Neurological Change According To Resting Pulse Rate Following Chiropractic Care: A Case Series

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Abstract

Introduction: This report describes a method of determining what type of general neurological changes have occurred, if any, following chiropractic care according to resting pulse rate (RPR) in individual patients. The method may be of interest to chiropractors and other clinicians who have a neurological focus in their practices.

Methods: Multiple pre-adjustment RPR measurements were compared to multiple post-adjustment RPR measurements on an individual patient basis using t test and effect size statistics.

Results: In two of the five patients, a statistically significant decrease (improvement) was observed in mean post-adjustment RPR compared to mean pre-adjustment RPR ($p < 0.02$), with large effect sizes (of approximately 1.2). In the other three patients, mean post RPR was essentially unchanged according to their t test p-values.

Conclusion: According to the method used in this study, general neurological function improved in two of the five patients, evidenced by the statistically significant decrease in RPR, along with large effect sizes. Further study using other chiropractic techniques, and with other patients is indicated.

INTRODUCTION

Chiropractic care

In subluxation-centered chiropractic care, the objective is to improve neurological function by adjusting a condition known in chiropractic as vertebral subluxation. [1-2] There are a number of operational definitions for vertebral subluxation depending upon the particular technique used. For example, Grostic technique has its operational definition for identifying vertebral subluxation, Gonstead has its operational definition, and so on. [3] In terms of a concept definition, there is general consensus that vertebral subluxation consists of a slight vertebral misalignment which results in a neurological disturbance. [4] There are a number of procedures that assess the misalignment component, such as bony palpation and radiographic imaging. Skin temperature analysis and leg length contracture assessments are examples of clinical tests that characterize a neurological component within the subluxation-centered chiropractic model. [5]

Resting pulse rate

Another measure that is potentially useful in neurologically-focused practices, e.g., in subluxation-centered chiropractic, is resting heart rate, also known as resting pulse rate when obtained by manual palpation of a peripheral artery. [6] Resting pulse rate (RPR) is a good fit for subluxation-centered chiropractic because it is a neurological measure, being controlled by centers in the brain stem. Further support for using RPR as a neurological assessment is found in 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: a) is supported by outcomes research showing that a lower RPR is associated with better health outcomes (e.g., longer life span) compared to a higher RPR; [11-17] b) has good agreement with ECG-derived heart rate; [18-19] c) has good (inverse) agreement with heart rate variability (where lower RPR [a healthy finding] tends to correlate with higher heart rate variability [also a healthy finding]); [20] d) that increases over time is associated with worse health outcomes (e.g., risk of death) compared to RPR that does not increase; [12, 15] and e) has been observed to decrease (improve) following chiropractic care. [21-22]

Group analysis versus individual analysis

Typically in healthcare research, statistical analysis is reserved for studies involving groups of patients rather than for an individual patient. However, if modeling assumptions are satisfied (e.g., normal distribution of the data), statistical methods can be applied to the individual patient, for example in comparing pre- versus post-intervention data. Such analyses would help to answer the question of whether any change that might have occurred following intervention, happened by chance alone.

Self-measurement by the patient

Also typical in healthcare and health care research is that clinicians collect the data. However, self-measurement by the patient (e.g., for blood pressure and heart rate) is an emerging option which can contribute important and useful information in research and in practice. [23-24] In addition, self-measurement by the patient can provide: a) additional data at the convenience of the patient which in turn increases the rigor of the case study design and b) a sense of satisfaction by the patient as he or she becomes an active participant in their care plan.

Purpose of the study

The present study is similar to a previous study for an individual patient where RPR was also self-measured by the patient and used as an outcome measure. [25] The difference in the present study is that it includes more patients, with each patient having more pre-adjustment RPR measurements. In this line of research, statistical analysis compares pre-versus post-adjustment RPR data on an individual patient basis, with the patient serving as his or her own reference or "control."

The purpose of the present study was to: a) describe a research method that clinicians can use in practice to determine what type of general neurological change, according to RPR, has initially occurred following intervention. Changes that would be expected in the post period compared to the pre are as follows: Improvement (decreased RPR), worsening (increased RPR), or no change (same RPR); and b) apply the method to individual patients.

