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Heart Rate Variability Following Spinal Adjustment: A Practice-Based Study

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Abstract

Background: The autonomic nervous system (ANS) plays a major role in governing health and adaptability because it controls many vital functions. Consequently, it is important that the governing system itself remain healthy to respond with precision to internal and external challenges. A gold standard test for ANS health is heart rate variability (HRV).

In the traditional chiropractic model, improving neuro- adaptability through spinal adjustment is a core objective. Emerging research suggests that chiropractic spinal adjustment improves ANS health, evidenced by improved (increased) HRV. In this study the author analyzed HRV before versus immediately after spinal adjustment that he provided to a group of his patients to see if they too experienced improved neuro-adaptability.

Methods: Sixteen consecutive and consenting patients from the author's chiropractic practice participated in the study. Pre-adjustment HRV (rMSSD) findings were compared to their post-adjustment HRV findings using the paired t test and effect size statistics.

Results: Mean HRV increased (improved) by 5.7 milliseconds, a change that was statistically significant ($p = 0.02$) with a large effect size (of 0.5).

Conclusion: In this study, a neurological benefit was gained by this group of patients in the form of improved autonomic nervous system function and adaptability, evidenced by improved heart rate variability. Further study with a larger group of patients and a longer period of time for follow-up is a reasonable next step.

INTRODUCTION

The autonomic nervous system (ANS) controls many vital functions including heart rate. By controlling vital functions, the ANS is a major contributor to a key element of good health: adaptability. Controlled by the medulla oblongata in the ANS, heart rate is mediated by two different nerve supplies: A parasympathetic supply which decreases the rate as needed, and sympathetic supply which increases the rate as needed. Consequently, heart rate has a natural and healthy variation of time between beats. This variability reflects a coordinating effort by the ANS to respond to internal and external challenges to the body. These challenges occur even in the resting state.

Improvement in ANS adaptability is a key factor in improving one's health. [1] Additionally, research indicates that a healthy ANS, evidenced by a healthy HRV test result, is a prerequisite for healthy longevity. [2] Thus, HRV is an important method for assessing ANS adaptability. [2] Moreover,

> "The autonomic nervous system plays a major role in human homeostasis. Autonomic dysfunction and altered HRV are observed in many life-threatening conditions, like myocardial infarction, multiple organ dysfunction syndrome, sepsis and severe brain injuries." [3]

In general, a higher amount of HRV is better (healthier) than a lower amount. [3] (As a side-note, this is the opposite of resting heart rate, where a lower value is healthier than a higher value [4].) The higher amount of HRV there is, the more adaptive the ANS is, thereby allowing better responses (greater adaptability) to imposing challenges.

To visually illustrate the clinical significance of HRV, Figures 1 and 2, based on other published studies, show that higher HRV is associated with better health. Figure 1 compares HRV in two groups: a *non-hypertensive* group (N-HP) versus a *hypertensive* group (HP). Compared to the hypertensive group, the non-hypertensive group had a higher (better) HRV ($p < 0.05$). The rMSSD in the figures is a time domain HRV statistic and is a calculation of the root mean square of successive differences between heart beats. A higher rMSSD reflects a higher amount of HRV. In the present study, the terms *rMSSD* and *HRV* are used interchangeably.

Figure 1

From reference #5.

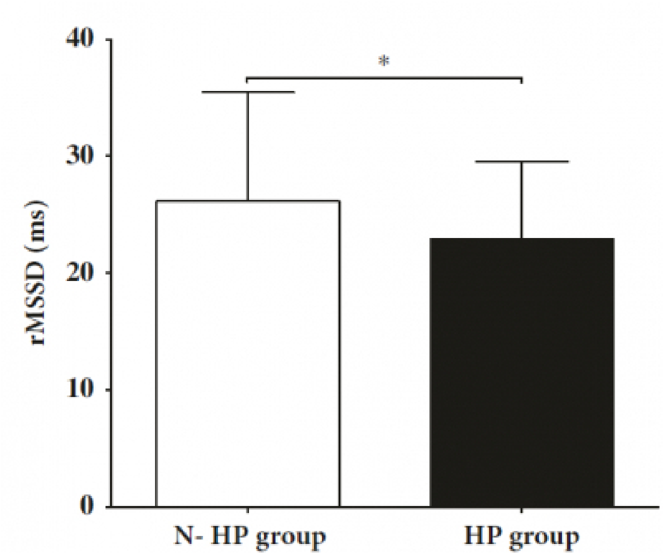
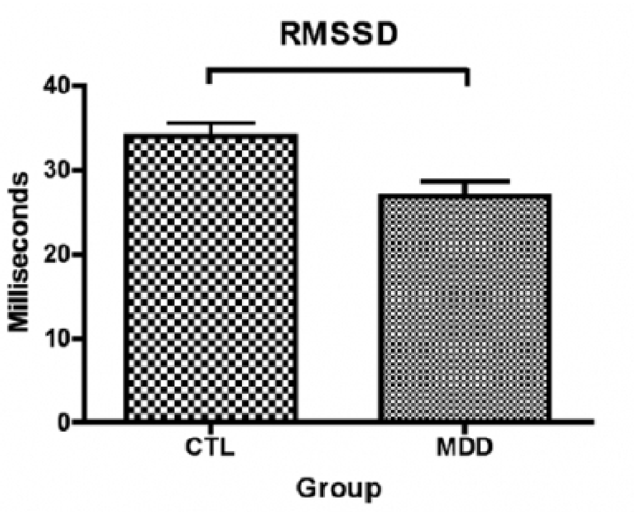


