ORIGINAL ARTICLE

https://doi.org/10.1590/1806-9282.20220406

Comparison of the autonomic nervous system dysfunction between different chronic spine disorders: neck pain versus low back pain

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SUMMARY

OBJECTIVE: This study aims to compare heart rate variability (HRV) between patients with chronic neck pain and patients with chronic low back pain and to correlate the chronic pain variables with heart rate variability indices.

METHODS: This is a cross-sectional study. We divided the sample into two groups: neck pain (n=30) and low back pain (n=30). We used the Numeric Pain Rating Scale, Neck Disability Index, Roland-Morris Disability Questionnaire, Pain-Related Catastrophizing Thoughts Scale, Tampa Scale of Kinesiophobia, and Pain Self-Efficacy Questionnaire. For heart rate variability analysis, we used the following indices: mean RR, standard deviation of all RR intervals, mean heart rate, root mean square differences of successive RR intervals, triangular index, triangular interpolation of the interval histogram, low-frequency band in arbitrary units and in absolute values, high-frequency band in arbitrary units and in absolute values, standard deviation of the instantaneous beat-to-beat variability (standard deviation 1), long-term standard deviation of continuous RR intervals (standard deviation 2), and Stress Index. We used Student's t-test for comparisons and Spearman's coefficient for correlations.

RESULTS: We observe insignificant values in the differences between the groups. Disability and self-efficacy were correlated with heart rate variability only in patients with chronic neck pain, whereas catastrophizing and kinesiophobia showed greater correlations with heart rate variability in patients with chronic low back pain.

CONCLUSIONS: Autonomic dysfunction of individuals with chronic neck pain, when compared to patients with chronic low back pain, does present insignificant differences.

KEYWORDS: Musculoskeletal disorders. Neurology. Parasympathetic nervous system. Sympathetic nervous system.

INTRODUCTION

Autonomic nervous system is responsible for managing, in part, the heart rate; thus, due to neurological actions to preserve the organism's homeostatic balance, the sympathetic and parasympathetic components generate variations in the intervals between heartbeats (from moment to moment), called RR intervals[1], obtained by electrocardiograph or cardiofrequency meters[2]. Heart rate variability (HRV), a method that uses indices derived from RR intervals, is used to study the sympathetic and parasympathetic interaction of the autonomic nervous system in situations of health, disease, and human performance[3].

Clinically, HRV (divided into time and frequency domains) is used to monitor the autonomic nervous system's regulation on organism (when a patient is in pain, sympathetic activity increases, whereas when a patient is relaxed, the parasympathetic system takes control). A drop in the time-domain parameter indicates an increase in the sympathetic activity (or a decrease in the parasympathetic activity). A high frequency and the standard deviation of all RR intervals, in the frequency domain, represent a state of excitement of the parasympathetic system, whereas a low frequency, and low-frequency/high-frequency ratio, represents a state of inhibition of the parasympathetic system, or a state of excitement of the sympathetic system. As such, several mathematical models (HRV indices) are calculated in an attempt to describe the activities of the autonomic nervous system[4].

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Conflicts of interest: the authors declare there is no conflicts of interest. Funding: This work was partially supported by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), finance code 001.
Received on April 27, 2022. Accepted on April 30, 2022.

Autonomic dysfunction is a situation in which there is an autonomic imbalance between sympathetic and parasympathetic activities (sympathovagal balance), and the scientific literature shows some clinical conditions that have autonomic dysfunction, which are identifiable by HRV indices, such as temporomandibular disorder[5], fibromyalgia[6], diabetic neuropathy[7], neurofibromatosis[8], cancer[9], brain death[10], chronic pain[1], COVID-19[11], neurological dysfunction[12], coronary artery disease[13], ventricular arrhythmia, and sudden cardiac death[14].

Regarding scientific literature about chronic pain in the spine, studies have shown that both chronic neck pain (CNP)[1,15] and chronic low back pain (LBP)[1,16] (when compared to healthy controls) are correlated with autonomic dysfunction (identified by HRV indices)[15–17]. We know that HRV indices are correlated with pain intensity, disability, and catastrophizing in individuals with CNP[15]; besides, there is evidence in the literature suggesting that patients with LBP have lower parasympathetic activation and consequently sympathetic predominance[16].

