IMMEDIATE EFFECT OF CHANDRANADI PRANAYAM ON HEART RATE VARIABILITY AND CARDIOVASCULAR PARAMETERS IN PATIENTS OF DIABETES MELLITUS AND HYPERTENSION

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ABSTRACT:

Diabetes mellitus (DM) and hypertension (HT) are widely prevalent psychosomatic lifestyle disorders that often coexist. Chandranadi pranayama (CNP), an exclusive left nostril breathing technique, has been reported to be useful in reducing heart rate (HR) and blood pressure (BP) in normal subjects as well as hypertensives and is part of yoga therapy schedules for patients of HT and DM. This study investigated the immediate effects of 5 minutes of CNP on HR, BP and heart rate variability (HRV) in patients of HT, DM and in those having both (DMHT). Thirty nine participants receiving standard medical care from the department of medicine, JIPMER were recruited. HR, BP and short-term supine HRV were recorded before and after 5 minutes of CNP. Analysis showed significant ($p < 0.05$) fall of HR and BP indices in all three groups with no difference between groups. However in short term HRV analysis, there were differences between the responses of DM and HT patients with regard to mean RR and mean HR. Preexisting intergroup differences with regard to SDNN, RMSSD, HF power and total power were negated after the performance of CNP. Pre-post intra group comparisons showed significant increases in Mean RR and Mean HR in both HT and HTDM groups while there were significant increases in LFnu and LF/HF ratio with significant decrease in HFnu in DM group. The post CNP responses of DM group in Mean RR, SDNN, Mean HR, RMSSD, LF power and total power were contrary to responses in the other groups. This is the first report comparing immediate effects of CNP in patients of HT and DM. The reduction in HR and BP indices in all three groups may be attributed to an overall normalization of autonomic cardiovascular rhythms along with improvement in baroreflex sensitivity irrespective of the disorder. The HRV findings are more complicated but show a trend towards a normalization of the pre existing autonomic differences between groups that is typical of Yoga techniques. HRV changes in DM patients were contrary to HT and DMHT patients in many parameters and this may be due to a greater degree of cardiac autonomic neuropathy in them. Further studies are required to enable better understanding of mechanisms involved as well as to determine how long such effects persist. We recommend the addition of this simple and cost effective technique to regular management protocols of HT and DM.

Key words: chandra nadi pranayama, heart rate variability, diabetes mellitus, hypertension

INTRODUCTION:

Heart rate variability (HRV), the beat-to-beat alterations in heart rate, is a simple noninvasive measurement for investigating autonomic influence on the cardiovascular system. [1] Low HRV and baroreflex sensitivity reflect impaired cardiovagal adaptability and suggest excessive sympathetic and/or insufficient parasympathetic tone that are, in turn, strong independent predictors of cardiovascular morbidity and mortality. [2]

Streeter et al recently proposed a theory to explain the benefits of Yoga practices in diverse, frequently comorbid medical conditions based on the concept that Yoga practices reduce allostatic load in stress response systems such that optimal homeostasis is restored. [3] They hypothesized that stress induces an imbalance of the autonomic nervous system (ANS) with decreased parasympathetic and increased sympathetic activity, under activity of the gamma amino-butyric acid (GABA) system, the primary inhibitory neurotransmitter system, and increased allostatic load. They further hypothesized that Yoga-based practices correct underactivity of the parasympathetic nervous system and GABA systems in part through stimulation of the vagus nerves, the main peripheral pathway of the parasympathetic nervous system, and reduce allostatic load. According to their theory the decreased parasympathetic nervous system and GABAergic activity that underlies stress-related disorders can be corrected by Yoga practices resulting in amelioration of disease symptoms. HRV testing has a great role to play in our understanding intrinsic mechanisms behind such potential effects of Yoga.

