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Original Research Article

To Study the Effect of One Minute Controlled Deep Breathing on HRV among Newly Diagnosed Hypertensives

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Abstract

Aim: The aim of the present study was to study the effect of one minute controlled deep breathing on HRV among newly diagnosed hypertensives.

Methods: This was a cross-sectional Study conducted in the Department of Physiology, J.N.K.T. Medical College, Madhepura, Bihar, India for one year. The study consisted of two groups: 50 Newly diagnosed hypertensive patients, between the age group of 35-50 yrs, of both genders as cases and 50 age and gender matched normal healthy individuals as Controls.

Results: The mean values of all the time domain parameters were found to be significantly reduced in hypertensives when compared with the controls. The mean of HRV parameters between controls and in cases before & after 1 minute controlled deep breathing showed statistically significance. In frequency domain analysis LF/HF was significantly increased in hypertension subjects. A significant increase ($p<0.05$)in time domain parameters was seen in hypertensive subjects after one minute controlled deep breathing. The LF/HF was also reduced following controlled deep breathing.

Conclusion: Our study has shown a significant reduction of HRV in Newly Diagnosed Hypertensives compared with controls which is highly suggestive of cardiovascular autonomic impairment. HRV parameters showed a significant improvement after controlled breathing in hypertensives. Hence HRV may be used as a tool in addition to the blood pressure measurement to assess the underlying autonomic disturbances in newly diagnosed hypertensive individuals.

Keywords: Hypertension, Heart Rate Variability, Controlled Deep Breathing, Autonomic dysfunction

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Introduction

Urbanisation, changing lifestyles, and competitive streaks in all spheres of life have made anxiety, stress, depression, and resultant psychosomatic illnesses an inevitable part of human life. Stress and autonomic dysfunction are the common risk factors for future cardiovascular disease (CVD) and also negatively impact cognitive functions, which are often overlooked. [1] HRV is an index of the autonomic balance of an individual defined as oscillations between consecutive heartbeats, and it is considered a physiological phenomenon. [2] Heart rate variability (HRV) is a non-invasive physiologic measure of autonomic function that facilitates the identification of people at the risk of developing cardiovascular complications. [3] Dysfunctional regulation of the hypothalamic-pituitary-adrenal (HPA) axis has been identified as an important biological mechanism underlying stress-related diseases. [4]

Heart rate increases during inhalation and decreases during exhalation in a respiratory cycle and this phenomenon is called respiratory sinus arrhythmia (RSA). [5] Heart rate variability biofeedback (HRVBFB) or resonance breathing is breathing at a slow rate, usually 4.5 to 7 breaths per minute, which depends on each individual, to maximise their RSA. [6] Self-training in resonance breathing lowers stress, blood pressure, and improves mood. [7] Training on resonance breathing improves vagal tone, thereby improving HRV, which is an index of stress and health. [8]] Enhanced vagal tone improves cognitive abilities based on the neuro-visceral integration model. [9] Self training in resonance breathing, mindfulness meditation, and aerobic exercise for five weeks has been shown to improve cognitive functions such as attention control and executive function in young adults. [10]

Cardiac innervation by the parasympathetic nervous system (PNS) and the sympathetic nervous system (SNS) acts by modulating the heart rate (HR) (chronotropic activity) and the contraction of the cardiac muscle (inotropic activity). The peripheral vasculature, in turn, is controlled only by the SNS, which is responsible for peripheral vascular resistance. The SNS also mediates the baroreceptor reflex (BR), which mediates blood pressure (BP). Cardiovascular autonomous dysfunction consists of an imbalance between sympathetic and parasympathetic activity with increased peripheral sympathetic activity and reduced vagal (parasympathetic) tone, and it constitutes an important drive shift of the autonomous function in primary hypertension. [11-14] Thus, surrogate markers of autonomic regulation investigation, such as HRV, may be useful in the follow-up and evolution of hypertensive syndromes. There are many methods that allow both direct and indirect assessment of the ANS function. An indirect method, relatively easily accessible, is evaluation of heart rate variability (HRV) in ambulatory electrocardiography. It has been postulated that a noninvasive assessment of ANS activity, e.g., via analyzing heart rate variability (HRV), may be useful in identifying patients at risk of developing MetS in the future. [15]

The aim of the present study was to assess the cardiovascular autonomic function in newly diagnosed hypertensive individuals using HRV as a tool and to study the effect of one minute controlled deep breathing on HRV among newly diagnosed hypertensives.

