Effect of Chiropractic Care on Heart Rate Variability and Pain in a Multisite Clinical Study

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Abstract

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 $\pm$ 2.2 to 2.1 $\pm$ 2.0 ($P < .001$). The mean heart rate reduced from 76.7 $\pm$ 12.7 to 74.3 $\pm$ 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 $\pm$ 968 to 444 $\pm$ 1069 ($P < .01$), the low-frequency component increased from 403 $\pm$ 753 to 465 $\pm$ 755 ($P < .05$), and the total power increased from 1063 $\pm$ 1886 to 1265 $\pm$ 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. (J Manipulative Physiol Ther 2006;29:267-274)

Key Indexing Terms: *Heart Rate; Chiropractic; Manipulation; Spinal*

The autonomic nervous system involuntarily controls the functions of the body systems. There are 2 branches of the autonomics, the parasympathetic nervous system (PNS) and the sympathetic nervous system (SNS), that work as antagonists in their control of the body systems. One target of the autonomic nervous system is the heart rate (HR). Heart rate variability (HRV) analysis has been used extensively as a measurement of fitness level, and recent studies now indicate that it may be a useful tool in detecting and following disease processes. Heart rate variability analysis determines the balance between PNS and SNS using time and frequency domain measurements.[1,2]

Heart rate variability has been used clinically to determine the balance of the autonomic nervous system.[1-4] The HRV was measured by the beat-to-beat variation in R-R intervals of the heart beats recorded by an electrocardiogram (ECG).[5-8] The time and frequency domain analysis is commonly used in the HRV analysis. This study uses SD of normal-to-normal (SDNN) and square root of the mean squared differences (RMS-SD) for time domain analysis and total power, high-frequency (HF), low frequency (LF), and very low frequency (VLF) for frequency analysis. Time domain is the easiest to measure and is done with all noise heartbeats removed from analysis. Calculations of mean SDNN RMS-SD are associated with fast parasympathetic variability. Standard deviation of normal-to-normal (NN) reflects the overall variability over a specific time interval, but is also reliant on the time of recovery. With this measurement, either the HR or the intervals between successive normal complexes are determined. In a continuous ECG record, each QRS complex is detected and the NN intervals

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are also measured. The NN interval is defined as all intervals between adjacent QRS complexes resulting from sinus node depolarization. A standard spectral analysis is applied to the 5-minute interval, including total power, HF, LF, and VLF. High-frequency power is evaluated in the range of 0.15 to 0.4 Hz. This band represents PNS tone and fluctuations caused by spontaneous respiration known as respiratory sinus arrhythmia. Low-frequency spectrum is evaluated from 0.04 to 0.1 Hz and represents both SNS and PNS tone. The VLF is evaluated from 0.0033 to 0.04 Hz. Shorter recordings are related to negative emotions and worries. Total power is the net effect of all possible physiologic mechanisms contributing to HR variability that can be detected over 5 minutes. The LF/HF ratio is used to indicate balance between the SNS and PNS tone. Thus, a decrease in this score might indicate either an increase in PNS or a decrease in SNS tone.[9]

Power spectral density (PSD) provides the basic information of how power is distributed as a function of frequency. Only an estimate of the true PSD of the signals can be obtained through mathematical algorithms. Measurements can be measured by short-term or long-term components by the distribution of power and frequency further subdivided into high, low, and ultralow frequencies. Interference includes ectopic beats, arrhythmic events, missing data, and noise. Progressive beats and long-term readings can significantly reduce interferences.[9]

The mathematical transformation of HRV into PSD is commonly used as a noninvasive test of integrated neurocardiac function because it can distinguish sympathetic from parasympathetic regulation of the HR.[5] Recent studies suggested that HRV could be used to predict cardiovascular diseases.[10,11] From a random sample of 149 men and 137 women from the general population as well as from 129 consecutive patients with acute myocardial infarction, we report significant HRV differences in normal middle-aged population compared with patients of the same sex and age who had an acute myocardial infarction.[12] They found that all measures of HRV were significantly and substantially lower in patients with acute myocardial infarction than in the general population ($P < .001$).[12] The relatively lower LF power indicates an alteration of the sympathicovagal balance, and the significantly stronger correlation of HR with HRV may be indicative for a more pronounced effect of sympathetic activation on autonomic modulation in the case of myocardial infarction.[12]

Preliminary experiments suggest that the measurement of HRV can be used to monitor the effectiveness of chiropractic care.[13,14] However, a large-scale randomized trial is still lacking. These results led to the conclusion that a large-scale study was needed to gather more information on the ability of HRV to function as a tool to objectively measure patient response. The research question put forward for this study was whether normal chiropractic care in routine service would lead to changes in HRV. Therefore, the null hypothesis was that chiropractic care would not induce any changes in HRV both in a single visit and in a 4-week visit. The purpose of this multisite clinical study is to assess the autonomic nervous system activity before and after chiropractic treatment using a commercially available instrument and to compare those responses to other well-known objective measures of patient response to treatment.

