceral health.[1-3] Although there is a paucity of peer-reviewed studies in support of anecdotal perceptions, there are reports that provide evidence to support these perceptions.[1,4,5] Moreover, although several studies have investigated chiropractic vertebral subluxation, spinal manipulative therapy, and cranial adjusting in relation to autonomic function,[1,2-10] few studies have been done to link specific outcomes to specific levels adjusted.[1,4,5] Other studies have given mixed support to the view that the response of the autonomic nervous system is related to the region of the spine adjusted.[1,6,7,11] Despite the limited evidence suggesting that changes in autonomic activity are consistently linked to chiropractic adjustments, autonomic mediated reflex responses including changes in heart rate, blood pressure (BP), pupillary diameter, and distal skin temperature, as well as, endocrine and immune system effects, have been clearly demonstrated.[1,6,7,11-14] Certain of these findings, such as heart rate, BP, and skin temperature, are consistent with observations of chiropractic clinicians regarding the possible relationship between spinal dysfunctions and visceral disorders, keeping in mind that, in this article, "the bulk of the positive data obtained was elicited with noxious stimulation…."[1]

The parasympathetic nervous system arises from the cell bodies of the motor nuclei of cranial nerves III, VII, IX, X, and XI in the brainstem and from the second, third, and fourth sacral segments of the spinal cord. The parasympathetic nervous system is known as the craniosacral flow. The cell bodies of the sympathetic fibers are in the lateral horns of the spinal segments T1 through L2, the so-called thoracolumbar outflow.[15] Because of the proximity of the upper cervical vertebrae to the brainstem, parasympathetic influences dominate these segmental levels; and therefore, a cervical adjustment could likely result in a parasympathetic response (slowing down of heart beat, lowering of BP, constriction of pupils). In those spinal regions where sympathetic innervation is substantial (upper thoracic and upper lumbar), a chiropractic adjustment could elicit a sympathetic response (stimulation of heart beat, raising of BP, dilation of pupils). Previous research has demonstrated the existence of spinal reflex centers and a measure of segmental organization where sympathetic mediation dominates.[1] A segmental organization has not been apparent in the parasympathetic outflow.[1]

It was hypothesized that, if a thoracic segment was adjusted, a sympathetic response would be elicited because the sympathetic fibers go through the L2-3 interspace and because the upper thoracic, especially the C7-T1 junctions, involve the stellate ganglion that stimulates the sympathetic chain ganglia. As well, because of the relationship of the C1 and C2 vertebrae to the parasympathetic nerve fibers associated with the brainstem, it was hypothesized that, if an upper cervical segment was adjusted, a parasympathetic response would be elicited. The objective of this study was to investigate responses, pre– and post–cervical and thoracic chiropractic adjustments, in relation to the classic thoracolumbar-sympathetic and cervical-parasympathetic pathways.[15]

Methods

The Institutional Review Board of Sherman College of Straight Chiropractic provided approval of this study, and informed consent was signed by all participants. The first 40 volunteers meeting the inclusion criteria of being between the ages of 21 and 55 years, nonhypertensive, and with no history of heart disease were entered as participants in the study. Each of the 40 participants was evaluated over 5 visits spanning 2 weeks per subject between July 2005 and May 2007. Baseline characteristics were asymptomatic men or women between the ages of 25 and 55 years (men, mean ± 6.50 SD; women, mean ± 5.83 SD). Each participant was evaluated by one or more of the following preadjustment and postadjustment assessments.

Chiropractic assessments included motion and static palpation, leg length symmetry measurements, and thermography.[16] When assessments indicated the need for an adjustment, the force was administered according to the diversified technique methodology. Systolic and diastolic BP and pulse rate were measured using a digital BP device (Marshall 97 Auto Oscillometric Electronic Digital BP and Pulse Monitor; Omron Healthcare, Inc, Vernon Hills, IL). Blood pressure was taken on the left arm of the participant, measured one time preadjustment and one time postadjustment. Heart rate variability (HRV) refers to the beat-to-beat variation in heart rate. Five-minute recordings yielding power spectral analysis of HRV were obtained using the Active ECG instrument from BioCom Technologies, Poulsbo, WA. On the day that an adjustment was scheduled to be administered, the participant, after having his or her BP measured and while still in the seated position, had a self-adhesive electrode attached by taping it to the left wrist, over the radial and ulnar arteries. Participants were assessed approximately the same time of day, each recording within 15 minutes. A recording time of 5 minutes was followed throughout the study. Each participant was assigned a specific time to be adjusted to maintain constancy in regard to the known diurnal effect that has been associated with HRV.[17] After the adjustment, within a 10-minute time frame, the same protocol as described above was repeated; and data were recorded as postadjustment.