Figure 2 is from a study on HRV and mental health, in particular, major depressive disorder (MDD). Those in the control group (CTL), who did not have the depressive disorder, had a higher (better) HRV compared to those with the depression ($p = 0.003$). [6]

Figure 2

From reference # 6.



Chiropractic application

In the traditional chiropractic model, adjustment of a condition known as *vertebral subluxation* is a core objective. [7] This condition occurs when a vertebra gets jolted slightly out of position (e.g., from a fall or bump to the head or neck) and disturbs nearby spinal nerves and/or spinal cord. A subluxation can disturb different aspects of the nervous system, including the ANS. It has long been theorized that the subluxation ultimately interferes with the body's ability to adapt. [8] Thus, the traditional purpose of chiropractic spinal adjustment is to correct neurological disturbance with ultimate goal of improving adaptability.

HRV is a good fit for the neurologically-focused practice such as in the traditional chiropractic model because it (HRV) is: a) neurologically-based (a clinician-centered consideration) and b) supported by outcomes research (a patient-centered consideration). HRV helps the author in his practice to determine: a) whether or not his patient needs a spinal adjustment, and b) amount of neurological progress his patient is making.

Purpose of the study

The purpose of the study was to investigate HRV changes immediately following spinal adjustment (in one office visit) for a small group of patients from the author's chiropractic practice. The null hypothesis was that HRV would not change following spinal adjustment while the alternative hypothesis was that HRV would change.

METHODS

Sample

Beginning October 25, 2018, consecutive and consenting patients were recruited from the author's practice. All invited patients consented and participated. This date (10-25-18) was when the author introduced HRV research protocols to his practice. Recruitment of patients continued until a statistically significant HRV difference was achieved when comparing pre- versus post-adjustment HRV. To this end, a total of 16 patients were recruited. This number of patients is similar to the number of patients in an HRV study conducted by researchers at the UCLA School of Medicine, where 18 patients participated. [9]

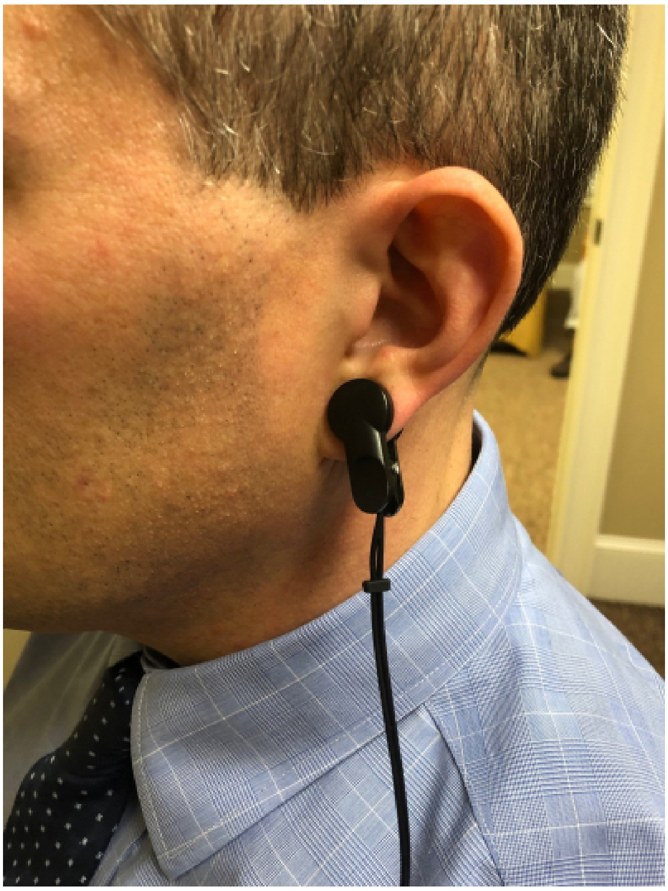
Some patients were new to the author's practice while others were established patients. In either case, their first visit on or after the aforementioned date (of 10-25-18) was used for the study, thereby preventing patients from being "cherry-picked." Patients typically sought care for symptomatic relief of neuro-musculo-skeletal type symptoms.

