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Monitoring Neurological Function With Resting Pulse Rates Over A 2 Year Period For An Individual Patient: A Feasibility Study

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Abstract

Objectives: The purpose of the study was to describe feasibility and explore preliminary findings of a potential method that could be used to document general neurological health over a relatively long period of time for an individual patient.

Methods: In this retrospective study, an asymptomatic adult male self-measured his resting pulse rate (RPR) over a 2 year period for a total of 351 measurement sessions, and each session consisted of 2 trials which were averaged. A chart of the measurements revealed three time frames of relatively low and high RPR periods that seemed to be associated with healthier and less healthy periods. Consecutive periods were compared using a measure of effect size and one-way analysis of variance statistics. In addition, the patient's 2 paired trials per measurement session were evaluated for reliability using: a) outlier detection for absolute differences, and b) intraclass correlation coefficient (ICC).

Results: Statistically significant differences were observed between periods ($p < 0.001$) with large effect sizes (> 0.5). In addition, the patient's RPR measurements showed acceptable reliability, evidenced by: a) only 1.7% of the data being outliers, and b) an acceptably high ICC value ($r = 0.862$, $p < 0.0001$).

Conclusion: This technique could feasibly document neurological changes for an individual patient over time. Based upon these preliminary findings, further study using this method with other chiropractic patients is indicated.

INTRODUCTION

Improving neurological health is an area of interest for various health care professionals, such as those who practice within chiropractic. [1-2] In practice, short-term monitoring is usually of interest, e.g., from visit-to-visit within a period of days or a few weeks. However, neurological monitoring could be expanded when patients are cared for over a period of months or years. Such monitoring might be able to assess whether neurological improvement has occurred over the longer term, or whether there have been periods of improvement versus other periods when there was no improvement or worsening.

One potential option for monitoring neurological health in chiropractic practice is resting pulse rate (RPR). [3] RPR may be considered a proxy neurological assessment because it is controlled by neurological centers in the brain stem. In addition, RPR is supported as having a neurological component such as through the autonomic nervous system. [4-7]

Outcomes research indicates that a lower RPR is associated with better health outcomes (eg, longer life span) compared to a higher RPR. [8-10] In addition, RPR: a) has good agreement with resting heart rate derived from electrocardiogram; [11] b) good (inverse) agreement with heart rate variability (where a lower RPR, a healthy finding, inversely correlates with higher heart rate variability, also a healthy finding); [12] and c) has been shown to improve (decrease) following chiropractic care. [13-15] Thus, RPR is a neurological measure that is potentially useful for chiropractic practices that include neurological outcome measures.

Self-measurement of blood pressure and resting heart rate by a patient could provide useful clinical data. [16-17] If statistical analysis of the RPR data could be applied at the level of the individual patient, such analysis might benefit the patient and clinician by adding rigor to longitudinal assessment of the patient's neurological health. Previously studies have tested statistical analysis at the level of the individual patient in the context of chiropractic research. [18-19] However, long-term neurological monitoring of a chiropractic patient has not yet been described. Therefore, the purpose of the study was to explore feasibility and describe preliminary findings of a potential method that could be used to document general neurological health (according to RPR) over a relatively long period of time for an individual patient.

METHODS

A 59 year old asymptomatic white male chiropractic patient, who is also a chiropractor and author of the paper, signed a consent form for this case study. The patient received instructions on the protocols to use for self-measuring RPR, including a frequency of at least twice per week on a convenience schedule. The RPR measurements occurred over a 2 year period, from May 9, 2014 to May 9, 2016, for a total of 351 RPR measurement sessions (average of one measurement every 2.1 days). The measurements were obtained: a) on different days; b) during the same hour of the day (10:00 AM – 11:00 AM); c) at the left radial artery, counting for 30 seconds, two periods, each separated by 30 seconds. The average of these 2 periods was multiplied by 2 to obtain a beats per minute (BPM) value, now referred to as "RPR measurement"; d) in the seated position after at least 5 minutes of seated rest, which research indicates is a sufficient amount of time to obtain a stable RPR; [20] and e) after at least 2 hours of no food or caffeine consumption. There are two common positions for obtaining RPR: supine 8 and seated. [9] The seated position was selected for this preliminary study for convenience purposes. During the study period, the patient: a) did not consume medication, b) does not recall drinking any coffee (he rarely drinks coffee), and c) was under chiropractic maintenance (wellness) care plan, receiving 6 adjustments (manipulations) over the 2 year period for atlas (C1) subluxation correction. For this case, the operational definition for when an adjustment was given was a consistently higher RPR than prior average RPR (mean of 2 trials), e.g., 72 BPM on a given visit, then 73 BPM on the next visit, and 74 BPM on the third consecutive visit. An adjustment was not necessarily given every time the criterion presented itself. However, when an adjustment was made, the criterion was present. A determination of the misalignment component of chiropractic subluxation of the atlas (C1) was made according to bony palpation and pre-existing radiographs in which both agreed on the directional misalignment for atlas. Radiographs as a method of detecting the misalignment component for atlas has been used in a previous study on hypertension and atlas adjustment. [21] The 6 adjustments of the atlas in this case were given by 2 different licensed chiropractors, one per adjustment, using toggle recoil or a percussion type instrument.

