



# Power Spectral Analysis of Heart Rate Variability in Hypertension: A Cross Sectional Study from Davanagere, South India.

Mangala Gowri S.R<sup>1</sup>, Kumari K<sup>2</sup>

## Abstract

**Background:** Hypertension is the most common disease. It markedly increases both mortality and morbidity. Hypertension is associated with autonomic dysregulation. Heart rate variability (HRV) is a useful noninvasive, powerful tool for quantitative assessment of cardiac autonomic function. The aim of this study was to assess the cardiac autonomic function status in patients with essential hypertension by analyzing frequency domain measures of heart rate variability.

**Methods:** 50 hypertensive and 50 normotensive male subjects between the age group of 40-60 years were selected. Computerized ECG system with Niviqure software was used for the study. Frequency domain measures of heart rate variability such as Low frequency (LF), High frequency (HF) and LF/HF ratio were assessed to observe both sympathetic and parasympathetic nerve function status. Statistical analysis was done by using unpaired "t" test.

**Results:** Significant increase in the SBP, DBP, PP and MAP among hypertensives ( $p < 0.001$ ). Mean low frequency (Hz), LF power ( $\text{ms}^2$ ) and LF (nu) was significantly ( $p < 0.001$ ) reduced in hypertensive subjects compared to normotensives. There was reduction in values of Mean HF ( $\text{ms}^2$ ) in hypertensive. But it was not statistically significant compared to normotensives.

**Conclusion:** Cardiac autonomic function tests can predict the future risk of hypertension, which necessitates intervention at the primary health care level for its prevention.

**Keywords:** Frequency domain; Heart rate variability; Hypertension; Sympatho vagal balance.

## Corresponding Author:

<sup>1</sup>Dr. Mangala Gowri Shamnur Rajashekarappa MBBS, MD, Asst. Prof. Physiology, Mahatma Gandhi Medical College & R.I., Puducherry, India.

Email: [dr.gowrishamnur@gmail.com](mailto:dr.gowrishamnur@gmail.com)

<sup>2</sup>Dr. Kanya Kumari, Professor, Department of Physiology, Subbaiah institute of medical science and research center, Purule, Shimoga

Full list of author information is available at the end of the article

## Background

Hypertension is the most common disease in south Asian countries and it has been enormously increased both mortality and morbidity in last few decades [1, 2]. Especially in India, obesity, hypertension and diabetes have recently been observed to be prevalent not only in middle aged population, but also in young adults, which has been primarily attributed to the abrupt change in lifestyle [2, 3]. The adverse effects of hypertension principally involve the blood vessels, the retina, the heart and kidneys including central nervous system [1]. Hypertension is responsible for cardiovascular mortality, which results 20- 50% of all deaths [4]. Different factors are responsible which includes genetic (40 - 60%), high salt intake, and heavy consumption of alcohol, obesity and lack of exercise in the development of hypertension [5]. Physiologically blood pressure and heart rate are controlled by the autonomic nervous system (ANS), so ANS plays a vital role for the development of hypertension [6].

Scientific research revealed that, in the patients with essential hypertension has faulty noradrenaline reuptake in the cardiac sympathetic nerves which amplify the sympathetic neural signal so drugs used during treatment, to modify the sympatho-parasympathetic balance. Overall cardiac health and balance between sympathetic and parasympathetic control on cardiac activity can be analyzed by Heart rate variability (HRV) [7-9]. Heart rate variability is an index of cardiac autonomic regulation [10]. Thus HRV is a useful noninvasive, powerful tool for quantitative assessment of cardiac autonomic function. It is an accurate reliable, reproducible, yet simple to measure and to process [11].

The terminology HRV indicates the oscillations of the intervals between consecutive heart beats. This phenomenon correlates the autonomic influence on the sinus node. Power spectral analysis of heart rate fluctuations was introduced in 1981 by Akselrod et al to quantitatively evaluate beat-to-beat cardiovascular control [12]. In the recent years, spectral analysis of heart rate variability (HRV) has been enormously used as a diagnostic tool to assess autonomic functions in different clinical disorders. This also provides a sensitive and early indicator of health impairments [13].

