Original article

Inter- and intraexaminer reliability in palpation of the "primary respiratory mechanism" within the "cranial concept"

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Abstract

Inevitable subjectivity makes interexaminer reliability of manual assessment procedures a special matter of concern. The cranial concept (CC), one aspect of osteopathy, deals with very subtle changes that have to be palpated. One of the main principles of the CC is the primary respiratory mechanism (PRM), which is hypothesized to be a palpable physiological phenomenon that occurs in rhythmic cycles, called flexion- and extension-phase, which are independent from cardiac and respiratory rates. Palpation of the PRM is one of the first steps in assessment within the CC.

An inter- and intraexaminer reliability study design for repeated measures was used in this study. Forty nine healthy subjects were palpated simultaneously twice, once at the head and once at the pelvis.

PRM-frequency (f), the mean duration of the flexion phase and the mean ratio of flexion- to extension-phase were used as the main outcome measures. Inter- and intraexaminer reliability and correlations to the respiratory rates were analysed for all three parameters.

Inter- as well as intraexaminer agreement could not be described beyond chance agreement, as the range within the 95% limits of agreement (e.g. for $f = 6.6$ cycles/90 s) for all cases resembled the total range of values (e.g. for $f = 7$ cycles/90 s) that were produced. A significant effect of the examiners' respiration was found for both examiners at the pelvis ($P = 0.004$ for one examiner, $P < 0.0001$ for the other examiner), and for one examiner only at the head ($P = 0.0017$). No correlation could be found for the subjects' respiratory rates.

In conclusion, PRM-rates could not be palpated reliably and under certain conditions were influenced by the examiners' respiratory rates. These results do not support the hypotheses behind the PRM. The role of PRM palpation for clinical decision making and the models explaining the PRM should therefore be rethought.
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1. Introduction

The cranial concept[1] (CC), originally introduced and developed by W.G. Sutherland (1873–1954) (A.S. Sutherland and A.L. Wales, editors, 1998) and H.I. Magoun (1951, reprint, 1997), can be regarded as part of the osteopathic approach in manual medicine.

Despite criticisms within and from outside the osteopathic community, its publicity is increasing (Abehsera, 2001).

The physiological aspect of the CC is built on two main hypotheses:

(1) The idea of mobility within the osseous and membranous structures of the skull, the hypothesis of cranial mobility.

(2) The "primary respiratory mechanism" (PRM), an autonomous rhythmic phenomenon inherent to every living organism, independent of thoracic respiration and cardiac pulse. The cyclic changes of the PRM are represented by an expanding phase called flexion and a contracting phase called extension.

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[1] Different terms like craniosacral osteopathy, biodynamic cranial osteopathy, craniosacral therapy, etc. are more or less describing the same.

Cranial mobility as well as the physiological basis of the PRM is still a matter of discussion (Klein and Burnotte, 1985; Ferré and Barbin, 1990; Rogers and Witt, 1997; Green et al., 1999; Klein, 2002; Hartman and Norton, 2002) and due to methodological deficiencies investigations that tried to prove the existence of the PRM (Baker, 1971; Frymann, 1971; Mitchell and Pruzzo, 1971; Michael and Retzlaff, 1975; Retzlaff et al., 1976a, b, 1978; Tettambel et al., 1978; Upledger and Karni, 1979; Rommeveaux, 1992; Oleski et al., 2002) have to be regarded critically. A recent study (Adams et al., 1992) only mentions cranial mobility, being due to cardiac and thoracic respiratory rhythmic influences. Several physiological models try to explain the PRM such as the hypothesis of cerebral motility (Sutherland, 1998), the "muscle reaction model" (Upledger and Vredevoogd, 1994), the "pressurestat model" (Upledger, 1994), the "tissue pressure model" (Norton, 1991) or the "entrainment hypothesis" (McPartland, 1997).

The CC says that these rhythmic changes make the osseous and membranous structures of the cranium and in consequence the fascial system of the entire body move in certain patterns, which can be palpated (Upledger and Vredevoogd, 1994; Becker, 1997; Sutherland, 1998). The movements or changes induced by the PRM are thought to be very small. So the observation of that phenomenon is taking part near the limits of tactile perceptible events (Upledger and Vredevoogd, 1994) and requires special training as already stated by Sutherland himself (Sutherland, 1990, 1994, 1998). In this context several authors report that palpation of the PRM is easier at the parietals, the squamous part of the occipital bone, the greater wings of the sphenoid bone and the sacrum (Upledger and Vredevoogd, 1994; Liem, 1998; Sutherland et al., 1998).

