Analysis Of Resting Pulse Rates Before And After A Single Chiropractic Adjustment For An Individual Patient: A Descriptive Study

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Abstract

Purpose: Valid methods are needed in subluxation-centered chiropractic to monitor the patient's neurological status. Resting pulse rate (RPR) may be a useful option in this regard since it is neurologically controlled, supported by outcomes research (indicating that a lower RPR is healthier than a higher RPR), and sufficiently user-friendly to include on all patient visits. This report describes a novel method for assessing neurological function before and after a single chiropractic adjustment for an individual patient using RPR. The study is particularly unique in that: a) RPR was used to determine when to adjust, b) the patient self-measured his RPR, and c) statistical analysis was used for an individual patient (statistical analysis is typically used for groups of patients rather than for an individual patient).

Methods: Three RPR measurements that increased on consecutive visits over a five day period were observed and considered to represent a neurological disturbance, along with a vertebral misalignment. A diagnosis of atlas subluxation was made and an adjustment was given using toggle recoil. The three pre-adjustment RPRs were compared to 21 post-adjustment RPRs, also from consecutive visits (over a four week period) using the two sample t test and effect size statistics.

Results: Mean pre-adjustment RPR was 81.0 beats per minute (BPM) compared to a mean post-adjustment RPR of 72.0 BPM. This 9.0 BPM decrease following the adjustment was statistically significant ($p = 0.03$) with a large effect size (of 1.8).

Conclusion: This report describes a novel method of assessing neurological function before and after an adjustment using resting pulse rate. Further study using this method for other patients, and in more rigorous research to validate the method, are reasonable next steps.

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INTRODUCTION

Vertebral subluxation

Dr. D.D. Palmer, the founder of chiropractic taught that the objective of chiropractic care is to improve neurological function by adjusting a condition known as *vertebral subluxation*. [1] This objective continues in modern times for a majority of chiropractors. [2] Though there are various *operational definitions* of vertebral subluxation among the many chiropractic techniques, there is general agreement on a *concept definition* for vertebral subluxation. In concept, a vertebral subluxation essentially consists of a slightly misaligned vertebra that that results in a neurological disturbance. [3] The purpose of adjusting a vertebral subluxation is to improve neurological function in the patient, which in turn helps to improve the patient's health. [4] Other terms have been applied to what seems to also describe this condition such as, "functional articular lesion" where the purpose of chiropractic intervention is to "produce (a) beneficial neurological effect." [5]

Valid methods for monitoring neurological function are important in subluxation-centered practice. In practice, the presence of a neurological disturbance means that it is time for the patient to be adjusted (assuming a slight vertebral misalignment is also present). Both components – nerve disturbance and slight misalignment are prerequisites for a chiropractic diagnosis of *vertebral subluxation* to be made. Bony palpation and radiography are examples of tests intended only for the misalignment component of vertebral subluxation, and therefore do not convey information about nervous system function. Without knowledge of whether a neurological disturbance is present, the subluxation-centered chiropractor cannot know whether a misalignment is a vertebral subluxation (with a neurological disturbance, where adjustment would be indicated) or only a misalignment (that does not result in a neurological disturbance, thanks to the body's innate striving to maintain and health itself, and where adjustment would *not* be indicated). There are a number of tests that chiropractors have used over the years to determine whether a general neurological disturbance is present, such as paraspinal thermal pattern analysis. [6] The documentation of improved neurological function, using a doctor-centered outcome (such as thermal pattern analysis) following a chiropractic adjustment helps to substantiate whether the chiropractic objective of improving neurological health in the patient has been accomplished.

Resting pulse rate

Methods for monitoring general neurological status could also include resting heart rate, which is controlled by neurological centers in the medulla oblongata. When obtained by palpating a peripheral pulse, resting heart rate is sometimes called resting *pulse* rate, and the two terms are often used interchangeably. In the present case, since peripheral pulse palpation was used, the latter term, resting pulse rate (RPR) is used in this report. A pulse meter (e.g., finger pulse oximeter) was not used in the study since a distinct number was desired. Pulse meters on the other hand typically display pulse rates that tend to fluctuate somewhat from moment-to-moment. By counting the rate (by palpation) for a set time (e.g., for 30 seconds), as was done in this study, a distinct number is provided at the end of the count period.

