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Research report

The palpated cranial rhythmic impulse (CRI): Its normative rate and examiner experience

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A B S T R A C T

This retrospective review study aims to contribute data regarding the normal range of the palpated cranial rhythmic impulse (CRI) rate from a population of 734 healthy subjects, each determined by a different examiner. Experience levels ranged from 1 to 25 years training/practice in cranial osteopathy. This study reports an overall CRI rate range (mean $\pm$ SD) of 6.88 $\pm$ 4.45 cpm for all subjects (valid $N = 727$). The examiner population was subdivided into three groups based upon the level of examiner experience. The rates obtained from each subgroup, from least experienced to most experienced, are as follows: Level 1 (one year of experience), 7.39 $\pm$ 4.70; Level 2 (two years of experience), 6.46 $\pm$ 4.10; Level 3 (three-twenty five years of experience), 4.78 $\pm$ 2.57. Both group mean values of the reported palpated CRI rates and their standard deviations showed an inverse relationship with the level of examiner experience, i.e., as experience increases, the mean CRI rate and its deviation decreases. In the light of the findings of this study, the currently accepted range of the palpated CRI, 8—14 cycles/minute, should be reconsidered to be as low as 2—7 cycles/minute.
Précis: CRI rate means and ranges as assessed by experienced examiners are, respectively, lower and narrower.

1. Introduction

In the paradigm of cranial osteopathy, a controversial rhythmicity, the cranial rhythmic impulse (CRI), has been described, discussed, and debated.[1—5] It is defined in the Glossary of Osteopathic Terminology[6] as "a palpable rhythmic fluctuation believed to be synchronous with the primary respiratory mechanism." The fact that the CRI is debatable and incompletely understood makes it subject to question and, therefore, of interest for corroboration of its normative parameters.

In 1939, William G. Sutherland first proposed cranial osteopathy and, what he suggested was a means of holistically coordinating the approach to patient care, the primary respiratory mechanism (PRM).[7] He described it as a biphasic phenomenon, independent of pulmonary respiration, with an "inspiratory" and an "expiratory" phase. It is interesting to note that nowhere in the early descriptions of the cyclic PRM is there specific mention of its rate or normative range. In fact, it wasn't until 1961, well after Sutherland's

death, that Woods and Woods first published the term cranial rhythmic impulse and a normative rate for it (10—14 cpm).[8]

The establishment of normative parameters for the rate of the CRI subsequently has been controversial due to: (1) the lack of an accepted objective approach, (2) the esoteric nature of the phenomenon, (3) the subjective nature of the CRI's detection through palpation, (4) the relatively low number of researchers experimentally measuring the rate, and (5) the comparatively low subject population numbers in many of the published studies. Recognized osteopathic textbooks[5,9,10] cite the rate in the range of 8—14 cpm, consistent with the original, 1961, Woods and Woods study.[8] This range still is often cited as definitive even though a much lower range has been reported repeatedly.[11—18] Past reported measured rates for the palpated rate of the CRI are presented for comparison in Table 1, along with the values from this study.

The aims of this study were (1) to define the normative rate of the CRI and (2) to compare palpated CRI rates obtained by practitioners at three experience levels.

2. Methods

The study was organized around the teaching activities of one of the authors (NS) in compliance with the legal requirements of the Commission Nationale de l'Informatique et des Libertés (CRIL) and

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Table 1
Reported cranial rhythmic impulse (CRI) rate ranges.

Authors	CRI Rate (Range or Values)	Subjects in Study (N)	Year Reported
Woods and Woods[8]	10—14	62	1961
Norton et al.[11]	3.2—4.1	24	1992
Wirth-Pattullo and Hayes[12]	3—9	12	1994
McAdoo and Kuchera[13]	6.63—9.37	128	1995
Hanten et al.[14]	3.6 & 4.2	40	1998
Rogers et al.[15]	3.28 & 4.83	28	1998
Sommerfeld[16]	2.3—3.6	49	2004
Moran and Gibbons[17]	2.92—4.17	11	2004
Nelson et al.[18]	2.46—6.62	44	2006
This Study	(mean ± SD)		2009
All subjects	2.43—11.33	727	
1 year experience	2.69—12.09	463	
2 years experience	2.36—10.56	190	
3—25 years experience	2.21—7.35	74	

the Helsinki Accord. Students who participated in the academic program were taught to palpate the CRI and tested to establish their ability to monitor it. The data for this study were taken from these evaluations.