Together with observation, percussion and auscultation, palpation can be regarded as one of the main tools for structural diagnosis in manual medicine (Greenman, 1996). Interexaminer reliability of palpation within the CC has rarely been assessed. In an early paper, nearly perfect interexaminer reliability for different findings during an assessment of the cranial system is reported (Upledger, 1977), but these results are misleading because of inadequate statistical analysis. According to Alley (1983), reliability studies prior to 1983 suffer methodological and statistical deficiencies. Inter- and intrarater reliability for the palpation of the PRM has recently been assessed by different authors (Wirth-Pattullo and Hayes, 1994; Norton, 1996; Hanten et al., 1998; Rogers et al., 1998; Moran and Gibbons, 2002).

This study aimed to assess the agreement within two examiners concerning the palpation of the PRM as described in the CC referring to the following hypothesis: If the PRM represents a physiological phenomenon whose effects occur as presumed by the CC and if

further on these effects can be reliably palpated by trained persons, then clinical relevant intra- and interexaminer agreement with respect to the assessment of the cycles of the PRM should be reached by two trained examiners palpating one subject simultaneously and repeatedly within a short time interval. In addition, the PRM cycles should not show any dependency on examiners' and subject's respiratory rates.

2. Materials and methods

2.1. Subjects

Forty-nine symptom-free voluntary subjects ($n = 49$) with a mean age of 37.45 ± 7.52 (min $= 19$; max $= 61$) were assessed. Thirty-four were female, 15 male. The subjects were recruited from the student body of the *Vienna School of Osteopathy* as well as from acquaintances of the students. Subjects who had undergone severe trauma, surgery and current acute pain in the area of the cranium, the spine and the pelvis as well as current and past neurological diseases were excluded. The subjects were informed about the procedure during the measurements as well as the fact that no treatment would take place.

2.2. Materials

The palpatory findings of both examiners were recorded via two foot switches. In order to get the examiners blind, the switches were muted using forklight barriers. The signals from the switches were recorded directly as digital units "on" and "off". The recording of the respiratory rates of the examiners and the subjects was carried out by strain gauges (Measurements Group® Type: N2A-06-S153R- 35B), glued to metal bows, which were attached to the individuals by a non-elastic belt fastened around the thorax.

For further processing, the measured signals were amplified and sent to an analogue-digital converter (ELV Elektronik AG®; measuring module type M232) connected to a PC via a serial interface. The time-related resolution was 500 ms. The software was written in LabWindows® CVI 16 Bit-Version 4.0.1. Each single measurement could be started, ended and selectively stored, showing starting time and the measured time period for further analysis.

2.3. Examiners

Two examiners took part in this study. Both had graduated from the *Vienna School of Osteopathy*. For 2 years, they had participated in a postgraduate project in co-operation with the *Osteopathic Centre for Children* (London), where the main emphasis for clinical work

was based on the principles of the CC. At the time of the study, both have undergone about 300 h training in cranial techniques and theory and had 7 years of clinical experience behind them. They could therefore be considered as experts in the cranial approach to treatment.

2.4. Procedure

For the measurements two treatment couches were used. While the examiners were palpating one of the subjects, the next subject was already lying on the other table. So sufficient relaxation of the subjects could be guaranteed for palpation. During palpation the subject was lay supine. One practitioner was seated at the head, palpating the cranium, the other one at the side near the pelvis, palpating the sacrum. In order to blind the examiners, a curtain was hung down from the ceiling at about the middle of the treatment coach. Belts with the integrated metal bows for the recording of respiratory rates were fixed to the examiners' and the subject's chests. Afterwards the correctness of the signals was checked.

The examiners were told to press the foot switch as soon as they felt the beginning of a flexion-phase and let go at the beginning of the extension-phase of the PRM. So the palpated PRM appeared as a rectangular wave on the display. The measurement period lasted over 90 s. This time period seemed to be long enough to obtain sufficient opportunity to determine and compare the frequency of the PRM-rates and short enough to avoid early fatigue of the examiners. The examiners could use their own hand-holds and had about 1 min to become orientated. Both examiners used known standard holds. Each examiner palpated each subject twice, once at the head and once at the pelvis. The position for the first measurement was randomized. Breaks were taken after eight subjects.