Methods

Study Sites

Chiropractors from the United States were recruited in the study through alumni newsletters, subsequent follow-up letters to nonresponders, and contact with various chiropractic technique organizations. Interested physicians called back regarding participation in the study. Upon initial telephone conversation, all physicians were given a detailed description of the study and their study-related responsibilities if they chose to participate. Field practitioners were screened for their site's ability to conduct clinical research and their ability to recruit patients for this type of study. Eligible and interested study sites were identified and entered into the study. The recruitment process and the study protocol were approved through the institutional review board of the Logan College of Chiropractic, Chesterfield, Mo. All study subjects read and signed the approved informed consent documents before they underwent any study-related procedure. Each study site was provided appropriate sponsor-donated hardware and software, study documents (including case report forms), mailing envelopes, and floppy disks. Physicians collected HRV data at their private practices.

Subjects. Each participating physician was asked to randomly recruit a minimum of 10 subjects from their practice to participate in the study. Among the 10 subjects, 8 were monitored to collect HRV data before and after 1 chiropractic adjustment in a single visit. The other 2 subjects were followed for 4 weeks to collect HRV data once every week and were to be randomly chosen from a group whose treatment was scheduled to last at least 4 weeks after they began study-related procedures. If clinical study sites were interested in collecting data beyond the mandatory 10 study subjects, additional forms were provided.

Subjects were to be randomly selected from different racial, sex, and age groups into this study. Patients with bodily pain (either chronic or acute, including low back and/or neck pain and/or headache) were recruited into the study. Any individual with coronary heart diseases, uncontrolled hypertension, or other diseases such as osteoporosis or bony pathology or individuals for whom chiropractic care is contraindicated are excluded from the study. Individuals who did not comply with the written informed consent form were also excluded from the study.

Procedure. At each scheduled study-related visit to the chiropractor, patients checked in and were asked to sit for

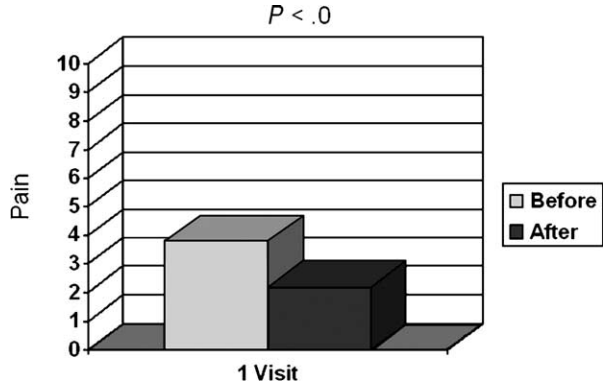

Fig 1. *Visual analog scale after 1 chiropractic visit (n = 625).*

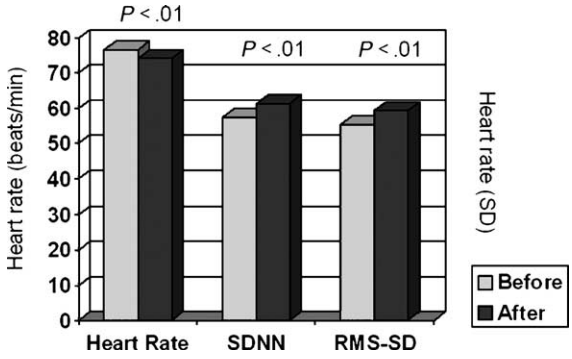

Fig 2. *Time domain analysis of HRV after 1 chiropractic visit.*

5 minutes in the room where the HRV measurements were made. During those 5 minutes, they filled out the pretreatment questionnaire. Patients then had a 5-minute HRV recording made. After completion of that day's chiropractic and associated treatments, patients were again asked to sit for 5 minutes. During those 5 minutes, they filled out the posttreatment questionnaire. They then had another 5 minutes of HRV recording made. After each study-related treatment session, the chiropractor who performed the treatment was asked to fill out a patient treatment questionnaire detailing the type and location of treatment given to the patient during that visit.

