Evaluation of Heart Rate Variability in Hypertensive Subjects

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ABSTRACT

The autonomic nervous system, which is divided into sympathetic and parasympathetic divisions, plays a vital role in cardiovascular regulation. It has been demonstrated that heart rate variability can provide an objective measure of autonomic function. The Peripheral Pulse Analyzer has been used to research heart rate variability in healthy and hypertensive people in order to better understand the effects of hypertension on autonomic activity. Subjects were separated into two age groups: 18-30 years and 31-44 years, and variability factors were compared in terms of gender, age, and disease stratification. Statistical analysis revealed a significant reduction in the coefficient of variation for the variability parameter represented as a logarithm (to the base 10) in contrast to the raw or average value of the parameter, resulting in greater discriminatory strength in various stratified groups. Excluding age and gender sensitive factors, there is a significant difference in the amplitude of the low frequency component for lower age group male/female hypertensives and the amplitude and area of the low frequency component for higher age group female hypertensives. These findings are consistent with earlier research of a comparable scope. However, higher age group male controls and hypertensives could not be distinguished by variability study, most likely because to comparable changes indicated by senility and hypertension. As a result, the amplitude and area of the low frequency component in the heart rate variability spectrum have been identified as hypertension-specific parameters.

Keywords: Heart rate variability, Hypertension, Autonomous nervous system, Low Frequency, High Frequency

INTRODUCTION

The autonomic nervous system is a control system that acts automatically and governs biological functions such as heart rate, blood pressure, respiratory rate, digestion, involuntary muscle contraction, pupil size, gland secretion, and so on. It is divided into sympathetic and parasympathetic divisions, which have opposing responses. Stimulation of the sympathetic nervous system raises heart rate, constricts blood vessels, lowers gastro-intestinal motility, and so on, whereas stimulation of the parasympathetic nervous system has the opposite effect. Variability in physiological markers can be used to study variations in sympathetic and parasympathetic activity [1].

The most studied physiological variability is heart rate variability (HRV); additional variables studied include peripheral blood flow variability (PBFV), systolic and diastolic blood pressures (SBP, DBP), and the peripheral pulse morphology index (MIV). Long-term variability (about 24 hours) reigns supreme, with ultra-low frequency (ULF) indicating circadian, thermoregulatory, and other rhythms. Short-term variability produces three spectral components: Very Low Frequency (VLF), Low Frequency (LF), and High Frequency (HF) peaks at frequencies 0.004-0.039, 0.04-0.15, and 0.15-0.4 Hz, respectively [2]. The HF frequency component is thought to be a marker of vagal modulation, while the LF frequency component is thought to be a sign of sympathetic modulation. VLF is poorly understood; some researchers have linked it to renin-angiotensin system activity [3].

Acharya et al. [4] studied the manifestations of clinical disorders such as myocardial infarction, hypertension, diabetes, renal failure, cardiac arrhythmia, and so on. They also looked at how smoking, alcohol, beta blockers, calcium channel blockers, and sleep affect HRV. In most disorders, there is a drop in total power (TP) and HF power in HRV. In myocardial infarction, hypertension, and diabetes, for example, HF power is shown to be diminished. In addition to these generic symptoms, a great number of investigations concerning specific diseases in quest of specific manifestations have been done.

Akselrod et al [3] employed a nona-peptide converting enzyme inhibitor to block the renin-angiotensin system in four unanesthetized dogs and found a 2-to-4-fold increase in area under VLF in three of the four dogs. The measurement of baroreflex sensitivity by bradycardia and tachycardia has revealed an inverse relationship with blood pressure variability and a direct relationship with heart rate variability [5, 6]. The rise in HF power indicates increased baroreflex response sensitivity [4, 7]. In the presence of hypertension, power spectral density analysis of heart rate and arterial pressure revealed an increase in the LF component [8, 9, 10]. An investigation of the HRV spectrum at work demonstrated an increase in LF/(VLF+HF) during the frozen frame and a decrease during internal coherence [11]. In contrast to 1111 female patients, new onset hypertension was found to alter the HRV spectrum in 931 male subjects [12].