Both time-related components of HRV as well as power analysis data were recorded. The standard deviation of average normal to normal R-R intervals (SDNN) was the only time-related measurement recorded in this study. Power analysis components involving low frequency (LF), high frequency (HF), LF/HF ratio, and total power were also recorded.[18]

Statistical analysis

Pre- to postadjustment changes were analyzed by Student repeated-measures *t* test (<.05). Clinical effect (mean 1 − mean 2/SD of mean 1) was also used in the interpretation of data. Clinical effect is a measure of the strength of the relationship between 2 variables. Statistical significance tells how likely it is that an observed finding could have occurred by chance, whereas effect size measures the magnitude of a treatment effect.[19]

Protocols

The first 2 visits established preadjustment/baseline findings including BP, pulse rate, and HRV. Participants were assigned to a group based on their subluxation findings determined by the assessment protocol (previously described in “Methods”). On the third and fourth visits, each subject received an adjustment to either a cervical or thoracic segment, as indicated. The fifth visit consisted of recording postadjustment findings. The time between preadjustment and postadjustment visits was 1 week. Postadjustment BP, pulse rate, and HRV components were determined among subjects and compared with their respective preadjustment findings. The adjustment administered was either a supine diversified cervical adjustment or a prone diversified thoracic adjustment.

Results

Changes in pre- and postadjustment findings for the measured autonomic responses are shown in Tables 1 and 2.

Pulse rate and BP

The pulse rate did not vary significantly pre- to postadjustment between cervical- or thoracic-adjusted subjects. As well, systolic pressure showed no significant difference pre- to postadjustment in those subjects receiving either cervical or thoracic adjustments, nor between the groups (Table 1). However, diastolic pressure dropped significantly postadjustment among those receiving cervical adjustments (P = .038, Table 1).

Pulse pressure

Pulse pressure (systolic − diastolic) increased significantly among those receiving cervical adjustments (P = .044), but did not vary significantly among those receiving thoracic adjustments.

Heart rate variability

Among the 40 participants, only 7 of those receiving adjustments were also subjected to HRV analysis. Information relevant to the objective of this study regarding HRV is presented in Tables 1 to 3.

Among this group, the SDNN of normal R-R intervals showed an autonomic response in accordance with the segment adjusted. The SDNN in the group that was later to receive cervical adjustments was significantly lower (preadjustment, P = .021, Table 1) than that in the preadjustment group that would later receive thoracic adjustments. As well, the postadjustment values were also significantly lower in the cervical group than the thoracic group (P = .000, Table 1). Thus, overall, the SDNN in the group in which cervical adjustments were to be administered was significantly lower pre- and postadjustment when compared with that in the thoracic group pre- and postadjustment.

Total power

Total power revealed a similar profile (Table 1); that is, both pre- and postadjustment total power was significantly less in the cervical group in comparison with the thoracic group. As well, total power decreased,

Table 1 Changes in pre- to postadjustment findings in cervical vs thoracic regions in relation to various autonomic responses

