Heart rate variability by Poincaré plot analysis in patients of essential hypertension and 12-week yoga therapy

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ABSTRACT

Background: Hypertension is one of the psychosomatic disorders prevalent throughout the world. It needs not only medical management but also lifestyle modification as it is the major contributing factor in the pathogenesis of the disease. Yoga is one such tool that can be used in the management of hypertension. To measure the effect of yoga, various scientific communities have frequently used heart rate variability by spectral analysis. This study was conducted to evaluate the therapeutic potential of yoga by Poincaré plot analysis of heart rate variability.

Aims and Objective: To study the effect of 12-week yoga therapy on heart rate variability by Poincaré plot analysis in patients with essential hypertension.

Materials and Methods: Patients satisfying the study criteria from the Medicine Outpatient Department of Jawaharlal Institute of Postgraduate Medical Education and Research (JIPMER), Puducherry, India, were included in the study after obtaining a written informed consent. Seventy patients were randomly divided into two groups: control and yoga. Yoga group received supervised yoga training (3 days in a week for 12 weeks) in addition to routine medical care. Resting cardiovascular parameters, heart rate variability by Poincaré plot analysis was recorded at the onset of study and after the 12 weeks intervention period in both the groups. Data were analyzed using the appropriate statistical test. p-Value of <0.05 was considered to be significant.

Results: A significant decrease was observed in blood pressure, mean arterial pressure, and rate pressure product in yoga group at the end of study period. A significant improvement was observed in Poincaré plot analysis in the form of increase in SD1 and SD2 in the yoga group.

Conclusion: Poincaré plot analysis can be used independently to evaluate the effects of yoga in patients with hypertension.

KEY WORDS: Poincaré plot; Hypertension; Yoga; Heart rate variability

INTRODUCTION

Hypertension (HT) is a chronic disorder prevalent throughout the world. It affects almost people of all age group and race.

It is considered as a risk factor for many conditions such as stroke, myocardial infarction, renal failure, and peripheral arterial disease.[1] Based on etiology, HT is classified into primary or essential HT and secondary HT. Death due to HT is estimated to be about 6% worldwide.[1] Studies have shown that HT is the leading cause among risk factors of cardiovascular disease, and it is estimated that about 1.56 billion people will have HT by 2025 all over the world.[2] In India, the prevalence of HT is more among urban population (20%–40%) compared to rural population.[3] As far as cause of disability-adjusted life years is concerned, HT is ranked third and has been identified as leading risk factor for mortality.[4]
Medical management of HT includes various drug regimen. HT needs lifelong use of drugs and in most of the patients high blood pressure (BP) is under-corrected. This can be attributed to the lifestyle of the individuals such as lack of physical exercise and sleep, dietary pattern, smoking, and alcohol. Because some of the risk factors are modifiable, treatment should be aimed at reducing the risk factors to reduce the high BP. The treatment of HT needs not only awareness about the disease and management but also primary prevention in the form of lifestyle modification in general population.

Yoga is practiced in India since ancient times. It is considered as a technique that helps in coordination between mind and body. Many studies have put forth the therapeutic potential of yoga in various diseases such as HT, diabetes mellitus, and coronary arterial disease. Yoga is also found to improve overall performance and working ability. Many existing studies on effect of yoga lack appropriate control groups and have got many selection bias. Well-designed and rigorous controlled studies are essential to elucidate the effects of standardized yoga programs.

Autonomic nervous system is important in the maintenance of normal BP. Studies have shown that autonomic imbalance contributes to the pathogenesis of HT and yoga training is instrumental in restoring sympathovagal balance.

Heart rate variability (HRV) is a commonly used tool to assess the limbs of autonomic nervous system. Many studies are based on HRV by spectral analysis. HRV by Poincaré plot analysis (PPA) is a nonlinear method that helps in recognizing the autonomic control of heart rate (HR). PPA is a quantitative visual technique compared to conventional fast Fourier transform indices.

This study was designed to see the effect of yoga on HRV by PPA in patients with essential HT.

**MATERIALS AND METHODS**

The study was conducted after obtaining clearance of the institute ethical committee.

Patients with HT from Medicine Outpatient Department of Jawaharlal Institute of Postgraduate Medical Education and Research (JIPMER), Puducherry, India, were assessed for eligibility, and 70 patients meeting the study criteria were selected. The patients belonging to the age group 35–55 years were recruited in the study. Patients with secondary HT, diabetes mellitus, coronary arterial disease, and physical conditions hindering performance of yoga were excluded from the study. All the 70 patients were randomly divided into control group (36 patients) and yoga group (34 patients). The randomization technique serially numbered, opaque, sealed envelope (SNOSE) used was. Block randomization was applied to allocation sequence. All tests were carried out in Autonomic Function Testing Laboratory, JIPMER, after obtaining the written informed consent from both the groups. Subjects were asked to avoid smoking, alcohol, and drugs that may interfere with the testing. After supine instrumentation, lead II electrocardiography (ECG) was recorded continuously for 5 min using data acquisition system (MP100; BIOPAC) with AcqKnowledge 3.8.2 software. The RR interval variation trend was analyzed using HRV software (version 1.1; Biomedical Signal Analysis Group, University of Kuopio, Kuopio, Northern Savonia, Finland) for PPA. BP (systolic and diastolic) and HR were recorded at the end of 5-min ECG recording using MX3 (OMRON, USA).
12-Week Intervention
Antihypertensive medication received by the patients of both the group was not interrupted. In addition to the medical treatment, yoga group received yoga therapy from trained yoga therapists under our observation for 3 days in a week. Subjects were encouraged to do the same at home for rest of the weekdays. The yoga therapy module was validated by Advanced Center for Yoga Therapy Education and Research (ACYTER), JIPMER, in accordance with guidelines of the Morarji Desai National Institute of Yoga (MDNIY), New Delhi, India. Attendance register was maintained for yoga sessions, and the subjects whose attendance was at least 70% were included in the data analysis.