RPR is considered a clinical neurological assessment, as noted by the following excerpts from the scientific literature:

a) "The resting heart rate is also a marker of haemodynamic and autonomic nervous system states…" [7]

b) "Dysregulation of the autonomic nervous system…[is] indicated by elevated resting heart rate." [8]

c) "Resting heart rate [is] a low tech and inexpensive measure of autonomic tone…" [9]

d) "Heart rate not only reflects the status of the cardiovascular system, but also serves as an indicator of autonomic nervous (sympathetic and parasympathetic/vagal) system activity and metabolic rate." [10]

RPR is also supported by outcomes research indicating that a lower RPR is associated with healthier outcomes compared to a higher RPR, as shown in Figure 1, and from this summary paper in 2008:

> "Over the past 30 years, at least 38 studies have looked at the connection between heart rate and cardiovascular or all-cause mortality…These studies have covered a wide variety of populations: men and women, black and white, healthy and diseased, and younger and older. After adjusting for risk factors and lifestyle, at least 32 studies show that an elevated heart rate is an independent risk factor for mortality and morbidity in healthy people with and without hypertension; it is also an independent risk factor in patients with coronary artery disease, myocardial infarction, and heart failure…" [11]

Figure 1

Re-used with permission from Oxford University Press. The figure (from reference #7) shows that higher resting heart rates tend to be associated with higher death rates.

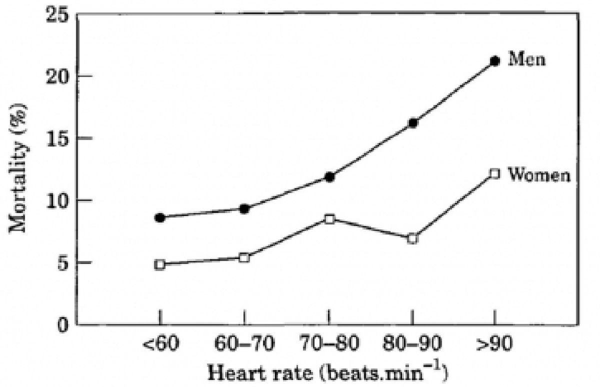


Figure 1 **All-cause mortality for 12 years against resting heart rate levels, men and women, aged 40–80 years.**

A number of similar studies have been published since 2008. [12-17] In addition, RPR has good agreement with: a) ECG-derived heart rate [18-20] and b) heart rate variability. [20] As well, entire papers have focused on RPR and its relationship with various outcomes such as metabolic syndrome, heart disease, and all-cause mortality. [13, 15, 17] The research also indicates that increased RPR over time (as differentiated from research that uses only one baseline measurement) is associated with risk of death:

> "Subjects with decreased heart rates (HRs) during the 5 years had a 14% decreased mortality risk…whereas subjects with increased HRs during the 5 years had a 19% increased mortality risk…In conclusion, change in HR at rest over 5 years was an independent predictor of mortality in middle-aged men." [12]

Similar findings have been reported in women. [9] Thus, extrapolating from long term studies to short-term visit sequences that are commonly observed in chiropractic practice (e.g., over a period of 1 week for a new patient), short-term decreases in RPR on consecutive visits (that remain decreased) could be viewed as a healthy neurological finding. Conversely, increased RPR on consecutive visits, also over the short-term, (that remain increased) could be viewed as neurologically unhealthy, indicating a need for chiropractic adjustment (again, assuming that a slight misalignment of a vertebra is also present). Research has recently begun to address the question of clinical significance of short-term RPR changes:

> "Among relatively healthy adult volunteers, a short term RPR reduction, (mean change between visits of less than or equal to approximately zero BPM) was associated with a healthier (lower) RPR baseline compared to an RPR increase (mean change of +4 BPM or greater) which was associated with a less-healthy (higher) RPR baseline." [21]

Thus, RPR is:

a) Neurologically-based (keeping with the focus of chiropractic care)

b) Easy to perform (so that it can be used on all visits, and/or taught to patients so they can measure their own RPR)

c) Numerically-based (adding objectivity to chiropractic analysis)

d) Supported by patient-centered outcomes research (that is relevant to the patient, e.g., lower RPR associated with longer life span).