2.5. Statistical analysis

The independent variables were: examiner A and B, examiner location pelvis (P) and cranium (C) and measurements T1 (first measurement) and T2 (second measurement). The palpated PRM-rates were described by the three dependent variables:

- PRM-Frequency (f), which means the number of flexion-phases in 60 or 90 s;
- mean duration of the flexion-phases per examination (MDF);
- mean ratio of the lengths of the flexion- to extension-phase per examination ($R_{F/E}$).

The researchers decided to determine these three summary measures because the distribution between flexion- and extension-phase can be expected to be

irregular (Lockwood and Degenhardt, 1998). Thus f, MDF and $R_{F/E}$ would enable differentiated possibilities in data analysis and future interpretation.

The three dependent variables were tested with regard to systematic differences under various conditions. For this, including the random factor subject, a four-way analysis of variance (ANOVA) (Kirk, 1982) was used. The dependent variables f, MDF and $R_{F/E}$ were tested separately with regard to the factors location (L), examiner (O) and examination-time (T). Interrater reliability was tested by using the 95% limits of agreement as described by Bland and Altman (1986): *Mean difference $\pm 1.96 \times$ standard deviation of the differences*. Possible interactions between palpatory findings and respiratory rates of subjects and examiners were tested. In this case, analysis of covariance models (Kirk, 1982) was used. Besides the factors subject, examiner, location and time, the respiratory rates were tested as covariables in the models. These analyses were carried out separately for the independent variables f, MDF and $R_{F/E}$. If interactions were present, the respective factors were analysed separately for each examiner (A,B) or location (P,C). The correlations between the three summary measures and the respiratory rates were additionally described using Pearson's correlation coefficient (r).

3. Results

The palpated PRM-frequencies ranged from 2.3 (SD 0.8) to 3.6 (SD 0.8) cycles/min (see Fig. 1). For MDF we could find values ranging from 8.0 (SD 4.3) to 10.6 (SD 4.1) s. Due to skewed distribution the values for $R_{F/E}$ have been $\log_{10}$ transformed and ranged from –0.15 (SD 0.22) to 0.09 (SD 0.16). ANOVA analysis showed a significant influence of the examiner ($P < 0.0001$) as well as a significant interaction between examiner and location ($P < 0.0001$) could be found for the variable f.
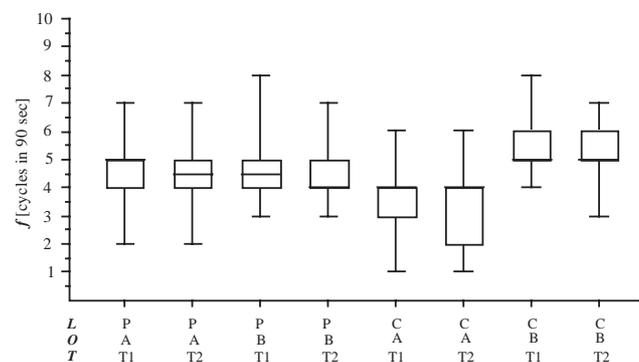

Fig. 1. Boxplot of the palpated PRM-rates (f) under the different conditions for location (L) pelvis (P) and cranium (C), examiner (O) A and B and examination-time (T) T1 and T2. The whiskers show the 95% range, the box represents 50% of the measured values.

Table 1
Results of the analysis of interexaminer agreement using the 95% limits of agreement (Lts)

Factor	n	MDiff A−B	SD A−B	95% Lts	
				Low	High
PRM-frequency (*f*)					
C	49	−1.65	1.70	−4.99	1.68
P	49	−0.06	1.66	−3.32	3.20
T1	49	−0.88	1.59	−3.99	2.24
T2	49	−0.84	1.45	−3.68	2.00
Mean duration flexion-phases (*MDF*)					
C	48	1.12	5.02	−8.71	10.95
P	49	−0.93	4.28	−9.33	7.46
T1	49	−0.17	5.26	−10.48	10.13
T2	49	0.33	4.27	−8.04	8.70
Mean ration flexion- to extension-phase ($R_{F/E}$)					
C	49	−0.17	0.41	−0.97	0.63
P	49	−0.13	0.28	−0.57	0.51
T1	49	−0.12	0.37	−0.84	0.60
T2	49	−0.8	0.35	−0.77	0.61

Mdiff—mean difference, Low—lower limit, High—higher limit, SD—standard deviation, A, B—examiners, C—examiner location cranium, P—examiner location pelvis, T1—first measurement, T2—second measurement.