CASE SERIES AND METHODS

Patients

Five chiropractic students, who were also chiropractic patients (now referred to as "patients") were recruited by the author as a convenience sample in January 2016 for the study. The patients signed a consent form and the study was approved by the Institutional Review Board at Sherman College of Chiropractic. The study lasted approximately two months. The patients did not report having any medical conditions and consisted of three males and two females, ages 25-33 (Table 1).

Measurement protocol

Self-measured RPR was obtained in the seated position after at least 5 minutes of seated rest. Two 30-second measurements were obtained, 30 seconds apart, and recorded by the patients as 30 second counts. The author later averaged the two measurements and multiplied the average by 2 to obtain a beats per minute (BPM) value. A digital timer was used by the patients and the first beat was counted as "1" instead of zero since the former shows to have better agreement with ECG-derived heart rate compared to the latter. [26] Patients measured their RPR at the same general time of day (e.g., some measured consistently in the mornings while others measured consistently in the evenings), approximately three times per week. The number of RPR measurements among the patients ranged from nine to 25 readings in the pre-adjustment period, and eight to 20 readings in the post-adjustment period (Table 2).

Reliability of measurements

The patients received training from the author on research protocols for measuring their RPR. During this training session, each patient was tested against the author's RPR findings and these findings are reported in Table 1. The mean of the patient's and author's measurements was calculated and reported as "RPR test mean." The absolute difference between test (training) RPR measurements taken by the author and each patient was also calculated and ranged from 0 to 4 BPM and is reported as "RPR test diff." As a method to estimate percent error between patient and author, the absolute difference was divided by the aforementioned mean and reported as "Percent test. All percentages fell within a 10th percentile and were therefore considered acceptable.

As a second measure of reliability, the absolute difference between the two RPR trials for each patient's measurement session was also calculated. These differences were further analyzed for outliers within each patient's own data, with the formula [27]:

Lower fence: quartile 1 – (1.5 * interquartile range)

Upper fence: quartile 3 + (1.5 * interquartile range)

Values that fell below or above these fences were considered outliers.

Pre and post periods

The patients had received chiropractic care prior to the study but abstained from their care while they established their RPR baseline for the study. This pre-adjustment baseline period is now referred to as the "pre" period. The average time between their last adjustment and their first RPR measurement in the study's pre period was 20.8 days, ranging from 5 days to 66 days. A patient's "post" period began with his or her first adjustment in the study. The time frames were similar for pre and post periods, ranging from 18-43 days for pre and 17-42 for post. The total study period varied between patients, ranging from 40 days for one patient to 62 days for another (Table 1).

Potential confounders

At the time of RPR measurement, patients recorded the last time they consumed food, caffeinated products, alcohol, tobacco, and medication. Patients also noted the time of the RPR measurement as well as level of mental stress at the time (low, medium, or high; coded by the author in analysis as 1=low, 2=medium, and 3=high).

During the study, the patients had either never consumed tobacco products or it had been at least 24 hours prior to their RPR measurements. No medications were consumed except for patient #2 for some of his pre measurements, and these measurements were omitted in analysis. Only a small amount of information was missing for potential confounders, for two patients, as follows. Patient # 4: mental stress information missing once in the pre period and once in the post; food intake (time since) – once in the post period; caffeine - twice in the pre period ; Patient 5: caffeine once in the pre period.

In patient #2, a substantial difference in caffeine (hours since consumed) was observed between his pre (mean = 14.5 hours) and post (mean = 20.4 hours). Such a difference could result in an increased mean pre RPR and a decreased mean post RPR, which would make it appear that RPR improvement had occurred following chiropractic care. As a remedy to better equalize the caffeine times between pre and post for this patient, only measurements that had caffeine times that were greater than or equal to the mean of both pre and post groups for this patient, which was a mean of 17.8 hours, were included for this patient. All other co-factors for patients were reasonably similar (Table 1).