To insure quality data collection and data analysis, we applied 3 levels of quality control in the study. The first level was to control the data collection process using a quality control data management system. Once a physician was qualified for the study and issued an active ECG scanner (Biocom Technologies, Poulsbo, Wash), a study handbook was mailed to the physician. In the study handbook, 10 sets of data sheets were included, such as the consent form, the pain questionnaires, and the physician's treatment and HRV recording logs. Two postage-paid envelopes were included in the handbook for physicians to send their initial 2 patients' information back in the first envelope and to send all additional data back in the second envelope. All sites were then required, before they could start collecting data, to complete a study initiation procedure. This involved 1 of 3 methods: (*a*) the chiropractor came to the college for training in study procedures and equipment use, (*b*) personnel from the lead site went to study sites to train personnel, or (*c*) study personnel at sites were trained via a conference call. Once the data collection quality was determined to be acceptable from the initial 2 patient samples from each clinic, a call was made to the physician indicating that the site could continue work on the remaining patients. If the data for the quality control purpose were not acceptable, a phone call would tell physicians how to solve those problems.

The second level of quality control was to control the noise in the ECG recordings after data had been collected. In many cases, the researchers asked the physicians to try several tactics to remove the noises in the ECG signal, such as cleaning the skin before attaching the electrodes, removing the power cord from a laptop computer, changing the electrode placement, and keeping the subject still while taking the HRV recording. After applying these methods, the noise was usually reduced significantly. The third level of quality control was to clean the data after it was collected. This cleaning involved checking all ECG tracings to make sure that abnormal spikes that did not assemble to normal QRS complexes were removed from the recordings.

Heart rate variability. MedPond's active ECG scanner (Seattle, Wash) was used in the HRV data collection with digital signal processing software. The active ECG records an electrocardiograph signal, computing the instantaneous changes of HRV after each recording session. The active ECG unit connects to the subject through 3 small electrodes that attached to left arm, right arm and left leg. Eight subjects had pre- and posttreatments given for 1 visit only and 2 subjects had HRV measurements made at least twice a week for 4 weeks. A baseline HRV was recorded before treatment was given. The HRV recording was always taken in the sitting position for 5 minutes.

Pre- and posttreatment questionnaires and forms. All forms were provided to the site in a study binder. Originals were returned to the lead site and copies were kept by each study site, except for the consent form that was not duplicated and was kept at the study site. All forms were time and date stamped, and all forms contained the unique study subject identification number and were dated and initiated by study personnel once completed. Patients were assigned a study identification number and were identified by that identification number on all forms. All forms were date and time specific so that the chronology of treatment and HRV recordings could be checked.

Pain measures included the patients' perceived level of pain, measured with the visual analog scale (VAS).[15,16] The VAS is a 10-cm line on which the patient places a single "X" to record the amount of pain perceived. The VAS is scored by measuring the distance from the left end of the