Diabetes mellitus (DM) and hypertension (HT) are widely prevalent psychosomatic lifestyle disorders that often coexist and in whom factors such as sedentary habits and physical, emotional and mental stress play a major role. They also probably have synergistic detrimental effects on the cardiovascular system especially with regard to the cardiac autonomic function. Various reviews have suggested that Yogic practices may have a role in prevention and management of diabetes as well as co-morbid conditions like HT and dyslipidemia [2, 4, 5]. It is interesting to note that even a short lifestyle modification and stress management education program based on yoga reduces risk factors for cardiovascular disease and DM within a period of 9 days. [6]

Chandranadi pranayama (CNP), an exclusive left nostril breathing technique, has been reported to be useful in reducing heart rate (HR) and blood pressure (BP) in normal subjects as well as hypertensives and is part of yoga therapy schedules for patients of HT and DM. Potential health benefits of unilateral forced nostril breathing (UFNB) have been postulated and many studies done on normal subjects. [7, 8, 9] Further clinical research is however needed to establish the efficacy of these techniques in various psychosomatic conditions such as HT and DM and we have recently reported beneficial HR and SP reducing effects of CNP in hypertensive patients on regular standard medical management. [10] This was attributed to a normalization of autonomic cardiovascular rhythms with increased vagal modulation and / or decreased sympathetic activity along with improvement in baroreflex sensitivity.

With the above in mind, the present study planned to investigate immediate effects of 5 minutes of CNP on HR, BP and HRV in established patients of HT, DM and in those having both (DMHT).

Table 1: Demographic characteristics of the different study groups of patients of hypertension (HT), diabetes mellitus (DM) and both hypertension and diabetes mellitus (DMHT).

	HT	DM	DMHT
Number	14	12	13
Age	50.14 ± 12.04	41.08 ± 9.73 ƚ	56.15 ± 8.49
Gender	8 M / 6 F	8 M / 4 F	9 M / 4 F
BMI	27.21 ± 3.21	25.00 ± 2.05	26.62 ± 3.66
Respiratory rate during basal recording	18.43 ± 2.68	19.31 ± 5.88	18.00 ± 3.34
Respiratory rate during CNP	8.29 ± 4.10	7.62 ± 4.17	6.62 ± 1.26
Respiratory rate during post CNP recording	18.14 ± 3.46 *	17.77 ± 5.10	16.15 ± 4.04 **
Medications	Amlodipine, Enalopril Atorvastatin and Aspirin	Glimipride, Glibenclamide Metformin, Rosaglitazone Proglitazone, Insulin	Amlodipine, Enalopril Atorvastatin, Glimipride Glibenclamide, Metformin Rosaglitazone, Progiltazone Insulin and Aspirin

ƚ , p = 0.0143 for inter group comparisons of age by ANOVA with * for DM vs DMHT.
* p < 0.05, ** p< 0.01 by paired t test for comparisons between pre and post CNP RR during HRV recordings.

MATERIALS AND METHODS:

This study was conducted at the Advanced Centre for Yoga Therapy Education and Research (ACYTER) that has been established as a collaborative venture between the Morarji Desai National Institute of Yoga, New Delhi and JIPMER, Puducherry with funding from Department of AYUSH in the Ministry of Health and Family Welfare, Government of India. Ethical approval has been obtained by ACYTER from the Institutional Ethics Committee for studies on the effect of yoga therapy on HT and DM. The present study was conducted as a pilot study as part of this larger study.

Thirty nine participants were recruited from those attending regular Yoga therapy sessions at ACYTER, JIPMER by convenience sampling. All were receiving standard medical care for more than 3 years on outpatient in the department of medicine, JIPMER. Demographic characteristics of the participants are given in Table 1.

All tests were carried out in ACYTER Yoga Research laboratory between 9 and 11 am. The environment was quiet, with comfortable temperature and subdued lighting. The subjects were briefed about the study protocol and written informed consent was obtained from them. They were advised to come at least one hour after light breakfast, with empty bowel and bladder, refrain from smoking and alcohol on the day of test and take their morning dosage of antihypertensive agent after the procedure to avoid interference with cardiac autonomic functions.