Reference RPR for this patient, based on a sample of 1,210 healthy individuals having the same demographics (for race, gender, and similar age) is 71.0 BPM (SD = 13.9). [22] The 351 RPR measurements were charted in Excel 2010 (Microsoft Corp., Redmond, WA).

RESULTS

Three relatively distinct periods were observed (Figure 1), as follows: period 1 (low RPR), period 2 (high RPR) and period 3 (low RPR). These periods are highlighted by the software-generated polynomial trend line in Figure 1. The beginning and endpoints of the periods were determined by the RPR measurement that was closest to the intersection of the overall mean line and trend line in areas of the trend line that decreased and increased.

Even though the relatively large sample sizes allowed us to relax the ANOVA normality assumption, normal probability plots nonetheless indicated an acceptable normality of the data for each of the periods. The samples (periods) are considered independent of each other to the extent that the majority of their data are months apart. Finally, the use of ANOVA for within a subject (e.g., for an individual patient) is considered appropriate. [23]

Lifestyle habits such as level of exercise, which can affect RPR, remained consistent for this patient across the three study periods. Comparison of consecutive periods was the main outcome variable of the study. The periods were compared using the analysis of variance (one-way ANOVA) statistic (with Bonferroni correction of p-values, which is a conservative statistical approach) in Stata IC 12.1 (StataCorp, College Station, TX). The number of RPR measurements in each period was as follows: 100 in period 1, 182 in period 2, and 69 in period 3. The relatively large number of measurements allows for a statistical analysis with sufficient power to detect a difference in means, even at the level of the individual patient.

The magnitude of the difference between periods was evaluated with an effect size measure, using a pooled standard deviation, (calculated in Excel). In addition, the patient's mean RPR for all 351 measurements was compared to his reference RPR, which is mentioned above (= 71 BPM 22).

Reliability of the patient's measurements between the 2 trials performed (on the 351 measurement sessions) was evaluated with 2 statistical approaches:

a) Outlier detection (in Excel) for absolute differences in BPM between the patient's 2 trials, using the formula where the lower limit was calculated with quartile 1 – (1.5 * interquartile range), and upper limit calculated with quartile 3 + (1.5 * interquartile range); [24]

b) Intraclass correlation coefficient (ICC), in Stata IC 12.1 (StataCorp., College Station, TX). Normal probability plots for each of the 2 trials (351 measurements per trial) showed acceptable normality of the data.

For all analyses, RPR data were analyzed in BPM. Two-tailed p-values less than or equal to the conventional alpha level of 0.05 were considered statistically significant.

Overall mean RPR for the 351 measurements was 69.0, standard deviation (SD) = 4.9, ranging from 56 BPM to 85 BPM over the 2 year study period. The difference between the patient's overall mean RPR (69.0) versus his reference RPR (of 71.0 BPM) [22] was statistically significant ($p < 0.0001$) with a small effect size (of 0.2).

Reliability of data

The upper limit for outliers was a 5 BPM absolute difference between the patient's 2 trials in each of the 351 measurement sessions. There were six RPR measurements (out of the total 351 RPR measurements, = 1.7%) identified as outliers; five of them showed a 6 BPM difference and one showed a 12 BPM difference. Thus the majority (98.3%) of the data was considered to show acceptable reliability according to outlier detection. The ICC value which included the aforementioned outliers, showed high repeatability of measurements between the 2 trials (ICC = 0.862, $p < 0.0001$).