Low HRV has been linked to an increased risk of hypertension in normotensive people. In hypertensives, mean variability and the HF component are shown to be much lower [13, 14]. Da Silva et al. [15] discovered that before therapy, LF power reduces and LF/HF increases, but returns to normal following treatment. Following treatment, HF reduces. In hypertensives, the LF/HF ratio increased much more than in normal patients after mental stress [16]. Lufti et al. [17] discovered that systolic, diastolic, and mean blood pressure all correlate positively with LF and the LF/HF ratio, while SBP correlated adversely with HF and total power.The coexistence of hypertension and type 2 diabetes has resulted in a considerable shift in heart rate recovery; it has a synergistic effect, causing autonomic recovery to deteriorate [18]. Solanki et al. [19] found a decline in HRV parameters in a population that was unaffected by optimal pressure or glycemic control [20].The goal of this study is to compare changes in the spectrum of HRV in controls and early untreated hypertension individuals in separate groups. The study's findings are summarised in this paper.

MATERIALS AND METHODS

The research was conducted in the Medical College, Baroda. The controls and hypertensive subjects, aged 18 to 45 years, were drawn from the institute's student and employee populations based on inclusion and exclusion criteria. Smokers, tobacco chewers, those on regular medication, and those who had previously suffered from serious illness were all excluded from the study. Subjects with a history of cardiovascular disease (excluding hypertension) or autonomic dysfunction were also excluded from the trial. Initially, the subject's information, background, and consent were obtained. The individuals were then pleasantly rested in the supine posture for 15 minutes.

Continuing in the supine position, blood pressure is measured twice with a digital BP monitor (Omron HEM7121), with the second reading being used to determine whether the person should be included in the study. The control group included people with blood pressures less than 130/80. Those who had a blood pressure of more than 140/85 on two different days were classified as having hypertension. These participants were thus newly diagnosed hypertensives who had not received any treatment. The data was divided into eight categories based on age,

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gender, and hypertension. Table-I shows the demographic features of these subjects. A minimum sample size of 16 was determined by taking the precision level to be 50% of the sample standard deviation.

TABLE I: Demographic characteristics of Controls and Hypertensive subjects

Parameters	Controls				Hypertension			
	CML*	CFL*	CMH*	CFH*	HML*	HFL*	HMH*	HFH*
Number of subjects (n)	34	34	34	34	23	27	30	20
Weight (kg)	70.24±8.10	63.50±11.43	73.94±9.69	64.21±10.82	80.04±13.56	67.26±10.36	69.4±11.2	65.80±10.77
SBP (mmHg)	112.21±8.67	108.76±9.96	117.41±7.59	107.52±9.46	148.70±8.16	147.22±6.19	150.90±13.0	148.90±12.2
DBP (mmHg)	75.35±6.09	70.91±7.21	76.03±7.64	70.76±6.09	93.13±7.00	93.04±2.95	97.3±8.5	93.15±7.34
Pulse Rate (bpm)	80.03±8.21	74.71±11.21	75.62±7.37	75.36±10.96	82.65±10.36	77.67±8.41	78.80±10.50	73.40±11.46
Age (yrs)	21.47±3.31	19.91±2.67	36.65±4.80	37.42±3.95	26.52±3.20	27.78±2.69	39.10±3.70	41.30±4.41

(*Alphabets represent Control/Hypertension, Male/Female and Lower-age/Higher-age sequentially)

Peripheral blood flow (PBF) was measured in all patients to determine heart rate variability using a Peripheral Pulse Analyzer. PBF recordings were made in accordance with the technique and criteria specified for HRV investigations. After a 10-minute rest period, five consecutive recordings of 275 seconds each were made for the first reading. A two-hour window was set aside for recording, notably after breakfast or lunch. With the participant supine, carrier electrodes C1 and C2 were attached in the form of a loop around the right upper extremity slightly below the elbow and palm, respectively.S1 and S2 sensing electrodes were implanted 5 cm apart around the wrist. Prior to acquisition, the subject's information was filled out. A click on the ACQUIRE button in the application programme initiates data acquisition, which by default ends after 275 seconds. If there is a motion artefact, it can be halted and restarted. Data is saved in a file together with the subject's information. The collected data is subsequently processed in the graphical user interface.