High HRV is a sign of good adaptation indicating the efficient functioning of ANS. Conversely, low HRV signifies inadequate adaptation of the ANS, indicating physiological malfunction. HRV analysis can be performed by time domain and frequency domain measures. Time domain measures are the means and standard deviations of R-R intervals obtained by continuous ECG, where NN (normal –to- normal) indicates all R-R intervals. Spectral analysis of RR intervals provides the frequency domain analysis which separates the heart rate spectrum into a range of components and quantifies autonomic influences on the heart. The high frequency (HF) denotes parasympathetic activity (vagal influence) whereas, the low frequency (LF) includes both sympathetic and parasympathetic activity. Controversy exists in the interpretation of LF component. There are different theories in the literature proposing different origins for LF component. It is considered by some as a marker of sympathetic modulation and by others as a parameter that includes both sympathetic and parasympathetic influences. The balance between the Autonomic influences can be observed by the ratio of LF: HF [14].

The role of the autonomic nervous system in essential hypertension is an important area of investigation and hence the present study is taken up to compare measures of HRV between hypertensive and normotensive subjects.

## Material and Methods

### Study design, participants and collection of data

The present study was conducted in the Department of Physiology, JJM medical college, Davanagere between June 2010 to June 2012.

After selection, all subjects were explained about the procedures to be undertaken. They were encouraged for voluntary participation and allowed freedom to withdraw from the study whenever they like even after participation. Informed written consent was taken from the participants who agreed to enroll to the study. Subjects were advised to have their meal by 9:00 pm, to have a good sleep at night before and to remain free from any physical or mental stress, not to take sedatives or any drugs affecting central nervous system. They were also instructed to avoid tea or coffee at breakfast and attend Neuro-physiology lab between 9.00 AM to 11.00 AM at JJM medical college, Davanagere on the day of examination.

All subjects were clinically examined and detailed history was taken with reference to duration of hypertension, family history, personal history like smoking, alcoholism etc and previous drug history. Physical examination was done and anthropometric measurements like height, weight was taken. BMI (Body mass index) calculated as per Quetlet's index. Then the subject was kept under complete bed rest in supine position for 15-20 minutes in a cool and calm environment. During this period subject was advised not to talk, eat or drink and also not to perform physical or any mental activity.

### Recording of blood Pressure

Blood pressure was recorded in supine position using mercury sphygmomanometer. A standard adult size cuff measuring 23 cm by 12 cm was used for all subjects. Three readings were taken and average of second and third was used for the study.

### Recording of ECG & HRV

Subjects were rested in supine position for at least 10 minutes, after which resting ECG was recorded in the same position for 5 minutes. ECG was acquired using digital ECG system, an instantaneous heart rate at RR intervals were continuously plotted using Niviqure software on a Microsoft window based computer. The digital ECG system was used to save multiple records and provided with additional filter settings, calculation tools, automated analysis and auto report generation facilities. Heart Rate Variability parameters in frequency domain method such as Low frequency (LF), High frequency (HF) and LF : HF ratio were analyzed.

**Inclusion criteria**

50 known cases of hypertensive male subjects (age group of 40-60 years) have been taken based on availability and voluntary involvement. Due to relatively less number of female participants, we had considered only male subjects in this cross sectional study.

50 normotensive male subjects (age group of 40-60 years) were considered in this study. All the cases of normotensive subjects medical history, blood pressure has been taken prior to the experiment, to confirm that they are not suffering from any cardiovascular diseases.

**Exclusion criteria**

Subjects with secondary arterial hypertension – like pheochromocytoma, renal artery disease etc, diabetes mellitus, congestive cardiac failure, symptomatic coronary artery disease, atrial fibrillation; Smokers and alcoholics; history of drug treatment other than antihypertensive were not included in this study. Subjects who were not willing to participate voluntarily excluded.

**Ethical committee approval**

Prior to the experiment, permission had taken from the Institutional ethical committee. We had followed all the guidelines and ethics for the human experimentation in this research work.

**Data management and statistical analysis**

The data collected was analyzed using Statistical Package for the Social Sciences (SPSS) for Windows Version 16.0 (SPSS Inc; Chicago, IL, USA). The comparison between different variables was tested using the t test. Unpaired t test done among the subjects. A p value less than 0.05 was considered statistically significant.