The use of RPR in chiropractic research is not new since a number of studies at the group level have included it as an *outcome* measure. [22-25] Another study, in a group of 23 healthy adults included a novel approach where RPR was also used also for determining *when* to adjust. [26] In that study: a) adjustment was given if the second of two consecutive RPR measurements increased compared to the first RPR measurement; and b) one post-adjustment RPR measurement was obtained for each patient on the subsequent (post-adjustment) visit as the outcome measure. The present study takes this RPR approach to the next level - of the individual patient – in an attempt to bridge the gap between research and practice regarding objective neurological analysis. Compared to the previous group study, [26] the present study includes a larger number of RPR measurements for pre-and post-adjustment (for an individual patient). Similar to the aforementioned group study, the present study also uses RPR to determine when to adjust and then statistically compare pre-adjustment RPR to post-adjustment RPR. In this way the patient serves as his own reference or control. Although the present report contains elements of a case study, its main purpose is to describe a novel method of neurological analysis for an individual patient using RPR.

CASE REPORT AND METHODS

The patient was a 57 year-old white male who was under a wellness type chiropractic care plan. The patient signed an informed consent form for this report and the study was approved by the Institutional Review Board at Sherman College of Chiropractic. RPR measurements were obtained:

a) In July and August of 2015, on different days;
b) By the patient who was also a DC (and therefore trained on how to measure RPR). In other research, self-measurement of RPR by the patient has been shown to provide clinically useful information. [27] In addition, self-measurement by the patient brings a benefit of larger amounts of data to be collected, at the patient's convenience;
c) In the seated position after a minimum of 5 minutes seated rest, which recent research suggests is a sufficient amount of time for RPR to stabilize after being mobile [28]
d) At the radial artery, counting for 30 seconds, two trials, with a 30 second interval between trials. The average of the two measurements was multiplied by a factor of 2 to achieve a BPM value and was used for analysis;
e) Counting the first beat as 1 (instead of 0);
f) Using a digital timer;
g) At the same hour of day (between 10:00 AM and 11:00 AM), at least two hours after food intake, and at least 24 hours after alcohol consumption;

In addition, the patient did not take any medication, did not smoke, and does not recall having drunk any coffee (he rarely drinks coffee).

Chiropractic analysis

The operational definition of a neurological disturbance in the study consisted of at least three RPR increases on consecutive visits. This number of visits (three) was selected to be consistent with other chiropractic visit schedules for new patients that, for example, use a pattern analysis approach, to establish a baseline of measures to account for variability of findings. The normal RPR for this patient, based on a sample of healthy adult U.S. males, ages 40-59, is 71 beats per minute (BPM) [29] with a 95% confidence interval of 70 BPM – 72 BPM. [30]

In July 2015, consecutive RPR increases were observed, as shown on the left side of the graph in Figure 2a below, with the first increase occurring on 7-17-15 (comparing to 7-16-15). The RPR increases were assumed to represent: a) a neurological disturbance, particularly those that were higher than this patient's "normal" (of 71 BPM), and b) the neurological component of vertebral subluxation.

Examination of the misalignment component for atlas (C1) consisted of bony palpation and pre-existing radiographs using the hole-in-one (HIO) method of misalignment analysis. [31] The misalignment exam indicated a side-slip of atlas. Thus, the presence of a neurological disturbance, along with the atlas misalignment provided the basis for the chiropractic diagnosis of *atlas subluxation*. The focus on this level of subluxation was based on the aforementioned research that showed neurological improvement (decrease) of RPR following adjustment for atlas subluxation. [26]

Chiropractic adjustment

The adjustment was made on 7-22-15 using toggle recoil in the side-posture position with drop headpiece. Following the adjustment, RPR measurements continued for an approximate four week post-adjustment period (7-23-15 through 8-19-15, Figure 2a; Table 1). The time from adjustment to the last post-adjustment RPR in this study was 28 days, to mimic the time that commonly occurs between chiropractic wellness appointments. Prior to the 7-22-15 adjustment, the patient was adjusted five months earlier, in February 2015. Thus, a sufficient amount of "wash-out" time from the earlier adjustment was considered to have occurred prior to the adjustment on 7-22-15.