However, the autonomic dysfunction in CNP, compared to LBP, has not been investigated, and this creates a gap in studies of the nervous system focusing on chronic pain of the spine. As such, the aim of this study was to compare the HRV of patients with CNP and patients with LBP and to correlate the chronic pain variables with HRV indices.

METHODS

Study design

This is a cross-sectional study. Participants included in the study validated their participation by signing the informed consent form. All procedures were approved by the Ethics Committee on Research of the Universidade Federal do Maranhão (opinion number 3.408.949).

Participants

The recruitment of participants took place after the research was disseminated verbally, as well as using posters, pamphlets, social networks, and messaging applications from January 2020 to September 2020. We carried the collection of variables out in a reserved, bright room, without external noise, and air-conditioned at 23°C, located in a physiotherapy clinic (Buriticupu, MA, Brazil).

We calculated the sample size using the software G*Power (version 3.1.9.7, Universität Düsseldorf, Germany), considering an effect size of 0.80 when comparing two independent groups (t-test, two-tailed), according to a previous study[18]. We performed the calculation with an alpha error of 5% and a statistical power of 80%. Thus, the number of required sample was estimated as 26 participants per group.

This study is composed of two groups: CNP (n=30) and LBP (n=30). The inclusion criteria for both the groups were as follows: age between 18 and 59 years, both sexes, sedentary or irregularly active, and with a report of pain for more than 90 days. In addition, as a diagnostic criterion for neck pain, we considered a score on the Numeric Pain Rating Scale (NPRS) ≥3[19,20] and on the Neck Disability Index (NDI) ≥5 points[21,22], and for low back pain, we considered a score on NPRS score ≥3[19,20] and on the Roland Morris Disability Questionnaire (RMDQ) ≥5 points[23,24].

The exclusion criteria considered in this study were as follows: presence of specific chronic pain, with pain attributable to a specific and identifiable cause, such as history of spinal surgery and/or vertebral fractures, spondylosis, and spondylolisthesis, presence of radiculopathy and/or herniated disk confirmed by imaging and neurological impairment by physical examination (presence of altered sensitivity, reflex, and/or muscle strength); physical therapy treatment history for spine pain in the last 90 days or medicated (analgesics and/or anti-inflammatory) in the last 7 days; medical diagnosis of cancer, rheumatological, neurological, psychiatric, cardiovascular, or metabolic diseases; and report of other concomitant acute or chronic pain[25].

Pain measurement

In addition to the NPRS[20], NDI[22], and RMDQ[24], we applied the following instruments: Pain-Related Catastrophizing Thoughts Scale (PCTS)[26], Tampa Scale of Kinesiophobia (TSK)[27], Pain Self-Efficacy Questionnaire (PSEQ)[28], and International Physical Activity Questionnaire (IPAQ)[29].

NPRS is a scale used to quantify the pain intensity using a sequence of 11 numbers, in which 0 represents "no pain" and 10 "the worst pain imaginable." The pain intensity was assessed at rest and after active spinal movements. This scale is validated for Portuguese[20].

NDI is a questionnaire adapted and validated for the Brazilian population[22], capable of measuring disability in individuals with neck pain. It consists of 10 items with 6 response possibilities, ranging from 0–5. The total score varies from 0 to 50 points; the higher the value, the greater the disability[15,22].

RMDQ is a questionnaire adapted and validated for the Brazilian population, capable of measuring disability in individuals with low back pain. It consists of 24 items that describe situations experienced by people with low back pain, with

scores ranging from 0–24 points. Thus, the higher the score, the greater the disability[24].

PCTS consists of nine items arranged on a Likert scale, which varies in numerical measure from 0–5, associated with the words "almost never" and "almost always." The total score is obtained by adding the total score and dividing by the number of items answered. The final score ranges from 0–5 points; the higher the score, the greater the occurrence of catastrophizing thoughts, according to the version adapted for the Brazilian population[26].

