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Role of Low-Frequency Currents on the Autonomic Nervous System in Subjects with Chronic Hypertension

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Abstract: Hypertension is one of the major causes of cardiovascular morbidity and mortality and is associated with altered autonomic nervous system activity. Low-frequency currents may influence cardiovascular responses through their effects on autonomic regulation. The present study was conducted to evaluate the role of low-frequency currents on the autonomic nervous system in subjects with chronic hypertension. An experimental study was conducted on 28 clinically stable participants aged 18 to 80 years. The participants were divided into two groups of 14 each. Group 1 received transcutaneous electrical nerve stimulation in the cervicothoracic ganglion region, whereas Group 2 did not receive transcutaneous electrical nerve stimulation. Heart rate, systolic blood pressure, diastolic blood pressure, respiratory rate, height, weight, and body mass index were assessed. Within-group analysis showed significant changes in heart rate, systolic blood pressure, diastolic blood pressure, and respiratory rate in Group 1. In Group 2, heart rate, systolic blood pressure, and respiratory rate did not change significantly, whereas diastolic blood pressure did. Between-group analysis showed a significant difference in respiratory rate, whereas no significant difference was found in heart rate, systolic blood pressure, or diastolic blood pressure. The findings suggest that low-frequency transcutaneous electrical stimulation may influence selected cardiovascular and respiratory responses in subjects with chronic hypertension. However, further studies with larger sample sizes and direct assessment of autonomic function are required to establish its effect on cardiovascular autonomic regulation.

Keywords: *Autonomic Nervous System; Blood Pressure; Heart Rate. Hypertension; Low Frequency Currents; Transcutaneous Electrical Nerve Stimulation.*

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I. INTRODUCTION

The primary cause of cardiovascular death and morbidity worldwide is systemic hypertension. Nonetheless, it is a problem that is inexpensive and quickly identified. Uncontrolled hypertension increases the risk of damage to target organs and contributes significantly to the burden of disease in the population. Consequently, vigorous management of hypertension is essential to maintaining and safeguarding India's public health[1].

Blood pressure regulation is significantly influenced by the autonomic nervous system. Individuals with hypertension exhibit altered autonomic nervous system function, including decreased parasympathetic tone and increased sympathetic activity[2].

The primary risk factors for hypertension are age, obesity, stress, alcohol use, smoking, physical inactivity, and poor food. These factors can all change the vascular endothelium's integrity and result in a variety of problems[3].

The retina and the heart are two major end-organs of hypertension illness that are frequently studied using morpho-functional approaches. However, there are fewer techniques available for researching the brain as an end organ, they include computed tomography, which is either expensive or exposes the patient to radiation, and the electroencephalogram's specificity is typically regarded as being too low for this use[4].

A common treatment for both acute and chronic pain is transcutaneous electric nerve stimulation (TENS). Nevertheless, this therapeutic approach alters the reactions of the cardiovascular system, leading to vasodilation, a rise in

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blood flow, and a reduction in systemic arterial blood pressure, heart rate, and peripheral vascular resistance—all of which are related to controlling the autonomic balance.[5]

Due to sympatho-inhibition, low-frequency peripheral nerve stimulation may cause extensive vasodilation of the muscles and skin in both humans and animals. In humans, this reaction has been linked to a drop in arterial pressure and systemic vascular resistance[6].

Increased endogenous opioid synthesis or receptor sensitivity may be the cause of the observed decreased pain perception in hypertensive and normotensive patients at risk for high blood pressure. By employing two physiologically different but subjectively identical forms of transcutaneous electrical nerve stimulation (TENS), a pain-reduction method, the current study examined the issue. During three testing sessions, men with varying resting blood pressures and a history of hypertension in their parents received either no-TENS stimulation, low-frequency (2 Hz) TENS, which is believed to stimulate endogenous opioid activity, or high-frequency (100 Hz) TENS. Measurements were made of blood pressure (BP) and other physiological indicators during this period. After that, a 5-minute arm ischemia and a series of electric shocks were given as pain inducers. In the no-TENS and high-frequency TENS conditions, the negative association between pain and resting systolic blood pressure (SBP) and between pain and a parent's history of hypertension was significantly reinforced by the administration of low- frequency TENS. Low-frequency TENS also caused a small but significant acute drop in SBP, especially in people with higher resting blood pressure. These results offer more proof that opioid pathways play a part in blood pressure regulation and hypoalgesia.[7]

