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NONLINEAR ANALYSIS OF HEART RATE VARIABILITY USING POINCARE PLOT METHOD AMONG YOUNG PREHYPERTENSIVES

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Abstract

Background: It's well established that individuals with prehypertension are at risk of hypertension and cardiovascular diseases, and yet proficient interventions are lagging behind in India. Heart rate variability analysis is widely used as a potential tool for assessing the autonomic status.

The traditional methods lack specificity and due to non stationarity of the analyzed signal, non linear analysis method is being used in this study. We selected Poincare method for analysis.

Aim: The aim of the present study is to analyze the cardiovascular autonomic status of prehypertensive individuals using Poincare lot method of HRV.

Methodology: The work was the part of the health check up programme organized during orientation period by Sri Manakula Vinayagar Medical College and Hospital for all 150 students of age group 18-25 years, joining first year MBBS course, 2014.

Basic anthropometric measurements and resting cardiovascular parameters were measured. Blood pressure was measured three times with 5 min interval to screen the prehypertensives. HRV was recorded in supine posture in terms of Poincare plot analysis.

Results: Of the 150 subjects, 135 (80 females and 55 males) satisfied the inclusion criteria and were selected for the study. The prevalence rate of prehypertension in females was 37.5% and in males it was 68.2%. SD1 and SD2 descriptors reported a significant decrease among prehypertensives of both sexes with p value in females equal to 0.056 and 0.048

respectively and males 0.0001 and 0.001 respectively. Also SD1 and SD2 showed negative correlation with all BP parameters.

Conclusion: Poincare plot can be used independently as a prognostic tool for the assessment of the extent of autonomic dysfunction in prehypertensives.

Introduction

Hypertension, being a major risk factor for cardiovascular diseases (CVDs), is a significant issue of medical and public health. In India it accounts for nearly 10.8% of all deaths [1]. Effective management strategies are though being practiced in clinical set up but imperative measures on prevention are still lacking in India. Prehypertension (preHTN) defined as systolic blood pressure [SBP] 120–139 mmHg and/or diastolic blood pressure [DBP] 80–89 mmHg [2], is also associated with increased cardiovascular risk factors [3]. Sympathovagal imbalance is documented as the possible mechanism for the development of prehypertension [4].

Autonomic nervous system (ANS) is accountable for maintenance of normal blood pressure and Heart Rate Variability (HRV) is accepted as the most sensitive and non invasive marker for assessing the two limbs of ANS. Traditionally used linear statistical measures (time and frequency domain) assume that the analyzed segments of R-R interval series are stationary or the variations are harmonic or sinusoidal in nature and in some cases these methods are insensitive and are highly susceptible to interference by ectopic rhythm.

Evidence exists stating that the cardiovascular regulation occurs in a non-linear fashion [5]. Considering the above fact, the non linear methods of HRV are recently being widely used as potential tools for gaining insight into autonomic control over the cardiovascular system. One of the non linear methods is the Poincaré plot method, named after Henri Poincaré which is a popular geometric, qualitative visualization tool for dynamic systems due to its instinctive display of the dynamic properties on a time series. A typical Poincaré plot is a representation of a time series on a cartesian plane, constructed as a relationship between RRi (x-axis) and RRi+1 (y-axis), which means that each point in the plot corresponds to two consecutive RR intervals [6]. Tulppo et. al. [7] fitted an ellipse to the shape of the Poincaré plot and defined two standard descriptors of the plot SD1 and SD2; the minor axis (width) and the major axis (length) of the ellipse respectively. The line of identity (LOI) is the 45° imaginary diagonal line on the Poincaré plot. SD1 measures the dispersion of points along the line perpendicular to the LOI, depicts short-term HRV and is considered as an indicator of parasympathetic activity whereas SD2 assesses dispersion of points along the LOI, portrays both long and short-term

HRV and represents overall variability. Their ratio (SD1/SD2) shows the ratio between short and long variations of RR intervals [8]. A search of the pertinent literature for the drafting of the present study revealed that extensive studies show cardiac autonomic dysfunction among hypertensives and prehypertensives using HRV analyzed using time and frequency domain measures but, till date no study has reported non linear analysis of HRV using poincare plot among young prehypertensives in India.

Materials and Methods

The study was conducted after obtaining clearance from the Human ethical committee. The work was the part of the health check up programme organized during orientation period by Sri Manakula Vinayagar Medical College and Hospital for all 150 students of age group 18-25 years, joining first year MBBS course, 2014. All the study participants gave written informed consent prior to participation. Subjects with systolic blood pressure >140 mmHg, Diastolic blood pressure > 90 mmHg, subjects with ongoing medical illness or any drug treatment were excluded from the study.