TSK is a validated scale for the Brazilian population capable of assessing kinesiophobia. It is a self-administered instrument and consists of 17 items. For each item, there are four options with their respective values in ascending order: totally disagree (equal to 1 point), partially disagree (2 points), partially agree (3 points), and totally agree (4 points). It is necessary to invert the scores of items 4, 8, 12, and 16 to calculate the final score, which ranges from 17 to 68. The higher the score, the greater the kinesiophobia[27].

PSEQ is a self-administered instrument capable of evaluating and expressing, in numbers, the patient's confidence in manifesting themselves in the situations presented in the 10 items (taking pain into account). For each item, there are six options with their respective values in ascending order, representing self-efficacy from 0 "not confident" to 6 "totally confident." The final score (0–60) is obtained by adding the values. The higher the score, the greater the self-efficacy in pain conditions[28].

IPAQ indirectly measures the level of physical activity of individuals and has validation for the Brazilian population. The instrument has four questions (with two options each) that investigate the physical effort performed at work and the activities of daily living, including walking to get from place to place, regular or not recreational activities, sports, moderate, and vigorous physical exercises. After analyzing the questionnaire and following the instructions, it is possible to classify individuals into sedentary, irregularly active, active, and very active[29].

Heart rate variability measurement

We measured HRV using a Polar V800 cardiofrequency meter (Polar Electro OY, Kempele, Finland) and a sensor attached to the rib cage (sternum region) to capture the heart rate; this instrument is already used in research in this scenario[14,15]. Before collection, all individuals were instructed to avoid eating chocolate, avoid drinking coffee, and avoid using thermogenic and energy drinks; during the procedure, they were instructed not to speak or sleep.

Before obtaining the RR intervals from moment to moment, each individual remained at rest for 10 min in the supine position. Then, we made two HRV records: 10 min in the supine and 10 min in the standing positions. In addition, we observed each participant's respiratory rate (described as breaths per minute); to maintain the individual rhythm of the breathing cycle, the participants were unaware that the researcher observed and recorded each inspiration/expiration.

Heart rate variability analysis

With the aid of a microcomputer, we transferred the files to the Kubios HRV analysis software, version 2 beta (Matlab, Kuopio, Finland), and analyzed them using a series of 256 sequential RR intervals, from which was chosen, using qualitative visual inspection, the section with the highest signal stability and normal distribution. The series of RR intervals was observed at the frequency of 5 Hertz (Hz), and the data were filtered to remove variations below 0.04 Hz and above 1.0 Hz; only segments >90% of purely sinus beats were included in the final analysis. Therefore, a quantitative analysis of the variability of RR intervals was performed using linear and nonlinear methods in the domains of time and frequency.

Heart rate variability indices

We used the indices with the largest scientific contingent[15,30-33]. Linear indices were as follows: RR intervals mean (mean RR) expressed in milliseconds (ms); standard deviation of all RR intervals (STD-RR) between two consecutive normal heartbeats, in ms; heart rate mean (mean HR) expressed in beats per minute (bpm); root mean square differences of successive RR intervals (rMSSD) in ms; triangular index (RR Tri) in ms; triangular interpolation of the interval histogram (TINN) in ms; low-frequency band in arbitrary units (LF) between 0.03 and 0.14 Hz and in absolute values (power LF) in ms^2; and high-frequency band in arbitrary units (HF) above 0.15 Hz and in absolute values (power HF) in ms^2. Nonlinear indices were as follows: standard deviation of the instantaneous beat-to-beat variability (SD1); long-term standard deviation of continuous RR intervals (SD2); and stress index.

Statistical analysis

We compared the categorical variables through Fisher's exact and/or chi-squared tests. For comparisons between quantitative variables, we used Student's t-test for unpaired and normally distributed samples, with analysis performed using histograms and Shapiro-Wilk's test. In the correlations between the variables, we used the Spearman's correlation coefficient (rho). The interpretation of the coefficients was based on the following classification: from 0.26 to 0.49, weak; from 0.50–0.69, moderate; from 0.70–0.89, strong; and from 0.90–1.00,

very strong[34]. We used the SPSS software (version 17, Chicago, Illinois, USA) for data processing.