Materials and Methods

This was a cross-sectional Study conducted in the Department of Physiology, J.N.K.T. Medical College, Madhepura, Bihar, India for one year . The study consisted of two groups: 50 Newly diagnosed hypertensive patients, between the age group of 35-50 yrs, of both genders as cases and 50 age and gender matched normal healthy individuals as Controls.

The Patients with hypertension on medications, and those with symptoms of acute target organ damage viz angina, dyspnoea, orthopnoea or with evidence of co-morbid cardiovascular disease (Myocardial infarction, Symptomatic heart failure) were excluded from the study. Subjects with history of Diabetes Mellitus, COPD, renal failure, cerebrovascular disease were also excluded. All the participants gave their written & informed consent for the study. The tests were performed in the AFT lab of the Department of Physiology, J.N.K.T medical College, Madhepura Bihar, between 10 AM and 1 PM. The lab environment was quiet, the temperature was maintained between 25 to 28˚C and the lighting subdued. Subjects were asked to empty their bladder before the tests.

All the subjects underwent detailed clinical examination. Anthropometric measurements height and weight were recorded. Subjects were seated quietly for at least 5 minutes in a chair, with feet on the floor, and arm supported at heart level BLOOD PRESSURE was recorded using JNC 7 standard protocol. HRV

The recommendations of the Task Force 1996 were followed for HRV. ECG was acquired using RMS Polyrite D Hardware 2.2(India) An RR series was extracted from ECG using maximum amplitude and sharpness for the peaks for R wave detection, these are RMS proprietary algorithms and validated with Fluke biomedical, USA. After exclusion of artifacts and ectopics a stationary 256s RR series was chosen and analyzed using RMS 2.5.2 software on a window based PC. Respiratory movements were recorded using respiratory belt which analyses inspiration and expiration. Time domain analysis was used for long term HRV changes and frequency analysis was used for short term HRV changes.

In our study, ECG was first recorded for 5 minutes with the eyes closed and with normal quiet respiratory movement for both case and control group to determine the HRV at supine rest. The case group was then instructed to breathe slowly and deeply at the rate of 6 breaths per minute in such a way that they take 5 seconds for inspiration and 5 seconds for expiration and ECG was recorded to determine HRV on one minute Controlled deep breathing.

The data collected were statistically analyzed using SPSS-21.0 version. Independent T test was used to compare between cases (newly diagnosed HTN) and controls (healthy individuals). ANOVA test was used to compare between three groups followed by POST HOC TUKEY test. P value <0.05 was considered as statistically significant.

Results

Table 1: Comparison of general parameters between controls & cases

	Controls	Cases	p-value
	Mean ± SD	**Mean ± SD**	
Age in Yrs	45.05 ± 5.48	44.08 ± 5.55	1.00
Ht cm	162.88 ± 6.84	164.76 ± 6.74	0.98
Wt kg	65.15 ± 10.30	64.96 ± 10.98	0.94
BMI kg/m^2	24.06 ± 4.56	23.77 ± 3.67	0.89
RHR beats/min	66.44 ± 8.6	76.00 ± 11.39	< 0.01

SBP mmHg	114.00 ± 18.02	144.00 ±16.76	< 0.01
DBP mmHg	76.84 ± 9.44	98.52 ± 10.02	< 0.01

The mean valuesof all the time domain parameters were found to be significantly reduced in hypertensives when compared with the controls.

