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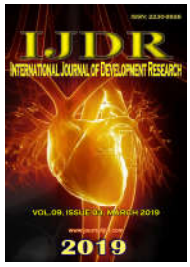

ORIGINAL RESEARCH ARTICLE | OPEN ACCESS

ACUTE EFFECT OF NON-INVASIVE ELECTRICAL STIMULATION OF THE VAGUS NERVE UPON BLOOD PRESSURE AND HEART RATE VARIABILITY IN HYPERTENSIVE INDIVIDUALS

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ABSTRACT

Introduction: The auricular neuromodulation (ANM) of the vagus nerve can be performed through the stimulation of the inferior and superior conchae area (tragus) and in the outer ear. **Objective:** The aim of study was to verify the effects of noninvasive auricular electrical stimulation of the vagus nerve on HRV and Blood Pressure (BP) in hypertensive individuals. **Methodology:** A cross-sectional study, sample 30 hypertensive subjects. The experimental group - 15 individuals, 58.4 years old. Control group - 15 individuals, 60 years old. The intervention takes 40 minutes for each subject. The electrical stimulation of the vagus nerve was performed using a TENS unit. The stimulus was applied continuously for 20 minutes with a pulse width of 120 ms, pulse frequency of 25 Hz. Student's t test was used, $p < 0.05$ for statistical significance. **Results:** Intra group comparisons indicates a statistically significant difference (p 0.001). Inter group comparison demonstrated a statistically significant difference (p 0.001) for all variables. **Conclusion:** The results indicate that acute auricular neuromodulation of the vagus induces positive responses in HRV and BP in hypertensive individuals. The results obtained herein may justify further investigations into the effectiveness of this technique for the treatment of hypertensive individuals.

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INTRODUCTION

Heart rate variability (HRV) uses different parameters based on the time variation between successive heart beats to analyze and quantify cardiac modulation by the sympathetic and vagal components of the autonomic nervous system (ANS).

It is well known hypertension induces changes in HRV, i.e., whereas cardiac parasympathetic modulation predominates in a regulated ANS; there is predominance of sympathetic modulation and lower parasympathetic modulation in cardiac individuals (MALPAS, 2010). Cardiovascular dysfunctions may result from physiological changes in blood pressure, resting heart rate, cardiac output, autonomic cardiac modulation, among other parameters. As increased sympathetic activity leads to higher blood pressure and heart rate and may disrupt cardiac autonomic modulation; an overstimulation of this system may be considered a risk factor in cardiovascular disease (BESNIER *et al.,* 2016; HEROUVI *et al.,* 2013). The ANS is divided into the sympathetic and parasympathetic nervous system. The main function of the ANS is to control the body's visceral functions and maintain homeostasis. It is activated primarily by centers located in the spinal cord, the brainstem and the hypothalamus. The fibers of the parasympathetic nervous system originate in the central nervous system from neurons located in regions of the brainstem that generate the cranial (III), facial (VII), glossopharyngeal (IX) and vague (X) nerves (HALL, 2017). The vagus nerve is the main parasympathetic element of the ANS. It has 80% afferent and 20% efferent nerve fibers. Its main function is to transmit information from the body to the brain, as well as to act on the regulation of organs and maintenance of homeostasis.

The vagus also performs other functions in the body, such as blood pressure and heart rate regulation. It is also involved in the control of the digestion, inflammation and immunity processes (CLANCY *et al.,* 2013; HOWLAND, 2014; OLSHANSKY *et al.,* 2008). Additionally, the vagus nerve has a somatosensory afferent branch located in the outer ear. This auricular branch is found in the external acoustic meatus: tragus and upper part of the concha. Since the vagus provides parasympathetic innervation to the heart, studies were developed to investigate the use of vagus electrostimulation to modulate cardiac function (WANG *et al.,* 2015). Among the electrostimulation methods, auricular neuromodulation (ANM) of the vagus nerve was developed as an alternative to surgical intervention, precisely because it is a non-invasive approach, that does not induce adverse reactions and promotes similar effects. It can be applied by electrostimulation of the inferior and superior conchae area (tragus) of the outer ear with skin electrodes connected to a TENS unit (CAPONE *et al.,* 2015; KREUZER *et al.,* 2012; LEUSDEN, SELLARO and COLZATO, 2015).