Comparisons of HRV indices between groups were expressed as mean, standard deviation (SD), mean difference (MD), confidence interval of difference (95%CI), and effect size calculated using Cohen's d, with the categorization based on the values established by Cohen[35]: less than 0.2 (small effect), about 0.5 (moderate effect), and greater than 0.8 (large effect). Due to the multiple comparisons between the groups, we used the Bonferroni's correction[36], with level of significance set at 0.003 (i.e., 0.05/number of comparisons performed), and the effect size >0.8. For the correlations, the level of significance was set at 0.05.

RESULTS

A total of 105 individuals were recruited for this study. There was a sample loss of 45 participants for the following reasons: presence of systemic disease (n=19), specific pain (n=14), atypical HRV signals (n=8), and withdrawal during collection (n=4). Thus, the final sample (n=60) composed of 30 participants in the CNP group and 30 participants in the LBP group; in both groups, most of the sample was women (CNP=86.7%; LBP=80%, p>0.05) and physically inactive (CNP=86.7%; LBP=80%, p>0.05).

Table 1 describes the characteristics of the study participants, with a significant difference (p≤0.003) observed only in the disability (on percentage). Table 2 describes the comparisons of HRV indices between the CNP and LBP groups; we observe insignificant values in the differences between the groups (p>0.003) and in the effect size (d<0.80). Then, we observe significant values of correlation (p<0.05) between HRV indices and other study variables (Table 3).

DISCUSSION

In comparison of HRV indices, we observe insignificant values in the differences between the groups and effect size. Regarding the disabilities generated by pain in the spine, we observed that LBP is 14.65% more disabling than CNP; however, the incapacity generated by CNP generates greater autonomic dysfunction, as shown by the highest correlations with HRV indices.

Regarding the HRV indices correlated with different chronic pain conditions in the spine, the literature presents several studies that corroborate some of our findings when indicating dysregulation of the parasympathetic nervous system[1,15,17], since this was confirmed both in patients with CNP and LBP in this study.

Table 1. Characteristics of the study participants: chronic neck pain (n=30) and chronic low back pain (n=30).

	Mean (SD)	95%CI	p-value
Age (years)			
CNP	31.5 (8.4)	28.34–34.66	0.692
LBP	30.6 (7.7)	27.78–33.55	
Body mass (kg)			
CNP	66.8 (11.1)	62.69–70.10	0.838
LBP	66.1 (15.9)	60.15–72.08	
Stature (m)			
CNP	162.0 (0.1)	1.60–1.64	0.781
LBP	163.0 (0.1)	1.59–1.66	
Body mass index (kg/m^2)			
CNP	25.4 (3.9)	23.10–26.93	0.563
LBP	24.8 (4.6)	23.10–26.54	
Waist (cm)			
CNP	78.6 (8.7)	75.40–81.90	0.655
LBP	79.8 (12.2)	75.30–84.47	
Chronicity of pain (months)			
CNP	63.0 (45.6)	45.94–80.06	0.425
LBP	54.0 (40.9)	38.70–69.30	
Pain at rest (NPRS, 0–10)			
CNP	6.5 (1.9)	5.85–7.28	0.837
LBP	6.6 (1.8)	5.98–7.36	
Pain after movements (NPRS, 0–10)			
CNP	7.0 (2.2)	6.22–7.92	0.863
LBP	6.9 (2.2)	6.14–7.79	
Catastrophizing (PCTS, 0–5)			
CNP	2.5 (1.2)	2.10–3.06	0.545
LBP	2.3 (1.1)	1.98–2.80	
Kinesiophobia (TSK, 17–68)			
CNP	42.8 (6.7)	40.28–45.32	0.738
LBP	43.4 (7.7)	40.52–46.34	
Self-Efficacy (PSEQ, 0–60)			
CNP	40.5 (12.6)	35.81–45.26	0.919
LBP	40.8 (12.6)	36.16–45.57	
Disability (score)			
CNP [NDI, 0–50]	14.1 (6.4)	11.73–16.54	N/A
LBP [RMDQ, 0–24]	10.3 (5.3)	8.30–12.30	
Converted disability (0–100%)			
CNP	28.2 (12.8)	23.46–33.07	0.002*
LBP	42.9 (22.2)	34.60–51.23	