Pulse Rate, BP Pulse Pressure	Cervical Segments	ES	Thoracic Segments	ES
N = 40	Mean ± SD		Mean ± SD	
Pre Pulse (beats/min)	69.6 ± 12.4	0.04	72.4 ± 9.0	0.06
Post Pulse (beats/min)	69.1 ± 7.6		71.9 ± 9.7	
Pre Systolic BP (mm Hg)	119.6 ± 13.3	0.03	117.3 ± 9.1	0.20
Post Systolic BP (mm Hg)	120.0 ± 9.9		115.5 ± 11.8	
Pre Diastolic BP (mm Hg)	80.9 ± 11.5	0.50	74.8 ± 11.1	0.30
Post Diastolic BP (mm Hg)	75.3 ± 11.2 * (*P* = .038)		77.8 ± 9.4	
Pre Pulse Pressure (mm Hg)	38.8 ± 7.4	0.82	41.0 ± 6.4	0.66
Post Pulse Pressure (mm Hg)	44.8 ± 8.2 * (*P* = .044)		36.8 ± 7.3	
HRV Findings				
n = 7				
Pre SDNN	65.6 ± 23.7	0.30	99.0 ± 31.4	0.05
Post SDNN	58.6 ± 14.9		97.3 ± 16.5	
Pre Cervical SDNN	65.6 ± 23.7			
Pre Thoracic SDNN			99.0 ± 31.4 † (*P* = .021)	
Post Cervical SDNN	58.6 ± 14.9			
Post Thoracic SDNN			97.3 ± 16.5 † (*P* = .000)	
Pre T Power	1211 ± 661.5	0.24	3174 ± 1509	0.35
Post T Power	1051 ± 484.6		2641 ± 732.8	
Pre Cervical T Power	1211 ± 661.5			
Pre Thoracic T Power			3174 ± 1509 † (*P* = .017)	
Post Cervical T Power	1051 ± 484.6			
Post Thoracic T Power			2641 ± 732.8 † (*P* = .000)	

Four participants were given cervical adjustments when indicated, and 3 were given thoracic adjustments. *Pre*, Preadjustment; *Post*, postadjustment; *T*, total.

* Significant differences were seen pre- to postadjustment after cervical adjustments in regard to a decrease in diastolic BP and increase in pulse pressure.

† Comparisons of group receiving cervical adjustments and group receiving thoracic adjustments.

although not significantly, postadjustment in both the cervical group and the thoracic group (Table 1).

LF/HF findings

Total power is a measure of total autonomic signal. The extent to which the sympathetic and parasympathetic outputs change or alter the sympathetic/parasympathetic balance, however, is recorded via the ratio of LF (sympathetic activity) to HF (parasympathetic activity). In this regard, LF/LH was decreased postadjustment in the cervical group and increased in the thoracic group (Table 2). Table 3 shows the extent of change in sympathetic and parasympathetic activity resulting in changes in ratio between the two (LF/HF). Observing the outcomes for each of the cervical group of 4, it can be seen that the decrease in ratio was, in each instant, a reflection of a greater increase or lesser decrease in the parasympathetic component as compared with sympathetic activity. All 4 participants received C1 cervical adjustments.

Among the 3 participants receiving thoracic adjustments, a similar, but reversed, pattern was observed. In each of the subjects, the increase in LH/HF ratio was increased because of a greater percentage increase in sympathetic activity or lesser percentage decrease in sympathetic activity. Two of the participants were adjusted at T1, whereas one received a T4 adjustment.

Effect size

The significant decrease in diastolic pressure among those receiving cervical adjustments was accompanied by a moderate (0.50) clinical effect (effect size [ES], Table 1). A large ES (0.82) accompanied the significant increase in pulse pressure observed among those receiving cervical adjustments, whereas the pulse pressure drop in those receiving thoracic adjustments

Table 2 Heart rate variability components demonstrating sympathetic and parasympathetic changes pre– to post–cervical or thoracic spinal segment adjustments

Components [†] n = 7	Cervical Segments Pre	Subjects Post	Age (y)	Time * (h)	Thoracic Segments Pre	Subjects Post	Age (y)	Time * (h)
T Power♂	524.4	434.7	44	48	874♂	2216	55	48
LF (s) [‡]	150.8	188.9			433	1301		
HF (p)	34.1	49.1			137	265		
LF/HF	4.40	3.90[a]			3.20	4.90[e]		
T Power♀	2630	1540	46	168	3701♂	1559	47	48
LF	1034	433			1659	406		
HF	746	681			1547	363		
LF/HF	1.40	0.60[b]			1.07	1.11[f]		
T Power♂	865	645	50	144	5868♀	4002	54	144
LF	369	274			1829	2062		
HF	141	192			3181	1308		
LF/HF	2.60	1.40[c]			0.60	1.60[g]		
T Power♀	746	825			53	48		
LF	214	241						
HF	263	494						
LF/HF	0.80	0.50[d]						