Statistical analysis

Three types of statistical analyses were done, each having its own purpose, as follows:

a) Pre-post RPR difference. This was the main test of the study, where the last three pre-adjustment RPR increases, that were considered abnormally high (7-20-15 through 7-22-15) were compared to the 21 post-adjustment RPR measurements using the two-sample t test. To quantify the magnitude of the difference between pre- and post-adjustment RPR, an effect size statistic was calculated, using a pooled standard deviation. [32]

b) RPR change (trend) over time. Pearson correlation compared visit sequence number to the corresponding RPR measurement. Correlation coefficients range from 0 to 1 (or 0 to -1), with a perfect *direct* correlation being 1 and a perfect *indirect* (or inverse) correlation being -1. The purpose of the correlation test was to quantify the linear trend for RPR change over time. No change in RPR over time would result in a correlation coefficient of 0. Here, dates of visits were coded, beginning with "1" for the last pre-adjustment (highest) RPR (7-22-15) and ending with 22 for the last post-adjustment RPR (8-19-15) for a total of 22 visit numbers and corresponding RPRs. A direct correlation coefficient, denoted with *r*, indicates that as the visit sequence numbers increase, corresponding RPR also increases, as shown in this example for three visits:

Visit 1 RPR 80 BPM

Visit 2 RPR 81 BPM

Visit 3 RPR 82 BPM

An inverse correlation, which is desirable in regard to RPR, indicates that as the visit sequence numbers increase, corresponding RPR *decreases* (improves), as shown in this example of three visits:

Visit 1 RPR 80 BPM

Visit 2 RPR 79 BPM

Visit 3 RPR 78 BPM

An inverse correlation coefficient is indicated with a minus sign, e.g., -0.501, which, would indicate a moderate strength, inverse correlation, and may or may not be statistically significant.

c) <u>Repeatability of the patient's RPR measurements</u>. Two tests were performed to assess repeatability of the patient's two RPR measurements (intra-examiner reliability) on the 27 visits charted in Figure 2a (7-15-15 to 8-19-15), as follows: a) Intraclass correlation coefficient (ICC), and b) paired t test. ICC tests repeatability of measurements and is similar to Pearson correlation in that the coefficients can range from -1 to 1. Here, a large positive coefficient (e.g., those between 0.8 and 1), along with a small p-value (e.g., of 0.05 or smaller) would be desirable, which would show strong agreement that was statistically significant. The paired t test determines whether there is a statistically significant difference between the two measures, in this case, between the two RPR measurements taken by the patient. Here, a large p-value (e.g., of 0.06 or larger) would be desirable, which would show that the difference between the two measurements is not statistically significant.

Normal probability plots for all variables indicated acceptable normality of the data. Thus, the statistical tests used were considered appropriate for these data. Two-tailed p-values less than or equal to the conventional alpha level of 0.05 were considered statistically significant. Briefly, the p-value indicates the probability that a statistical result happened by chance alone. As an example, a p-value of 0.04 would be statistically significant at the 0.05 level, indicating a low probability (of 4%) that the result (e.g., RPR decrease following an adjustment) happened by chance alone. Analyses were performed in Stata IC 12.1 (Stata Corp., College Station, TX) and Excel 2010 (Microsoft Corp., Redmond, WA).

RESULTS

Pre-post RPR difference

Mean pre-adjustment RPR was 81.0 BPM, standard deviation (SD) = 3.6, compared to 72.0 BPM (SD = 5.0) for mean post-adjustment RPR (Figure 2a, Table 1). This 9.0 BPM decrease following the adjustment was statistically significant ($p = 0.03$) with a large effect size (of 1.8).

Figure 2a

Resting pulse rates (RPRs) for the patient in this study. Arrow = adjustment. Pre-adjustment RPR (of 81.0 BPM) is the average of the last three pre-adjustment RPRs (7-20-15 to 7-22-15). Post-adjustment RPR (of 72.0 BPM) is the average of the remaining RPRs following the adjustment (7-23-15 to 8-19-15). The post-adjustment RPR decrease (of 9.0 BPM) was statistically significant ($p = 0.03$) with a large effect size (of 1.8).

