



Effect of Warm Foot Bath on Heart Rate Variability in Hypertension

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Warm foot bath is a simple, cost-effective, efficient treatment modality used in Naturopathy in the management of hypertension, a preventable and treatable global public health issue. This study was done to assess the effect of warm foot bath on heart rate variability and blood pressure and thereby to substantiate the clinical understanding of its effect in hypertensive individuals.

Methodology: From the inpatient department of Shri Dharmasthala Yoga and Nature cure hospital Shantivana, hundred subjects diagnosed with hypertension belonging to the age group of 30 to 60 years were recruited for the study and warm foot bath was given to all the patients. Subjects were assessed for Blood Pressure (BP) and Heart Rate Variability (HRV) before and after the intervention of 15 minutes.

Results: The data analysis shows a significant reduction in SBP ($p < 0.001$) and DBP ($P < 0.001$). Result showed there is significant reduction seen in MEAN RR, RMSSD, NN50, PN50, VLF and significant increase in LF, HR, LF/HF ratio p value of ($p < 0.001$). There is no significant change in MEAN HF ($p > 0.005$).

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Conclusion: The result of the study shows that warm foot bath reduces the sympathetic tone and shifts the Sympatho-vagal balance in favour of parasympathetic dominance and hence, it can be concluded that warm foot bath can be effectively used in the management of hypertension.
Trial Registration: Clinical Trial Registry - India (CTRI), CTRI Reg. No.- CTRI/2020/01/022640.

Keywords: Naturopathy; warm foot bath; hydrotherapy; hypertension; heart rate variability.

1. INTRODUCTION

Hypertension (HTN) is defined as the persistent elevation in the blood flow against the arterial wall [1]. Hypertension can be classified as primary (essential) HTN which has no identifiable cause and secondary hypertension with an underlying medical cause [2]. Globally hypertension was the leading cause of death and disability adjusted life years in 2010. The global burden of hypertension indicates that approximately one billion adults were hypertensive in 2000 and this is estimated to rise to 1.56 billion by 2025. Hypertension is now the most prevalent chronic disease in India and is rapidly increasing among both rural and urban population. Every year 2.6 lakh Indians die in India due to hypertension [3]. Risk factors associated with HTN include age, gender, marital status, occupation, alcohol consumption, extra salt intake and smoking history [4]. As there are various therapies and treatment protocols for hypertension but none of them provides complete cure. The first line of treatment for hypertension is preventive life style changes such as, the dietary changes, physical exercise, and weight loss, which have all been shown to significantly reduce blood pressure in people with HTN [5]. In conventional medicine, antihypertensive medicines have major role in management of hypertension but their use has been limited due to their tendency to cause adverse effects [6]. Hence to overcome this, non-pharmacological interventions such as CAM can be efficiently employed.

In hydrotherapy, baths are one of the ways in which water is applied to human body for therapeutic use. Baths may be full or partial immersions of the body in water of various temperatures [7]. Thermoneutral, warm & hot temperatures (33.5^o-41^oC) have been used widely for foot baths since antiquity [8].

Foot soak therapy with warm water has been proved stimulates the pituitary gland to release endorphin hormones that activate the parasympathetic nervous system. This results in systemic vasodilation resulting in decreased

peripheral resistance and decreased blood pressure. The impulse received by the parasympathetic nerves will be sent to the SA node through the vagus nerve. This encourages the release of acetylcholine which leads to decrease in heart rate [9]. In clinical practice, warm foot bath at 40^oC have shown beneficial effect in hypertensive individuals but its effect has not been proved scientifically. Heart rate variability (HRV) is an important tool in assessing cardiovascular function and is a quantitative marker for autonomic activity [10].

Hence, the current study is undertaken to understand the effects of warm foot bath at 40^oC for 15 minutes on the HRV among the individuals with hypertension.

2. MATERIALS AND METHODS

2.1 Subjects

Subjects are screened through a medical check-up and those satisfying the inclusion criteria were recruited for the study. Subjects will be recruited from in patient set-up of Sri Dharmasthala Manjunatheshwara Nature cure hospital, Shantivana, Ujire, Karnataka. Out of 150 subjects, 100 subjects were recruited for the study based on the inclusion and the exclusion criteria.

2.1.1 Inclusion criteria

The subject with the inclusion criteria of Age: 30 to 60 years [11], Subjects with essential hypertension satisfying the JNC-8 diagnostic criteria for hypertension with or without anti-hypertensive medications were included in the study.

2.1.2 Exclusion criteria

Subjects with Secondary hypertension, Subjects diagnosed with valvular heart disease, pericarditis or myocarditis, evidence of heart failure with ejection fraction 35%, acute coronary syndrome, previous Coronary artery bypass grafting, Percutaneous transluminal coronary

angioplasty with or without stenting, history of stroke, current abnormal thyroid function; chronic renal failure, pregnancy [12], Diabetes mellitus associated with hypertension, Female subjects during menstruation [13,14]. Subjects with open wounds were excluded.