The participants of this study ($N = 734$) were practicing clinicians (predominantly physical therapists, with some nurses, midwives and medical doctors). They were undergraduate and postgraduate students of osteopathy. Most were studying at, or graduates of, La Maison de la Thérapie Manuelle, an osteopathic school that holds classes in different European cities. Their formal two year course of study in cranial osteopathy consisted of 225 contact hours, including 150 h of didactic and 75 h of laboratory work. It was presented within an extensive academic osteopathic curriculum, typically after two years of general osteopathic studies. The Level 1 individuals participated at the end of their first year of cranial osteopathic study. The Level 2 individuals participated upon completion of the course at the end of their second year of study. The Level 3 individuals, having successfully completed the two year cranial program, participated as attendees of postgraduate courses in cranial osteopathy. The demographics of the study population, with respect to the city and year in which the course was given, the level of participants, and their number at that site and year, are as follows: 60.2% (of the total enrolment) at Biscarrosse, France: [2001] Level 1, 86; [2002] Level 1, 50, Level 2, 32, Level 3, 35; [2003] Level 1, 48, Level 2, 31; [2004] Level 2, 52; [2005] Level 1, 59, Level 2, 49. 29.3% at Paris, France: [2002] Level 1, 42; [2003] Level 1, 15, [2004] Level 1, 74, [2006] Level 1, 58, Level 2, 26. 5.2% at Lyon, France: [2003] Level 1, 16, [2004] Level 1, 22. 5.3% at Padova, Italy: [2003] Level 3, 39. The % of the total number of subject/examiners at each level were 64.0% level 1, 25.9% level 2, 10.1% level 3.

Data collection occurred at the end of the course at the same time in the academic schedule of each program. The time of day was variable depending upon each separate program's schedule. The data were collected in the teaching laboratory with the subjects always being examined in the same position, supine upon the examination table. The data were collected in each instance by the same individual (NS).

All participants palpated CRI rates on each other (734 different healthy individuals) within the controlled environment of the teaching laboratory. The groups were divided in half, with half of the group being examiners and the other half subjects. Upon completion of the protocol, the pairing was maintained and the individuals changed places, with the examiners becoming subjects and the subjects becoming examiners. With this structure, every participant was an examiner one time and a subject one time. At no time during and between both sessions was any communication between participating individuals permitted. The examiners were

asked to begin palpating the CRI using the classically described vault hold[5,9] and given enough time, *ca.* 2 min, to sense the oscillation. Following this acclimatisation period, they were told when to start and when to stop counting the CRI. They were not told how long they would be palpating, only to count the number of complete biphasic CRI cycles that they palpated during the acquisition period. They were timed, using a wristwatch with a sweep second hand for a predetermined number of minutes (all trials, 3 min) known only to the individual conducting the protocol. It was determined by our previous work[18—20] that this relatively brief time measurement window is sufficient to provide a good CRI sampling number without introducing error that could come with longer measurement periods. Following the data acquisition period, the investigator passed among the examiners and had them silently record their measured rate on a roll of paper after which that section of paper was torn from the roll and placed into an envelope. The reported number-of-cycles were kept private, and palpating participants were not aware of the rates that other participants reported. The investigator then moved to the next examiner and repeated the process until the rates acquired from all examiners had been gathered. Following this, the pairs exchanged positions, and the protocol was repeated. The numbers recorded on the paper fragments were tabulated on a spreadsheet identifying the experiential group and site. The CRI rate was then calculated in cycles/min for each recorded value by dividing the total number of CRI cycles counted per subject by 3, the time in minutes allowed at each measurement session.

3. Statistical analysis

Palpating participants were analyzed in three groups based upon their level of training and clinical experience: Level 1 ($N = 463$) consisted of students with 1 year of experience who successfully palpated the CRI; Level 2 ($N = 190$), 2 years of experience; Level 3 ($N = 74$), 3—25 years of experience. Although 734 individuals participated in the study, seven Level 1 students did not palpate a CRI rate, yielding a valid subject population of 727 volunteers. Data frequencies and descriptive statistics were computed using the SPSS statistical package (SPSS, Inc., SPSS 10.1).[21] The One-Way Analysis of Variance (one-way ANOVA) was used to assess whether a significant difference existed among the three experimental groups. In addition, pair-wise comparisons (of means) were performed among the three groups using both the Scheffé and the Least-Significant Difference range tests, with an alpha of .05 accepted as significant. Formal tests of normality were computed using the Shapiro—Wilk and the Kolmogrov—Smirnov tests. The distributions obtained (histograms) were analyzed further for their deviations from normality using Normal Q—Q plots and Detrended Normal Q—Q plots.