CNP: chronic neck pain; LBP: low back pain; SD: standard deviation; CI: confidence interval; NPRS: numeric pain rating scale; PCTS: pain-related catastrophizing thoughts scale; TSK: tampa scale of kinesiophobia; PSEQ: pain self-efficacy questionnaire; NDI: neck disability index; RMDQ: Roland-Morris disability questionnaire; N/A: not applicable.
*Significant difference (t-test; p-value≤0.003).

Table 2. Comparison of the heart rate variability indices between groups: chronic neck pain (n=30) and chronic low back pain (n=30).

	In supine						In standing					
	Group	Mean	SD	MD	95%CI	d	Group	Mean	SD	MD	95%CI	d
HRV (linear)												
Mean RR (ms)	CNP	803.31	111.11	-15.18	-69.64–39.28	0.144	CNP	638.53	115.30	-61.06	-117.35– -4.78	0.561
	LBP	818.49	99.32				LBP	699.59	102.10			
STD-RR (ms)	CNP	29.15	12.33	-4.18	-11.01–2.65	0.316	CNP	27.51	15.97	-1.75	-9.73–6.25	0.113
	LBP	33.32	14.03				LBP	29.26	14.93			
Mean HR (bpm)	CNP	75.93	9.51	1.55	-3.29–6.40	-0.116	CNP	96.58	15.33	9.19	2.13–16.24	-0.672
	LBP	74.38	9.23				LBP	87.40	11.74			
rMSSD (ms)	CNP	28.82	15.83	-7.91	-16.75–0.94	0.462	CNP	21.39	20.63	-1.93	-12.06–8.20	0.098
	LBP	36.73	18.30				LBP	23.31	18.50			
RR Tri	CNP	7.47	2.58	-1.15	-2.60–0.29	0.410	CNP	6.84	3.16	-1.35	-3.10–0.39	0.403
	LBP	8.62	3.01				LBP	8.20	3.58			
TINN (ms)	CNP	148.83	68.30	-20.37	-56.87–16.14	0.288	CNP	138.60	88.95	-2.80	-43.71–38.11	0.035
	LBP	169.20	72.88				LBP	141.40	67.96			
LF (nu)	CNP	50.99	19.12	8.40	-1.06–17.86	-0.459	CNP	66.98	21.75	2.53	-7.99–13.06	-0.124
	LBP	42.59	17.45				LBP	64.45	18.86			
HF (nu)	CNP	48.92	19.07	-8.37	-17.81–1.07	0.458	CNP	32.95	21.66	-2.58	-13.07–7.92	0.127
	LBP	57.29	17.43				LBP	35.53	18.84			
LF/HF (ratio)	CNP	1.72	2.36	0.77	-0.14–1.67	-0.440	CNP	4.36	5.68	1.04	-1.39–3.47	-0.221
	LBP	0.95	0.74				LBP	3.32	3.46			
Power LF (ms^2)	CNP	376.79	335.76	-111.25	-323.41–100.92	0.271	CNP	451.54	648.06	-89.52	-389.12–210.07	0.154
	LBP	488.04	473.59				LBP	541.06	502.06			
Power HF (ms^2)	CNP	394.96	416.70	-213.25	-449.57–23.06	0.466	CNP	243.38	404.59	-102.18	-386.77–182.41	0.186
	LBP	608.21	494.44				LBP	345.56	665.37			
HRV (nonlinear)												
SD1 (ms)	CNP	20.41	11.21	-5.60	-11.86–0.66	0.462	CNP	15.15	14.62	-1.37	-8.54–5.81	0.098
	LBP	26.01	12.96				LBP	16.51	13.11			
SD2 (ms)	CNP	35.43	14.42	-3.22	-11.27–4.83	0.207	CNP	34.88	19.15	-2.67	-12.14–6.81	0.146
	LBP	38.65	16.65				LBP	37.55	17.47			
SD2/SD1 (ratio)	CNP	1.95	0.70	0.35	0.03–0.66	-0.575	CNP	3.20	1.45	0.59	-0.02, 1.21	-0.493
	LBP	1.60	0.50				LBP	2.61	0.87			
Stress Index	CNP	22.39	38.12	7.83	-6.26–21.93	-0.287	CNP	19.57	7.94	1.32	-2.49–5.13	-0.179
	LBP	14.56	5.82				LBP	18.25	6.75			
Respiratory rate (bpm)												
	CNP	17.59	3.68	-0.09	-2.06–1.88	0.024	CNP	14.04	3.34	-0.82	-2.49–0.85	0.253
	LBP	17.68	3.95				LBP	14.86	3.13			