Data were derived from 4 participants given cervical adjustments when indicated and 3 given thoracic adjustments. Cervical adjustments were all C1, whereas thoracic adjustments were T1 for the first subject listed and T4 for the following two. Superscript letters *a* to *d* indicate that the decrease in LF/HF ratios represents a shift to increased parasympathetic activity (HF). Superscript letters *e* to *g* indicate that the increase in LF/HF ratios represents a shift to increased sympathetic activity (LF). *s*, Sympathetic activity; *p*, parasympathetic activity; T Power, total power.

* Time, in hours, between pre- and postadjustment HRV readings.
† Components of HRV. See "Methods" for descriptions.
‡ LF represents sympathetic activity; HF represents parasympathetic activity.

was not statistically significant; although the effect was moderate (0.66). Effect size for all other parameters (including HRV components of SDNN and total power) associated with those receiving cervical or thoracic adjustments were small to less than small.

Hence, although the HRV components of the SDNN and total power, both pre- and postadjustment (Table 1), exhibited statistically significant differences between the cervical compared with thoracic groups, those differences were accompanied by small clinical effects (ES).

Discussion

Autonomic specificity

Cervical adjustments

The data revealed a significant decrease in diastolic, but not systolic, pressure in those subjects receiving cervical adjustments. This observation has clinical applications because diastolic pressure has been shown to be a predictor separating patients with isolated vs essential hypertension.[19] In the present study, the significant reduction in diastolic pressure was also accompanied by a moderate clinical effect. Moreover, the decrease in diastolic pressure accounted for a significant increase in pulse pressure, which expressed a large clinical effect, but within normal limits.[18] This is likely explained, as it was also evident that, after cervical adjustments, parasympathetic activity was seen to dominate the LH/HF ratio. This could account for lessening of arterial constriction while increasing vasodilation. Although pulse pressure alone cannot be considered an adequate indicator without appropriate attention to both systolic and diastolic components, the pulse pressure finding plays a significant role in that either excessively high or low pulse pressures, commonly linked to changes in diastolic pressure, are considered risk factors for heart disease and premature death.[20]

HRV findings

In this study, the findings after a cervical adjustment were linked to an increase in parasympathetic

Table 3 Heart rate variability components demonstrating percentage sympathetic and parasympathetic changes pre– to post–cervical or thoracic spinal segment adjustments

Components *	Cervical Segments		% Change	Thoracic Segments		% Change
	Pre	Post		Pre	Post	
	Subjects			Subjects		
T Power♂	524.4	434.7		874♂	2216	
LF (s) †	150.8	188.9	0.67 ↑	433	1301	66.7 ↑
HF (p)	34.1	49.1	2.90 ↑	137	265	0.7 ↑
LF/HF	4.40	3.90[a]		3.20	4.90[e]	
T Power♀	2630	1540		3701♂	1559	
LF	1034	433	58.1 ↓	1659	406	75.5 ↓
HF	746	681	8.7 ↓	1547	363	76.5 ↓
LF/HF	1.40	0.60[b]		1.07	1.11[f]	
T Power♂	865	645		5868♀	4002	
LF	369	274	30.1 ↓	1829	2062	11.2 ↑
HF	141	192	26.5 ↑	3181	1308	58.9 ↓
LF/HF	2.60	1.40[c]		0.60	1.60[g]	
T Power♀	746	825				
LF	214	241	11.2 ↑			
HF	263	494	46.8 ↑			
LF/HF	0.80	0.50[d]				

Data were derived from 4 participants given cervical adjustments when indicated and 3 given thoracic adjustments. Cervical adjustments were all C1, whereas thoracic adjustments were T1 for the first subject listed and T4 for the following two. ↓ indicates a decrease in power spectrum signal; ↑ indicates an increase in power spectrum signal.

* Components of HRV. See "Methods" for descriptions.