Table 2: Comparison of HRV parameters between controls and in cases before & after 1 minute controlled deep breathing – ANOVA test

HRV parameters	Controls	Cases	Cases – Post Controlled Breathing	P –value
	Mean ± SD	**Mean ± SD**	**Mean ± SD**	
Mean RR sec	0.884 ± 0.10	0.784 ± 0.16	0.842 ± 0.12	<0.01
SDNN ms	48.72 ± 12.24	26.54 ± 16.84	42.72 ± 14.16	<0.001
RMSSD ms	42.18 ± 10.23	16.34 ± 5.55	36.14 ± 12.74	<0.001
pNN50 %	24.54 ± 7.53	6.94 ± 3.77	16.72 ± 8.64	<0.001
LFnu	56.74 ± 14.36	72.14 ± 6.44	66.54 ± 6.00	<0.001
HFnu	45.25 ± 16.24	30.02 ± 6.74	35.45 ± 6.00	<0.001
LF/HF	1.48 ± 0.72	2.58 ± 0.88	1.96 ± 0.57	<0.001

The mean of HRV parameters between controls and in cases before & after 1 minute controlled deep breathing showed statistically significance.

Table 3: Comparison of HRV parameters between control and in cases after controlled breathing – Post Hoc - Tukey test

HRV parameters	Controls	Cases – Post Controlled Breathing	P –value
	Mean ± SD	**Mean ± SD**	
Mean RR sec	0.884 ± 0.10	0.842 ± 0.12	0.16
SDNN ms	48.72 ± 12.24	42.72 ± 14.16	<0.06
RMSSD ms	42.18 ± 10.23	36.14 ± 12.74	<0.05
pNN50 %	24.54 ± 7.53	16.72 ± 8.64	<0.001
LFnu	56.74 ± 14.36	66.54 ± 6.00	<0.01
HFnu	45.25 ± 16.24	35.45 ± 6.00	<0.01
LF/HF	1.48 ± 0.72	1.96 ± 0.57	<0.01

Table 4: Comparison of HRV parameters in cases before and after controlled breathing – Post Hoc - Tukey test

HRV parameters	Controls	Cases – Post Controlled Breathing	P –value
	Mean ± SD	**Mean ± SD**	
Mean RR sec	0.784 ± 0.16	0.842 ± 0.12	0.16
SDNN ms	26.54 ± 16.84	42.72 ± 14.16	<0.06
RMSSD ms	16.34 ± 5.55	36.14 ± 12.74	<0.05
pNN50 %	6.94 ± 3.77	16.72 ± 8.64	<0.001
LFnu	72.14 ± 6.44	66.54 ± 6.00	<0.01
HFnu	30.02 ± 6.74	35.45 ± 6.00	<0.01
LF/HF	2.58 ± 0.88	1.96 ± 0.57	<0.01

In frequency domain analysis LF/HF was significantly increased in hypertension subjects. A significant increase ($p<0.05$) in time domain parameters was seen in hypertensive subjects after one minute controlled deep breathing. The LF/HF was also reduced following controlled deep breathing.

Discussion

Hypertension is defined as a blood pressure of ≥140/90mmHg (JNC criteria 7th Report). [16] Hypertension is an increasingly important medical and public health issue. Increasing age, body mass index, smoking, diabetes, extra salt intake and genetics are common risk factors. Hypertension (HTN) is a modifiable and major risk factor for coronary artery disease, heart failure, cerebrovascular disease and chronic renal failure. Overall prevalence for hypertension in India is 29.8% (95% confidence interval: 26.7–33.0). [17] Hypertension is attributable to 10.8% of all deaths in India. [18] HTN is directly responsible for 57% of all stroke deaths and 24% of all coronary heart disease (CHD) deaths in India. [19] NNMB tribal survey (2008-09) estimated the prevalence of hypertension among men and women was 25% and

23% respectively. [20] The mechanisms involved in regulation of BP are mainly neural, hormonal and renal control. Among them, neural control by ANS is the most important regulatory mechanism of short term regulation of blood pressure. ANS dysfunction is an important factor in the onset and progression of hypertension. [21]