After loading previously gathered data into the application, navigate to the PROCESSING Panel. The entire signal may be seen in the top graph by panning with the arrows on the right side. Placing the cursor on the second peak and then clicking on LOCATE PEAKS marks the systolic peak. As observed in the graph, vertical red lines appear on the peak points. The second graph, below the raw signal, shows the time elapsed between two peaks (similar to an ECG's approximate RR interval) as a function of time. By clicking on any irregularity in the lower graph, the corresponding signal in the upper graph is displayed.Peak can be edited using the arrow buttons and insert/delete buttons located at the bottom, to the right. The data that has been edited is then saved. The application allows you to navigate to the DISPLAY screen, which displays the Heart Rate Variability (HRV) spectrum. The left and right graphs show variability in the time domain and frequency domain, respectively. On the right side of the screen, the computed variability parameters are displayed. Data is transmitted to the selected excel sheet when you click SAVE EXCEL. The application is exited by clicking the cease button.

STATISTICAL ANALYSIS

The information saved in the Excel sheet is subsequently processed for statistical analysis. To begin, the average of five values of a certain HRV parameter (obtained from five recordings in a person) is calculated. The average values, abbreviated as Average (Avg), for all parameters in a given subject are thus produced. The mean and standard deviation (SD) values of these parameters are then calculated from this data for all patients in a given group. The procedure is repeated for each group. The computed mean has a reduced SD value when compared to the individual values provided by Jindal et al. [21].ANOVA and Tukey's HSD tests were used to determine the significance of differences in data stratified by age, gender, and disease. Because of the large scatter even in the averaged data, the logarithm of each individual value to the base 10 was used, which will be referred to as Log from now on. The entire statistical analysis that was performed on Avg data was replicated on Log data.

RESULTS

TABLE II: Group Mean and SD in controls and hypertensives

Groups Parameters	*Data Type*	*CML* Avg±SD	*CFL* Avg±SD	*CMH* Avg±SD	*CFH* Avg±SD	*HML* Avg±SD	*HFL* Avg±SD	*HMH* Avg±SD	*HFH* Avg±SD
TP (ms^2)	Avg	1357.05± 1120.56	1253.01± 1147.22	730.04± 558.97	1006.10±1 360.05	676.93± 830.93	697.64± 898.16	683.70± 756.50	503.11± 609.01
	Log	2.99±0.36	2.97±0.31	2.75±0.32	2.81±0.37	2.65±0.36	2.61±0.41	2.64±0.42	2.50±0.41
RR_Mean	Avg	852.11± 100.79	794.98± 115.51	811.22± 118.59	815.17± 122.01	737.23± 110.82	760.02± 103.90	770.33± 80.92	813.73± 144.18
(ms)	Log	2.92±0.05	2.89±0.06	2.90±0.05	2.91±0.06	2.86±0.06	2.87±0.06	2.88±0.04	2.90±0.08
Amp_VLF	Avg	13.47±8.46	9.48±6.12	13.43±8.09	11.77±8.13	11.32±7.84	14.05±7.22	12.63±7.62	17.21±7.80
(n.u.)	Log	1.03±0.31	0.89±0.26	1.05±0.24	0.96±0.35	0.95±0.30	1.08±0.24	1.02±0.27	1.19±0.19
A_VLF	Avg	32.98±18.47	26.21±13.73	36.09±15.33	32.41±15.69	30.06±18.46	35.13±18.14	36.25±17.32	45.75±14.17
(n.u.)	Log	1.42±0.31	0.89±0.26	1.51±0.20	1.44±0.28	1.39±0.27	1.47±0.26	1.50±0.24	1.63±0.15
Amp_LF	Avg	4.75±2.30	4.36±2.23	5.24±2.77	4.54±2.19	6.07±3.16	5.46±2.54	5.22±2.87	3.27±1.99
(n.u.)	Log	0.62±0.21	0.59±0.20	0.66±0.22	0.60±0.22	0.72±0.22	0.68±0.21	0.65±0.23	0.50±0.25
A_LF	Avg	34.81±14.33	32.98±13.25	34.71±12.41	32.21±13.71	40.00±15.20	36.45±14.91	34.25±14.02	25.49±11.21
(n.u.)	Log	1.50±0.19	1.48±0.18	1.51±0.16	1.46±0.20	1.56±0.19	1.51±0.20	1.49±0.19	1.36±0.21
Amp_HF	Avg	3.67±3.09	4.28±2.78	2.40±1.74	3.45±3.23	2.11±1.28	2.70±2.26	2.74±3.33	2.86±2.49
(n.u.)	Log	0.45±0.30	0.54±0.27	0.32±0.20	0.42±0.29	0.23±0.29	0.28±0.37	0.24±0.40	0.33±0.32
A_HF	Avg	30.12±15.98	39.25±14.70	26.04±13.97	32.34±15.42	28.14±14.63	26.69±13.38	26.99±17.18	26.23±14.15
(n.u.)	Log	1.41±0.25	1.55±0.18	1.35±0.23	1.45±0.22	1.38±0.25	1.35±0.26	1.34±0.29	1.35±0.25