For *MDF* the analysis showed no significant effect for *L* and *O*, for $R_{F/E}$ a systematic tendency for significant lower mean values for examiner A as for B ($P = 0.005$) could be found.

The data for inter- and intrarater agreement are summarized in Tables 1 and 2 and Fig. 2. For all three summary measures *f*, *MDF* and $R_{F/E}$ the range within the 95% limits of agreement for interexaminer agreement resembles the total range of ascertained values (see the bar-diagram in Fig. 2). The expected intrasubjective difference within the 95% limits of agreement can be seen in Table 2. As before, the ranges are quite as large as 95% of the total range of ascertained values for the respective parameters (see the bar-diagram in Fig. 2).

The analysis of possible effects of the respective examiner's respiratory rate (RE_O) and the subject's respiratory rate (RE_{SU}) on the palpated PRM showed the following results: For both examiners a significant effect of the examiner's own respiratory rate could be observed at the pelvis with $P = 0.004$ for examiner A (RE_A) and with $P < 0.0001$ for examiner B (RE_B) on the dependent variable *f*. At the head, the effect was significant for examiner B only ($P = 0.0017$). No significant influence of the RE_{SU} on *f* could be found. For the dependent variable *MDF*, as for *f*, a significant effect of RE_O has been found at the pelvis ($P = 0.0276$). At the head, no significant effects could be observed ($P = 0.8918$). For the dependent variable $R_{F/E}$ no significant effects of the examiners' as well as the subjects' respiratory rates could be found ($P > 0.05$).

Table 2
Results of the analysis of intraexaminer agreement using the 95% limits of agreement (Lts)

Factor	n	MDiff P−C	SD P−C	95% Lts	
				Low	High
PRM-frequency (*f*)					
A	49	−1.02	1.55	−2.01	4.05
B	49	−5.57	1.38	−3.28	2.14
Mean duration flexion-phases (*MDF*)					
A	49	−1.79	4.94	−11.48	7.90
B	49	0.36	2.42	−4.39	5.11
Mean ration flexion- to extension-phase ($R_{F/E}$)					
A	49	0.03	0.42	−0.79	0.86
B	49	−0.11	0.20	−0.50	0.29

Mdiff—mean difference, Low—lower limit, High—higher limit, SD—standard deviation, A, B—examiners, C—examiner location cranium, P—examiner location pelvis, T1—first measurement, T2—second measurement.
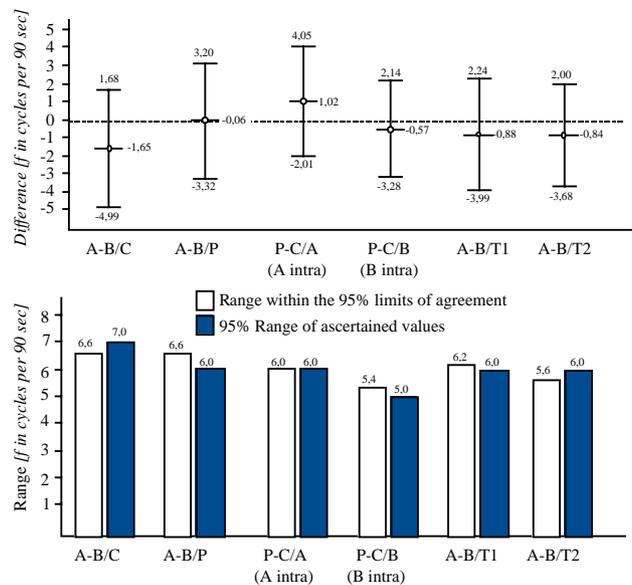

Fig. 2. Graphical presentation of the results for inter- and intraexaminer agreement for examiner A and B at the pelvis (P) and the cranium (C) for the palpated PRM-rates (*f*). The upper diagram shows the 95% limits of agreement. The bar-diagram below shows the range within the 95% limits of agreement in comparison with the 95% range of ascertained data (dark bars).

To describe the strengths of the effects detected in the analysis of covariance, correlation coefficients were estimated. At the pelvis, a moderate correlation between RE_O and *f* could be described with $r = 0.42$ ($P = 0.0024$) for examiner A and $r = 0.58$ ($P < 0.0001$) for B. For examiner B, moderate correlation with regard to *MDF* could be observed with $r = −0.55$ ($P < 0.0001$). The negative coefficient indicates that the examiner palpated shorter flexion-phases when her respiratory rate

increased. All other correlations for the location pelvis produced low values. At the head moderate correlation could only be found for examiner B with $r = 0.45$ ($P = 0.0012$) for f and $r = -0.57$ ($P < 0.0001$) for *MDF*.