According to Stavrakis *et al.* (2015) because of its influence on cardiac activity, ANM of the vagus nerve in patients with cardiopathy has shown beneficial results. However, Clancy *et al.* (2013) indicate that there are still gaps in the understanding of the effect of this technique in the regulation of blood pressure, cardiac variability and the baroreflex function. Hence, the aim of the present study was to investigate the acute effect of auricular neuromodulation stimulation of the vagus nerve on blood pressure and heart rate variability in hypertensive individuals.

METHODS

The present research was experimental, descriptive and quantitative. The sample consisted of hypertensive individuals, of both genders, 55 to 65 years of age, who were physiotherapy patients of the Osmane Resende Municipal Rehabilitation Center, the site of the study. The inclusion criteria were: Hypertensive individuals who underwent physiotherapy at the site of the study with 55 to 65 years of age. Exclusion criteria were individuals with fear of electrostimulation, smokers, alcoholics, cardiac patients, patients with vagal dystonia or who were using anxiolytic medications, antidepressants and beta blockers at the time of the study. After random draw, the participants were divided into two groups, each composed of 15 people: Group I called experimental group, was submitted to auricular neuromodulation. The group II called control group, did not received electro stimulation. Blood pressure and heart rate variability were assessed before and 20 minutes after the physical therapy sessions. The research protocol was previously approved by the technical manager of the study site. The study was developed in observance of Resolution 466/12 of the National Health Council. At the beginning of the study the research protocol was explained to all participants who then read and signed the informed consent form, agreeing to participate in the research. Before the intervention, an anamnesis was carried out, which included information on age, gender, race, social class, medication use, smoking habits, previous pathologies, physical activity, body weight and height. Height was measured in centimeters using a stadiometer with millimetric precision (Sanny, Brazil) and body weight was assessed with a weight scale (Welmy, Brazil). BMI was calculated as weight in kilograms divided by the square of the height in meters (kg / m2).

Blood pressure (BP) at rest was assessed with an automatic sphygmomanometer (Omron, HEM-7200, China), with participants in a seated position (90° knee angle) and arms resting on a table. HRV was assessed with the HRV4 Training Coach iPhone application. This app utilizes the iPhone camera (Iphone 7) to assess HRV through the photoplethysmographic method with the individual sitting with a 90° knee angle and with arms resting on a table (PLEWS, *et al.,* 2017). In this method the volunteer puts his finger on the camera of the device and through it heart rate is read and the R-R intervals are measured. This method has been previously validated, presenting a high correlation with the electrocardiogram and the Polar frequencimeter (PLEWS, *et al.,* 2017). Before BP and HRV evaluations the subjects were submitted to 15 minutes of rest to mitigate measurement errors induced by activities conducted prior to the tests (some of the participants walked to the test site). These measurements were performed before and after the experimental procedure. The intervention took place in May 2018, between 08 and 10 am, and had an approximate duration of 40 minutes for each subject. All subjects were instructed not to consume caffeinated beverages, tobacco or alcohol; not to perform physical activities for at least 12 hours prior to the evaluations and not to eat food and liquids for at least two hours prior to the tests. The intervention protocol was applied as follows: Initially a disinfection of the auricular pavilion was performed with a cotton dab with 70% alcohol. Then electrical auricular neuromodulation of the vagus nerve was performed using a TENS device (TENS tem eco basic).

The electrodes were placed on the tragus (cathode) and the ear lobe (anode). The stimulus was continuously applied for 20 minutes with a pulse width of 120 ms and pulse frequency of 25 Hz. The subject controlled the intensity to a comfortable range. The statistical analysis was conducted with the Microsoft Excel program and presented as mean, standard deviation and minimum and maximum values. The Shapiro-Wilk test was applied to analyze the normality of the sample. To analyze the effects of the intervention, the student's t test was used. *P* value <0.05 was considered as indicative of statistical significance.

RESULTS

The sample of the present study consisted of 30 hypertensive individuals, divided into 2 groups. The experimental group was composed of 15 individuals, of both genders, with 55 to 63 years of age (average age was 58.4). Control group had 15 individuals of both genders, predominantly females, with 55 to 65 years of age (average age was 60). Pre- and post-intervention blood pressure and heart rate variability assessment results of the experimental and control groups are presented in Table 1. BP and HRV were assessed before and immediately after the electrical stimulation of the vagus nerve in the auricular pavilion.