Table 1. *Descriptive HRV in 1 adjustment group*

					95% confidence interval for mean			
		n	Mean	SD	Lower bound	Upper bound	Minimum	Maximum
HR	1	511	76.7	12.7	75.6	77.8	49.1	117.3
	2	507	74.3	12.4	73.2	75.3	47.4	117.4
	Total	1018	75.5	12.6	74.7	76.3	47.4	117.4
RR	1	511	803.3	131.0	792.0	814.7	511.6	1221
	2	507	830.4	134.5	818.6	842.1	510.9	1265.4
	Total	1018	816.8	133.3	808.6	825.0	510.9	1265.4
SDNN	1	467	57.4	47.6	53.1	61.8	6.7	307.7
	2	462	61.5	49.5	57.0	66.1	6.7	317
	Total	929	59.5	48.5	56.3	62.6	6.7	317
RMS-SD	1	467	55.4	72.4	48.9	62.0	4.7	558.2
	2	462	59.5	73.5	52.8	66.3	1.8	518.9
	Total	929	57.5	72.9	52.8	62.2	1.8	558.2
TPOWER	1	511	1216.2	2359.5	1011.1	1421.3	10.4	18270.4
	2	507	1341.5	2310.5	1139.9	1543.1	11.4	21389.1
	Total	1018	1278.6	2334.9	1135.0	1422.2	10.4	21389.1
VLF	1	511	319.8	496.8	276.7	363.0	5	5872.3
	2	507	359.6	514.9	314.7	404.5	8.7	5454.9
	Total	1018	339.6	506.1	308.5	370.8	5	5872.3
LF	1	511	446.1	869.9	370.5	521.7	2.2	6773.4
	2	507	488.8	834.9	415.9	561.6	1.9	7494.6
	Total	1018	467.3	852.5	414.9	519.8	1.9	7494.6
HF	1	511	448.0	1283.1	336.5	559.5	1.1	10829.6
	2	507	485.7	1199.7	381.0	590.4	0.8	8439.7
	Total	1018	466.8	1241.8	390.4	543.2	0.8	10829.6
LF NORM	1	511	62.9	20.5	61.1	64.7	7.3	98.2
	2	507	61.2	21.0	59.3	63.0	8.8	98.5
	Total	1018	62.0	20.8	60.8	63.3	7.3	98.5
HF NORM	1	511	36.7	20.4	34.9	38.5	1.8	92.7
	2	507	38.5	21.0	36.7	40.3	0.6	91.2
	Total	1018	37.6	20.7	36.3	38.9	0.6	92.7
LF/HF	1	511	3.3	4.4	2.9	3.7	0.1	53.3
	2	507	3.1	4.6	2.7	3.5	0.1	67.6
	Total	1018	3.2	4.5	2.9	3.5	0.1	67.6

n, Number of observations; *NORM*, normalized; *RR*, R-R interval; *TPOWER*, total power.

line to the X and is scored out of a possible 10. In the present study, the VAS was administered at baseline and after chiropractic adjustment.

All continuous data were expressed in mean ± SD and confidence intervals. Student *t* test and analysis of variance (ANOVA) were used for comparisons of continuous variables measured in the study in the single-visit and 4-week groups. Student *t* test was used for VAS analyses. A probability of less than .05 was considered significant. The statistical program SPSS version 11.5 (SPSS Inc, Chicago, Ill) was used for all data analysis.

Results

Data completed from 96 physicians were cleaned and divided into single-visit and 4-week groups. The average age of the patient population (n = 539, 309 women and 170 men; some did not report their sex) in the single-visit group was 46 ± 15 years old. After 1 chiropractic adjustment, pain as analyzed by VAS was reduced from 3.7 ± 2.2 to 2.1 ± 2.0 ($P < .001$) (Fig 1). Statistically significant changes were also found in HRV analysis in HR, SDNN, RMS-SD (Fig 2, Table 1), HF, LF, and total power (Fig 3). The mean HR was reduced from 76.7 ± 12.7 to 74.3 ± 12.4 ($P < .01$), the SDNN increased from 57.4 ± 47.6 to 61.5 ± 49.5 ($P < .001$), the HF increased from 448 ± 1283 to 485 ± 1199 ($P < .01$), the LF increased from 446 ± 869 to 488 ± 834 ($P < .05$), and the total power increased from 1216 ± 2359 to 1341 ± 2310 ($P < .01$).

In the 4-week group, the average age of the patient population (n = 111 subjects, 95 women and 37 men) was 43 ± 16 years old. After 4 weeks of chiropractic adjustments, the VAS was reduced significantly before and after each visit, as determined by *t* tests, but the significant changes were not found using ANOVA (Fig 4). The reduction of pain from each treatment was not maintained to the next visit or over the 4-week period. The ANOVA analysis on the HRV 4-week data found changes in the SDNN, total power, VLF, and LF components that reached statistically significant levels ($P < .05$) (Figs 5 and 6,