HRV measurement

HRV was measured with: a) the App-based technology, *Heart Rate Variability Logger*. [10] A customized version of the App has shown good agreement with ECG technology; [11] and b) a sensor used with the App, the *Kyoto* ear clip (Figure 3) which senses blood volume changes using the optical technology of photoplethysmography (PPG). The sensor then sends a Bluetooth signal to the App. The Kyoto ear clip correlates strongly ($r > 0.900$) with ECG-based HRV. [12]

Figure 3

Ear clip sensor.



In accordance with standard protocols, patients rested in the seated position for a minimum of 5 minutes prior to their seated 1 minute measurement. App settings included: a) 60 second recording length, which agrees well with the standard 5-minute recording; [13] and b) 20% R-R filter per developer recommendations, to remove potential artifacts (e.g., motion and ectopic beats). [10] The office visit consisted of approximately 15 minutes and included the pre HRV measurement, adjustment, and post HRV measurement.

As mentioned above, the HRV statistic used was a time-domain measure: the root-mean square difference of successive R-R intervals (rMSSD), measured in milliseconds (ms). A higher rMSSD value reflects a greater (healthier) HRV compared to a lower value. [14] This statistic (rMSSD) is one of the main measures used in HRV research and practice and seems to the author to be the most reliable for his patients. The terms *rMSSD* and *HRV* are used interchangeably in the study.

As an example of App usage, Figures 4a-4c show heart rate screen shots of the Heart Rate Variability Logger software for a typical patient during a single visit where an adjustment was given. The patient had two readings immediately prior to an adjustment (Figures 4a and 4b). Both of these pre-adjustment readings show essentially the same low HRV value: 16.0 ms and 16.2 ms. Normal rMSSD for this patient is 19.0 ms to 28.0 ms [15-16] A post-adjustment HRV reading was taken approximately 1 minute after the adjustment and shows a substantial increase (improvement) in HRV, to 27.5 ms (Figure 4c). From a visual standpoint, the amount of "bumpiness" on the top part of the readings in these figures (e.g., area above horizontal line in Figure 4a) gives a rough idea on the amount of HRV, where more bumpiness represents more variability. The two pre-adjustment readings have some bumpiness while the post-adjustment reading has a bit more bumpiness (more variability). The greater HRV is substantiated by the marked numerical increase in the post-adjustment measurement (to 27.5 ms).