Study protocol

Students were requested to report to the neurophysiology lab and relax for 15min. A detailed review of medical history through structured questionnaire and physical examination were performed. All baseline characteristics and related anthropometrics including height, weight and body mass index (BMI) were acquired from the study participants. Blood pressure was measured in the right arm in the sitting position using a standard mercury sphygmomanometer. Three measurements were taken at 5 minutes interval and the mean of three measurements was considered for analysis. Based on the blood pressure measurements, according to Seventh Report of the Joint National Committee (JNC) on Prevention, Detection, Evaluation and Treatment of High Blood Pressure (JNC-7) [9], the study participants of both sexes were divided into two groups as normotensives and prehypertensives.

Normotensives -Systolic BP <120mmHg, Diastolic BP < 80mmHg

Prehypertensives- Systolic BP: 120 -139 mmHg and / or Diastolic BP 80-89 mmHg

HRV analysis

The recommendations of Task Force on HRV were followed [10]. The temperature of the recording room was kept at 25 to 28°C and lights were subdued. HRV recoding was done after 2 hrs of light breakfast between 9:30am to 11:30am. After supine instrumentation, lead II electrocardiography (ECG) was recorded continuously for 10 min using data acquisition

RMS polyrite D hardware version 1.0, India, with sampling rate of 200Hz/sec and normal breath rate of 12-18 breaths/min.

An RR series was extracted from ECG using maximum amplitude & sharpness of the peaks for R wave detection, these are RMS validated proprietary.

After exclusion of artifacts and ectopic beats a stationary 256s RR series was chosen and analyzed with Finland version 1.1 software for HRV (Bio-signal analysis Group, Finland).

Statistical analysis

The data was entered on Microsoft Excel spreadsheet and mean ± standard deviation were calculated. All calculations were accomplished by SPSS 22 and Graph pad Instat softwares. Statistical analysis of data was done by Student's unpaired t test. A p value less than 0.05 was considered statistically significant. The relation between various parameters was assessed by Pearson correlation analysis.

Results

Of the 150 students, 135 subjects (80 females and 55 males) satisfied the inclusion criteria and were selected for the study. Of the 80 females, 50 were normotensives and 30 prehypertensives. Among the 55 male subjects, 21 were normotensives and 34 prehypertensives. The baseline characteristics of normotensives and prehypertensives are recorded in table I.

	FEMALES (n=80)		**p value**	**MALES (n=55)**		**p value**
	Normotensives (n=50)	PreHTN (n=30)		Normotensives (n=21)	PreHTN (n=34)	
Age(years)	18.1±0.42	18.07±0.37	0.75	18.05±0.22	18.38±1.04	0.16
Height(cms)	158.32±7.02	158.43±6.56	0.95	171.76±8.64	172.08±6.89	0.88
Weight(kgs)	56.28±10.18	67.76±14.85	0.0001	68.71±11.06	88.72±23.31	0.0006
BMI(Kg/m^2)	22.38±3.29	26.86±5.06	<0.0001	22.99±3.04	29.5±6.07	<0.0001
HR(bpm)	76.26±6.48	89.47±17.75	0.0001	76±6.83	89.29±8.13	0.0001
SBP(mmHg)	108.86±6.06	127.6±7.02	0.0001	110.48±5.97	130.29±6.57	0.0001

DBP(mmHg)	66.54±5.58	80.16±6.74	0.0001	67.62±9.58	73.32±8.64	0.02
MAP(mmHg)	80.64±5.13	95.98±6.40	0.0001	81.90±7.33	92.31±6.98	0.0001
PP (mmHg)	42.32±5.47	47.43±5.10	0.0001	42.86±9.34	56.97±8.31	0.0001
RPP bpm*mmHg	83.26±10.54	114.82±26.4	0.0001	84.05±9.47	116.63±14.88	0.0001
SD1(ms)	40.31±16.47	30.35±12.58	0.056	59±19.38	39.02±15.65	0.0001
SD2(ms)	69.97±18.06	58.07±17.19	0.048	90.86±20.9	73.76±16.99	0.001

The subject of both sexes and groups were age matched (females: p=0.75; males: p=0.16). BMI varied significantly between the two groups of both sexes (p<0.0001). All blood pressure parameters, SBP, DBP, MAP, PP and RPP varied significantly between the normotensives and prehypertensives of both sexes with p value 0.0001.

SD1 and SD2 reported a significant decrease among prehypertensives of both sexes with p value in females equal to 0.056 and 0.048 respectively and males 0.0001 and 0.001 respectively.

Table II represents correlation between various blood pressure parameters with SD1 and SD2. All BP parameters were reported to be negatively correlated with SD1 and SD2.