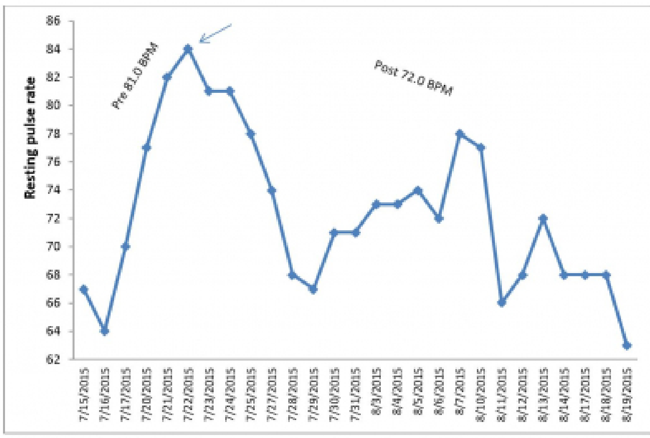


Table 1

Descriptive statistics for resting pulse rates (RPR) for the patient in the study. Type = pre- or post-adjustment. n = number of RPR measurements. BPM = beats per minute. SD = standard deviation.

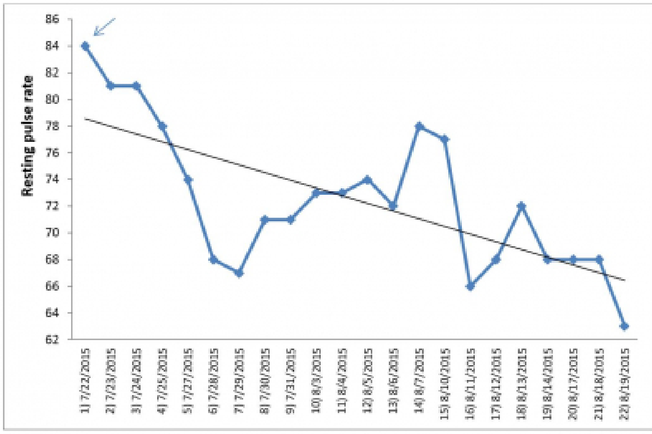
Type	n	Mean (BPM)	SD
Pre	3	81.0	3.6
Post	21	72.0	5.0

RPR change over time

The computer-generated trend line in Figure 2b indicates that RPR tended to decrease (improve) over time following the adjustment. This trend is verified quantitatively by the moderate strength, statistically significant, inverse correlation that was observed (between RPR and visit sequence number), where r = -0.681, p = 0.0005.

Figure 2b

Correlation between numbered visits (shown next to dates) and corresponding RPR. The correlation begins with the last (and highest) pre-adjustment RPR (7-22-15; arrow) and continues through the last post-adjustment RPR (8-19-15). The software-generated trend line indicates an overall decrease (improvement) in RPR over the post-adjustment period, which is verified quantitatively with the statistically significant, inverse Pearson correlation coefficient (r) of -0.681 (p = 0.0005).



Repeatability of the patient's RPR measurements

The intraclass correlation coefficient was strong and statistically significant: ICC = 0.908, p < 0.0001.

Mean absolute difference between the two RPR measurements was 1.4 BPM. Absolute differences ranged from 0 to 4 BPM, with 12 (44%) of the pairs showing a 0 BPM absolute difference; 11 (41%) of the pairs showing a 2 BPM absolute difference; and 4 (15%) of the pairs showing a 4 BPM absolute difference. The mean of the first RPR measurements was 72.2 BPM (SD 5.9), compared to 72.6 BPM (SD 5.7) for the second RPR measurements. The difference between these means (first versus second RPR measurements) was not statistically significant (p = 0.3). Thus, the patient's repeatability of the two RPR measurements was considered acceptable.

DISCUSSION

This report describes a potentially useful method of monitoring general neurological function for an individual chiropractic patient, using the low-tech method of resting pulse rate (RPR). In this study, RPR decreased (improved) following a single chiropractic adjustment. While the inclination might be to attribute the cause of the decreased RPR to the adjustment, more rigorous research would be required before such a claim could be substantiated. Such a study could have a design that included instances (in the same patient) where RPR showed similar increases but no adjustment was given, and then compare to an instance where adjustment was given. Here, initial RPR readings in both sets of data (*adjustment* versus *no adjustment*) should be similar since higher RPRs may be followed spontaneously by lower RPRs, even without adjustment. This theory (of higher RPR spontaneously followed by sharper decreases in RPR) is based on the clichés, *what goes up, must come down*; and, *the bigger they are, the harder they fall*; as well as anecdotal observations by one of the authors (JH). Thus, the present study indicates that RPR improved (decreased) *following* the adjustment but not necessarily because of the adjustment. Even though cause-and-effect relationships may not be scientifically demonstrable in practice, or in a case study, the chiropractor could nonetheless at least determine (with, for example, the RPR method described in this report) if neurological improvement has occurred following an adjustment.