4. Results

Seven Level I participants (1.5%) were unable to perform the CRI rate determination, while all participants in Levels 2 and 3 successfully performed the CRI rate determination. The valid examiner/subject population of the 734 potential pairings, therefore, was 727.

The mean reported CRI rate ($N = 727$) was (mean ± SD) $6.88 ± 4.45$ cycles per minute (Fig. 1 and Tables 2 and 3). Skewness ($2.510 ± .091$) and Kurtosis ($11.389 ± .181$) provide measures of the distribution (Table 2). (Skewness, or third moment, will take on the value of zero when the distribution is a completely symmetric bell-shaped curve. Kurtosis, or fourth moment, is a measure of relative peakedness or flatness of the curve. A normal distribution will have a kurtosis of zero.[21])

The mean (±SD) for each subgroup (Tables 1 and 3) is as follows: Level 1, $7.39 ± 4.70$; Level 2, $6.46 ± 4.10$; Level 3, $4.78 ± 2.57$ (Fig. 2).
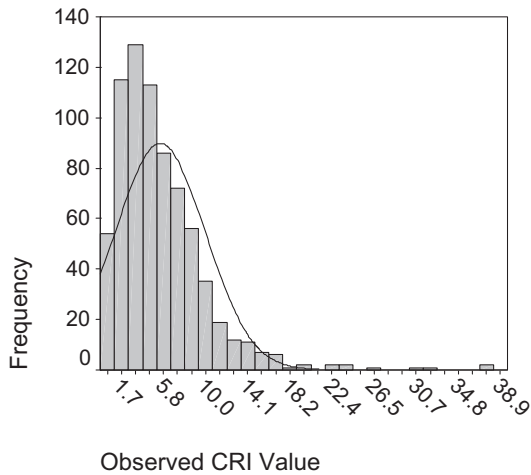
Fig. 1. Frequency histogram of cranial rhythmic impulse (CRI) rates. Each bar represents a CRI range of 1.38 cycles/minute (cpm); frequency is the number of the 727 participants in a given range (mean ± SD = 6.882 ± 4.446; N = 727). The solid line depicts the standard deviation (SD) curve derived from the histogram. Note; because of the skewed nature of the CRI data, the normal distribution curve presented in the figure is truncated on the left because it is impossible to palpate a rate lower than zero.

One-way analysis of variance for levels 1, 2 and 3 was significant ($P < 0.001$). The Scheffé post hoc test showed that all three groups were different, one from the other (Fig. 2 and Table 4).

In Fig. 3, parts A, B, and C, the histograms of Fig. 2 have been adjusted vertically so that the shape of the histograms is more apparent visually. Note that with increasing experience (Level 3), the width of the distribution is narrowest, and the skew is least. The maximum bars of the histograms, however, are located approximately at the same values of the CRI rate for all three groups.

Analysis of distributions for each group is presented in the normal probability plots of Fig. 3, parts D, E, and F. If the data are from a normal distribution, the plotted values should fall roughly around the diagonal lines in Fig. 3, parts D, E, and F. Points falling off the line indicate deviation from a normal distribution. Fig. 3, parts D and E, are similar in appearance and fall below the normality line for both low and high CRI values, with the deviation from normal being greatest for Level 1 (Fig. 3, part D). Fig. 3, part F, is distinctly different. Here the distribution approximates normality because the data points fall close to the normative line.

Table 2
Cranial Rhythmic Impulse (CRI) rate from all valid participants: Descriptive Statistics (Rates are reported as cycles per minute for data collection times of 3 min).

Statistics (All participants)	
N	
Valid	727
Missing	7
Mean	6.882
Std. Error of Mean	.1649
Median	6
Mode	3.33
Std. Deviation	4.446
Variance	19.766
Skewness	2.510
Std. Error of Skewness	.091
Kurtosis	11.389
Std. Error of Kurtosis	.181
Range	38.33
Minimum	1.00
Maximum	39.33

Table 3
Cranial Rhythmic Impulse (CRI) rate partitioned by experience level: Descriptive Statistics.

Level	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	463	7.392	4.700	.218	6.963	7.822	1.00	39.33
2	190	6.458	4.102	.298	5.871	7.045	1.33	33.67
3	74	4.775	2.570	.299	4.179	5.370	1.33	13.33
Total	727	6.882	4.446	.165	6.558	7.205	1.00	39.33

All values except Level and N are reported as cycles per minute for data collection times of 3 min.

The data in Fig. 3, parts D, E, and F, are scaled identically to facilitate comparisons. Note that the slope of the lines move to the vertical from Level 1 through Level 3, indicating a tighter grouping of the data, i.e., the data from experienced practitioners is less scattered, which also is reflected in the values of the standard deviations (Table 3).