Anthropometric parameters such as height (cm) and body weight (Kg) were recorded and BMI calculated using Quetlet formula. Height was measured by a wall mounted stadiometer and weight with spring balance avoiding zero and parallax errors. The subjects were then asked to lie in a comfortable supine posture on the couch and relax for 5 minutes.

HR and BP were measured using non-invasive semi-automatic BP monitor (CH – 432, Citizen Systems, Tokyo, Japan) apparatus and short-term supine HRV was recorded using Zephyr™ BioHarness™ USA and analyzed using Kubio software V 2.0 Finland. The following frequency and time domain indices were calculated from the HRV recordings.

Time domain indices:

1. Mean RR in milliseconds (ms).
2. SDNN- standard deviation of normal to normal intervals in ms.
3. Mean heart rate (1/min)

4. RMSSD- root mean square of successive standard deviations in ms.

Frequency domain indices:

1. LF Power (ms^2): Power in low frequency range (0·04–0·15 Hz)
2. HF (ms^2): Power in high frequency range 0·15–0·4 Hz
3. LF norm (nu): LF power in normalised units - LF / (Total Power–VLF)*100
4. HF norm (nu): HF power in normalised units - HF / (Total Power–VLF)*100
5. Total power (ms^2): LF power + HF power
6. LF / HF Ratio: LF [ms^2] / HF [ms^2]

The subjects were then instructed to close their right nostril with their right thumb and use gentle pressure to occlude the right nostril. They then performed the pranayama by breathing in and out though the unblocked left nostril in a calm and regular manner for a total duration of 5 minutes. They were instructed to use a conscious effort to breathe in low, mid and upper parts of their lungs in a sequential manner for both inspiration and expiration. Post test HR and BP measurements were recorded again at the end of the 5 minutes of CNP. Pulse pressure (PP) was calculated as SP-DP, mean pressure (MP) as DP + 1/3 PP, rate-pressure product (RPP) as HR × SP / 100 and double product (Do P) as HR × MP / 100.

Statistical analysis of pre and post intervention data was done using GraphPad InStat version 3.06 for Windows 95, GraphPad Software, San Diego California USA, www.graphpad.com. Wilcoxon matched-pairs signed-ranks test was used for intra group comparisons while inter group comparisons were done using ANOVA with Tukey-Kramer Multiple Comparisons Test for data with identical SDs and Kruskal Wallis with Dunn’s Multiple Comparisons Test for data with non identical SDs. P values less than 0.05 were accepted as indicating significant differences between pre and post test data.

RESULTS:

The results are given in Table 2 and 3. CNP resulted in a significant ($p < 0.05$) fall of HR and BP indices in all three groups of patients with no difference between groups (Table 3). However in short term HRV analysis, there were differences between the responses of DM and HT patients with regard to mean RR and mean HR. Preexisting intergroup differences with regard to SDNN, RMSSD, HF power and total power were negated after the performance of CNP (Table 2). Pre-post intra group comparisons showed significant increases in Mean RR and Mean HR in both HT and DMHT groups while there were significant increases in LFnu and LF/HF ratio with significant decrease in HFnu in DM group. The post CNP responses of DM group in Mean RR, SDNN, Mean HR, RMSSD, LF power and total power were contrary to responses in the other groups.

Table 2: Resting HRV analysis of patients of hypertension (HT), diabetes mellitus (DM) and both hypertension and diabetes mellitus (DMHT) before (B) and after (A) the performance of 5 minutes of chandra nadi pranayama (left uninostril breathing).