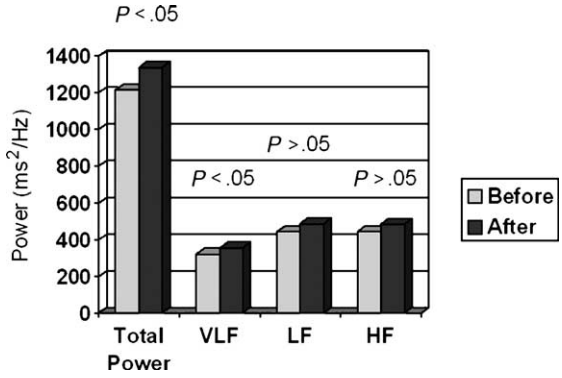

Fig 3. *Frequency analysis of HRV after 1 chiropractic visit.*

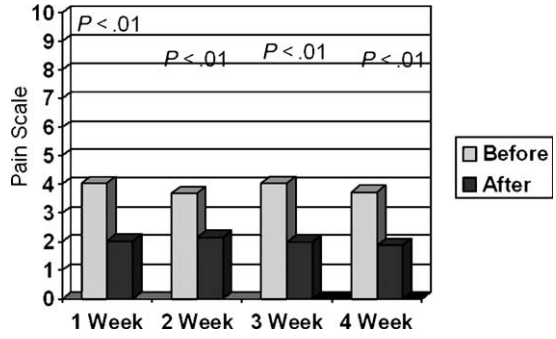

Fig 4. *Visual analog scale after 4 chiropractic visits (n = 132).*

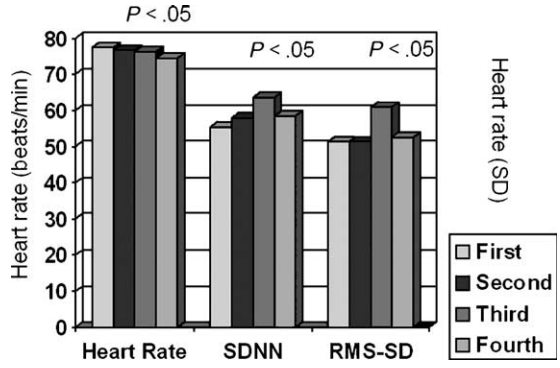

Fig 5. *Time domain analysis of HRV on 4 weeks of chiropractic visits.*

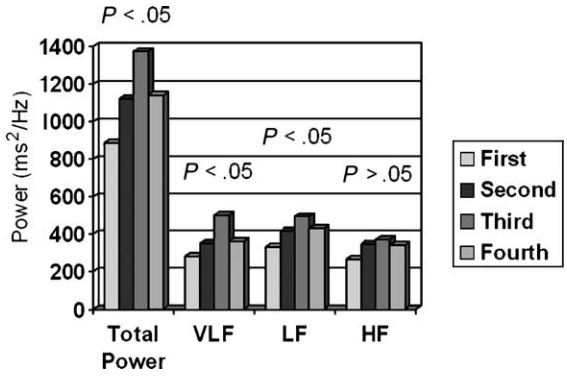

Fig 6. *Frequency analysis of HRV on 4 weeks of chiropractic visits.*

Table 2). The HR and the HF component did not change significantly ($P > .05$).

As a control for our studies, we examined the resting pre- and post-HRV of 157 subjects at a chiropractic college who were not recruited because of pain or discomfort. The average age of the control subjects was 30 ± 7.176 years old. Statistically significant changes were not found in HRV analysis in HR from 78.0 ± 11.922 to 76.8 ± 11.066 ($P > .05$), total power, HF, and LF (Fig 7).

The most widely used chiropractic technique in the study as reported by participating physicians was diversified adjustment (60.55%), followed by activator (11.19%) (Table 3).

Discussion

The chiropractic care group showed a significant improvement in HRV on both the single-visit and the 4-week visit groups, but not in the control group. Therefore, the null hypothesis was rejected.

The data collected show promise for HRV analysis as a tool used in chiropractic care. This finding is comparable to studies in related areas. One study examined the effect of moderate exercise on 88 sedentary postmenopausal women in a randomized controlled trial who were assigned to exercise (n = 49) or control (n = 39) groups.[17] The exercising women performed 8 weeks of aerobic exercise training at an HR equivalent to 50% of $\dot{V}O_2$max, consisting on average of 44 minutes per session, 3 to 4 times per week. The study found that after 8 weeks, women assigned to the exercise group increased all absolute time and frequency domain indexes and reduced resting HR compared with women in the control group. The LF and HF components expressed as normalized units remained unchanged after exercise intervention. They conclude that moderate aerobic exercise increases HRV in sedentary postmenopausal women.[17] It was interesting to note that this 8 weeks of exercise produced HRV changes similar to those that we found in our study with 4 weeks of chiropractic care.

