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Original Research Article

Comparative study of heart rate variability among hypertensives aged 45-60 years

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Abstract

Aim and Objective: This study aims to investigate the relationship between Heart Rate Variability (HRV) and hypertension in individuals aged 45-60 years. The objective of this study was to explore how HRV patterns differ in hypertensive patients compared to normotensive controls in this age group.
Introduction: HRV is considered a marker of autonomic nervous system function, and a decrease in HRV has been associated with increased cardiovascular risk.
Materials and Methods: A cross-sectional study design was employed, with data collected from 150 participants (75 hypertensive and 75 normotensive). The HRV was assessed through a 5-minute resting ECG using time-domain and frequency-domain parameters. Statistical analysis with MS excel was conducted to compare HRV indices between hypertensive and normotensive groups and to evaluate correlations with demographic and clinical variables.
Result: The lower SDNN, RMSSD, and pNN50 values in hypertensive individuals suggest reduced autonomic regulation, particularly a decline in parasympathetic activity.
Conclusion: Additionally, the higher LF/HF ratio observed in hypertensives indicates an imbalance favouring sympathetic over parasympathetic activity, which is consistent with autonomic dysfunction seen in hypertension.

Keywords: Heart Rate Variability (HRV), Hypertension, Autonomic nervous system, Parasympathetic activity, Middle-aged adults, Systolic blood pressure, Diastolic blood pressure

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1. Introduction

Hypertension (HTN) remains one of the most prevalent and concerning cardiovascular conditions globally, affecting millions of individuals, particularly those in middle and older age groups. It is well-established that hypertension increases the risk of heart failure, stroke, myocardial infarction, and other cardiovascular diseases (CVD).[1] Despite the availability of effective pharmacologic treatments for blood pressure (BP) control, the underlying pathophysiological mechanisms that contribute to hypertension, particularly those involving the autonomic nervous system (ANS), remain an area of active research. One promising area of exploration is Heart Rate Variability (HRV)**,** a non-invasive measure that reflects the balance and functioning of the autonomic nervous system (ANS), which plays a crucial role in regulating BP and other cardiovascular processes.[2]

HRV refers to the variation in the time intervals between successive heartbeats, which is influenced by both sympathetic (fight-or-flight) and parasympathetic (rest-and-digest) branches of the ANS. Low HRV indicates an imbalance, typically with heightened sympathetic activity and/or reduced parasympathetic activity, both of which are associated with increased cardiovascular morbidity and mortality.[3] Since hypertension is frequently associated with autonomic dysfunction—characterized by reduced parasympathetic activity and increased sympathetic tone—HRV has been studied as a potential marker of risk in hypertensive individuals. Previous Studies on HRV and Hypertension have explored the relationship between HRV and hypertension, showing consistent findings of reduced HRV in hypertensive individuals compared to normotensive controls. A study[4] observed that hypertensive patients had

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significantly lower HRV, particularly in the low-frequency (LF) and high-frequency (HF) bands, which reflect sympathetic and parasympathetic activity, respectively.[14] These findings indicated that hypertension might be linked to an imbalance between sympathetic and parasympathetic regulation of the heart, with increased sympathetic activity and reduced parasympathetic activity contributing to autonomic dysfunction.[10]

The increased LF/HF ratio in hypertensives suggests that they may be at greater risk for cardiovascular events due to heightened sympathetic tone.[5] further confirmed these findings, reporting that lower HRV (measured by both time-domain and frequency-domain parameters) was a predictor of adverse outcomes in hypertensive patients[8,12] including strokes and myocardial infarction. These studies highlight the potential of HRV as an early indicator of cardiovascular risk in hypertension.[13]

Another study by[6] suggested that BP variability (BPV), which is often seen in hypertensive patients, could also affect HRV. This study found that increased BPV was associated with lower HRV, pointing to a more complex interaction between blood pressure fluctuations and autonomic regulation. Additionally,[7] demonstrated that hypertensive patients with high BP variability and low HRV were at increased risk for stroke, reinforcing the idea that HRV could be an important predictor of long-term cardiovascular risk.[9] Lifestyle changes such as exercise, yoga, meditation, or even pharmacological treatments targeting autonomic balance might be explored as adjunct therapies in the management of hypertension.[11]

This study aims to assess HRV in hypertensive patients aged 45-60 years, comparing them with age-matched normotensive controls. By exploring HRV parameters in this demographic, we aim to provide further insight into the role of autonomic dysfunction in the pathophysiology of hypertension.

2. Objectives of the Study

1. To compare HRV parameters between hypertensive and normotensive individuals aged 45-60 years.
2. To explore the relationship between HRV measures and clinical variables (e.g., age, gender, BMI and duration of hyprtension).
3. To determine if HRV can be used as a predictor of cardiovascular risk in hypertensive individuals.