SD: standard deviation; MD: mean difference; CI: confidence interval; Cd: Cohen's d; HRV: heart rate variability; Mean RR: RR intervals mean; STD-RR: standard deviation of all RR intervals between two consecutive normal heartbeats; Mean HR: heart rate mean; BPM: beats or breaths per minute; rMSSD: root mean square differences of successive RR intervals; RR Tri: triangular index; TINN: triangular interpolation of the interval histogram; LF: low-frequency band in arbitrary units and in absolute values; HF: high-frequency band in arbitrary units and in absolute values; SD1: standard deviation of the instantaneous beat-to-beat variability; SD2: long-term standard deviation of continuous RR intervals.
Insignificant difference (independent t-test, $p>0.003$); insignificant effect size (Cohen's $d<0.8$).

Table 3. Correlations between heart rate variability indices and other study variables: chronic neck pain (n=30) and chronic low back pain (n=30).

	Chronic neck pain (n=30)							Chronic low back pain (n=30)						
	CPM	NPRSa	NPRSb	PCTS	TSK	PSEQ	NDI	CPM	NPRSa	NPRSb	PCTS	TSK	PSEQ	RMDQ
HRV supine (linear)														
Mean RR (ms)	0.184	-0.026	-0.226	-0.085	-0.112	0.144	0.069	-0.033	-0.024	-0.337	**-0.397***	-0.264	0.121	-0.210
STD-RR (ms)	-0.063	-0.248	-0.242	-0.140	-0.050	**0.571***	**-0.444***	-0.224	0.038	-0.308	**-0.414***	-0.180	0.216	-0.123
Mean HR (bpm)	-0.186	0.022	0.224	0.088	0.116	-0.142	-0.069	0.033	0.024	0.337	**0.397***	0.264	-0.121	0.210
rMSSD (ms)	-0.093	-0.211	-0.130	-0.211	-0.181	**0.504***	**-0.466***	-0.117	-0.048	**-0.362***	**-0.516***	-0.246	0.286	-0.199
RR Tri	-0.114	-0.361	**-0.386***	0.042	-0.049	**0.462***	**-0.376***	-0.161	-0.094	**-0.472***	**-0.475***	-0.215	0.193	-0.245
TINN (ms)	-0.107	-0.239	-0.226	-0.162	-0.059	**0.548***	**-0.448***	-0.196	0.040	-0.244	**-0.422***	-0.210	0.249	-0.112
LF (nu)	0.099	0.117	0.053	0.189	**0.427***	**-0.409***	0.336	-0.184	0.219	0.052	0.339	0.018	-0.322	0.092
HF (nu)	-0.099	-0.117	-0.053	-0.189	**-0.427***	**0.409***	-0.336	0.179	-0.217	-0.050	-0.349	-0.025	0.323	-0.091
LF/HF (ratio)	0.095	0.120	0.051	0.188	**0.425***	**-0.410***	0.330	-0.179	0.217	0.050	0.349	0.025	-0.323	0.091
Power LF (ms^2)	-0.104	-0.165	-0.281	0.139	0.233	0.125	-0.084	-0.305	0.118	-0.244	-0.234	-0.145	-0.087	-0.071