Since a previous chiropractic study showed a possible effect of BMI on blood pressure change following chiropractic care, [28] body mass index (BMI) was calculated with the patients' self-reported height and weight provided at the beginning of the study, using an online BMI calculator provided by the National Heart, Lung, and Blood Institute. [29]

Chiropractic adjustments

As noted in Table 1, patients recorded areas in the spine where they received adjustments, from the following categories: upper cervical, cervical, thoracic, lumbar, and pelvis (could include sacrum). Also recorded was patient position during the adjustment and name of technique. Adjustments were given by either chiropractic interns and/or licensed doctors of chiropractic. Spinal exams included various forms of manual palpation, leg length contracture assessments, and thermography. The named chiropractic techniques consisted of Diversified, Thompson, Gonstead, and Activator. These techniques are similar in that they incorporate high velocity, low amplitude type thrusts to the spinal level that is considered to be subluxated, sometimes resulting in a joint-popping (cavitation) sensation (except for Activator instrument adjustment). For Activator technique, only the instrument was used (without the Activator analysis). The Thompson technique typically uses a device within the adjusting table where a table section drops slightly to assist in the adjustment, usually without a joint cavitation sensation. Further descriptions of these techniques are available elsewhere. [3] The adjustments were applied mostly for cervical and pelvic subluxations, except for patient #4 who received adjustments for pelvis and thoracic subluxation.

Data analysis

Graphs for each patient's RPR were viewed for initial trends (of initial improvement or initial worsening) in the post period compared to the pre (Figures 1a-1e). For example, in patient #2, lower RPRs were observed initially in the post period compared to the pre, after which they begin to increase (after arrow on right in Figure 1b). In this case, only the initial trend (for improvement) was included in analysis. Had the initial trend been the opposite, where it showed an obvious trend of initial worsening (increased) RPRs, followed by improvement, then only the worsening part would be included in analysis. The data were limited in this way to answer the question of what changes occurred initially following intervention. This approach is in keeping with a case study approach in practice, where the clinician initially looks to see what changes (if any) occur initially following intervention.

Normal probability plots indicated acceptable normality of the pre and post RPR data for each patient. Pre RPR were compared to post RPR using the two sample t test, for each patient individually. The two sample t test was used since: a) pairing of pre and post RPR measurements was not relevant in this study, and b) the number of measurements was different between pre and post ("Pre obs" in Table 2). Two-tailed p-values less than or equal to the conventional alpha level of 0.05 were considered statistically significant. The magnitude of the pre-post difference was assessed with an effect size statistic (with a pooled standard deviation). All data were analyzed as beat per minute values and the main outcome variable of the study was the pre-post RPR difference for each patient as an individual.

RESULTS

Measurement reliability

Absolute differences between patients' two self-measured RPR trials was considered acceptable, ranging from 0-6 BPM for all measurements except for patient #1, who showed a statistical outlier with one of his differences – of 22 BPM. This patient's next largest difference was 12 BPM which was not an outlier. Analysis for this patient was performed with and without this outlier.

Pre-post RPR difference

Patient #1 (with and without the outlier) and patient #2 showed statistically significant decreases (improvements) in their mean post RPR compared to their mean pre RPR ($p < 0.02$) with large effect sizes (of approximately 1.2). The other three patients' mean post RPR was essentially the same as their mean pre RPR (differences were not statistically significant, $p > 0.3$) with medium effect sizes (of 0.3-0.4; Table 2).

DISCUSSION

Statistically significant decreases (improvements) in RPR occurred in two of the five patients in the study. The lifestyle (e.g., level of exercise) in both of these patients was essentially constant during their pre and post study periods. These two considerations, a statistically significant decrease in RPR, and consistent lifestyles in both pre and post periods, suggests that their improvement (decrease) in RPR was due to the chiropractic care they received. Still, the case study / case series type research design used in the present study does not permit a cause-and-effect claim to be made (between the care provided and subsequent RPR improvement).