Despite the significant reduction in HR in both treatment periods, it was noted that the reduction in HR was within just a few heart beats and did not seem to have any clinical significance to an individual patients. However, if this reduction is true, it will provide long-term benefit to the patients. Because this study used 1 adjustment and 4 weeks of adjustment, it is possible that longer-term treatment period may produce greater HR diminishment.

The reduction in pain before and after chiropractic care was similar to other studies that reported pain reduction after chiropractic adjustment.[18-20] In this study, subjects were not recruited because of pain. Indeed, many of the subjects were

Table 2. *Descriptive HRV in the 4-week care group*

					95% confidence interval for mean			
		n	Mean	SD	Lower bound	Upper bound	Minimum	Maximum
HR	1	111	77.4	12.0	75.1	79.7	53	113.7
	2	110	75.2	11.7	73.0	77.4	53.4	109.3
	3	109	76.7	12.1	74.4	79.0	50.4	124.1
	4	108	76.1	11.7	73.9	78.4	53.8	117.8
	Total	438	76.4	11.9	75.3	77.5	50.4	124.1
RR	1	111	796.2	121.1	773.4	819.0	527.6	1131.3
	2	110	816.3	123.4	793.0	839.6	549.2	1124.2
	3	110	799.8	120.2	777.0	822.5	483.6	1191.2
	4	108	870.6	680.2	740.9	1000.3	509.4	7766
	Total	439	820.4	353.5	787.3	853.6	483.6	7766
SDNN	1	103	49.6	21.7	45.4	53.8	13.5	115.3
	2	102	55.6	35.2	48.7	62.5	18	270.2
	3	99	58.0	37.1	50.7	65.4	15	205.7
	4	97	63.6	44.3	54.7	72.5	17.2	254.2
	Total	401	56.6	35.6	53.1	60.1	13.5	270.2
RMS-SD	1	103	42.3	28.5	36.7	47.9	10.1	177.7
	2	102	50.6	60.2	38.8	62.4	12.8	518.9
	3	99	51.4	54.7	40.5	62.3	8.8	355.2
	4	97	60.8	70.8	46.6	75.1	12.9	465.5
	Total	401	51.1	55.7	45.7	56.6	8.8	518.9
TPOWER	1	111	732.7	574.2	624.7	840.7	38.2	2972.6
	2	110	873.8	1097.6	666.4	1081.2	67.5	8604.4
	3	110	1122.4	1525.7	834.1	1410.7	41.3	10 554.5
	4	108	1373.6	2017.7	988.7	1758.4	48.8	10 839.8
	Total	439	1023.4	1419.9	890.2	1156.5	38.2	10 839.8
VLF	1	111	257.5	238.1	212.7	302.3	2.1	1385.5
	2	110	284.7	232.4	240.8	328.7	5.4	1007.4
	3	110	351.7	438.2	268.9	434.5	11.1	3206.5
	4	108	502.2	871.6	335.9	668.4	20.4	5865.3
	Total	439	348.1	519.6	299.4	396.9	2.1	5865.3
LF	1	111	290.8	279.3	238.2	343.3	6.8	1290.7
	2	110	339.0	450.4	253.8	424.1	6.7	3508.8
	3	110	418.7	525.0	319.5	518.0	5.9	2804.2
	4	108	496.8	669.5	369.1	624.5	9.2	3467.5
	Total	439	385.6	504.3	338.3	432.9	5.9	3508.8
HF	1	111	183.5	235.2	139.2	227.7	1.6	1250.9
	2	110	246.0	562.3	139.8	352.3	9.3	4088.2
	3	110	349.5	749.2	208.0	491.1	4.3	4543.8
	4	108	372.6	701.8	238.7	506.4	2.8	4290.8
	Total	439	287.3	598.8	231.1	343.4	1.6	4543.8
LF NORM	1	111	63.1	21.2	59.1	67.1	13	96.8
	2	110	62.5	19.8	58.8	66.3	6.4	97.6
	3	110	64.8	19.8	61.1	68.5	15	96.5
	4	108	64.2	17.9	60.8	67.7	23.2	94
	Total	439	63.7	19.7	61.8	65.5	6.4	97.6
HF NORM	1	111	36.6	21.3	32.6	40.6	3.2	87
	2	110	36.5	19.7	32.7	40.2	2.4	93.6
	3	110	34.6	19.8	30.9	38.4	3.5	85
	4	108	35.3	18.0	31.9	38.7	6	76.8
	Total	439	35.8	19.7	33.9	37.6	2.4	93.6
LF/HF	1	111	3.3	4.0	2.5	4.0	0.1	30.4
	2	110	3.4	5.0	2.4	4.3	0.1	40.3
	3	110	3.5	4.3	2.7	4.3	0.2	27.7
	4	108	3.0	3.0	2.4	3.6	0.3	15.7
	Total	439	3.3	4.1	2.9	3.7	0.1	40.3

n, Number of observations; *NORM*, normalized; *RR*, R-R interval; *TPOWER*, total power.