3. Materials and Methods

3.1. Study design

This was a cross-sectional, observational study conducted in a Narendra Modi Medical College, a tertiary care hospital. Participants were recruited through outpatient clinics, and the study was approved by the Institutional Review Board (IRB) of the hospital.

3.2. Participants

A total of 150 participants, aged 45-60 years, were enrolled in the study. The participants were divided into two groups:

1. Hypertensive Group (n=75): Patients diagnosed with hypertension (systolic BP ≥ 140 mmHg or diastolic BP ≥ 90 mmHg), visiting medicine OPD at Narendra Modi Medical College, Ahmedabad.
2. Normotensive Group (n=75): Age- and gender-matched individuals with normal blood pressure (systolic BP < 120 mmHg and diastolic BP < 80 mmHg).

3.3. Inclusion criteria

1. Age 45-60 years
2. Signed informed consent
3. Diagnosis of hypertension (for hypertensive group), based on OPD charts of patients visiting medicine department at Narendra Modi Medical college.
4. No significant comorbidities (diabetes, chronic kidney disease, etc.)

3.4. Exclusion criteria

1. History of cardiovascular diseases (e.g., heart attack, stroke)
2. Pregnant or lactating women
3. Use of medications that affect HRV (e.g., beta-blockers, anti-arrhythmic drugs) for more than a period of 3 months.

3.5. HRV measurement

HRV (STREME software) was assessed using a 5-minute resting electrocardiogram (ECG) in a quiet, comfortable environment. Patient were asked to rest for 10 minutes in supine position before starting the test. A pre-test reading was taken with normal breathing rate to standardise the test readings. The following HRV parameters were recorded:

1. Time-domain parameters
    a. SDNN (Standard Deviation of Normal-to-Normal Intervals): A measure of overall HRV.
    b. RMSSD (Root Mean Square of Successive Differences): Reflects parasympathetic activity.
    c. pNN50 (Percentage of successive RR intervals differing by more than 50 ms): Another measure of parasympathetic activity.
2. Frequency-domain parameters
    a. LF (Low Frequency, 0.04-0.15 Hz): Reflects both sympathetic and parasympathetic activity.
    b. HF (High Frequency, 0.15-0.4 Hz): Reflects parasympathetic activity.
    c. LF/HF ratio: A marker of sympathetic to parasympathetic balance.

The most commonly used time-domain variables are the standard deviation of all N–N intervals (SDNN) and the square root of the mean of the sum of the squares of differences between adjacent R–R intervals (RMSSD). (8)

The frequency domain is another method used to calculate HRV, of which the low-frequency (LF) and the high-frequency (HF) spectral components are common measures. In the frequency-domain method, cyclic fluctuations of RR intervals are quantified by the frequency of the fluctuation using Fourier transformation or auto regression spectral analysis. Typically, HF fluctuations are thought to be caused by respiration and are effectuated by parasympathetic outflow. Low-frequency fluctuations are probably the result of a blood pressure resonance phenomenon mediated by the baroreflexes and are effectuated by both sympathetic and parasympathetic fluctuations in outflow

3.6. Statistical analysis

The data were analyzed using MS Excel. Descriptive statistics (mean, standard deviation) were used to summarize demographic characteristics and HRV parameters. Between-group differences were assessed using independent t-tests (for normally distributed data) or Mann-Whitney U tests (for non-normally distributed data). Pearson's correlation coefficient was used to assess the relationship between HRV indices and clinical variables, such as blood pressure and age. A p-value < 0.05 was considered statistically significant.

4. Results

*4.1. Demographic characteristics (**Table 1**)*

Table 1: Table demonstrating demographic characteristics of the group

Variable	Hypertensive Group (n=75)	Normotensive Group (n=75)	p-value	Confidence Interval
Age (years)	52.4 ± 5.3	51.8 ± 5.1	0.67	0.6±1.664
Gender (Male/Female)	38/37	37/38	0.89	
BMI (kg/m²)	27.1 ± 4.3	25.6 ± 3.9	0.03	1.5±1.313
Duration of Hypertension (years)	7.8 ± 4.6	NA	NA	

HRV Parameters

*4.2. Time-domain Parameters (**Table 2**)*

Table 2: Table shows the variation in time-domain parameters

Parameter	Hypertensive Group (n=75)	Normotensive Group (n=75)	p-value	
SDNN (ms)	55.2 ± 10.1	65.7 ± 9.3	0.001	Significant
RMSSD (ms)	33.4 ± 7.8	44.1 ± 6.9	0.0001	Significant
pNN50 (%)	18.6 ± 5.3	25.3 ± 6.1	0.002	Significant

*4.3. Frequency-domain Parameters (**Table 3**)*

Table 3: Table shows the variation in frequency- domain parameters (No adjustments were made for confounding factors)