Following were the components of the therapy (45 min):
- Yogic counseling
- Preparatory practices (5 min)
- Asans or static postures (15 min; talasan, ardhakati chakrasan, ardha chakrasan, uttanpadasan, ardhahalasan, pavanmuktasan, makrasan, bhujangasan, vajrasan)
- Pranayam (15 min; chandranadi, pranav, nadishodhan)
- Relaxation techniques (10 min; kayakriya in shavasan, shavasan with savitri pranayam)
- Data Analysis

Data Analysis
Data were analyzed using SPSS software, version 22.0. Comparison of pre–post intervention was done using Student’s paired t-test within the group. Student’s unpaired t-test was used to compare the study and control group. p-Value of < 0.05 was considered to be significant.

RESULTS
Cardiovascular Parameters
At the end of 12-week yoga therapy, resting systolic blood pressure (SBP) and diastolic blood pressure (DBP) in yoga group showed a significant decrease. Mean arterial pressure (MAP) did not show a significant change in control group whereas in yoga group a significant (p < 0.001) decrease was observed. Also, a significant decrease (p<0.05) was
**Figure 3** A sample of Poincaré plot with its numerical descriptors SD1 and SD2. The data are consecutive RR intervals from a 5-min resting ECG of patient with hypertension belonging to yoga group before and after the study period.

**Figure 4** Resting cardiovascular parameters of control and yoga groups before and after 12 weeks of study period. Values are expressed as mean ± SD. *, comparison within group; †, comparison between groups. ***p < 0.001, **p < 0.01, †p < 0.05. SBP, systolic blood pressure; DBP, diastolic blood pressure; PP, pulse pressure; MAP, mean arterial pressure.
observed in SBP, DBP, and MAP when comparison was made between control and yoga group at the end of 12-week study period. Rate pressure product (RPP) did not show a significant change in control group but in yoga group, it decreased significantly \( (p < 0.01) \) after 12 weeks of yoga therapy.

Heart Rate Variability by Poincaré Plot Analysis
No significant change was observed in SD1 and SD2 at the end of study period in control group. In yoga group, SD1 did not show a significant change but SD2 showed a significant increase at the end of study period. Also, the values of SD2 showed a significant \( (p < 0.05) \) difference in yoga group as compared to control group at the end of study period.

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<th>Table 1: Poincaré plot analysis in control and yoga groups before and after the 12-week study period</th>
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<td>Parameter</td>
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Values are expressed as mean \( \pm SD \).
\*\( p < 0.05 \) comparison within group, \*\( p < 0.05 \) comparison between yoga and control group.

DISCUSSION

**Cardiovascular Parameters**
According to Knut et al.\[11\], there is increased sympathetic activity in patients with HT. A significant decrease in SBP, DBP, and MAP in yoga group shows that there is decrease in sympathetic activity after yoga therapy. This observation is in concurrence with many studies\[7,8,13–16\].

RPP was calculated as \( \text{SBP} \times \text{HR} \times 10^{-2} \), and it is considered as an index of myocardial oxygen consumption and load on the heart\[17\]. According to Prakash et al.\[18\] there exists an inverse correlation between RPP and total RR spectral power in patients with hypertension, which suggests that RPP can be used as a surrogate of overall HRV. A significant decrease in RPP in yoga group at the end of yoga therapy is a favorable outcome.
Heart Rate Variability by Poincaré Plot Analysis

RR interval PPA is a nonlinear method of HRV. PPA provides both summary and detailed beat-to-beat information on the behavior of HR and it is thought to express autonomic modulation of HR. There are two standard numerical descriptors of PPA, SD1 and SD2. SD1 measures the dispersion of points belonging to the Poincaré plot along the line perpendicular to the line of identity and depicts short-term HRV. SD2 assesses the dispersion of points belonging to the Poincaré plot along the line of identity and portrays both long- and short-term HRV.

According to Stein and Reddy, PPA could show complexity in HR patterns, which could not be picked by standard HRV measures such as standard deviation of all NN intervals (SDNN). However, SDNN is considered as an index of overall HRV according to the recommendations of the Task Force of the European Society of Cardiology. Also, Woo et al. suggested that PPA could be considered as a marker of sympathetic activation and could give prognostic information in patients with heart failure.

An increase in SD1 was noticed although not significant in yoga group (Table 1). Many studies have shown that reduced Poincaré plot indexes (SD1 and SD2) are indicative of reduced HRV. In our study, we observed an increase in SD1 and SD2 in yoga group, although SD1 increased insignificantly; it is clear that 12-week yoga therapy is instrumental in improving HRV in subjects with hypertension. Guzik et al. have shown that SD1 and SD2 are positively correlated to baroreflex sensitivity (BRS) and also a significant negative correlation has been noted between SD2 and SBP, DBP, and cardiac output. Therefore, an increase in SD1 and SD2 is an indicator of improvement in BRS. According to Brennan et al., SD1 and SD2 can be used as surrogate of BRS. Thus, PPA can independently show impaired autonomic modulation in a subject and could be clinically used for risk stratification and can give prognostic information.

Limitations

The intervention period was 12 weeks, which could be extended. Sample size could also be increased.

Conclusion

Yoga therapy can reduce myocardial oxygen consumption and is instrumental in controlling high BP if practiced regularly along with medications. HRV by spectral analysis is most commonly used tool to compare the sympathetic–parasympathetic balance. In our study, we showed that HRV by PPA, which is simple visual technique, can be used to compare the autonomic modulation in patients with essential HT.

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