2.1.3 Design

A single arm pre post study, was used in which each participant was randomly allocated pre and post after the intervention in sitting position.

2.1.4 Intervention

Subjects are asked to sit in a chair or advised to sit on the edge of the bed with backrest and are directed to immerse both legs in a plastic bucket filled with warm water. The temperature of the water is maintained at 40°C and the duration of the intervention is 15 minutes. For the intervention of warm foot bath 13 litres of warm water are used and the lower limbs are immersed approximately for 18 cm from the sole of the foot to above completely covering the calf muscles. After the completion of foot bath the water is wiped off with a towel [15].

2.1.5 Assessments

Blood pressure - The blood pressure was recorded before and after the intervention with a

sphygmometere by auscultation over the right brachial artery [16].

Heart rate and Heart rate variability – HR and HRV were assessed using a four-channel polygraph (BIOPAC, Montana, USA; model No: BSL 4.0 MP 36). The Ag/Agcl pre-gelled electrodes were placed according to the standard limb lead II configuration for recording electrocardiogram [10].

2.2 Data Extraction

Data were extracted from Fast Fourier Transform Analysis using the software Kubios 2.0 version. The energy in the HRV series of the following specific bands was studied that is the very low frequency (VLF) band (0.0-0.05 Hz), LF band (0.05-0.15 Hz), and HF band (0.15-0.50 Hz). The values of LF and HF bands were expressed as normalized units. In time domain HRV, mean RR, mean HR, RMSSD, NN50, pNN50 components were analysed [17].

2.3 Statistical Analysis

The raw data obtained from each subject in each recording session were tabulated separately. The normality assumption was carried out by Kolmogorov Smirnov test. Statistical analysis was done using statistical package for social sciences (SPSS 24.0).

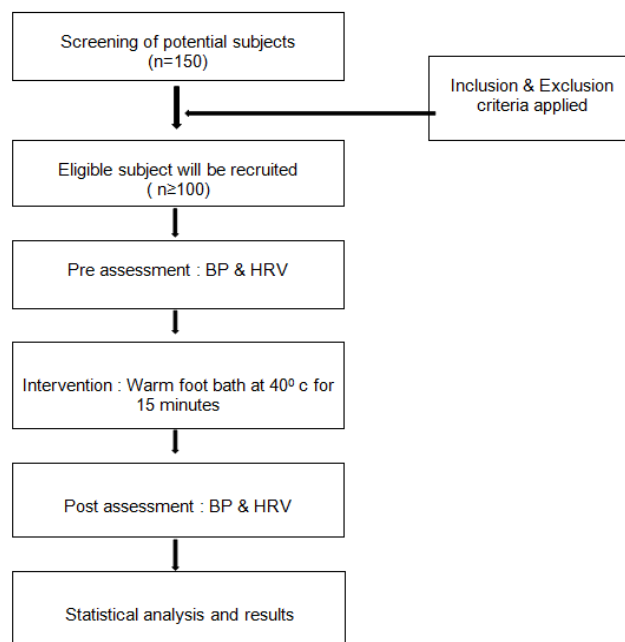


Fig. 1. Illustration of study plan

3. RESULTS

The study was done to evaluate the effect of warm foot bath on heart rate variability in hypertension. The data obtained was analysed for normality by using Kolmogorov Smirnov test. The pre-test and post-test scores of blood pressure, heart rate and heart rate variability were analysed. For data who does not follow normal distribution, therefore the non-parametric tests were applied.

In Table 1 showed distribution by age and sex. Pre-test and post-test, there were 68% of males

and 32% were females with the mean age of 46 years.

In Table 2 pre-test and post-test intervention was done, result obtained as following, there was significant decrease in SBP ($p < 0.001$) and DBP ($P < 0.001$).

Result showed there is significant reduction seen in MEAN RR, RMSSD, NN50, PN50, VLF and significant increase in LF, HR, LF/HF ratio p value of ($p < 0.001$).

There is no significant change in MEAN HF ($p > 0.005$).

Table 1. Distribution of patients by age groups and gender

Age groups	Male	Female	Total
30-39yrs	19	7	26
40-49yrs	18	7	25
50-60yrs	31	18	49
Total	68	32	100
Mean age	46.54	47.66	46.90
SD age	9.08	8.05	8.74

Table 2. Comparison of pre-test and post-tests variables by Wilcoxon matched paired test