Non-analgesic effects of transcutaneous electrical nerve stimulation (TENS), such as modifications to local circulation, have been demonstrated; nevertheless, research in this area has produced contradictory findings. Using laser Doppler flowmetry, this study assessed the effects of both low-frequency (4 Hz) and high-frequency (110 Hz) TENS on the blood circulation of the forearm skin. Using a skin thermistor, the impact on skin temperature was also evaluated. Thirty human volunteers in good health were enlisted and randomized to either the two treatment groups or the control group. TENS was applied in a double-blind manner to the skin overlying the median nerve for fifteen minutes. Prior to, during, and fifteen minutes following the application of TENS, blood flow and skin temperature readings were obtained. Blood perfusion significantly increased during the course of treatment as compared to the other two groups, according to the analysis's findings. Skin temperature did not alter much. The study's findings indicate that low-frequency TENS causes a localized rise in cutaneous blood flow[8].

➢ *Need of the Study*

In this study, patients with critical chronic hypertension had their blood pressure evaluated in order to confirm the effects of low frequency currents.

II. METHODOLOGY

The study design, the source, the subjects, the instruments, the evaluation process, and the data gathering techniques are all included in this.

➢ Method design - experimental study
➢ Type of data collection - random sampling

Sample size – 28

➢ *Inclusion Criteria* –

- Systolic blood pressure (SBP) >140 mm Hg and/or diastolic blood pressure (DBP) > 90 mm Hg are indicators of hypertension, which was previously diagnosed.
- Patients with clinical stability who are between the ages of 18 and 80, regardless of gender.

➢ *Exclusion Criteria* –

- Patient who had any of the following conditions: diabetes, obesity, myocardial infarction, congestive heart failure, or cardiac pacemakers.
- During the two months before to the trial, any changes in the ECG, smoking, beta-blocker treatment, or medication therapy were not included.
- The variations in skin condition at the TENS application site.
- Uncontrolled diabetes in patients with glycated hemoglobin ≥ 7.5% who are taking insulin or oral hypoglycemic medications.
- Secondary hypertension.
- Individuals who disregard the dietary and weight-loss modifications that their doctor has prescribed.
- The cervical-thoracic scoliosis ranges from moderate to severe.
- Obesity is defined as a body mass index (BMI) of greater than 35 kg/m.

➢ *Procedure* -

Group 1 will get transcutaneous electrical stimulation (TENS) in the cervicothoracic ganglion region, while Group 2 will not receive any TENS.

Two groups of patients—group 1 and group 2—will be formed. Group 1 will receive TENS in the area of the cervicothoracic ganglion. Patients in group two will not be stimulated. At the beginning and conclusion of the study period, both groups will be physically examined to ascertain anthropometric characteristics.

When the patient is standing barefoot, the height will be measured with a measuring tape and converted to centimeters. The BMI is determined by dividing the patient's height squared (m^2) by their weight (kg), will be categorized as normal if the BMI is less than 25 kg/m2, overweight if it is between 25 to 30 kg/m^2, and obese if it is greater than 30 kg/m^2.

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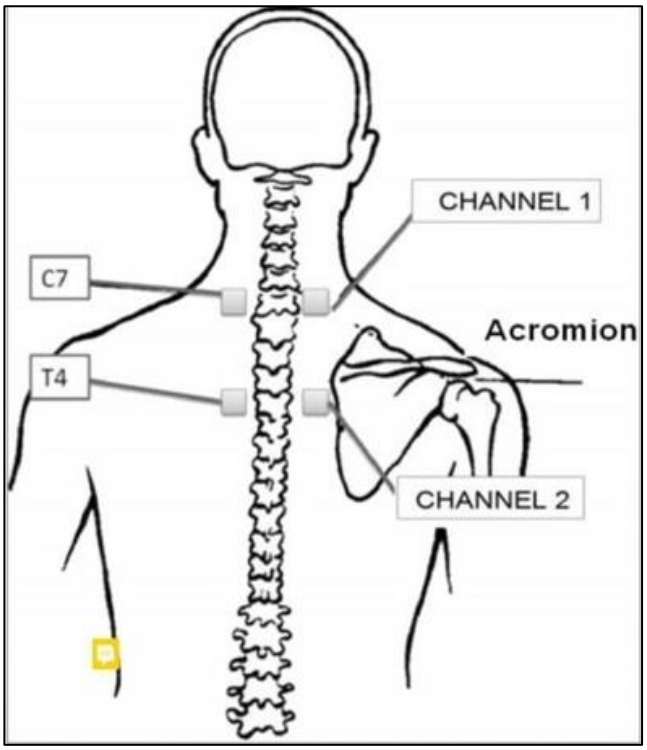


Fig 1 Diagram Illustrating Where Transcutaneous Electrical Nerve Stimulation (TENS) Should be Applied.