Further analysis of the three distributions is presented in the detrended normal probability plots of Fig. 3, parts G, H, and I. These detrended plots can also be used to detect patterns of how the histogram data depart from normality. In these displays, the differences between the usual z score for each case and its expected score under normality are plotted against the CRI values (the scale on the vertical axis remains in standardized units). Here, since the plot line is horizontal, the vertical plot scale enlarges, magnifying the view of the configuration.[21] (In a normal distribution, points will be scattered plus and minus about the horizontal line and will be clustered close to it.)

Again, Fig. 3, parts G and H (Levels 1 and 2), show similar curved displays having large positive wings. These distributions lie far from the normal. In contrast, the distribution of Level 3 (Fig. 3, part I) lies close to the normal with only a single point being an outlier.

5. Discussion

Why should we concern ourselves with the rate of the CRI? Cranial osteopathy, the PRM and the CRI are decidedly controversial, with a number of authors questioning their validity.[1−4] Further, the fact that there were 22 years between the introduction of the cranial hypothesis[7] and the initial use of the term cranial rhythmic impulse and the first publication of an observed rate for the CRI[8] could lead one to wonder if the rate was of any great relevance to early practitioners.

We would contend that resolution of the controversy over cranial osteopathy could come only from an acceptable understanding of its underlying physiology. As stated earlier, the CRI is an observable (palpable) rhythmic fluctuation believed to be synchronous with the PRM.[6] As an observable phenomenon associated with the PRM, the central concept in cranial osteopathy, it offers access for the study of the cranial hypothesis. Yet measured rates for the CRI tend to vary sufficiently from one study to another (Table 1) as to call into question what is being measured. Since it is assumed to be a biological rhythm, the CRI should have a normative rate and range. Identifying these values will allow better understanding of the phenomenon and possibly provide access to further study of the underlying physiology and therapeutic impact of cranial osteopathy.

Having normative values for the CRI also will aid in the teaching of cranial osteopathy. If a student has a clearly defined idea as to the rate of the physiological rhythm they are trying to learn to palpate, the objective of their studies becomes easier to identify. Testing a student's ability to palpate also will be facilitated. The use of a window of observation, similar to that employed in this protocol,
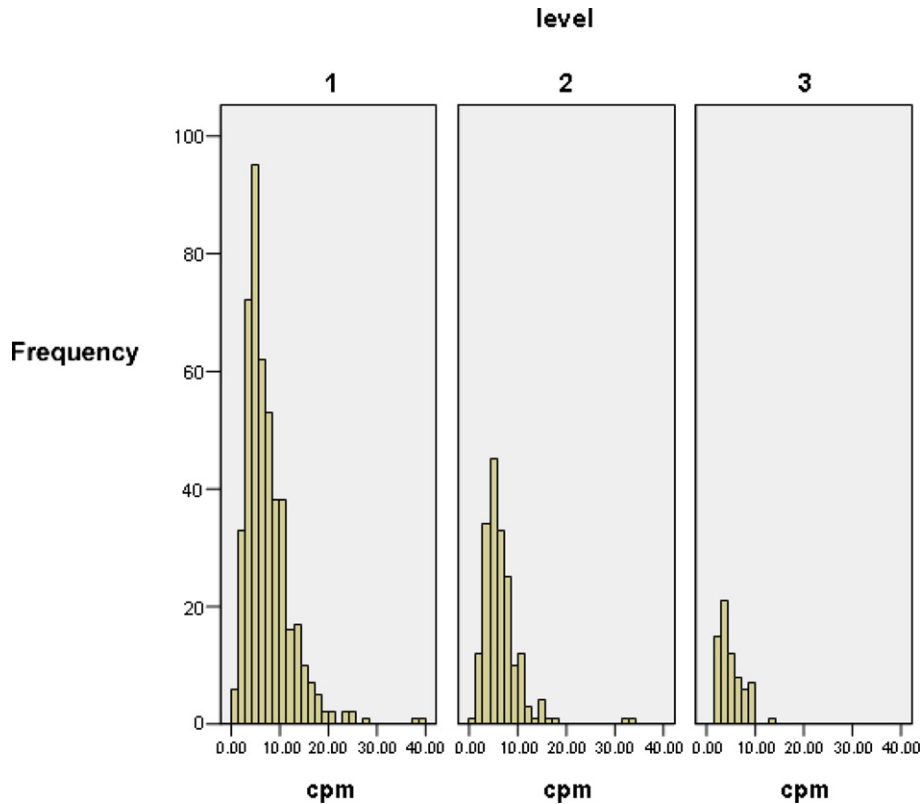
Fig. 2. Frequency histograms of cranial rhythmic impulse (CRI) rates partitioned by level of training. Level 1, 1 yr ($N = 463$); Level 2, 2 yr ($N = 190$); Level 3, 3—25 yr ($N = 74$). Each bar represents a CRI range of 1.43 counts per minute (cpm); frequency is the number of the total 727 participants in a given range for each training level.

becomes a feasible testing tool if well-documented rates for the CRI are available.