The two patients who experienced decreased RPR had the following commonalities: same gender (male), same race (white), similar ages (29-33), and similar BMI (27.4 and 27.5; Table 1). The finding of RPR decrease in only males following adjustment is similar to a finding in a previous small group study where only males as a group showed a statistically significant decrease in RPR following adjustment for atlas subluxation. [21] Other research also indicates that the two genders show different cardiovascular responses following health care intervention. [30]

Two of the three non-responding patients in this study were of Hispanic ethnicity. This also raises the question of whether ethnicity plays a role in RPR response to chiropractic adjustments. Although chiropractic is a drugless health care approach, different cardiovascular responses according to ethnicity have been reported in regard to drug therapy. [31] Larger sample sizes in future chiropractic research are required before a claim can be made that the two genders, and/or different ethnicities respond differently to chiropractic care according to the measure of RPR. If such differences exist, then another future step could be to determine whether certain chiropractic techniques work better for certain races and genders.

A statistically significant difference in RPR may or may not have occurred at the group level for these five patients. However, determining whether group change had occurred was not the objective of the study. The point of the study was to apply a practitioner-friendly research method to determine what type of general neurological change (if any) occurred in individual patients following chiropractic care.

The delivery of health care to a patient is no guarantee that the patient will be healthier following the care. Indeed, a recent report has indicated that medical error is the third leading cause of death in the U.S. [32] While there was no harm observed in the present study, three of the patients did not receive a neurological benefit (patients 3, 4, and 5), at least according to the neurological measure of RPR.

Strengths of the study include: a) the convenience of self-measurement by the patient, which provided an acceptable amount of data for statistical analysis, b) statistical analysis of individual patient data, thereby increasing the rigor of the case study design, and c) the patient served as his or her own reference or control.

Limitations to the study are that: a) it had an observational design and convenience sampling, both of which inhibit generalization of the study's findings to other patients; b) the study did not include a control group (receiving sham or no adjustment). Thus, the statistical analysis in this study does not address whether there was a cause-and-effect relationship between chiropractic care and the RPR change; it simply addresses the probability that the result (RPR change in the post period) happened by chance alone. Other research designs (such as a randomized clinical trial, which would also use statistical analysis) are needed to claim causality; and c) the patients comprised a relatively healthy sample.

Feasibility in practice

In practice, patients can be instructed to self-measure their RPR for a pre-adjustment baseline period. This may not work well in settings where new patients are seeking immediate symptomatic relief, and their clinicians may wish to provide that (immediate) relief. Thus, the method in this study, where the patient would abstain from receiving intervention while they establish their RPR baseline, may be more compatible in cases where immediate relief is not a priority (e.g., in wellness type care). In addition, the statistical analysis can be performed in common spreadsheet programs such as Excel.

CONCLUSION

This study describes a method to determine whether neurological change has occurred following intervention (such as chiropractic adjustments) using resting pulse rate (RPR). In two of the five patients where the method was applied, RPR decreased (improved) following chiropractic care, while the other three patients showed essentially no change in their RPR. Further study is indicated using larger samples (that include patients from the general population), other research designs, and other chiropractic techniques.

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- Anna Korpak, MS, and PhD candidate (biostatistician)

Table 1

Descriptive statistics for the five patients in the study. *

Variable	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5
Age	29	33	25	25	29
Gender	M	M	M	F	F
Race	White	White	Hispanic	Hispanic	White
BMI	27.4	27.5	23.0	20.6	39.9
RPR test mean	33	44	28.5	25	40
RPR test diff	0	0	2	0	4
Percent test	0	0	0.07	0	0.1
Prior adjustment	5	18	8	66	7
Time	1230-1453	1000-1000	2200-2200	917-1020	2000-2130
Pre food	2.0	12.5	3.9	2.6	2.1
Post food	1.6	9.6	4.8	2.2	2.5
Pre caffeine	24.2	24.3	10.3	2.5	10.2
Post caffeine	21.1	24.3	9.7	2.2	15.2
Pre alcohol	22.9	24+	20.8	24+	23.2
Post alcohol	24.9	24+	19.2	24+	23.6
Pre stress	1.8	1.1	1.9	1.6	1.1
Post stress	1.8	1.2	1.8	1.7	1.3
Pre days	18	43	25	28	13
Post days	22	17	20	34	42
Total study days	40	60	45	62	55
Chiro analysis	P, T, L	P, L	P, L	P, L	P, L
Technique	Div	Div	Div, Activ, Thomp	Div, Gon	Div, Thomp, Gon
Adjuster	Intern & DC	Intern	DC	Intern	DC & intern
Adj visits	8	4	5	5	9
Areas adjusted	UC, C, T, L, P	UC, C, P	UC, C, T, P	T, P	UC, C, T, L, P