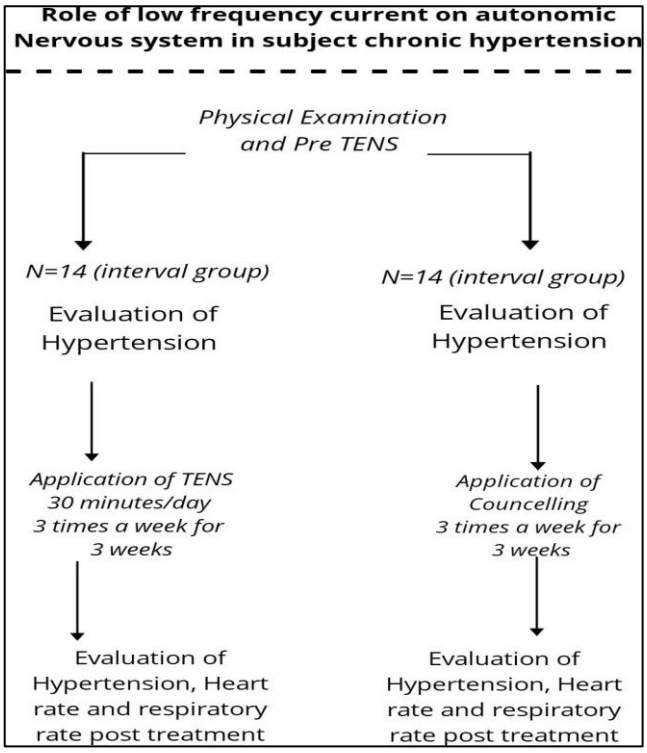


Fig 2 Role of Low Frequency Current on Autonomic Nervous System in Subject Chronic Hypertension

III. RESULTS

For the study, a total of twenty-eight participants were evaluated. In accordance with the inclusion and exclusion criteria, both male and female subjects have been enrolled in the study.

➢ *Descriptive Statistics*

Table 1 Descriptive Statistics

	Mean	Std. Deviation
AGE1	52.2857	12.76671
WEIGHT1	79.8571	7.19890
HEIGHT1	169.5714	5.98349
BMI1	28.5429	2.42985
AGE2	51.7857	6.10395
WEIGHT2	81.9286	12.18741
HEIGHT2	174.5714	6.06014
BMI2	27.1000	3.99172
Valid (listwise)		

SPSS Statistical Software (IBM SPSS Statistics for Windows) will be used for all analyses. In group 1, the average age and standard deviation of the male and female members are 52.28+12.76, the average height and weight are 79.85+7.19, 169.5+5.9, and the average BMI is 28.54+2.42.

Both male and female members of group 2 have mean and standard deviation ages of 51.7+6.1, mean and standard deviations of height and weight of 79.85+7.19 and 174.5+6.06, respectively, and mean and standard deviations of BMI of 28.54+2.42.

➢ *Descriptives of Outcome*

Table 2 Descriptive Statistics

	N	Mean	Std. Deviation
HR 1WK PRE1	14	83.7143	11.05531
SBP 1WK PRE1	14	152.9286	14.33910

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SBP 3WK POST1	14	138.7143	13.98036
DBP 1WK PRE1	14	92.8571	6.16263
DBP 3WK POST1	14	81.5714	1.60357
RR 3WK POST1	14	16.4286	1.15787
HR 1WK PRE2	14	78.2143	6.43522
HR 3WK POST2	14	79.8571	7.43026
HR 3WK POST1	14	78.0000	6.51625
RR 1WK PRE1	14	19.9286	1.59153
SBP 1WK PRE2	14	147.5714	8.12133
SBP 3WK POST2	14	141.5000	14.17880
DBP 1WK PRE2	14	88.4286	5.82718
DBP 3WK POST2	14	82.7143	3.72989
RR 1WK PRE2	14	17.7143	.99449
RR 3WK POST2	14	17.7143	.46881
Valid N (listwise)	14		