Table 1. Pre- and Post-Results - Control (CON) and Experimental (EX) Groups

EX PRE-	SBP	DBP	LF	HF	LF/HF
Mean	134.60	79.60	0.061	0.051	1.075
SD	14.10	8.59	0.024	0.018	0.445
Min	112.00	62.00	0.024	0.030	0.272
Max	170.00	95.00	0.097	0.096	1.828
SW	0.16	0.99	0.184	0.063	0.833
EX POS					
Mean	119.63	71.30	0.072	0.050	0.949
SD	50.44	29.60	0.041	0.023	0.460
Min	0.16	0.99	0.024	0.018	0.272
Max	170.00	95.00	0.184	0.096	1.828
SW	0.42	0.46	0.331	0.052	0.010
p value1	0.0001*	0.0001*	0.0001*	0.0001*	0.0001*
CON PRE-					
Mean	129.87	81.53	0.062	0.047	1.335
SD	7.66	6.40	0.022	0.015	0.372
Min	119.00	72.00	0.025	0.022	1.000
Max	145.00	90.00	0.097	0.071	2.448
SW	0.28	0.17	0.580	0.399	0.009
CON POS					
Mean	130.47	81.73	0.063	0.047	1.366
SD	7.26	6.57	0.020	0.012	0.455
min	122.00	72.00	0.022	0.031	0.573
max	145.00	91.00	0.095	0.068	2.467
SW	0.02	0.06	0.715	0.262	0.093
p value2	0.21	0.60	0.681	0.963	0.707

Legend: SD - standard deviation; SBP - systolic blood pressure; DBP - diastolic blood pressure; LH - low frequency; HF - high frequency; LH / HF - relation between low and high frequency; SW - Shapiro Wilk normality test; p value 1 - comparison between the experimental group (pre- and post-intervention - Student t test); p value 2 - comparison between the control group (pre- and post-intervention - Student t test).

Intragroup comparison indicates that in the experimental group statistically significant difference ($p < 0.05$) was observed for all variables (see table 1 - pre- x post). Adversely, there was no statistically significant differences in the Control Group. The inferential results obtained in the comparison of the variables between groups are shown in Table 2.

Table 2. Comparison between GE x GC Groups – Pre and Post intervention

PRE- EX x CON	SBP	DBP	LH	HF	LF/HF
P value	0.3053	0.4231	0.9375	0.3904	0.0452*
POST EX x CON	PAS	PAD	LH	HF	LF/HF
P value	0.0098*	0.0001*	0.0001*	0.0006*	0.0192*

Legend: SBP - systolic blood pressure; DBP - diastolic blood pressure; LH - low frequency; HF - high frequency; LH / HF - relation between low and high frequency; PRE- EX x CON: comparison between the experimental and control groups before the intervention (pre-test); POST EX x CON: comparison between the experimental and control groups after the intervention (post-test); p value: Student t test; * $p < 0.05$. Comparison between pre and pos-test groups was $p < 0.0192$.

Comparison between groups (pre- and post) indicates statistically significant differences ($p < 0.05$) in favor of the experimental group.

DISCUSSION

The present study demonstrated that auricular electrical neuromodulation of the vagus nerve induced a significant reduction in blood pressure and an improvement in heart rate variability in hypertensive individuals. The ear is innervated directly by cranial nerves, the vagus nerve has the function of regulating the cardiovascular system and the autonomic nervous system (WANG *et al.,* 2015). Ferreira *et al.* (2016) investigated the efficacy of seed auriculotherapy in reducing HR and BP. Their findings showed a significant reduction in systolic blood pressure (SBP) and HRV in 10 subjects, even though there was no statistically significant difference. The results were similar to the ones obtained in the present study, although auricular electrostimulation was used instead of stimulation with seeds. Clancy *et al.* (2014) showed that a noninvasive method of electrical stimulation of the auricular branch of the vagus nerve via TENS (200 μs, 30 Hz, n = 34) decreased LF / HF ratio, which indicates that TENS improves sympathetic-vagal balance. These findings are in accordance with the present study which also demonstrated an improvement in LF / HF ratio induced by ANM of the vagus. The present study used the photoplethysmography method which measures heart rate with a cell phone using the index fingertip.

This method analyses HRV by identifying the high frequency component (High Frequency - HF), the low frequency component (Low Frequency - LF) and the LF / HF ratio. According to Vanderlei *et al.* (2009) the HF component, corresponds to respiratory modulation and is an indicator of the vagus nerve acting on the heart. The LF component is due to the joint action of the vagal and sympathetic components on the heart, predominantly sympathetic. And the LF / HF ratio reflects the relationship between the sympathetic and parasympathetic components of the ANS, characterizing the sympathetic-vagal balance over the heart. Menezes, Moreira and Daher (2004) reported a decrease in HRV in hypertensive patients when compared to normotensive individuals, when analyzing HF, LF, LF / HF, probably due to sympathetic hyperactivity. The present study did not observe normotensive individuals, but when the hypertensive subjects underwent auricular electro stimulation there was a significant improvement in the LF / HF ratio when compared to the control group.