* *BMI* is body mass index. *RPR test mean* is average of author and patient's initial RPR on volunteer test subject in training session. *RPR test diff* is initial RPR absolute difference between patient and author in early training session, in BPM. *Percent test* is *RPR test diff* divided by *RPR test mean* to estimate patient's margin of error (all were within a 10th percentile). *Prior adjustment* is number of days between last adjustment prior to the study and first RPR measurement in the study. *Time* pertains to ranges for measurement times, in military time (e.g., 1453 = 2:53 PM). *Pre* and *post food, caffeine*, and *alcohol* is number of hours since ingestion of those substances. *Pre* and *post stress* is the level of mental stress recorded by the patients at the time they measured their RPR in the pre and post periods. *Pre* and *post days* are number of days in those periods. Chiro analysis is chiropractic analysis, consisting of *P* = palpation, *T* = thermography, and *L* = leg length inequality (contracture) assessments. *Technique* is method of adjustment; *Div* = diversified adjustment technique. *Activ* = activator instrument adjustment. *Gon* = Gonstead adjustment technique. *Thomp* = Thompson adjusting technique. *Adjuster* is person who provided the adjustments (*intern* is a student chiropractor under the guidance of licensed faculty chiropractors; DC is a licensed doctor of chiropractic). *Adj visits* is number of visits where adjustments were given in the post period. *Areas adjusted*: *UC* = upper cervical, *C* = cervical, *T* = thoracic, *L* = lumbar, *P* = pelvic area (could include sacrum).

Table 2

Summary statistics for the five patients in the study. *

Variable	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5
Pre obs	11	10	25	9	14
Post obs	12	8	20	14	18
Mean pre RPR (SD)	67.0 (7.2)	53.2 (3.2)	59.3 (2.1)	54.2 (2.7)	76.3 (3.2)
Mean post RPR (SD)	59.7 (5.5)	49.4 (2.3)	59.9 (1.9)	55.1 (3.9)	75.3 (2.5)
Difference	-7.3	-3.8	0.6	0.9	-1.0
p-value	0.0135	0.0099	0.338	0.515	0.342
ES	1.2	1.3	0.3	0.3	0.4

* Pre and post obs are number of resting pulse rate (RPR) measurements (observations, on different days) in those periods, in beats per minute. SD is standard deviation. Difference is mean post RPR minus mean pre RPR. p-value is the result of the two sample t test that compared pre RPR versus post RPR. ES is effect size that estimates the magnitude of the pre-post RPR difference.

Figures 1a - 1e. Resting pulse rates for each patient in line (upper chart) and column (lower chart) formats.*