	HT (n=14)		DM (n=12)		DMHT (n=13)		ANOVA	
	B	A	B	A	B	A	B	A
Mean RR (ms)	852.21 ± 105.57	880.67 ± 109.86 **	774.24 ± 83.77	769.77 ± 97.48	774.22 ± 134.76	786.83 ± 127.29 *	P = 0.1219	P= 0.0187 with * for D vs HT
SDNN (ms)	30.44 ± 16.33	34.14 ± 15.62	33.16 ± 15.21	29.12 ± 14.70	20.30 ± 10.32	23.31 ± 12.91	P = 0.0224 with * for DM vs DMHT	P = 0.0782
Mean HR (1/min)	71.56 ± 8.68	69.40 ± 8.84**	78.53 ± 7.89	79.24 ± 9.07	79.40 ± 11.23	77.93 ± 10.31 *	P = 0.0724	P = 0.0184 with * for DM vs HT
RMSSD (ms)	35.51 ± 23.92	36.45 ± 18.38	39.16 ± 19.84	29.17 ± 14.50	23.15 ± 12.08	24.35 ± 9.75	p = 0.0087 with ** for DM vs DMHT	P = 0.1145
LF Power (ms ^{2})	407.00 ± 493.854	615.143 ± 638.313	507.33 ± 750.13	475.00 ± 613.00	163.15 ± 170.29	331.85 ± 396.50	P= 0.0675	P= 0.3237
HF Power (ms ^{2})	576.93 ± 1092.44	379.79 ± 580.14	536.83 ± 483.83	372.58 ± 429.20	212.77 ± 339.50	301.85 ± 478.96	P=0.0125 with * for DM vs DMHT	P= 0.4891
LF (n.u)	47.19 ± 23.61	58.03 ± 20.60	45.36 ± 19.46	59.13 ± 21.00*	46.38 ± 15.65	52.39 ± 16.95	P = 0.9731	P = 0.6499
HF (n.u)	52.81 ± 23.61	41.97 ± 20.60	54.64 ± 19.46	40.88 ± 21.00*	53.62 ± 15.65	47.61 ± 16.95	P = 0.9731	P = 0.6499
Total Power (ms ^{2})	984.29 ± 1501.74	994.86 ± 1105.56	1044.0 ± 1143.18	848.00 ± 867.43	376.00 ± 494.36	633.69 ± 774.61	P=0.0115 with * for DM vs DMHT and * for HT vs DMHT	P = 0.2979
LF/HF	1.44 ± 1.44	2.02 ± 1.52	1.03 ± 0.64	2.06 ± 1.42*	1.09 ± 0.92	1.39 ± 0.93	P = 0.9994	P = 0.3614

Values are given as mean ± SD. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ by Wilcoxon matched-pairs signed-ranks test for intra group comparisons. Inter group comparisons by ANOVA with Tukey-Kramer Multiple Comparisons Test for data with identical SDs and Kruskal Wallis with Dunn's Multiple Comparisons Test for data with non identical SDs. * $p < 0.05$ for intergroup post hoc comparisons.

Table 3: Heart rate (HR), systolic pressure (SP), diastolic pressure (DP), pulse pressure (PP), mean pressure (MP), rate-pressure product (RPP) and double product (Do P) in of patients of hypertension (HT), diabetes mellitus (DM) and both hypertension and diabetes mellitus (DMHT) before (B) and after (A) the performance of 5 minutes of chandra nadi pranayama (left uninostril breathing).

	HT (n=14)		**DM (n=12)**		**DMHT (n=13)**		**ANOVA**	
	B	A	B	A	B	A	B	A
HR (beats/min)	70.86 ± 11.18	67.86 ± 9.80 *	74.67 ± 6.62	71.08 ± 7.49 **	74.69 ± 11.31	71.92 ± 10.07 **	P= 0.6415	P=0.4894
SP (mm Hg)	137.00 ± 14.54	130.50 ± 13.53 *	126.00 ± 12.48	123.25 ± 12.75 *	130.85 ± 8.19	128.00 ± 12.27	P= 0.0804	P=0.2332
DP (mm Hg)	83.71 ± 8.42	80.86 ± 8.37 *	80.08 ± 8.58	78.67 ± 9.36	82.00 ± 7.78	79.08 ± 6.93 *	P=0.5412	P=0.7686
PP (mm Hg)	53.29 ± 14.54	49.64 ± 9.20	45.92 ± 6.60	44.58 ± 6.99	48.85 ± 10.60	48.92 ± 12.12	P=0.2555	P=0.2440
MP (mm Hg)	101.48 ± 8.41	97.40 ± 9.43 **	95.39 ± 9.55	93.53 ± 10.09 **	98.28 ± 6.14	95.38 ± 7.04	P=0.1762	P=0.5478
RPP (units)	97.47 ± 20.57	89.27 ± 19.14 **	94.03 ± 11.70	87.32 ± 10.14 **	97.48 ± 14.46	91.46 ± 11.68 **	P=0.8306	P=0.7747
DoP (units)	72.35 ± 15.22	66.66 ± 14.02**	71.13 ± 8.42	66.25 ± 7.86***	73.50 ± 12.38	68.41 ± 9.45**	P=0.8938	P=0.8693