4. Discussion

Measuring the perception of the PRM by using a foot switch can produce erroneous values caused by possible difficulties in simultaneously palpating and activating the switch. The number of presented measurements ($n = 98$) and the fact that the spread of the final values concerning palpated data were between acceptable limits (e.g. 0.7–5.3 cycles/min for f) do support the assumption that these kind of errors can be considered to be small. The examiners themselves neither claimed to have problems in using the foot-switches nor did they subjectively interfere the quality of palpation. We did not test interrater reliability for thoraco-abdominal respiration palpation like Wirth-Pattullo and Hayes (1994) and Norton (1996). Possible influences of the experimental context on the observers' concentration cannot be excluded.

One of the essential issues in data analysis was the description of inter- and intraexaminer agreement (or reliability). Interclass correlation coefficients (*ICC*) are frequently suggested for the description of agreement for continuous data (Haas, 1991, 1995; Altman, 1999) and have repeatedly been used for the calculation of inter- and intraexaminer reliability for the palpation of the PRM (Wirth-Pattullo and Hayes, 1994; Hanten et al., 1998; Rogers et al., 1998; Moran and Gibbons, 2002). As Bland and Altman (1986) state, the interpretation of the comparison between two measures can be misleading, when correlation is mixed up with agreement. So we decided to use a method suggested by these authors, using the 95% *limits of agreement* (Bland and Altmann, 1986) as explained above.

The number of examiners used to conduct this reliability study was minimal (two examiners). But as the probability of treatment effects increases with the number of examiners (i.e. repetition of measurements), it was probably wise to limit their number. As the analysis of interexaminer agreement is more meaningful if the sample size is bigger, the latter was favoured for this project. As mentioned above, the examiners' degree of experience can be expected to be sufficient. The study was limited to healthy subjects. Nevertheless, inter- and/or intraexaminer agreement for symptomatic subjects could be better than for asymptomatic subjects. Comparing asymptomatic with symptomatic subjects randomly might provide more specific information. Unadjustment either by time or by location has to be taken into account for the assessment of inter- and intrarater agreement. However, this essential problem has to be considered for most reliability study designs.

The PRM-frequencies palpated in this study are similar to recent publications (Norton et al., 1992; Wirth-Pattullo and Hayes, 1994; Norton, 1996; Hanten et al., 1998; Rogers et al., 1998; Moran and Gibbons, 2002) and differ to an older publication (Upledger, 1977), which described a faster rhythm ranging from 6 to 12 cycles/min (0.1–0.2 Hz).

Several authors have suggested explaining the PRM as an expression of variations of known physiological rhythms like heart rate and respiratory rate (Frymann, 1971; Upledger, 1977; McPartland, 1997; Nelson et al., 2002). Comparing the results (0.04 (SD 0.02) to 0.06 (SD 0.01) Hz) with the frequency spectrum of heart rate variability, they cover the lower part of the low-frequency spectrum, known as *Mayer waves* which ranges from 0.04 to 0.15 Hz and seems to be expressed by changes in blood pressure (Camm et al., 1996). Norton et al. (1992) report a mean duration of the flexion phase with 7.7 (SD 1.4) s, the *MDF* found in this study is longer and ranges from 8 (SD 4.3) to 10.6 (SD 4.1) s.

Recent publications (Wirth-Pattullo and Hayes, 1994; Norton, 1996; Hanten et al., 1998; Rogers et al., 1998; Moran and Gibbons, 2002) report low or absent interrater reliability for the palpation of the PRM. Our results are similar. In contrast to the other authors, we described agreement in addition to the palpated f, i.e. for the *MDF* and the $R_{F/E}$ and used a larger sample size. In neither case, interexaminer agreement could be described beyond chance agreement. For intraexaminer agreement the results differed. Norton (1996) reported significant intrarater correlation for the cycle lengths palpated by the same examiner at the head and at the pelvis. Hanten et al. (1998) as well as Moran and Gibbons (2002) found intrarater reliability to be fair to good for palpation of the PRM-rates. We found, like Rogers et al. (1998), intraexaminer reliability to be low. See a summary of published data in Table 3.