➢ *With in Group Analysis*

Table 3 Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Standard Deviation	Standard Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
HR 1WK PRE1-HR 3WK POST1	5.71429	9.05053	2.41886	.48867	10.93991	2.362	13	.034
SBP 1WK PRE1 - SBP 3WK POST1	14.21429	9.01434	2.40918	9.00956	19.41901	5.900	13	.000
DBP 1WK PRE1 - DBP 3WK POST1	11.28571	5.52517	1.47666	8.09558	14.47585	7.643	13	.000
RR 1WK PRE1-RR 3WK POST1	3.50000	1.95133	.52152	2.37334	4.62666	6.711	13	.000
HR 1WK PRE2-HR 3WK POST2	- 1.64286	7.82115	2.09029	- 6.15865	2.87294	-.786	13	.446
SBP1WK PRE2 - SBP 3WK POST2	6.07143	21.17496	5.65925	- 6.15463	18.29749	1.073	13	.303
DBP 1WK PRE2 - DBP 3WK POST2	5.71429	8.55236	2.28571	.77630	10.65227	2.500	13	.027
RR 1WK PRE2-RR 3WK POST2	.00000	1.03775	.27735	-.59918	.59918	.000	13	1.000

➢ *Between Group Comparisons*

Table 4 Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
HR 3WK POST1	Equal variances assumed	.570	.457	-.703	26	.488	- 1.85714	2.64130	- 7.28641	3.57212
	Equal variances not assumed			-.703	25.56	.488	- 1.85714	2.64130	- 7.29091	3.57663
SBP 3WK POST1	Equal variances Assumed	.022	.884	-.523	26	.605	- 2.78571	5.32171	- 13.7246	8.15323

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	Equal variances not assumed			-.523	25.99	.605	- 2.78571	5.32171	- 13.7247	8.15333
DBP 3WK POST1	Equal variances assumed	7.908	.009	- 1.05	26	.302	- 1.14286	1.08508	- 3.37327	1.08755
	Equal variances not assumed			- 1.05	17.64	.306	- 1.14286	1.08508	- 3.42579	1.14008
RR 3WK POST1	Equal variances assumed	13.151	.001	- 3.85	26	.001	- 1.28571	.33386	- 1.97197	-.59946
	Equal variances not assumed			- 3.85	17.15	.001	- 1.28571	.33386	- 1.98962	-.58181

In the analysis the effect of low frequency current on blood pressure dose not show any changes in the three session per week protocol.

IV. DISCUSSIONS

Over the years, hypertension has increased in prevalence and expense. Several medications are needed for adequate management, and treatment frequently fails. Damage to the target organ or even an autonomic imbalance is the cause of this.

According to studies, central inhibition and renal denervation both significantly lower blood pressure by inhibiting the sympathetic nervous system; nevertheless, these procedures are expensive and intrusive. Furthermore, further research has demonstrated that electric current can also be used to non-invasively block the sympathetic nervous system. Nevertheless, more research is required to fully understand how electrical stimulation affects the metabolic system.14

In hypertension patients, the acute effects of applying different TENS frequencies to the paravertebral ganglionic region on the sympathetic and parasympathetic nervous systems are being investigated for the first time in this study. In this work, we showed that low-frequency

TENS reduced low-frequency sympathetic modulation in patients with essential hypertension, improving cardiovascular autonomic regulation, which is linked to cardiovascular risk factors.[13]

The small sample size and the lack of direct testing of the sympathetic nervous system employing muscular sympathetic nerve assessment or plasma catecholamine evaluation—methods that may have been used to elucidate the effects of TENS on sympathetic outflow—are among the study's shortcomings.

For safety and the identification of possible causes of sympathetic activity, as well as for future non-pharmacological treatment, this study has clinical implications for the importance of elucidating TENS's effects on patients with sympathetic hyperactivity, especially in the rehabilitation clinic.

V. CONCLUSION

According to our first findings, when low-frequency TENS is administered to the paravertebral ganglionic region in hypertensive patients, It increases the parasympathetic nervous system's activity while decreasing the sympathetic nervous system's; nonetheless, blood pressure remained unchanged.

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