Power HF (ms^2)	-0.228	-0.251	-0.349	-0.057	-0.203	**0.493***	**-0.442***	-0.115	-0.109	**-0.426***	**-0.518***	-0.170	0.229	-0.216
HRV supine (nonlinear)														
SD1 (ms)	-0.093	-0.211	-0.130	-0.211	-0.181	**0.504***	**-0.466***	-0.117	-0.048	**-0.362***	**-0.516***	-0.246	0.286	-0.199
SD2 (ms)	-0.095	-0.251	-0.348	-0.102	-0.007	**0.531***	**-0.432***	-0.281	0.052	-0.261	-0.354	-0.149	0.107	-0.084
SD2/SD1 (ratio)	0.146	-0.011	-0.157	0.086	0.270	-0.223	0.263	-0.200	0.053	0.096	0.267	0.145	-0.307	0.145
Stress Index	-0.038	0.291	0.310	0.091	-0.012	**-0.549***	**0.381***	0.174	-0.059	0.302	0.443*	0.222	-0.224	0.157
HRV standing (linear)														
Mean RR (ms)	-0.049	0.125	-0.334	0.043	-0.072	0.074	-0.136	-0.088	-0.040	-0.112	**-0.451***	**-0.389***	-0.074	-0.090
STD-RR (ms)	**-0.448***	-0.002	-0.236	-0.090	-0.225	0.196	**-0.408***	**-0.397***	-0.042	-0.178	-0.224	-0.164	-0.102	0.083
Mean HR (bpm)	0.049	-0.125	0.334	-0.043	0.072	-0.074	0.136	0.088	0.040	0.112	**0.451***	**0.389***	0.074	0.090
rMSSD (ms)	**-0.432***	0.121	-0266	0.021	-0.211	0.126	-0.215	-0.269	-0.104	-0.218	**-0.453***	**-0.373***	-0.074	-0.012
RR Tri	-0.277	0.007	-0.270	-0.069	-0.074	0.112	**-0.414***	-0.278	0.028	-0.142	-0.270	-0.240	-0.142	0.085
TINN (ms)	**-0.484***	0.039	-0.169	-0.041	-0.179	0.079	-0.309	**-0.424***	-0.042	-0.181	-0.197	-0.175	-0.093	0.135
LF (nu)	**0.393***	-0.118	0.074	-0.205	0.128	-0.019	0.041	0.051	0.099	0.059	0.336	0.326	0.016	0.042
HF (nu)	**-0.393***	0.118	-0.074	0.205	-0.128	0.019	-0.041	-0.051	-0.099	-0.059	-0.336	-0.326	-0.016	-0.042
LF/HF (ratio)	**0.393***	-0.118	0.074	-0.205	0.128	-0.019	0.041	0.051	0.099	0.059	0.336	0.326	0.016	0.042
Power LF (ms^2)	-0.087	-0.135	-0.324	-0.212	-0.106	0.298	**-0.447***	-0.321	0.032	-0.078	0.074	-0.027	-0.170	0.111
Power HF (ms^2)	**-0.444***	0.093	-0.264	0.037	-0.213	0.232	-0.343	-0.268	0.015	0.013	-0.244	**-0.416***	-0.079	0.112
HRV standing (nonlinear)														
SD1 (ms)	**-0.432***	0.121	-0.266	0.021	-0.211	0.126	-0.215	-0.269	-0.104	-0.218	**-0.453***	**-0.373***	-0.074	-0.012
SD2 (ms)	**-0.403***	-0.038	-0.267	-0.055	-0.110	0.175	**-0.427***	**-0.424***	-0.020	-0.175	-0.158	-0.127	-0.132	0.113
SD2/SD1 (ratio)	0.340	-0.168	0.138	-0.148	0.081	0.020	-0.088	-0.031	0.008	0.037	**0.440***	0.350	0.003	0.001
Stress Index	**0.435***	-0.034	0.262	0.082	0.289	-0.183	**0.368***	**0.367***	0.076	0.229	0.309	0.214	0.092	-0.078