† LF represents sympathetic activity; HF represents parasympathetic activity.

dominance. This was apparent when observing the changes occurring in pre- to postadjustment HRV total power that reflects the balance between LF (ie, sympathetic tone) and HF (e, parasympathetic tone). It was evident that, in each patient, the pre- to postadjustment decrease in LF/HF was due to either a larger increase in parasympathetic activity or a lesser decrease in parasympathetic activity when compared with sympathetic activity (Table 2). These findings are consistent with other studies that have linked upper cervical chiropractic adjustments to parasympathetic mediated regulatory systems.[1,4,5]

Thoracic adjustments

Among those individuals receiving thoracic adjustments, the findings indicated that the responses were sympathetic in nature. There were no statistically significant changes in regard to BP parameters. There was a substantial decrease in pulse pressure, although not statistically significant, accompanied by a moderate clinical effect. Consequently, because the clinical effect is a measure of the strength of the relationship between 2 variables rather than revealing how likely it is that an observed finding occurred by chance, in many cases, it is a better measure of research outcomes because indices are independent of sample size.[18]

Heart rate variability data revealed that total power, which is a measure of total autonomic signal, decreased substantially postadjustment. When considering the balance between parasympathetic/sympathetic activity (LF/HF), it was evident that, in each patient, the pre- to postadjustment decrease in LF/HF was due to either a larger increase in sympathetic activity or a lesser decrease in sympathetic activity when compared with parasympathetic activity (Table 2). These findings are consistent with other studies that have linked thoracic chiropractic adjustments to sympathetic mediated regulatory systems.[1,4,5]

Other HRV parameters

A significantly higher level of activity was observed between both pre- and postadjustment cervical SDNN when compared with pre- and postadjustment thoracic SDNN. In and of itself, this finding is not clinically significant because both groups were within the reference range of healthy subjects regarding SDNN.[18] Moreover, although both groups demonstrated decreases in SDNN activity postadjustment, these changes represented small clinical effects. However, a recent study showed a significant relationship between subjects' anxiety and low HRV, possibly explaining the significant readings.[21] This relationship existed independent of age, sex, heart rate, and BP. The present study showed a similar association between parameters of HRV, as changes occurred irrespective of sex, age, or time between pre- and postadjustments for recording the changes. Furthermore, people with low HRV were shown to have more stability in their HRV scores than healthy subjects.[21] Because the subjects in this study reported no health problems, this may explain a greater fluctuation in the SDNN and total power levels of activity.

The observations of this study suggest that cervical adjustments could manifest a shift to parasympathetic dominance, whereas thoracic adjustments could manifest a shift to sympathetic dominance. Furthermore, these responses, sometimes significant and other times yielding a moderate to large clinical effect (ES), but not statistically significant, serve collectively to further suggest a specificity of autonomic responses in relation to the segment(s) adjusted. An additional observation is that, because of the large range of normal in regard to the components of HRV, significant change can occur while the results are still within reference range, thus leading to misinterpretations of significant changes, when in fact they may be normal adaptive responses to an external force. This study was limited by the fact that, out of 40 subjects, only 7 received HRV analysis. Because most of the information regarding parasympathetic/sympathetic balance arise from that assessment, it will be imperative that future studies use this technology.

Conclusion

Future study requires randomized trials with a larger population receiving adjustments and with all participants being assessed with HRV recordings. Because most of the subjects in this study exhibited normal reference ranges in the parameters studied, future study should also include subjects with predetermined dysfunctional autonomic tone.

In summary, we found that diastolic pressure dropped significantly postadjustment among those receiving cervical adjustments, which was accompanied by a moderate (0.50) clinical effect (ES), and that pulse pressure (systolic − diastolic) increased significantly among those receiving cervical adjustments, accompanied by a large ES (0.82). Although the decrease in pulse pressure for those receiving thoracic adjustments was not statistically significant, the decrease was accompanied by a moderate ES (0.66). When LF/HF dropped in the cervical group, it was due to either a larger increase or a lesser decrease in parasympathetic activity when compared with sympathetic activity. The converse relationship was observed in the group receiving thoracic adjustments. This study could have the benefit of leading to a better understanding of the effects of chiropractic adjustments and autonomic responses regarding organ dysfunctions in general.

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