Figure 4a

(pre-adjustment 1) HRV = 16.0 ms

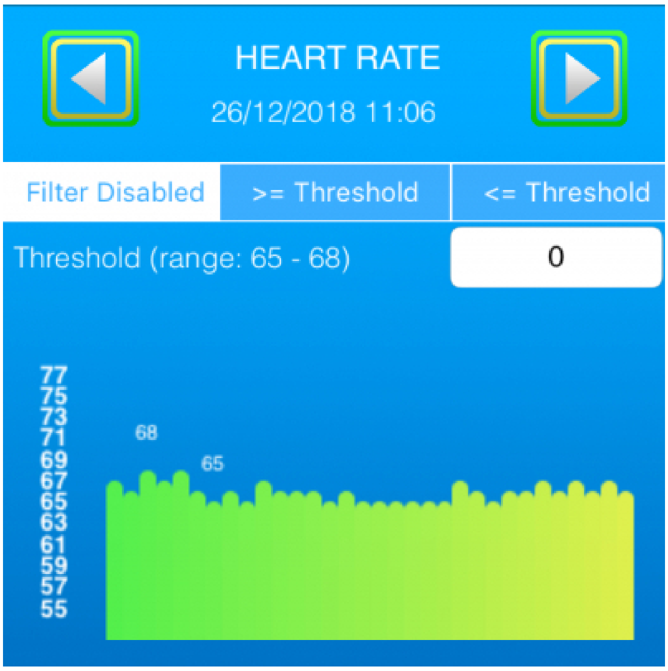


Figure 4b

(pre-adjustment 2) HRV = 16.2 ms

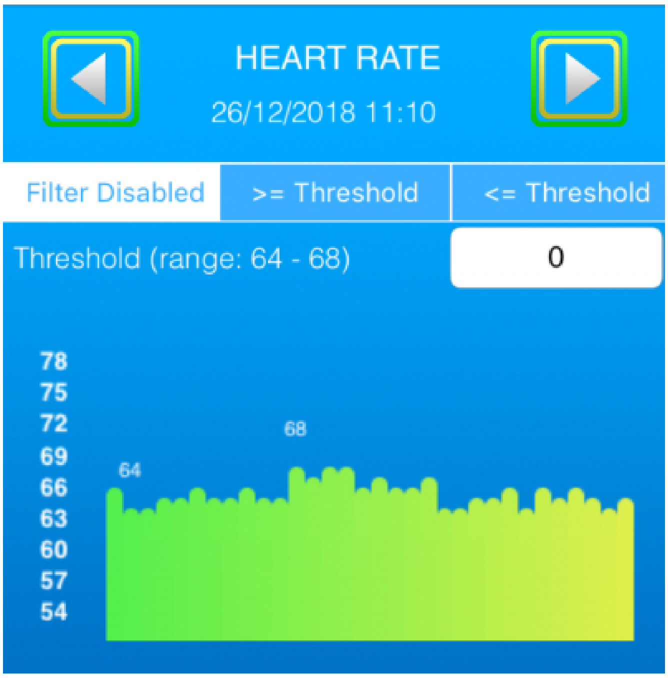
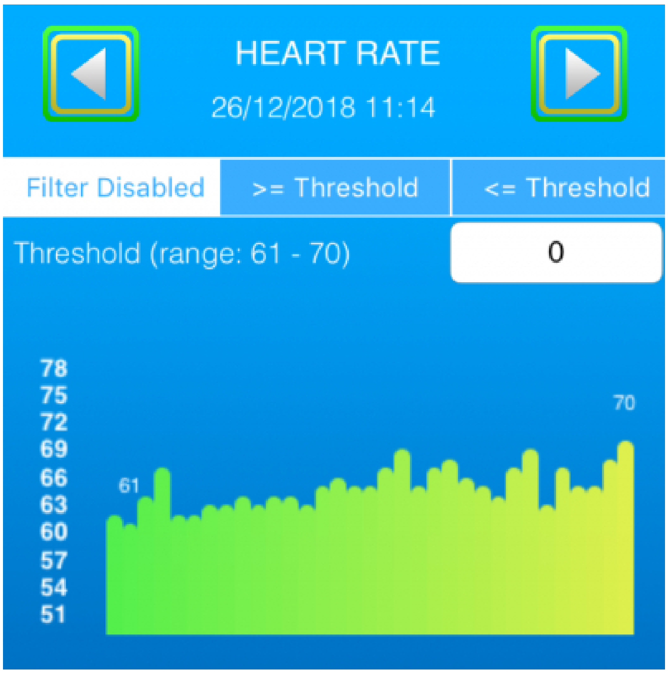


Figure 4c

(post-adjustment) HRV= 27.5 ms



Spinal analysis and adjustment

Spinal adjustment was the only intervention in the study and was given by the author based on evidence of neurological disturbance and vertebral misalignment (the two main components of vertebral subluxation). Neurological disturbance was diagnosed based on at least one of the following that showed compelling evidence of autonomic dysfunction: a) skin temperature pattern analysis, [17] b) resting heart rate, [18-19] and c) HRV. [15-16] Misalignment was diagnosed using manual palpation and, in some cases when necessary, digital x-ray.

Statistical analysis

HRV readings *prior* to the adjustment ("pre") for the 16 patients were compared to their HRV readings approximately 1-5 minutes *after* the adjustment ("post"). Probability plots for both pre and post HRV indicated acceptable normal distribution. Thus, the paired t test was considered appropriate for this study and was performed in Stata 12.1 (StataCorp, College Station, Texas). A two-tailed p-value less than the conventional significance level of 0.05 was considered statistically significant. As previously mentioned, data collection (inclusion of patients) was stopped once the mean pre-post HRV difference reached statistical significance. Magnitude of the pre-post HRV difference was assessed with an effect size statistic (using a pooled standard deviation) in Excel 2016 (Microsoft Corp, Redmond, WA).