Conclusion

Auricular neuromodulation (ANM) of the vagus nerve induced significant alterations in the autonomic nervous system, which were not observed in the control group. In the experimental group, there was a decrease in systolic and diastolic blood pressure and positive changes in the LF / HF ratio, which indicate that the intervention stimulates the autonomic nervous system with predominance of the sympathetic nervous system.
Overall this study indicates that acute ANM of the vagus in the auricular pavilion induced positive responses in HRV and PA. These results may justify further investigations of the effectiveness of this technique for hypertensive individuals.
It was not possible to identify whether these effects could be augmented or extended if the intervention lasted longer. We therefore suggest the importance of longitudinal studies with a larger sample size to further evaluate the effects of auricular neuromodulation of the vagus nerve in individuals with hypertension.

REFERENCES

CAPONE, F. *et al.* 2015. The effect of transcutaneous vagus nerve stimulation on cortical excitability. *J Neural Transm,* v.122, n.5, p.679-85.

CLANCY, J. A., DEUCHARS, S. A., DEUCHARS, J. 2013. The wonders of the Wanderer. *Experimental Physiology,* v.98, n.1, p.38-45.

FERREIRA, A. P., ROCHA, T. C., NETO, A. F. E., RODRIGUES, K. L. S. ALEIXO, L. B., RAMOS, P. S. 2016. Respostas cardiovasculares agudas à uma sessão de auriculoterapia em indivíduos normotensos. *Rev Bras Cien Med Saúde,* v.4, n.4, p.1-7.

HOWLAND, R. H. 2014. New developments with vagus nerve stimulation therapy. *Journal of psychosocial nursing and mental health services,* v.52, n.3, p.11-14.

KREUZER, P. M. *et al.* 2012. Transcutaneous vagus nerve stimulation: retrospective assessment of cardiac safety in a pilot study. *Frontiers Psychiatry,* v.3, n.70, p.1-7.

LEUSDEN, J. W. R. V., SELLARO, R., COLZATO, L. S. 2015. Transcutaneous Vagal Nerve Stimulation (tVNS): a new neuromodulation tool in healthy humans? *Frontiers Psychology,* v.6, n.102, p.1-4.

MALPAS, S.C. 2010. Sympathetic nervous system overactivity and its role in the development of cardiovascular disease. *Physiol Rev.,* v.90, n.2, p.523-557.

MENEZES, J. R. A. S., MOREIRA, H. G., DAHER, M. T. 2004. Análise da variabilidade da frequência cardíaca em pacientes hipertensos, antes e depois do tratamento com inibidores da enzima conversora da angiotensina II. *Arq Bras Cardiol.,* v.83, n.2, p.165-168.

OLSHANSKY, B., SABBAH, H. N., HAUPTMAN, P. J., COLUCCI, W. S. 2008. Parasympathetic nervous system and heart failure: pathophysiology and potential implications for therapy. *Circulation*, v.118, n.8, p.863-871.

PICON, R. V., FUCHS, F. D., MOREIRA, L. B., RIEGEL, G., FUCHS, S. C. 2012. Trends in prevalence of hypertension in Brazil: a systematic review with metaanalysis. Plos One, v.7, n.10.

PLEWS, D. J., SCOTT, B., ALTINI, M., WOOD, M., KILDING, A. E., LAURSEN, P. B. 2017. Comparison of Heart-Rate-Variability recording with Smartphone Photoplethysmography, Polar H7 Chest Strap and Electrocardiography. *Sports Physiology and Performance,* v.12, n.10, p.1324-1328.

VANDERLEI, L. C. M., PASTRE, C. M., HOSHI, R. A., CARVALHO, T. D., GODOY, M. F. 2009. Noções básicas de variabilidade da frequência cardíaca e sua aplicabilidade clínica. *Rev Bras Cir Cardiovasc.,* v.24, n.2.

WANG, Z. *et al.* 2015. Low-level transcutaneous electrical stimulation of the auricular branch of vagus nerve ameliorates left ventricular remodeling and dysfunction by downregulation of matrix metalloproteinase 9 and transforming growth factor beta1. *J Cardiovasc Pharmacol,* v. 65, n. 4, p. 342-8.

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