Figure 1a

Patient 1

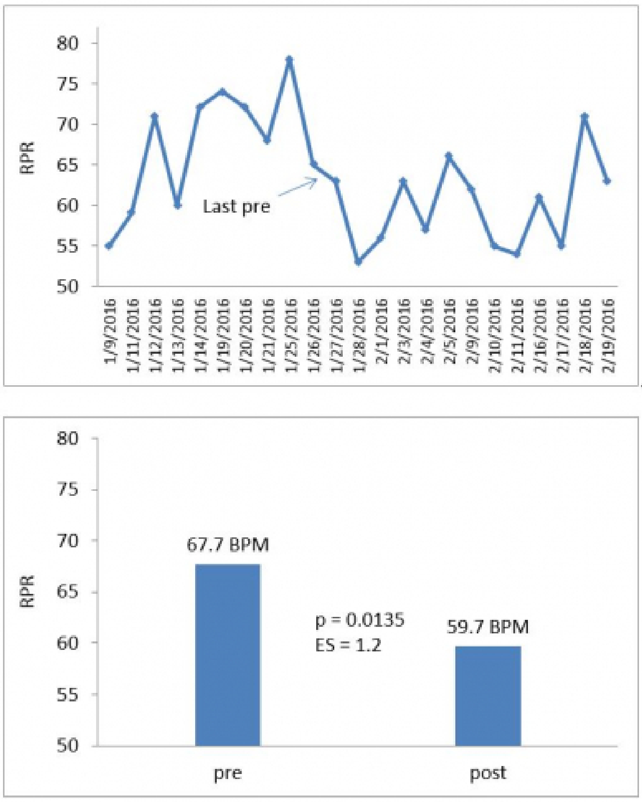


Figure 1b

Patient 2 **

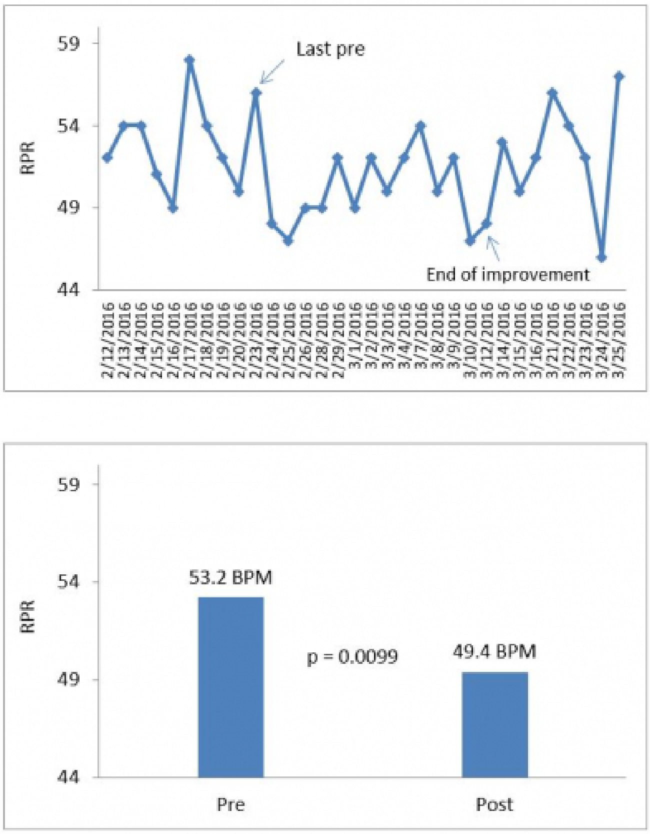


Figure 1c

Patient 3

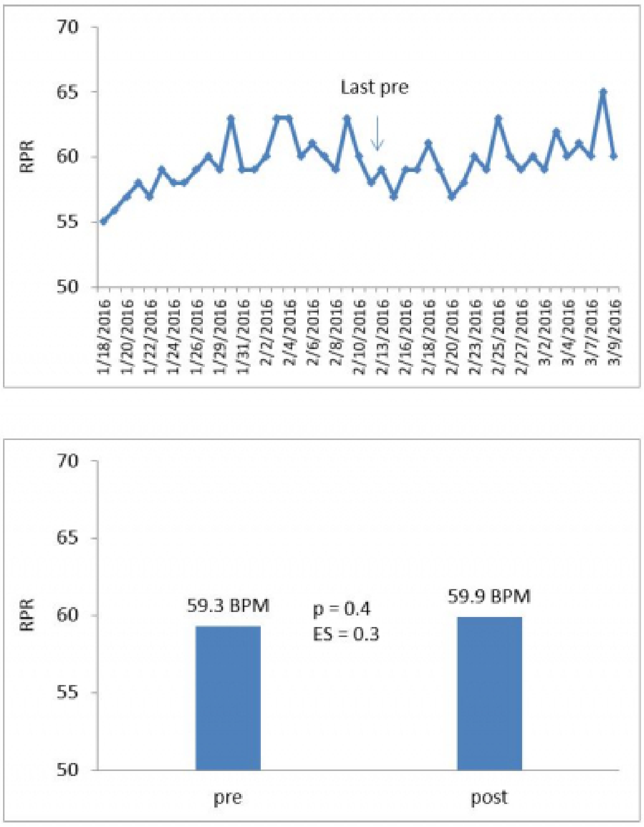


Figure 1d

Patient 4

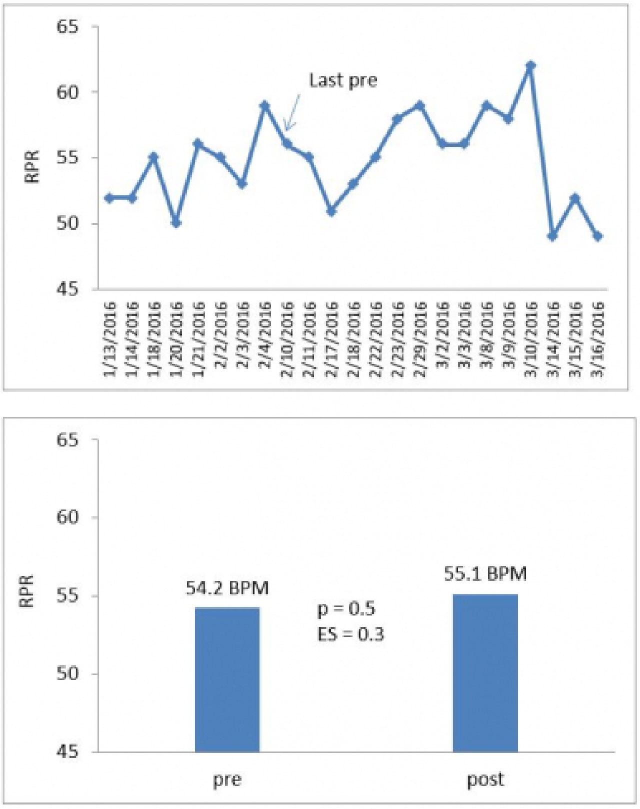
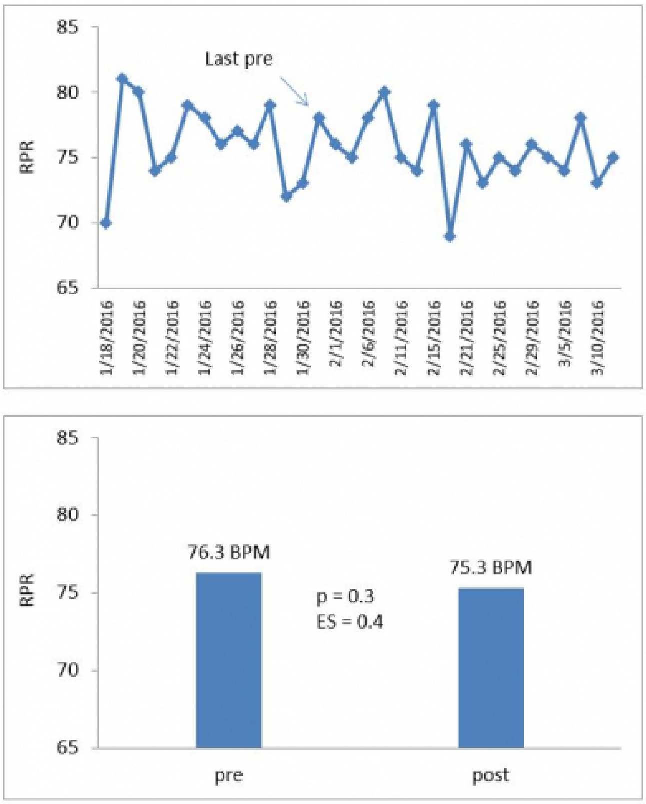


Figure 1e

Patient 5



*For all patients, adjustments began after last pre RPR measurement (arrow indicating "Last pre"). p is p-value for pre-post difference. ES is effect size.

** Arrow on right side of graph for this patient (#2) indicates the point at which improvement (decrease in RPR) was considered to have stopped.

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