Parameter	Hypertensive Group (n=75)	Normotensive Group (n=75)	p-value
LF (ms²)	210 ± 90	175 ± 82	0.03
HF (ms²)	120 ± 58	170 ± 75	0.004
LF/HF Ratio	1.75 ± 0.64	1.16 ± 0.51	0.0001

4.4. Correlation analysis

A Pearson correlation analysis was conducted to assess the relationship between HRV parameters and clinical variables (e.g., systolic and diastolic BP). (**Table 4**)

Table 4: Table demonstrate the Pearson corelation analysis

Variable	SDNN	RMSSD	pNN50	LF/HF Ratio
Systolic BP	-0.38 (p<0.001)	-0.42 (p<0.001)	-0.35 (p<0.001)	0.41 (p<0.001)
Diastolic BP	-0.31 (p=0.01)	-0.33 (p=0.01)	-0.29 (p=0.02)	0.36 (p=0.005)
Age	-0.22 (p=0.04)	-0.18 (p=0.09)	-0.15 (p=0.12)	0.16 (p=0.11)

5. Discussion

This study shows that hypertensive individuals aged 45-60 years have significantly lower HRV compared to normotensive controls. The lower SDNN, RMSSD, and pNN50 values in hypertensive individuals suggest reduced autonomic regulation, particularly a decline in parasympathetic activity. Additionally, the higher LF/HF ratio observed in hypertensives indicates an imbalance favouring sympathetic over parasympathetic activity, which is consistent with autonomic dysfunction seen in hypertension.

Our findings are in line with previous studies that have reported lower HRV in hypertensive patients. The significant correlation between HRV parameters and blood pressure highlights the potential of HRV as a marker for cardiovascular risk in hypertensive individuals. Notably, HRV can provide a non-invasive, easily measurable tool for assessing autonomic function and may help predict the risk of cardiovascular events in this population.

Risk of bias: Cardiovascular disease at baseline was assessed in all participants. Even those who were on antihypertensive medications project a risk of bias. Heart rate variability was assessed prior to the outcome in few subjects to rule out bias and confounding factors.

The instrument used to measure N–N intervals was clearly described in all observations, but previous studies lacked data on the assessment of HRV from the recordings. Diagnosis of hypertension was verified by medical records and practitioner's registries in all selected individuals

Seven studies adjusted for potential confounders, one study only presented unadjusted risk estimates.[11]

6. Limitations

6.1. Cross-sectional design

The study's cross-sectional design limits the ability to draw causal inferences between hypertension and HRV. While the data demonstrate an association, they cannot definitively establish whether reduced HRV contributes to the development of hypertension or whether hypertension leads to decreased HRV.

6.2. Sample size

Although the sample size of 150 participants (75 hypertensive and 75 normotensive) is adequate for initial findings, a larger sample would provide greater statistical power and may help to identify more subtle differences or subgroup effects (e.g., gender, age within the 45-60 years group). ·

Additional co-founders such as diet, lifestyle, physical activity can be considered.

6.3. Medication confounding

Participants in the hypertensive group were receiving various antihypertensive medications, which could influence HRV. While medication was not an exclusion criterion, it could introduce a confounding factor. Future studies should control for the potential effects of specific antihypertensive drugs on autonomic function

7. Future Applications and Directions

7.1. HRV as a predictive marker for cardiovascular events

Future longitudinal studies could explore HRV as a predictive biomarker for cardiovascular events in hypertensive patients. This would help identify individuals at higher risk for heart attacks, strokes, and other cardiovascular conditions based on their autonomic dysfunction profile.

7.2. Personalized hypertension management

HRV monitoring could be integrated into personalized hypertension management plans. By assessing autonomic function, healthcare providers might better understand the underlying mechanisms of hypertension in individual patients, potentially guiding more tailored treatment strategies (e.g., optimizing medication regimens or lifestyle interventions).

7.3. Development of HRV-based therapies

Since low HRV is linked to sympathetic dominance and autonomic imbalance, future research could investigate therapeutic interventions aimed at improving HRV. Lifestyle changes such as exercise, yoga, meditation, or even pharmacological treatments targeting autonomic balance might be explored as adjunct therapies in the management of hypertension.

8. Conclusion

This study provides evidence that reduced HRV is associated with hypertension in middle-aged individuals (45-60 years). HRV testing could serve as a valuable tool for monitoring autonomic dysfunction in hypertensive patients, offering insights into their cardiovascular risk Further longitudinal studies are needed to determine whether HRV can be used as a predictive marker for future cardiovascular events in this population. Despite the limitations, this study contributes valuable insights into the relationship between HRV and hypertension in middle-aged adults. Future research is needed to build on these findings and explore the potential of HRV as both a diagnostic and therapeutic tool in the management of hypertension and other cardiovascular diseases. By addressing the limitations outlined and focusing on the applications mentioned, HRV could become an integral part of personalized healthcare and risk assessment for hypertensive patients.

9. Source of Funding

None.

10. Conflict of Interest

None.

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