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RESEARCH ARTICLE

A comparative study on vagal activity in normotensive, pre-hypertensive, and hypertensive individuals

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ABSTRACT

Background: Hypertension is the most common non-communicable disease which on a long term can lead to coronary artery disease and stroke. Pre-hypertension is one step toward hypertension. Pre-hypertension if detected at an earlier stage and intervened, the risk of hypertension and consequently the cardiovascular risk of the individual can be reduced. Vagal tone is an indirect measure of the baroreflex arc integrity. The present study was done to evaluate the vagal (parasympathetic) activity in normotensive (NT), pre-hypertensive (PT), and hypertensive (HT) individuals. **Aims and objectives:** The aims of this study were to compare the differences in vagal activity in NT, PT, and HT individuals. **Materials and Methods:** The following parasympathetic function tests were performed on 30 NT, 30 PT, and 30 HT subjects: (1) Heart rate (HR) response to standing, (2) HR response to deep breathing, and (3) Valsalva maneuver. **Results:** Our findings showed that there is a severely impaired parasympathetic activity in HTs and a mildly impaired parasympathetic activity in PTs. **Conclusion:** In PTs, non-pharmacological measures like deep breathing exercises and yoga might improve the vagal tone and help in the prevention of hypertension and its complications in future.

KEY WORDS: Hypertension; Prehypertension; Vagal Activity; Parasympathetic Activity

INTRODUCTION

Hypertension is a major non-communicable disease prevalent worldwide.[1] Hypertension is a multifactorial causative disease with heredity playing a prominent role. The other risk factors include obesity, physical inactivity, excess salt intake, smoking, and alcoholism. Hypertension is also said to be a "silent killer" disease as it does not produce any clinical symptoms at the earlier stage but may lead to various long-term diseases and complications if left untreated.[2,3] The most important blood pressure (BP) reflex mechanism is the baroreflex mechanism as it controls the BP within seconds and is the most relevant reflex in autonomic function testing (AFT).[4] The heart rate (HR) is generally a function of the vagal tone.[5] Thus, modulation of vagus nerve activity through the baroreflex mechanism allows changes in the HR subsequently causing a change in the BP.[4] Scientific studies have shown that hypertension is forewarned by the alteration in the autonomic reactivity even when the BP values of these people were found to be in the high normal range. Therefore, these people who are called pre-hypertensives (PTs) can easily develop hypertension than the normotensives (NTs). Thus, if this group is promptly diagnosed and intervened, there are high chances for preventing the onset of hypertension disease and, hence, the cardiovascular risk.[6] AFT is a simple, non-invasive quantitative test to find out the patients with altered autonomic function states.[7] Thus, the present study was done to evaluate the vagal (parasympathetic) activity differences between NTs, PTs, and hypertensives (HTs).

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Aims and Objectives

The aims of this study were to compare differences in vagal activity in NT, PT, and HT subjects.

MATERIALS AND METHODS

Institutional Ethical Committee clearance was obtained and 90 subjects (30 in each group) in the age group of 25–55 years were recruited. Group I - NTs with BP of 100–119/60–79 mmHg; Group II - PTs with BP of 120–139/80–89 mmHg; and Group III - Stage-I HTs with BP of 140–159/90–99 mmHg.[1] Patients on any anti-HT drugs, obese subjects, smokers, and diabetics were excluded from the study. The following parasympathetic function tests were performed with the PHYSIOPAC-PP4 instrument.[7]

Orthostatic Test

Five minutes of supine rest was given. Then, the subject attained a standing posture immediately. ECG recording was done throughout the procedure. 30:15 ratio was calculated from ECG. The longest R-R interval at 30th beat divided by the shortest R-R interval at 15th beat gives the 30:15 ratio.[7]

Deep Breathing Test

The patient was instructed to have deep breaths during the procedure and ECG recording was done. For 6 cycles per minute, the inspiration was done for 5 s and expiration for 5 s. The longest divided by the shortest R-R interval gives the E:I ratio. Deep breathing difference (DBD) is the difference of maximum and minimum HR during 1 min of deep breathing.[7]

Valsalva Maneuver

The patient was instructed to blow out into the mouthpiece attached to the sphygmomanometer to sustain an expiratory pressure at 40 mmHg for a duration of 15 s. ECG was recorded during the rest period, during the maneuver and for 30 seconds following the release of the respiratory strain. Valsalva ratio (VR) is calculated as the longest R-R interval divided by the shortest R-R interval during this whole ECG recording.[7]

Comparison of values between the groups was done by one-way ANOVA. *Post hoc* Tukey test was done to compare the values within the groups.

RESULTS

NT group: 30 NTs with an average systolic BP 108.9 ± 5.84 mmHg and diastolic BP 70.4 ± 4.28 mmHg; PT group: 30 PTs with an average systolic BP 128.5 ± 4.47 mmHg and diastolic BP 84.27 ± 2.55 mmHg; HT group: 30 HTs with an average systolic BP 147.3 ± 4.25 mmHg and diastolic BP 94.6 ± 2.83 mmHg.

Basal HR, 30:15 ratio, E:I ratio, DBD, and VR showed a significant (P = 0.0001) difference in all the three groups [Table 1]. 30:15 ratio, E:I ratio, DBD, and VR were more reduced (P = 0.0001) in HTs than in PTs group [Table 2].