The mean valuesof all the time domain parameters were found to be significantly reduced in hypertensives when compared with the controls. The mean of HRV parameters between controls and in cases before & after 1 minute controlled deep breathing showed statistically significance. In frequency domain analysis LF/HF was significantly increased in hypertension subjects. A significant increase ($p<0.05$) in time domain parameters was seen in hypertensive subjects after one minute controlled deep breathing. The LF/HF was also reduced following controlled deep breathing. The Resting heart rate was increased significantly in the hyperstensive subjects, which might be due to an increase in centrally originating oscillations in sympathetic drive to the heart. This is similar to the findings observed in Singh et al 1998. The SDNN was significantly decreased in the hypertensives ($p < 0.01$). The findings are in accordance with Singh et al 1998 [22]; E.S.Prakash et al 2005. [23] pNN 50 and RMSSD are measures of high frequency variations in HR and are highly correlated. [24]

Respiration has a significant effect on the HR oscillations and parasympathetic activity is very closely related to respiratory sinus rhythm. HRV during timed deep breathing is a major index of HR variation in the time domain because it has been shown to be one of the most reliable and reproducible markers of parasympathetic modulation of cardiac function. [25] The SDNN, RMSSD and pNN50% were significantly increased in the hypertensives after one minute controlled deep breathing ($p <0.001$).This might be due to relative increase in vagal activity and a reduction in sympathetic activity observed during slow breathing. Slow breathing may reduce sympathetic activity by enhancing central inhibitory rhythms. The increase in tidal volume, which compensates for the reduced breathing rate in order to maintain minute ventilation [26] could be responsible for these autonomic changes through a reduction in sympathetic activity. [27] The HFnu showed a significant increase, while LFnu and LF/HF were significantly decreased after one minute controlled deep breathing($p<0.01$).

In one study, it was found that participants with higher HRV showed better performance on cognitive tasks than those with low HRV. [28] A systematic review by Forte et al. has indicated that HRV can be used as an early biomarker of cognitive impairment in a healthy population. [29] It is postulated that better cognitive performance in the intervention group in the study can be recounted to improved HRV following four weeks of resonance breathing training. In the current study, the perceived stress level was found to decrease significantly after four weeks of RF breathing training. Similar to this study, Steffan et al. have proved that RF breathing elevates current mood. [30] In a recently published meta-analysis of 24 studies, it was established that breathing at resonance frequency reduced self-reported stress and anxiety with a large effect size. [31] It was further suggested that it had benefits even for those without clinical levels of anxiety. It has been postulated that increasing vagal activity increases physical and emotional resilience. Hence, improving vagal activity by RF breathing intervention for four weeks may be the possible cause of the improved perceived stress score in the intervention group participants. Further, Mather and Thayer proposed that high-amplitude oscillations in heart rate produced by resonance breathing modulate brain oscillatory activity in brain regions associated with emotion regulation. [32] The improvement in cognition and perceived stress by resonance breathing can further be explained by the Neuro-Visceral Integration Model, rationalised by Thayer et al. [33] This substantiates the functional relationship between the prefrontal cortex and the heart via the central autonomic network (CAN). The CAN includes structures like the anterior cingulate gyrus, ventromedial pre-frontal cortices, the central nucleus of the amygdala, the periaqueductal grey matter, the nucleus tractus solitarus, the nucleus ambiguus, the ventro-lateral/medial medulla, etc., involved in stress-regulation, emotional and cognitive responses.

Conclusion

Our study has shown a significant reduction of HRV in Newly Diagnosed Hypertensives compared with controls which is highly suggestive of cardiovascular autonomic impairment. HRV parameters showed a significant improvement after controlled breathing in hypertensives. Hence HRV may be used as a tool in addition to the blood pressure measurement to assess the underlying autonomic disturbances in newly diagnosed hypertensive individuals. Life style modifications like Yoga, meditation and exercise may improve the parasympathetic component of ANS which in turn will improve HRV and reduce cardiovascular risk.

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