**Results:**

Subject’s base line data is shown in table 1. Among the hypertensives, mean age was more than normotensives, which is significant.

Table 2 shows there was increase in the systolic blood pressure, diastolic blood pressure, pulse pressure and mean arterial pressure in hypertensive subjects compared to normotensive subjects was highly significant (p<0.001). There was significantly increase in heart rate among hypertensives.

**Table - 1: Anthropometric parameters between normotensive and hypertensive subjects**

	Normotensive subjects	Hypertensive subjects	Normotensive subjects V/S Hypertensive subjects	
	Mean±SD	Mean± SD	t-value	p -value
Age (yrs)	48.4±6.3	51.6±5.4	2.89	0.005 <sup>†</sup>
Height (mt)	1.61±0.04	1.63±0.04	0.08	0.96 <sup>x</sup>
Weight (kg)	61.04±4.11	63±5.53	0.01	0.97 <sup>x</sup>
BMI(kg/m <sup>2</sup> )	23.33±2.2	24±1.98	1.62	0.11 <sup>x</sup>

<sup>†</sup>P<0.01, statistically significant

<sup>x</sup>P>0.05, statistically not significant

**Table - 2: Blood pressure (mm Hg) parameters between normotensive and hypertensive subject**

Blood pressure parameters	Normotensive subjects	Hypertensive subjects	Normotensive V/S Hypertensive subjects	
	Mean± SD	Mean±SD	t-value *	p-value
HR/bpm	65.81±8.68	71.34±7.91	-3.33	0.001 <sup>†</sup>
Systolic BP	118.8±9.1	147.8±6.7	18.10	0.001 <sup>†</sup>
Diastolic BP	77.6±5.2	90.3±3.5	14.49	0.001 <sup>†</sup>
Pulse pressure	41.2±7.46	57.56±7.24	4.46	0.001 <sup>†</sup>
Mean arterial pressure	91.33±5.73	109.59±3.5	5.71	0.001 <sup>†</sup>

<sup>†</sup>P<0.01, statistically significant

The frequency domain parameters of HRV indices are shown in table 3. The changes in the values of VLF between two groups were not significant. Mean low frequency (Hz), LF power (ms<sup>2</sup>) and LF (nu) was significantly (p<0.001) reduced in hypertensive subjects compared to normotensives. There was reduction in values of Mean HF (ms<sup>2</sup>) in hypertensive. But it was not statistically significant compared to normotensives. There was statistically significant reduction in LF/HF ratio in hypertensive subjects compared to Normotensives (p<0.001).

**Table - 3: Spectral analysis of heart rate variability between normotensive and hypertensive subjects**

Spectral analysis		Normotensive	Hypertensive subjects	Normotensive V/S Hypertensive subjects	
		Mean± SD	Mean± SD	t value	p- Value
Peak frequency (Hz)	VLF	0.017±0.01	0.017±0.01	0.31	0.76 <sup>x</sup>
	LF	0.08±0.03	0.06±0.02	3.40	0.001 <sup>†</sup>
	HF	0.26±0.11	0.25±0.15	0.13	0.90 <sup>x</sup>
Peak Power (msec <sup>2</sup> /Hz)	VLF	2299.5±345.4	2187.2±534.9	1.25	0.22 <sup>x</sup>
	LF	1076.2±496.6	787.9±484.2	2.95	0.01 <sup>*</sup>
	HF	356.3±223.2	339.3±174.9	0.42	0.67 <sup>x</sup>
Frequency in normalized units (nu)	LF	49.70±16.41	43.00±12.00	2.32	0.02 <sup>*</sup>
	HF	48.41±17.17	49.87±15.30	-0.45	0.66 <sup>x</sup>
	LF/HF	1.64±0.74	0.93±0.37	6.07	0.000 <sup>†</sup>

<sup>†</sup>P<0.01, statistically significant

<sup>\*</sup>P<0.05, statistically significant

<sup>x</sup>P>0.05, statistically not significant

## Discussion

Hypertension is the most prevalent non communicable disorder that affects many organs of the body including cardiovascular system [1]. This study analyzes the effect of hypertension on cardiac autonomic functions of hypertension patients. In recent years HRV has gained much importance, it is used as a technique employed to explore the activity of ANS, and as an important early marker for identifying different pathological conditions.