Differences between periods

Mean RPR was 67.8 BPM (SD = 4.5) for period 1, 70.8 BPM (SD = 4.8) for period 2 (an increase of 3.0 BPM compared to period 1), and 66.1 BPM (SD = 4.0) for period 3 (a decrease of 4.7 BPM compared to period 2). The RPR difference between period 1 versus period 2 was statistically significant ($p < 0.001$) with a large effect size (of 0.6). A similar finding was observed for the RPR difference between period 2 versus period 3 ($p < 0.001$), also with a large effect size (of 1.0; Figure 2).

Results were essentially unchanged when the aforementioned outliers were excluded (3.0 BPM increase from period 1 to period 2, same decrease (of 4.7 BPM) from period 2 to period 3, and same p-values and effect sizes for period comparisons).

DISCUSSION

This is the first study to describe the measurement of an individual patient using RPR over time. In the present case, the patient experienced relatively better neurological health in periods 1 and 3 which coincided with relatively low mean RPR compared to period 2. The reason for the RPR differences between periods is largely unknown and beyond the scope of this study. However, one possibility may be the number of adjustments being inversely related to mean RPR, where lower RPR mean, as observed in periods 1 and 3, corresponded with fewer adjustments, compared to period 2 (which had a higher mean RPR and a higher number of adjustments). This would be consistent with the cliché that less is more in the context of health care, where less health care may result in better health. [25] The increase could nonetheless be due to other factors, since RPR has been shown to be relatively low following adjustments. [13-15] Even in the period where the RPR was relatively high, period 2, the patient's mean RPR was still below his norm [22] though only be 0.1 BPM (71.0 BPM versus 70.8 BPM).

Although differences between periods were statistically significant, there remains a question as to whether such changes (of a few beats per minute on average) are clinically significant. A study on a sample of asymptomatic 5,139 males, ages 42-53 who received RPR measurements over a 20 year period may provide some understanding on the question of clinical significance. 8 In that study, an RPR that increases by an average of more than 3 BPM from a range of 64-70 BPM, which is similar to the change from period 1 to period 2 in the present study, shows a lower survival rate compared to a decreased RPR by 4 BPM or more, which is similar to the change from period 2 to period 3 in the present study. In another study, on patients with hypertension, each beat of RPR change corresponded to a 1% change in mortality risk. [26] There were some differences in the present study compared to these studies. The present study position of measurement by the patient was seated was seated whereas these others were supine, the difference of which has been observed to be statistically significant. [27] Nonetheless, it appears though that the difference may be only an average of 1.5 BPM. 27 In addition these comparison studies [8, 26] tended to be longer in duration than the present case study. Whether the changes between periods is clinically significant or not, their mean values nonetheless indicate which direction the patient is moving: Increased RPR mean = wrong direction; decreased RPR mean = right direction.

The mechanism for heart rate changes in response to spinal adjustment is largely speculative at present. An hypothesis for reduced RPR is that the blood vasculature is relaxed by way of neural inputs to the pontomedullary reticular formation and contralateral interomediolateral cell column. [28]

A unique feature of the present study is the higher frequency of measurement, for an individual patient, along the order of an average of 1 measurement every 2 days, over a 2 year period. Such frequency would seem to provide a comprehensive neurological assessment of an individual patient using a patient-friendly method.

Practical application

The patient could be taught proper protocols on how to self-measure their RPR, as was done in the present study. Furthermore, the patient could be taught how to enter their own data into a spreadsheet (as the patient in this study did), and then email the document to the attending chiropractor for analysis. In this way, the chiropractor would have a wealth of neurological data for the individual patient over time.

Strengths and limitations to the study

Strengths and unique aspects of the study include: a) the patient was an active participant, self-measuring his RPR at his convenience; b) the large number of measurements for an individual patient; c) statistical analysis applied to the level of the individual patient, which helps the clinician determine whether the differences between periods occurred by chance alone; and d) the method may bolster the rigor of case study type designs. Some of the statistical methods used were performed in software that is readily available to clinicians, such as Excel. The ANOVA statistical test is also available in Excel. As an alternative, t test procedures (available in Excel as well), could have been used, comparing 2 periods at-a-time, e.g., period 1 versus period 2; then period 2 versus period 3 (versus comparison of all periods at one time in ANOVA).