Previous publications (Upledger, 1977; Wirth-Patullo and Hayes, 1994; Hanten et al., 1998) agreed in finding low correlations between the palpated PRM-rate and the subjects' respiratory as well as cardiac rates. This is in agreement with our results concerning the subjects' respiratory rates. In addition, our results indicate a tendency for the examiners' respiratory rates to have an effect on the PRM-frequencies palpated at the pelvis. This means that the examiners tend to palpate higher PRM-frequencies and shorter lengths of the flexion-phase when their own respiratory rate increases and or decreases. At the head the results for the examiners differ. These results are in agreement with the suggestions of Norton (1991), drawn from the tissue pressure model.

Table 3
Results of published data on inter- and intraexaminer reliability for the palpation of the PRM described by intraclass correlation coefficient (*ICC*), Pearsons correlation coefficient (*r*) and range within the 95% limits of agreement (Lts)

Publication	Interexaminer		Intraexaminer
Wirth-Pattullo and Hayes (1994)	$ICC = -0.02$	$P = 0.0001$	
Norton (1996)	$r_{Head} = -0.275$ $r_{Pelvis} = -0.296$	$P = 0.115$ $P = 0.089$	$r = 0.926 P < 0.001$
Hanten et al. (1998)	$ICC = 0.22$		$ICC = 0.78/0.83$
Rogers et al. (1998)	$ICC_{Head} = 0.08$ $r_{Head} = 0.12$ $ICC_{Feet} = 0.19$ $r_{Feet} = 0.23$		$ICC_{Head} = 0.18/0.26$ $r_{Head} = 0.17/0.27$ $ICC_{Feet} = 0.30/0.29$ $r_{Feet} = 0.30/0.29$
Moran and Gibbons (2002)	$ICC_{Head} = 0.05$ $r_{Head} = 0.17$ $ICC_{Sacrum} = -0.02$ $r_{Sacrum} = -0.035$		$ICC_{Head} = 0.47/0.73$ $ICC_{Sacrum} = 0.65/0.52$
Values of this study	$Lts_{Head} = 6.6$[a] $Lts_{Pelvis} = 6.6$[a]		$Lts = 6.0*/5.4*$

[a] The values indicate the number of cycles/90 s.

5. Conclusion

Considering the limitations of the study and the fact that neither inter- nor intraexaminer agreement was found for the palpation of the PRM in this study, which is in agreement with similar publications, the following suggestions can be discussed:

- The PRM could be highly influenced by the examiner's mental images in connection with perception. The physiological existence of the PRM cannot be regarded as proven (Green et al., 1999). Echternach (1994) states in this context that under normal conditions clinicians do not try to measure a phenomenon whose existence is unclear. So the use of palpatory findings, concerning the PRM as means for clinical decision making, should be rethought. The presumption seems possible as there could be found certain influences of the examiners' own respiratory rates on the palpatory findings.

- The PRM is a phenomenon that is too subtle to be palpated reliably. This contradicts the fundamentals and the development of the CC. In the beginning, the PRM has solely been manually detected. To prove this assumption, the changes induced by the PRM should be scientifically proven and tests on manual perceptive possibilities should suggest that the threshold for such a perception lies above the measured changes for the PRM. Roppel et al. (1978) report a threshold from about 0.5 to 0.25 mm, whereas mechanical recordings (Frymann, 1971) showed

amplitudes from 0.012 to 0.025 mm. We do not consider here the validity of the reported values for these measurements.

- The PRM is a metaphysical (vitalistic), not a physiological concept. The frequent use of metaphoric terms like "breath of life" or the "tide" instead of the PRM, which were already introduced by Sutherland himself (Sutherland, 1990, 1998), suggest such an interpretation. If this is so, the physiological models explaining the PRM should be dropped.

- The PRM is the result of the interaction between known physiological rhythms of the examiner and the subject. In this context, Norton (1991) found that within a computer-model simulated variations especially of the examiner's heart- and respiratory frequencies had the strongest influence on changes of the resulting frequency. If this is, so Norton's work, could explain low interexaminer agreement.

- The examiners are not skilled enough. In the present study, with regard to the professional experience of the examiners, this argument is not justified.

This study does not assess the existence of the PRM as a rhythmical phenomenon, neither it is possible to assess the clinical efficiency. However, the results presented do not support theories behind the PRM, calling for a physiological autonomous rhythmical event that is manually detectable. The results imply that the PRM cannot be palpated consistently among different examiners as well as within one examiner and under certain conditions the examiner's respiratory rates seem to have a distinct influence on what the examiner perceives as

the PRM. What the examiner actually does perceive, remains unclear.

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