(TP: Total power; RR-mean: Mean of RR interval values; Amp_VLF: Amplitude of VLF peak; A_VLF: Area of VLF peak; Amp_LF: Amplitude of LF peak; A_LF: Area of LF peak; Amp_HF: Amplitude of HF peak; A_HF: Area of HF peak; ms2 = milli-second square, n.u. = Normalized unit)

Table II displays the mean and standard deviation (SD) values calculated from Avg and Log data for each group. As can be observed, the coefficient of variation for Log data has decreased dramatically. The histogram plot for a specific parameter in a specific group has been found to be more symmetric for Log data than for Avg data. Table III provides ANOVA and Tukey's HSD statistic values for Avg and Log data. The probability values for eight comparisons between diverse groups stratified by gender, age, and disease are provided. For gender stratification, male and female controls are compared in lower age groups (CML CFL) and higher age groups (CMH CFH).CML CMH and CFL CFH are age stratification codes, while CML HML, CFL HFL, CMH HMH, and CFH HFH are disease stratification codes.

TABLE III: Analysis of Variance and Tukey's HSD test

Groups Parameters	Data Type	ANOVA ($F_{crit.}$=2.017)	Tukey's HSD test (p-value)							
			CML_ CFL*	CMH_ CFH*	CML_ CMH*	CFL_ CFH*	CML_ HML*	CFL_ HFL*	CMH_ HMH*	CFH_ HFH*
TP	Avg	7.58	0.994	0.992	**0.003**	0.088	**0.001**	**0.003**	1.000	0.871
	Log	31.17	1.000	0.771	**0.001**	**0.002**	**0.001**	**0.001**	0.157	**0.001**
RR_Mean	Avg	6.78	0.258	1.000	**0.015**	0.872	**0.002**	0.071	0.736	1.000
	Log	15.89	**0.001**	1.000	**0.013**	0.764	**0.001**	0.087	**0.046**	1.000
Amp_VLF	Avg	2.74	0.518	0.991	1.000	0.923	0.968	0.203	1.000	0.073
	Log	13.47	**0.001**	**0.029**	0.981	0.373	0.354	**0.001**	0.942	**0.001**
A_VLF	Avg	3.31	0.736	0.941	0.987	0.879	0.996	0.568	1.000	**0.033**
	Log	14.28	0.103	0.178	**0.045**	**0.022**	0.978	**0.001**	1.000	**0.001**
Amp_LF	Avg	3.51	0.897	0.667	0.985	1.000	0.492	**0.045**	1.000	0.967
	Log	10.77	0.833	0.186	0.735	0.999	**0.005**	**0.005**	1.000	**0.010**
A_LF	Avg	2.733	0.872	0.977	1.000	1.000	0.823	0.210	1.000	0.850
	Log	9.93	0.983	0.365	1.000	0.993	0.115	0.741	0.997	**0.001**
Amp_HF	Avg	5.26	0.754	0.874	0.080	**0.041**	**0.042**	**0.002**	1.000	0.997
	Log	19.03	0.072	0.061	**0.004**	**0.004**	**0.001**	**0.001**	0.402	0.275
A_HF	Avg	3.95	0.078	0.452	0.917	0.420	1.000	**0.003**	1.000	0.622
	Log	14.61	**0.001**	**0.005**	0.405	**0.003**	0.986	**0.001**	0.999	**0.018**