	HR	SBP	DBP	MAP	PP	RPP
SD1	-0.24 (0.004)*	-0.32 (0.0001)*	-0.27 (0.001)*	-0.31* (0.0002)*	-0.15 (0.09)	-0.3 (0.0004)*
SD2	-0.09 (0.28)	-0.17 (0.04)*	-0.09 (0.28)	-0.14 (0.11)	-0.13 (0.1)	-0.14 (0.1)

All data are expressed as Pearson's correlation coefficient, as appropriate. *P≤0.05. Numbers in parenthesis represents p value

Discussion

In our study we observed that the prevalence of prehypertension is greater among males than females, 61.82% and 37.5% respectively. Similar results are also reported by other studies [11, 12] indicating that males are more prone to develop prehypertension at early age compared to females.

The major finding of our study is that, the prehypertensives report to have increased sympathetic and reduced parasympathetic activity, which is in concurrence with previous studies [13,14], where analysis was done by time and frequency domain. It has been shown that during escalated sympathovagal activation the heart rate behavior becomes

extremely unstable. In that case heart rate dynamics can be better identified by non linear analysis, than by traditional analysis techniques of HRV [15].The traditional methods require stationarity of the analyzed signal which is not so. Moreover, the Poincaré plot index SD1 is less affected by changing breathing rate [16]. The interfering factor by respiratory sinus arrhythmia (RSA) [17], premature beats, compensatory pauses, or even technical artifacts can be easily identified and removed in the plots. Also, it is well proven that SD1 shows perfect correlation with RMSSD, HF and baroreflex sensitivity; and SD2 is correlated to total HRV and twice as much correlated to LF than HF thus inferring that SD1 describes about parasympathetic tone and SD2 reflects about sympathetic tone [18].

The autonomic nervous system plays a crucial role in body homeostasis, with sympathetic and parasympathetic being its limbs of control mechanisms. They are not "opposites"; rather, the interactions are very complex [19]. Sympathetic activation can inhibit parasympathetic activation presynaptically and vice versa. In a normal heart, parasympathetic muscarinic receptor activation plays a cardioprotective role by counterbalancing the excess adrenergic activation [20], implying that vagal tone dominates during rest.

The study reported that SD1 and SD2 significantly decreased among the prehypertensives of both sexes. Decrease in SD1 indicates decreased vagal tone and decrease in SD2 represents increased sympathetic activity in prehypertensives of both sexes, with males showing a more noteworthy decrease. Thus, the major underlying mechanism of prehypertension is vagal withdrawal and sympathetic augmentation.

Resting HR is considered as an index of cardiac autonomic function and predictor of CVDs and mortality [21]. In our study resting HR showed as significant escalation among the prehypertensives compared to normotensives and proved to have significant negative correlation with SD1. This directly implies that prehypertensives have prominently increased sympathetic tone compared to their counterparts. A summary of data on resting heart rate and cardiovascular disease indicates a pessimistic relationship between increased heart rate and adverse outcomes [22].

RPP was calculated as SBP * HR * 10^{-2}, and it is considered as an index of myocardial oxygen consumption and load on the heart [19]. RPP reported a significant increase among prehypertensives of both sexes and showed significant negative correlation with SD1 descriptor. Higher RPP at rest indicates that prehypertensives have higher myocardial oxygen consumption at rest. Lesser RPP represents increased parasympathetic tone that is cardioprotective but in prehypertensives increased RPP reflects decreased vagal tone as SD1 decreases.

Pulse pressure (PP=SBP-DBP), increase is found to be associated with high cardiovascular risk [23] and a marker for preclinical vascular disease [24]. It is a function of increased systolic ejection to distend conduit arteries to accommodate the ejected blood. In our study PP was significantly elevated among the prehypertensives that may be attributed due to either elevated contractility or diminished vascular compliance.

Also in our study all blood pressure parameters show negative correlation with SD1 and SD2 descriptors and in specific systolic blood pressure showed significant negative correlation with both descriptors.

Prehypertension is a precursor of clinical hypertension and studies reveal that prehypertensives report to have comparatively more circulating soluble adhesion molecules which are the markers of endothelial dysfunction than the normotensives [24] indicating that prehypertensives are at higher cardiovascular risk and require early intervention and life style modifications.

The study stands distinctive from other researches on preypertensives as this is the first study that reports about the sympathovagal balance assessed by Poincare plot in prehypertensive individuals taking gender segregation also in account.

Conclusion

Hereby, we promulgate that HRV analysis by Poincaré plot is an easy visual and discernible tool to detect the early autonomic changes making it a potential prognostic and diagnostic marker for the assessment of cardiovascular autonomic status.

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