### Comparative findings of blood pressure parameters

In our research study the mean value for systolic, diastolic, Pulse and mean arterial pressure is significantly higher in hypertensives compared with normotensives. A number of research findings support this [15, 16].

### Spectral analysis of heart rate variability

There was significantly increased heart rate in hypertensive subjects compared to normotensives. Our study supports research reports by Singh et al, Purcell H et al, and many others [17-20].

Fast resting heart rate is significantly correlated with higher blood pressure, and increased heart rate is prospectively related to the development of hypertension. Individuals with hypertension have increased sympathetic tone manifested by higher heart rate [18].

In our study there was not a statistically significant change in very low frequency values between hypertensive and normotensive subjects. There was a statistically significant reduction in the value of LF peak frequency (Hz), LF power (ms<sup>2</sup>) and LF (nu) in hypertensive subjects compared to normotensive subjects. Research works by Tabassum R et al, Huikuri et al and many others also documented similar findings [11, 17, 19, 21-24].

Some studies have reported dissimilar results in Frequency domain analysis of heart rate variability in hypertensive individuals. Usually, the LF spectrum is said to be modulated by sympathetic and parasympathetic activities. Our results regarding LF may be consequent to the reduction observed in the parasympathetic activity in hypertensive individuals. Some studies reported that when the heart rate varied under strictly controlled circumstances, the LF spectrum was mainly influenced by sympathetic activity. However other data suggest that the heart rate variability is calculated under unrestricted conditions, the LF spectrum reflects mainly the parasympathetic activity, in accordance with our findings[25].

There was reduction in high frequency values in hypertensive subjects but it was not statistically significant.

## Conclusion:

Testing cardiovascular autonomic function is an important area of investigation in hypertensive patients, to look for its dysregulation. Our study showed that HRV is significantly reduced in hypertensive patients compared to controls, indicating a decrease in the baroreceptor reflex. There is impairment in cardiac autonomic function characterized by sympathetic over activity and also showed sympatho-vagal balance in hypertensive patients is towards higher sympathetic and lower vagal modulation. Since reduced HRV is associated with cardiac arrhythmias, this suggests hypertensive patients may have risk for occurrence of cardiac arrhythmias in future. These simple noninvasive measures can be used for early detection and treatment of cardiac arrhythmias and other variations in cardiac autonomic function.

## Study limitations and future scope of the study

Outcomes of our study are interesting enough to encourage other researchers to do further broad spectrum studies. In the present study female gender was not considered, and the sample size is relatively less. Another longitudinal study could be carried out with a larger sample size and comparative data analysis between two genders is recommended in future.

## Abbreviations

Autonomic nervous system [ANS], body mass index [BMI], blood pressure [BP], diastolic blood pressure [DBP], electrocardiogram [ECG], high frequency [HF], high frequency in normalized units [HF (nu)], heart rate variability [HRV], low frequency [LF], low frequency in normalized unit [LF (nu)], low frequency to high frequency ratio [LF:HF], millimeter of mercury [mmHg], milliseconds square [ms<sup>2</sup>], systolic blood pressure [SBP].

## Competing interest

Authors do not have any competing interests regarding this research work.

## Authors' contribution

All authors contributed to the conception and design of the study, performed the experiment, interpreted the data, drafted the manuscript, and revised it. Mangala Gowri S.R conducted the data analysis, interpreted the data, and revised the manuscript. Kumari K critically revised the manuscript. Final manuscript was approved by all authors. All authors had full

access to all of the data (including statistical reports and tables) and take responsibility for the integrity of the data and the accuracy of their analysis.

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**Authors' information**

<sup>1</sup>Dr. Mangala Gowri Shamnur Rajashekarappa  
Assistant Professor, Department of Physiology  
Mahatma Gandhi Medical College & R.I,  
Cuddalore Main Road,  
Puducherry – 607402.

<sup>2</sup>Dr.Kanya Kumari  
Professor  
Department of Physiology  
Subbaiah Institute of Medical Science and Research Center  
Purule  
Shimoga

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