(*Comparison between two groups designated by abbreviations given in Table-I)

As shown in the table, ANOVA reveals a statistically significant difference in HRV parameters in Avg and Log data generated from 8 separate groups. Tukey's HSD analysis reveals a fine difference, which shows a truly significant difference between any two groups. Significantly differing values are marked with the word "bold." Gender stratification reveals no significant difference in Avg data from control subjects in various age groups, however Log data reveals a significant difference in 3 out of 16 comparisons. Similarly, for Avg and Log data, age stratification demonstrates a significant difference in 3 and 8 comparisons (each out of 16). As a result, it can be seen that Log data is more sensitive in detecting major differences than Avg data.

For illness stratification, the control and hypertension groups are compared for gender and age. Control-malelower (CML), for example, has been compared to hypertensivemalelower (HML), and so on. A significant difference is observed in 8 and 16 comparisons (each out of 32) in Avg and Log data, indicating that Log data is more sensitive. In Avg data, excluding age and gender sensitive parameters, a significant difference (highlighted in italics and bold) is seen in A VLF for CFH HFH; Amp LF for CFL HFL; and A HF for CFL HFL. Similarly substantial differences (highlighted in italics and bold) are detected in Amp LF for three (out of four) comparisons; and A LF for CFH HFH in Log data.

DISCUSSION

Gender stratification reveals no significant difference in Avg data from control subjects in various age groups; however, Log data reveals a significant difference in 3 of 16 comparisons. Similarly, for Avg and Log data, age stratification demonstrates a significant difference in 3 and 8 comparisons (each out of 16). As a result, Log data looks to be more sensitive than Avg data. This is most likely owing to the Log data's substantially lower coefficient of variance (12.04 percent in contrast to 82.6 percent for TP). Gender stratification differs significantly across all three comparisons, implying that gender stratification may be eliminated with little danger of error (9.4 percent). However, when the danger of inaccuracy increases, age segregation must be maintained (34.4 percent).

Maintaining age and gender stratification, comparison of data in hypertensive subjects with that of respective control subjects shows a significant difference in 8 and 16 comparisons (each out of 32) in Avg and Log data, suggesting higher sensitivity of Log data for the reason specified for control data. As a result, further debate will be confined to Log data only. Age

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and gender sensitive factors (TP, RR mean, Amp VLF, A VLF, Amp HF, and A HF) must be excluded from these comparisons because they do not change as a result of hypertension [22].As a result, the substantial difference in Amp LF for lower age group male/female hypertensives and Amp LF as well as A LF for higher age group female hypertensives appears to be hypertension-specific. However, no parameter is unique to older male hypertensives. It is possible that this is due to the fact that senile alterations in older males are similar to hypertension. Because female hypertensives in the higher age group have two specific factors, namely Amp LF and A LF, whereas male hypertensives in the higher age group do not have a specific parameter, it appears that gender stratification cannot be avoided.
Previous research [8, 9, 10] has linked hypertension to an increase in the LF component and a decrease in the HF component. In the current investigation, the LF component is found to be altered in either amplitude or area. As a result, this investigation confirms earlier findings. Thus, this study suggests that an increase in LF amplitude or/and area is specific for hypertension and can be used to detect hypertension early.

CONCLUSION

The study shows that log data provides better discrimination in variability factors than raw or average data. The amplitude or strength of the LF component in the HRV spectrum has been found to be specifically related to untreated hypertension in young males and young and old females, and hence can be utilised to detect hypertension in these groups.

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