Parameters	Treat. time	Mean	SD	Mean diff.	SD diff.	% of change	T- value	Z - value	p- value																																																																																																																											
SBP (MMHG)	PRE	140.31	9.51	17.19	6.84	12.25	0.00	8.6818	<0.001, S																																																																																																																											
	POST	123.12	6.17							DBP (MMHG)	PRE	97.61	5.52	14.36	5.82	14.71	0.00	8.6385	<0.001, S	POST	83.25	3.50	MEAN RR	PRE	842.31	76.03	56.23	90.19	6.68	1043.0	5.0956	<0.001, S	POST	786.08	104.23	MEAN HR	PRE	39516.5	88172.7	-22861.3	112742.2	-57.85	1518.50	3.4607	<0.001, S	POST	62377.8	113872.	RMSSD (MS)	PRE	159.30	66.14	37.62	52.79	23.62	832.00	5.8211	<0.001, S	POST	121.68	53.41	NN50 (COUNT)	PRE	31.14	15.43	8.94	11.51	28.71	674.50	6.3626	<0.001, S	POST	22.20	11.85	PNN50 (%)	PRE	11.95	4.36	4.09	4.91	34.21	149.00	7.9627	<0.001, S	POST	7.86	4.30	VLF(%)	PRE	97.98	14.91	17.48	27.96	17.84	204.00	7.2981	<0.001, S	POST	80.50	30.61	LF(NU)	PRE	40.35	12.86	-9.95	20.63	-24.66	1222.50	4.3716	<0.001, S	POST	50.30	15.63	HF(NU)	PRE	50.93	13.90	-0.45	14.97	-0.87	2467.50	0.1977	>0.05, NS	POST	51.38	13.91	LF/HF (%)	PRE	0.85	0.34	-0.21	0.51
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SBP, Systolic blood pressure; DBP, Diastolic blood pressure; PP, Pulse pressure; MAP, Mean arterial pressure; RR, the intervals between adjacent QRS complexes or the instantaneous heart rate; HR, Heart rate; RMSSD, The square root of the mean of the sum of the squares of differences between adjacent NN intervals; NN50, The number of interval differences of successive NN intervals greater than 50 milliseconds; pNN50, Proportion derived by dividing NN50 by the total number of NN intervals; LF, Low frequency band of the HRV; HF, High frequency band of the HRV; LFHF ratio, Ratio of low frequency to high frequency

4. DISCUSSION

The present study evaluated the effect of warm foot bath on heart rate variability in hypertension. This was a pretest and posttest study with a sample size of 100 subjects who were randomly allocated into pretest and posttest.

The assessment criteria were BP and HRV. There was no adverse effect reported during and after the intervention. Results showed significant increase in LF, HR and LF/HF ratio and significant decrease in SBP, SDP, MEAN RR, RMSSD, NN50, PN50, VLF. These findings are suggestive of para sympathetic activity.

In the HRV low frequency (LF) band of the HRV is mainly related to sympathetic, cardiac and autonomic balance when expressed in normalized units, while the efferent vagal activity is a major contributor to the high frequency (HF) band. The LF/HF ratio is correlated with the sympathovagal balance, respectively, and suggests the HRV power spectrum including its LF component, is mainly determined by parasympathetic system [18,19].

An article shows that lower limb hot water immersion acutely induced beneficial hemodynamic and cardiovascular responses to peripheral arterial disease and healthy elderly controls [20]. Another study done by Samruddhi Chintaman Vyas et al., suggest that 20 min of hot arm and foot bath shows significant reduction in SBP and DBP Since BP is directly related to peripheral resistance [21]. This effect could be possibly through increased peripheral circulation due to a reduction in peripheral vascular resistance. Because HAFB is mentioned to produce dilatation of blood vessels of arms and legs [22]. Another study they have showed that lavender cream with foot bath was used to reduce stress, anxiety and depression in pregnant women [23]. Another study showed the effects of temperature on systemic circulation with foot bath [24]. Another study suggest that foot baths can be an effective method of relaxation, since it increases parasympathetic activity and decreases sympathetic activity [25]. Another article by Saeki Y et al. investigated the effects of foot bathing with mechanical stimulation on autonomic nerve and immune function which increased parasympathetic activity and increase in white blood cell count and natural killer cell activity [26]. Another

previous study done on thermal therapy showed the reduction in BP has reported to be associated with the reduction in total peripheral resistance and improvement in peripheral circulation [27].

And thus, a significant reduction in these variables such as SBP and DBP. MEAN RR, RMSSD, NN50, PNN50 (Time domain) and significant increase in LF, HR, LF/HF ratio (Frequency domain) and there is no significant change in HF (Frequency domain) after Warm foot bath suggestive of para sympathetic activity.

5. STRENGTH OF THE STUDY

- It was a pre post study with the clinical application.
- Standard assessment equipment is used to assess HRV hence a precise, reliable data was obtained.

6. LIMITATION OF THE STUDY

- Experimental design was without control group.

7. CONCLUSION

The results of this study showed a strong parasympathetic dominance following a Warm foot bath. It can be concluded that Warm foot bath is a safe, easier and effective method to increase parasympathetic activity as evidenced by the better sympathovagal balance in the current study.

Hence, Warm foot bath can be effectively employed in the management of hypertension without side effects. Further its application can be extended in prevention and management of cardio vascular and stress related disorders as elevated parasympathetic activity at rest is classically associated with health and well-being.

TRIAL REGISTRATION

Clinical Trial Registry - India (CTRI), CTRI Reg. No.- CTRI/2020/01/022640.

CONSENT

As per international standard or university standard, patients' written consent has been collected and preserved by the authors.

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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