DISCUSSION

Basal HR

Basal HR was significantly increased in PTs and HTs when compared to NTs. Basal HR is a better indicator of vagal activity.[4] Similar results of increased basal HR were shown by Dogru MT *et al*. thus suggestive of a reduced parasympathetic activity occurring in PTs and HTs.[6]

Orthostatic Test (30:15 ratio)

30:15 ratio was significantly reduced in PTs and HTs when compared to NTs. In HT group, 30:15 ratio was more reduced than in the PT group.

30:15 ratio value of ≥ 1.04 is considered as normal, 1–1.03 is considered as borderline, and ≤ 1.0 is considered as abnormal. Abnormal 30:15 ratio indicates severe impairment of parasympathetic function and a borderline 30:15 ratio indicates mild impairment of parasympathetic function.[7,8] 30:15 ratio in the HT group was in

Table 1: Comparison of basal HR, 30:15 ratio, E: I ratio, DBD, and VR between NT, PT, and HT subjects

Parameters	NT	PT	HT	*P*-value
Basal HR (beats/min)	69.6±4.51	75.7±4.61	77.67±4.71	0.0001*
30:15 ratio	1.31±0.1	1.02±0.03	0.89±0.08	0.0001*
E: I ratio	1.4±0.11	1.06±0.03	0.88±0.08	0.0001*
DBD	18.67±3.94	11.77±1.99	7.53±1.97	0.0001*
VR	1.63±0.11	1.31±0.08	1.1±0.07	0.0001*

One-way ANOVA used, *P<0.05-significant. NT: Normotensive, DBD: Deep breathing difference, VR: Valsalva ratio, PT: Pre-hypertensive, HR: Heart rate, HT: Hypertensive

Table 2: Comparison of basal HR, 30:15 ratio, E: I ratio, DBD, and VR within groups

Parameters	NT versus PT (*P*-value)	NT versus HT (*P*-value)	PT versus HT (*P*-value)
Basal HR	0.0001*	0.0001*	0.952
30:15 ratio	0.0001*	0.0001*	0.0001*
E: I ratio	0.0001*	0.0001*	0.0001*
DBD	0.0001*	0.0001*	0.0001*
VR	0.0001*	0.0001*	0.0001*

Post hoc Tukey test used; *P<0.05-significant. HR: Heart rate, HT: Hypertensive

correspondence to the abnormal values, thus suggesting a severe impairment of parasympathetic function in HTs. Similar results were shown by Rolinda *et al*. and Prakash *et al*.,[9,10] borderline 30:15 ratio was seen in the PT group. The studies done by Pal *et al*. also showed similar results in PTs thus suggesting a mild parasympathetic impairment.[11]

Deep Breathing Test (E:IRratio)

PTs and HTs had a significant fall in E:I ratio when compared to NTs. HTs showed a significant reduction in E:I ratio than in the PT group.

E:I ratio of ≥ 1.09 is considered as normal, 1-1.09 is considered as borderline, and ≤ 1.0 is considered as abnormal.[5,12] Abnormal E:I ratio was seen in HT group which is indicative of a severely impaired parasympathetic activity. This was confirmed by the studies of Rolinda R *et al*. and Prakash *et al*.[9,10] The E:I ratio in PT group showed a borderline value. Pal GK *et al*. observed the similar results in PTs and explained that vagal dysfunction is the cause of prehypertension.[11] Similarly, DBD was also more reduced in HTs suggesting a severely reduced parasympathetic activity and mildly reduced in PTs indicating a mildly reduced parasympathetic activity.[7,12]

Valsalva Maneuver (VR)

VR was significantly more reduced in HTs when compared to PTs and NTs. There was also a significant reduction in VR in PTs compared to NTs.

VR of ≥1.40 is considered as normal, 1.20–1.40 is considered as borderline, and ≤1.20 is considered as abnormal.[7,12] HTs showed an abnormal VR which was confirmed by the studies of Pandurang Narhare *et al*. and Lata Patil *et al*. thus indicating a severely impaired parasympathetic activity.[13,14] PTs showed a borderline VR. Nalina N *et al*. showed the similar result in children with family history of hypertension.[15]

All our findings on HTs showed that there is a severely impaired parasympathetic activity and on PTs showed that there is a mildly impaired parasympathetic activity. The decreased parasympathetic activity occurring in both pre-hypertension and hypertension is generally difficult to explain. There is an established negative correlation between aortic stiffness and parasympathetic function.[16] The decreased parasympathetic function could be due to abnormality of baroreceptor resulting from carotid artery stiffness or prolonged baroreflex latency.[9] The impaired endothelium causing an arterial dilation might change the baroreflex capacity.[17] Thus, the role of impaired parasympathetic activity is supposed to be a major cause in the pathogenesis of prehypertension and hypertension.[18]

Limitations

1. Follow-up was not done for the study population.
2. Psychological stress of the individual would have been a confounding factor which could not be eliminated in our study.

CONCLUSION

With the knowledge gained by our study, we suggest that it is essential to improve the vagal tone both in PTs and HTs by yoga and meditation to prevent hypertension as well as to reduce the cardiovascular risk.

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