RESULTS

The 16 patients consisted of four females and 12 males, with a mean age of 57.5 years, standard deviation (SD) = 15.0, ranging from 34 to 85 years old.

Mean pre HRV was 20.8 ms (SD = 12.6), compared to a mean post HRV of 26.5 ms (SD = 11.9). This 5.7 ms increase (improvement) in the post-adjustment HRV is statistically significant ($p = 0.02$) with a large effect size (of 0.5) (Table 1, Figure 5).

Table 1

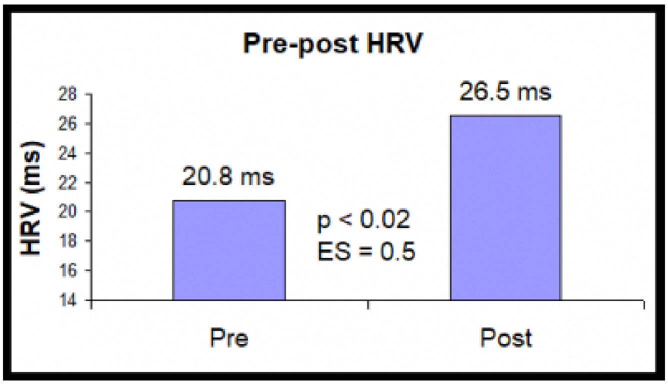
Summary statistics

Variable	n	Mean	SD
Pre HRV	16	20.8	12.6
Post HRV	16	26.5 *	11.9

* Statistically significant improvement ($p = 0.02$) with a large effect size (of 0.5). n= 16 patients. SD = standard deviation.

Figure 5

pre-post HRV difference in chart format for the 16 patients. ES = effect size. ms = milliseconds.



Areas of the spine that were adjusted, along with corresponding HRV changes are shown in Table 2.

Table 2

Areas of spinal adjustment and corresponding HRV increase

Area adjusted	n	Mean HRV change
Atlas (C1) only	10	7.4
Atlas and lumbar or pelvis	4	1.1
Pelvis only	2	6.7

n is the number of patients (e.g., 10 patients had atlas-only adjusted which corresponded with a mean HRV increase of 7.4 ms).

DISCUSSION

In this study, patients experienced a benefit following spinal adjustment above and beyond symptomatic relief. This benefit was in the form of improved health of the autonomic nervous system (ANS), evidenced by the increased (improved) heart rate variability (HRV). These findings are consistent with previous chiropractic research that also found improved HRV following spinal adjustment [20-22]. The study is also consistent with chiropractic research that looked at other ANS-based measures such as hypertension [23-24] and resting heart rate. [25]

It will be noticed that larger improvements were observed when only one area was adjusted. (Table 2). This finding should be viewed with caution however, given the substantially smaller number of patients in two of the three categories (in Table 2). For example, the pelvis-only category had only two patients.

Limitations

Limitations to the study include those that typically pertain to studies having an observational (non-randomized) design such as the one used here. For example, generalization is probably limited to patients at the practice from where they were recruited. Another limitation is the relatively small sample size (of 16 patients).

It could be said that the HRV improvement may be related to symptomatic relief, as suggested elsewhere. [26] In the author's practice, if patients experience symptomatic improvement immediately following their spinal adjustment, they typically say so then and there. In such cases, a note is made in the patient's file in this regard. However, for this sample of patients, there is no such comment in their files within the approximate 1-5 minute time frame following their adjustment, when the post adjustment HRV reading was obtained. Thus, it appears that the improved HRV observed in these patients is due to beneficial neurological effects of the spinal adjustment.

Clinical significance

The increased HRV by 5.7 ms in this study is statistically significant but is it clinically significant (important to the patient)? It would appear that this amount of change is clinically significant based on Figures 1 and 2 above. In Figure 1, mean HRV for the non-hypertensive groups is approximately 26 ms compared to the approximate 23 ms in the hypertensive group, a difference of only (approximately) 3 ms, which of course is less than the 5.7 ms observed in the present study. Figure 2 shows an approximate 6 ms difference between controls and patients suffering with major depression. This 6 ms difference is essentially the same as the 5.7 ms difference observed in the present study.

CONCLUSION

Patients in this study showed improved autonomic nervous system health immediately following their spinal adjustment, evidenced by their improved heart rate variability. Future study could: a) include a larger sample and b) determine how long the improved HRV lasts.

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