The establishment of normative values in the clinical sciences, however, ordinarily means the conduct of studies with large N numbers. This study provides a statistical N of 727 subjects (Tables 1 and 2). This number of cases (all different subjects) is 83% larger than the sum of all comparable studies identified in Table 1.

Both the reported CRI rate means and standard deviations in this current study showed an inverse relationship with the level of examiner experience, i.e., as experience increased, means and standard deviations decreased. This is consistent with what one would expect: (1) beginning level students ought to show a greater range of palpatory results because of an increased possibility for error (increased SD), (2) the intermediate training level's values would fall somewhere between beginners and experienced practitioners, and (3) the more experienced examiners should be capable of more precisely palpating the CRI, yielding a decreased variance. The data do show that these

variance expectations for the three levels are valid (Table 3, means; Table 4, multiple comparisons), with the experienced group demonstrating an SD that approximates half that of the two less experienced groups.

During the implementation of the protocol the CRI counting period was reasonably short, 3 min, and it was the same in all instances, even though the participants did not know for how long they were counting. The data from the experienced practitioners presented in Table 3 and Fig. 3 demonstrates that the CRI values were reasonably closely clustered for the experienced group. This indicates that the experimental protocol was, therefore, reasonably well designed and that the spread in CRI values observed for the two less experienced groups was the result of practitioner inexperience and not the result of a poorly designed protocol.

Further, and in support of the reliability of experienced examiners, are respective histograms of Levels 1, 2, and 3 CRI values and their analyses through normal probability and detrended normal probability plots (Fig. 3). These plots demonstrate that CRI values

Table 4
Statistical significance of differences in results among the three educational levels.

Levels Compared		Difference Between Mean Rates	Std. Error	95% Confidence Interval For the Difference Between Means		P
(I)	(J)	(I − J)		Lower bound	Upper bound	
1	2	.935	.377	.0096	1.8593	.047[a]
1	3	2.618	.548	1.2737	3.9615	<.001[a]
2	3	1.683	.600	.2122	3.1540	.020[a]

All values except Level and P are cycles per minute.
[a] The mean difference is significant at the .05 level (Scheffé multiple comparisons).