Limitations to the study include: a) only one patient was observed, and b) no cause-and-effect claim can be made between the care provided and the RPR findings (whether decreased (periods 1 and 3) or increased (period 2), since the study had an observational (case study) type design. It is unknown if other subjects would experience the same results. It is also not clear what physiological basis may be responsible for possibly observed findings. More research is needed to explore the physiology behind these hypotheses. Another limitation is that even though the average of 2 readings per week was achieved, there were weeks that 2 readings did not happen. Most of the RPR readings were 2-3 days apart but there were larger intervals between consecutive measurements such as two instances of a 17 day interval, 4 instances of a 7 day interval, and 9 instances of a 6 day interval. This report also may have some influence of experimenter bias since the author was also the patient. However, as this is a preliminary study, the primary outcome was to demonstrate that this method is feasible.

CONCLUSION

The method described in this study assessed resting pulse rate as a proxy assessment for general neurological health for an individual patient. In the present case, the patient experienced 2 time frames that were relatively healthier from a neurological standpoint compared to the one time period where the resting pulse rate was relatively higher. Further study using this method with other patients is indicated.

FUNDING SOURCES AND CONFLICTS OF INTEREST

No funding sources or conflicts of interest were reported for this study.

Figure 1. The 351 resting pulse rate (RPR) measurements over a two year period.*

* Trend line is an order 4 polynomial line generated by Excel software. Mean RPR for all measurements = 69.0 BPM, indicated by red horizontal line. Period 1: Begins with 6-20-14, marked by first circle on left, where first decreasing part of trend line crosses mean RPR line, and ends on 2-16-15, marked by second circle from left, where first increasing part of trend line crosses mean RPR line. Period 3: Begins with1-19-16, marked by circle on right, where second decreasing part of trend line crosses mean RPR line. Period 2 consists of all points in between periods 1 and 3.

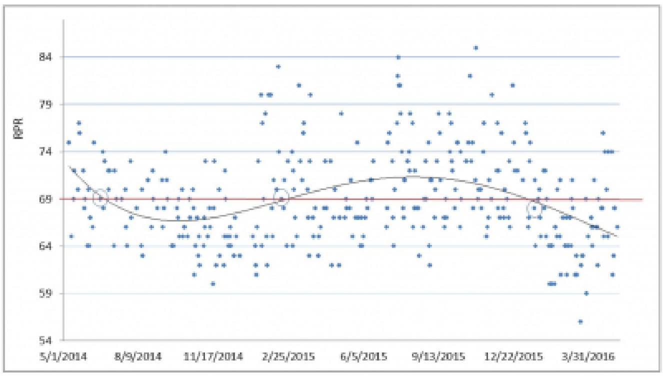

Figure 2. Mean RPR in column form by period with summary statistics. *

*p is p-value and ES is effect size. both of which pertain to differences between adjacent (consecutive) periods (period 1 versus period 2 and period 2 versus period 3).

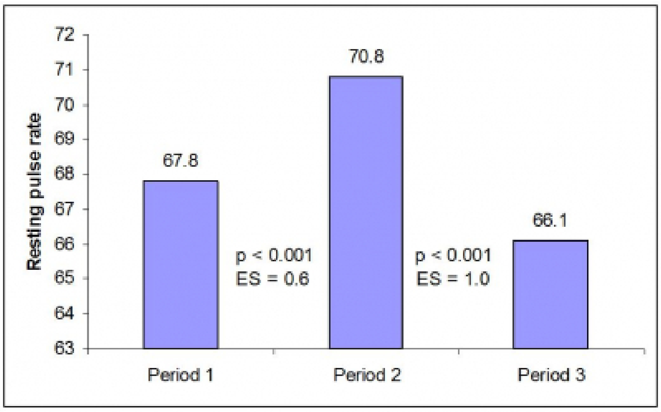

Table 1. Data by period.*

* Months = number of months in the period. n, mean, and SD respectively pertain to number of RPR measurements, mean of RPR, and standard deviation of RPR in the period. n-adj is number of adjustments in the period.

Period	Dates	Months	n	Mean	SD	n-adj
1	6-20-14 to 2-16-15	8	101	67.8	4.5	1
2	2-19-15 to 1-14-16	11	165	70.8	4.8	5
3	1-19-16 to 5-9-16	4	69	66.1	4.0	0

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