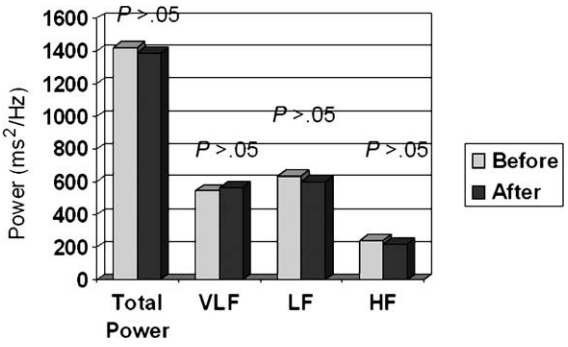

Fig 7. *Frequency analysis of HRV on the control group.*

asymptomatic. Nevertheless, the pain reduction still reached a statistical significance in the single-visit group (Fig 1). The 4-week group also showed pain reduction after each chiropractic visit. It was observed that the initial pain reported on the VAS in the 4-week group was higher than the single-visit group (4.035 VAS) (Fig 4). This higher initial pain might simply reflect why these subjects were seeking long-term chiropractic care. All pain was reduced with each chiropractic treatment, but the pain recurred by the time of the following visit. Thus, each chiropractic treatment resulted in transient pain reduction, but a course of 4 treatment weeks was not sufficient to maintain the pain relief. It has been reported that low back pain was reduced and sustained in a 4-year study of chiropractic and medical patients.[18] In this study, the authors found that most improvement was seen by 3 months of treatment, and this improvement was sustained for 1 year. They concluded that their findings were consistent with systematic reviews of the efficacy of spinal manipulation for pain and disability in acute and chronic low back pain.[18]

In the current study, the results were based on several different chiropractic adjustment techniques. The most widely used chiropractic technique in the study as reported by participating physicians was diversified technique (Table 3). The second most common technique used in the study was activator methods. Because of the higher percentage of physicians using diversified and activator adjustments, it might be safe to assume that the major effect of this study came from these 2 techniques on pain reduction and increased HRV.

The most frequently found problem in the physician's data file for quality control was the missing HRV data in the computer disk and the noise in the ECG recording. The second most frequently found problem was the erratic ECG signals in some of the recordings. It was found that 1 or 2 abnormal QRS complexes could cause the total power to jump 5% to 10% higher in value. To prevent the noise signal from affecting the final results, we applied data cleaning at the end of the study. All 5 minutes of ECG tracings were checked by a researcher minute by minute to remove erratic noise signals that did not resemble normal QRS complexes.

Table 3. *Chiropractic techniques used by the field physicians in the study*

Technique used	Rank	Frequency	Percentage
Diversified	1	330	60.55
Activator	2	61	11.19
Gonstead	3	53	9.72
Toftness	4	32	5.87
Logan	5	20	3.67
SOT	7	9	1.65
Upper cervical	8	8	1.47
Others	6	32	5.87
Total		545	100

SOT, sacro-occipital technique.

The researchers believed that the quality control of the HRV data played an important role in the integrity of the findings.

This study suggests that HRV may be a good quantitative outcome assessment tool for monitoring patients' autonomic nervous system activity in chiropractic care. Our short-term study now points toward the need for a long-term HRV study on the effect of chiropractic adjustments.

Conclusions

This multiclinic study of HRV showed increased HRV and reduced pain measured by the VAS after a single chiropractic adjustment. Similar findings were also seen in the 4-week group, except that the pain reduction was transient instead of a gradual reduction of pain over the 4 weeks of chiropractic adjustments. Heart rate variability measurements using the active ECG scanner appeared to be a good outcome assessment tool for monitoring patients' autonomic nervous system activity.

Biocom Technologies, Poulsbo, Wash, provided the HRV scanners and software.

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