Frequencies

Normal Q-Q Plots

Detrended Normal Q-Q Plots
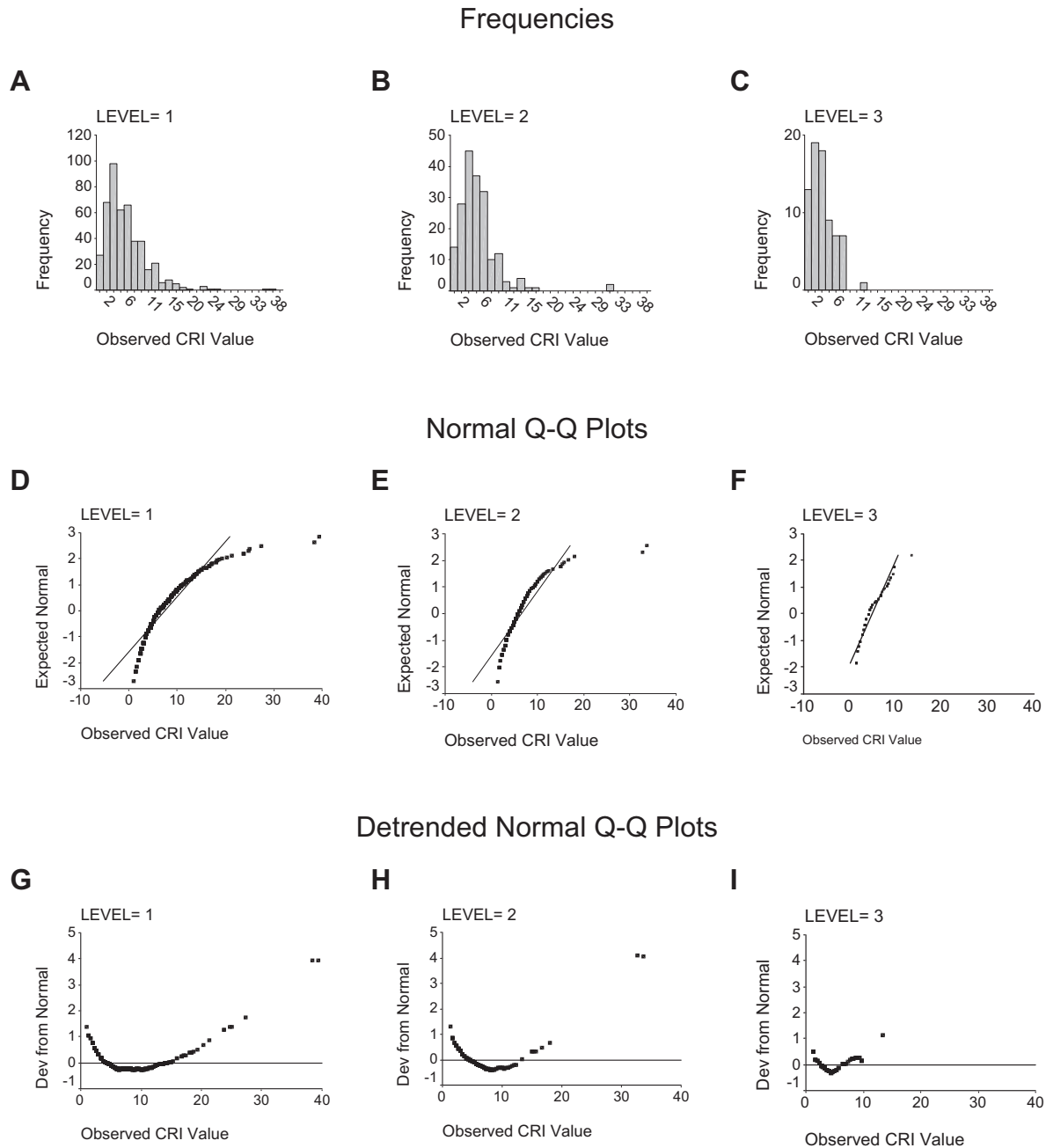
Fig. 3. Analysis of histogram distributions through Frequency, Normal Q–Q, and Detrended Normal Q–Q plots. (The histograms of Fig. 2 have been adjusted vertically for this figure so that the shape of the histograms is more apparent visually.) The duration of training/clinical experience of each group is indicated as Level 1 (1 year), Level 2 (2 years), and Level 3 (3–25 years). Parts A–C: Further analysis of the data of Fig. 2, presented as expanded histograms. The relative amplitude of these histograms has been adjusted vertically from Fig. 2 for visual comparison; each bar represents a CRI increment of 1.33 cycles/min. Parts D–F: Normal Q–Q plots. The diagonal lines in each plot represent a computed normal distribution based upon the histogram immediately above it. The actual data points also are plotted. [Each observation in a normal probability plot is plotted against the corresponding quantile of a standard normal distribution (its expected z score or standard score)—the observed data values are plotted on the horizontal axis and the "expected" values under normality on the vertical axis.[21]] Comparing the data points to the computed normal distribution line gives an indication of the degree and characteristics of deviation from normality. The slope of the line indicates the breath of the distribution, with narrow (compact) distributions approaching the vertical. Parts G–I: Detrended Normal Q–Q plots. These plots amplify the spread in the data relative to the computed normal distribution represented by the horizontal line. Deviations from normality may fall above or below this line. Data from a distribution that is statistically normal will appear spread above and below the horizontal line in an apparent random fashion. Kolmogorov–Smirnov and Shapiro–Wilk tests for normality both show that all three plots deviate from normality ($P < 0.001$); however, Level 3 is much closer to normality than either Levels 1 or 2.

obtained from experienced practitioners (Level 3) reflect a normal statistical distribution, as would be expected from a healthy human subject population. The less experienced practitioner groups (Levels 1 and 2) contain higher frequency readings, with the least experienced group (Level 1) containing the greatest proportion of such readings. The tendency of novice practitioners to report higher CRI rates relative to experienced practitioners may represent an inability of less experienced practitioners to filter out other rhythmic phenomena, such as respiration from the subject, or rhythms from their own bodies. Or it may reflect a tendency for certain beginners to apply manual force in anticipation of the CRI cycle, to lead the CRI cycle as opposed to merely following it. Also of note is the fact that it was only in the Level 1 group that examiners failed to palpate any rate for the CRI.