In the present case, there were some increases in RPR after the adjustment, e.g., from 7-30-15 to 8-7-15 (Figure 2a). However, a decision was made at that time to employ the *watchful waiting* approach, to see if the RPR would decrease on its own, without further adjustment. Thanks to the body's innate (inborn) striving to maintain and heal itself, such decreases did occur, without further adjustment. Indeed, the overall general RPR decrease in the post-adjustment period compared to pre-adjustment remained statistically significant despite these temporary RPR increases.

This is not the first chiropractic case study to provide numerical neurological data from multiple visits for an individual patient. A previous interesting case study has done this using blood pressure as the measure [33] but did not perform a statistical analysis of the measurements as the present study did with RPR. The advantage of including the additional step of a statistical test, even for one patient, is that an estimate can be made on the probability that the improvement (or worsening) of a numerical neurological test happened by chance alone. Another difference is that the present study statistically analyzed the test that was used to determine when to adjust the patient. Previously, a case series showed a test for determining when to adjust (thermal pattern analysis from multiple visits) but did not statistically quantify the findings. [34] Part of the challenge in such quantification is that subluxation indicators that are feasible for use on every visit typically do not produce a numerical value as RPR does.

Although statistical analysis in health care research is typically reserved for studies involving *groups* of patients, it can nonetheless be used in the case of an *individual patient*, provided that statistical assumptions are satisfied (e.g., normality of the data for parametric testing). Indeed, there is precedent for such analysis in the case of an individual patient. [35] Moreover, analysis at the level of the individual patient, with the patient serving as his or her own reference (or control), may be of greater interest to the clinicians than group studies of other patients. Technically, statistical inference from a case study involving only one patient would be applied only to the individual patient being analyzed. However, if other case studies using this method show similar findings, then generalizations to other chiropractic patients may become more valid. The use of statistical analysis in a case study would seem to increase its rigor.

The method used in this report is unique in that: a) It involved multiple RPR measurements for a pre-adjustment baseline, as well as for the post-adjustment period; b) statistical analysis was applied (to assess the probability that post-adjustment change occurred by chance alone) in the context of a case study type design; c) only one adjustment was given; d) the patient self-measured the RPR; e) the patient's measurements were analyzed for repeatability (reliability); and f) the test for determining when to adjust was also the outcome test of the study (RPR).

It may seem unusual that only one adjustment was given over the course of the many measurements obtained in this study. However, there is a precedent for such conservative care. As an example, patients in the B.J. Palmer Chiropractic Research Clinic also received: a) a number of pre-adjustment baseline examinations for determining when to adjust, b) adjustment only if indicated by the objective neurological measures, and c) post-adjustment examinations over period of weeks or months, without any further adjustment. [36]

The procedure of RPR is easy enough to perform so that: a) it can be done on all patient visits, and / or b) patients can be taught how to do it themselves. Self-measurement by the patient provides a twofold benefit: a) extra data for the clinician to analyze, and b) a sense of satisfaction by the patient in becoming an active participant in his or her care plan.

To include this method, even if only as an outcome measure (comparing pre- to post-adjustment) would seem to strengthen any chiropractic approach (technique). In addition, the method described here may be useful in future research that seeks to determine which chiropractic techniques are more neurologically beneficial than others, according to RPR.

Limitations to the study include those which typically pertain to a case study (e.g., limited generalize-ability of the findings due to only one patient in the study). Another limitation is the relatively small sample sizes that were used in the t test, particularly for pre-adjustment RPR (where only three measurements were used). However, a sample size this small (three measurements) can be used in a t test. [37]

CONCLUSION

The main purpose of the present report was to describe a potentially useful method of neurological monitoring in subluxation-centered chiropractic practice, and apply the method to an actual patient. The method uses resting pulse rate (RPR) to determine when to adjust, and whether the adjustment was followed by improved neurological function, by statistically comparing pre-adjustment RPR to post-adjustment RPR. Further investigation using this method in other chiropractic patients, and in other research designs are reasonable next steps.

Author Contributions	JH	MS
Research concept and design	X	
Collection and assembly of data	X	
Data analysis and interpretation	X	
Writing the article	X	
Critical revision of the article	X	X
Final approval of article	X	X

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