CPM: chronicity of pain in months; NPRSa: Numeric Pain Rating Scale at rest; NPRSb: Numeric Pain Rating Scale after movements; PCTS: Pain-Related Catastrophizing Thoughts Scale; TSK: Tampa Scale of kinesiophobia; PSEQ: Pain Self-Efficacy Questionnaire; NDI: Neck Disability Index; RMDQ: Rolan-Morris Disability Questionnaire; HRV: heart rate variability; Mean RR: RR intervals mean; STD-RR: standard deviation of all RR intervals between two consecutive normal heartbeats; Mean HR: heart rate mean; rMSSD: root mean square differences of successive RR intervals; RR Tri: triangular index; TINN: triangular interpolation of the interval histogram; LF: low-frequency band in arbitrary units and in absolute values; HF: high-frequency band in arbitrary units and in absolute values; SD1: standard deviation of the instantaneous beat-to-beat variability; SD2: long-term standard deviation of continuous RR intervals.

*Significant correlation (Spearman's correlation coefficient, $p<0.05$).

When using the heart as an object of investigation of the sympathetic and parasympathetic activities of the nervous system, this study concentrated the collections for the analysis of the physiological parameters in a specific organ that has greater proximity to the cervical region and the parasympathetic system. Thus, even if the CNP is less disabling than the LBP, it is possible to understand the fact that we found greater correlations with HRV indices in the CNP, since parasympathetic actions are more accurate and harmonic in the cervical-brain stem-heart complex, while sympathetic actions, located anatomically close to the lumbar region, are imprecise, less related to parasympathetic ramifications, and more systemic from a physiological point of view[15-17].

Since HRV has significant correlations with a wide range of psychosocial factors in which irregular emotional responses are associated with autonomic dysregulation and reduced HRV, when considering that LBP is more disabling than CNP and that HRV is considered an autonomic marker of emotional regulation capacity[37], it is possible to understand the fact that catastrophizing pain in patients with LBP is more correlated with linear and nonlinear HRV indices than in patients with CNP, because the more disabling the spinal pain, the more catastrophic thoughts and fear exist.

This study has limitations. The menstrual cycle was not a controlled variable, we recorded the RR intervals using a cardiofrequency meter, and the majority of the sample was women. Thus, we emphasize the need for further studies to reproduce this research using other devices for recording RR intervals, such as, electrocardiogram, H10 Polar[38], Bluetooth sensor (wireless)[39], and Elite HRV (smartphone app)[40]; in addition, we suggest studies to compare samples containing the same amounts of both sexes in the groups.

CONCLUSIONS

The autonomic dysfunction of individuals with CNP, when compared to patients with LBP, does present insignificant differences. Both groups showed correlations between pain measures and HRV; however, disability and self-efficacy were correlated with HRV only in patients with CNP, while catastrophizing and kinesiophobia showed greater correlations with HRV in patients with LBP.

Ethical approval: Research involving human subjects complied with all relevant national regulations, institutional policies (Resolutions 196/1996 and 466/2012), and is in accordance with the tenets of the Helsinki Declaration (as amended in 2013), and has been approved by the equivalent research ethical committee (protocol number: 3.408.949).

ACKNOWLEDGMENTS

I dedicate this publication to my beloved mother, Maria de Fátima Pontes Silva (Dona Pretinha), and grandmother, Maria Luiza de Oliveira Pontes (Dona Luiza, *in memoriam*), you kindly gave me (and give me) the strength to walk in the life's road; to my great friend Fabíola Almeida, who kindly gave me access to the clinic to evaluate the study participants; and to my good friend/brother/professor Almir Vieira Dibai Filho, who kindly trusted me. I love you all.

AUTHORS' CONTRIBUTIONS

APS: Conceptualization, Data curation, Formal Analysis, Writing – original draft. **DBD:** Conceptualization, Formal Analysis. **CAFPG:** Conceptualization. **CSS:** Formal Analysis, Writing – original draft. **FOP:** Formal Analysis, Writing – original draft. **CTM:** Conceptualization, Formal Analysis. **AVDF:** Conceptualization, Formal Analysis.

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