The data were gathered at several geographic locations as part of educational programs conducted by the same individual (NS). Training by one instructor raises the following question: Were the results due to the influence of that instructor? Published data suggest that this is not the case.[18] The accuracy of the palpated CRI rates of examiners in this study, particularly that of Level 3, is supported by the comparable mean of the aforementioned study involving experienced practitioners (44 U.S. trained, osteopathic physicians, each with a different subject, see Table 1, Nelson et al.). The results of the current study for Level 3 examiners are 4.78 ± 2.57 cycles/min: The comparable study reports 4.54 ± 2.08 cycles/min.[18]

The limitations of this study are as follows: (1) Sample size among experience levels was not equal, potentially affecting computed P values; however, it is unlikely, given the magnitude of the differences among the means and deviations of the three groups that equalizing the group sizes will alter the principal findings. (2) The rate was silently counted in the examiner's head and reported at the end of the designated time period. This leaves room for error in reporting, should the examiner lose count at some point during the measurement period, although the relatively short data acquisition period (3 min) greatly minimizes this risk. There is always the possibility that an examiner could misunderstand the instructions, perhaps counting half-cycles, i.e., flexion-1, extension-2, flexion-3, etc. The fact that the means are relatively close for all groups appears to indicate that this did not happen to any great extent. (3) No repetitive measurement tests were performed. Consequently the data for each individual is limited to a single data point. [A kappa analysis for interexaminer reliability was not attempted for this study because other attempts to do so by our laboratory have shown that the extended (repeated) examination time demanded by such a repetitious protocol fatigues both the examiner and the subject, increasing the variance of measurement as time progresses and lowering the power of the statistical analysis to the point where the analysis becomes useless.[19]] (4) Examiner bias existed in this study. Students were, in the course of their studies, taught "accepted" values for the CRI. The values taught were consistent with those published previously in the original study by Woods and Woods[8] and in recognized textbooks, 10–14 cpm.[5,9,10] The results of this study are, however, decidedly lower, 2.43–11.33 cpm, and the values obtained by experienced examiners are even lower, 2.21–7.35 cpm, The fact that the examiners were unaware of the time they would be palpating, minimizes the issue of the examiner's pre-expectations. The only way an individual could have manifested such a bias would have been to have looked at their watch during the protocol and manufacture what they thought was the "correct" rate. To the best of our knowledge, this did not happen. (5) The possibility of entrainment exists between the examiner and subject that could carry over when the individuals changed positions during the second part of the protocol, thereby influencing the second data set. Although this possibility exists we believe that the intervening positional changes that the participants experienced combined with the length of time between the termination of the first rate recording period and the completion of the subsequent data gathering was sufficiently long to mitigate any such entrainment.

That this study and the previous comparable study[18] demonstrate a decidedly lower rate for the CRI than the generally accepted rate needs to be explained. In our past studies, where we have documented a relationship between the CRI and low frequency oscillations (Traube-Hering-Mayer) in bloodflow velocity, we have demonstrated that the .1–.15 Hz component of these complex wave forms is of a relatively constant frequency,[18–20,22–24] although a 20% frequency modulation in the waveform has been noted.[19] The fact that palpation of the CRI by experienced examiners tracks the .1–.15 Hz oscillation, but

consistently at one-half its frequency, is perplexing.[18,19] It is of interest to note that we have identified a signal at .08 Hz that was resolved in flowmetry data but not reported in earlier work with lower reported signal-to-noise resolution.[20] That frequency, .08 Hz, is 4.80 cpm, a frequency that is strikingly close to the mean value (4.78 cpm) reported in this study and that (4.54 cpm) reported in our previous study.[18] It appears that it is this .08 Hz signal that the examiners may be tracking.

6. Conclusions

This study demonstrates that the distribution of the palpated rate for the CRI narrows as examiners become more experienced. Experienced examiners yield rates that fall upon a normative line of distribution that is more tightly grouped. Additionally, it is of interest to note that the rate of the CRI reported by experienced examiners in this study is essentially identical to the rate reported from our previous study.[18] Experienced examiners appear to be tracking the CRI at a rate that is coincident with a .08 Hz (4.8 cpm) signal identified by laser-Doppler flowmetry within cutaneous bloodflow velocities.[20]

The increased precision of CRI palpation with examiner experience indicates that the phenomenon that is being reported is, in fact, being perceived. Further, from the values reported, the accepted normative rate for the CRI should be lowered to 2–7 cpm.

References

1. Ferre JC, Barbin JY. The osteopathic cranial concept: fact or fiction? *Surg Rad Anat* 1991;**13**:165–70.
2. Green C, Martin CW, Bassett K, Kazanjian A. *A systematic review and critical appraisal of the scientific evidence on craniosacral therapy*. Joint Health Technology Assessment Series. Vancouver, BC: British Columbia Office of Health Technology Assessment (BCOHTA 99:1J); 1999. pp. 1–55.
3. Green C, Martin CW, Bassett K, Kazanjian A. A systematic review of craniosacral therapy: biological plausibility, assessment reliability and clinical effectiveness. *Complement Ther Med* 1999;**7**:201–7.
4. Hartman SE, Norton JM. Interexaminer reliability and cranial osteopathy. *Sci Rev Alt Med* 2002;**6**:23–34.
5. King HH, Lay EM. Osteopathy in the cranial field. In: Ward RC, editor. *Foundations for osteopathic medicine*. 2nd ed. Baltimore, MD: Lippincott, Williams & Wilkins; 2003. p. 985–1001.
6. Educational Council on Osteopathic Principles (ECOP) of the American Association of Colleges of Osteopathic Medicine (AACOM). *Glossary of osteopathic Terminology*. Chevy Chase, MD: AACOM, www.aacom.org; 2009. See also.
7. Sutherland WG. *The cranial bowl*. Mankato, MN: Free Press Company; 1939. reprinted 1986.
8. Woods JM, Woods RH. A physical finding relating to psychiatric disorders. *J Am Osteopath Assoc* 1961;**60**:988–93.
9. Magoun HI. *Osteopathy in the cranial field*. 2nd ed. Kirksville, MO: The Journal Printing Company; 1966.
10. Sergueef N. *Le B.A.BA du crânien*. Paris, France: SPEK; 1986.
11. Norton JM, Sibley G, Broder-Oldach R. Characterization of the cranial rhythmic impulse in healthy human adults. *AAO J* 1992;**2**:9–12. 26.
12. Wirth-Pattullo V, Hayes KW. Interrater reliability of craniosacral rate measurements and their relationship with subjects' and examiners' heart and respiratory rate measurements. *Phys Ther* 1994;**74**:908–16.
13. McAdoo J, Kuchera ML. Reliability of cranial rhythmic impulse palpation. *J Am Osteopath Assoc* 1995;**95** (Abs):491–EOA.
14. Hanten WP, Dawson DD, Iwata M, Seiden M, Whitten FG, Zink T. Craniosacral rhythm: reliability and relationships with cardiac and respiratory rates. *J Orthop Sports Phys Ther* 1998;**27**:213–8.
15. Rogers JS, Witt PL, Gross MT, Hacke JD, Genova PA. Simultaneous palpation of the craniosacral rate at the head and feet: Intrarater and interrater reliability and rate comparisons. *Phys Ther* 1998;**78**:1175–85.
16. Sommerfeld P, Kaider A, Klein P. Inter-and intraexaminer reliability in the palpation of the "primary respiratory mechanism" within the "cranial concept". *Man Ther* 2004;**9**:22–9.
17. Moran RW, Gibbons P. Intraexaminer and interexaminer reliability for palpation of the cranial rhythmic impulse at the head and the sacrum. *J Manipulative Physiol Ther* 2004;**24**:183–90.
18. Nelson KE, Sergueef N, Glonek T. Recording the rate of the cranial rhythmic impulse. *J Am Osteopath Assoc* 2006;**106**:337–41.
19. Nelson KE, Sergueef NS, Lipinski CM, Chapman AR, Glonek T. The cranial rhythmic impulse related to the Traube-Hering-Mayer oscillation: Comparing

laser-Doppler flowmetry and palpation. *J Am Osteopath Assoc* 2001;**101**: 163–73.
20. Nelson KE, Sergueef N, Glonek T. The effect of an alternative medical procedure upon low-frequency oscillations in cutaneous blood flow velocity. *J Manipulative Physiol Ther* 2006;**29**:626–36.
21. *SPSS® Base 8.0 Applications Guide*. Chicago, IL: SPSS Inc.; Copyright ©; 1998. 32,57–58.

22. Sergueef N, Nelson KE, Glonek T. The effect of cranial manipulation upon the Traube Hering Mayer oscillation. *Alt Ther Health Med* 2002;**8**:74–6.
23. Nelson KE, Sergueef N, Glonek T. Cranial manipulation induces sequential changes in blood flow velocity on demand. *AAO J* 2004;**14**:15–7.
24. Sergueef N, Nelson KE, Glonek T. The effect of light exercise upon blood flow velocity as measured by laser-Doppler flowmetry. *J Med Eng Tech* 2004;**28**: 143–50.