Values are given as mean ± SD. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ by Wilcoxon matched-pairs signed-ranks test for intra group comparisons. Inter group comparisons by ANOVA with Tukey-Kramer Multiple Comparisons Test for data with identical SDs and Kruskal Wallis with Dunn's Multiple Comparisons Test for data with non identical SDs. * $p < 0.05$ for intergroup post hoc comparisons.

DISCUSSION AND CONCLUSION:

This is the first report of the immediate cardiovascular effects of CNP in patients of HT and DM utilizing HRV analysis. We have also measured resting cardiovascular parameters, thus enabling us to understand the resultant effects and also to confirm previous reports on cardiovascular effects of CNP.

There was a significant fall of HR and BP indices in all three groups of patients and this reduction may be attributed to an overall normalization of autonomic cardiovascular rhythms along with improvement in baroreflex sensitivity irrespective of the underlying disorder. It has been previously reported that sympathetic activity is lower during left nostril breathing. [11] This is also supported by Innes et al who had earlier postulated two interconnected pathways by which Yoga reduces the risk of cardiovascular diseases through the mechanisms of parasympathetic activation coupled with decreased reactivity of sympathoadrenal system and HPA axis.[(2)]

The cardiovascular effects with regard to the RPP and Do P are more significant ($p < 0.01$ to $p < 0.001$) and this can be attributed to the cumulative benefits from a reduction in HR as well as BP. RPP and Do P are especially important in patient care as they are indirect indicators of myocardial oxygen consumption and load on the heart, and hence this reduction implies a lowering of the strain on the heart. [(12)] As RPP is also a surrogate marker of overall HRV, its reduction implies an improved cardiac autonomic regulation in our subjects. [(13)] As the HR also reduced significantly in our study, the fall in SP can be attributed to a reduction in cardiac output due to decreased venous return as well as decreased HR. Slow and deep regular breathing is known to harmonize respiratory and cardiovascular Meyer rhythms that then result in changes in HR as well as BP. Increased vagal modulation of SA and AV nodes along with enhancement of baroreceptor sensitivity may be responsible for reduction in HR and subsequent fall in SP in our subjects irrespective of their condition.

The HRV findings in all three groups are more complicated but show a trend towards a normalization of the pre existing autonomic differences between groups that is typical of Yoga techniques. Preexisting intergroup differences with regard to SDNN, RMSSD, HF power and total power were negated after the performance of CNP.

Significant increases in Mean RR with conversely significant decreases in Mean HR in both the HT and DMHT groups may be explained by the factors discussed above and strengthen the possibility of an enhanced harmonization of cardiac autonomic function. This seems to be more evident in the patients of HT and DMHT as LF power and total power also increased in these groups while it reduced in DM group. Increases in LF power are traditionally interpreted as an index of enhanced sympathetic activity but recent understanding is that LF power reflects baroreflex function and not cardiac sympathetic innervation. Moak et al reported that LF power derived from the interbeat interval spectrogram predominantly reflects baroreflex-mediated, phasic changes in cardiovagal and sympathetic noradrenergic outflows. [(14)] They concluded that in the setting of baroreflex failure, baseline LF power is reduced, regardless of the status of cardiac sympathetic innervation.

Changes in all three groups following CNP suggests that an improvement is occurring in the cardiac autonomic modulation irrespective of the increase or decrease in different HRV parameters. This implies a healthier heart, capable of responding to external and internal changes in an adequate manner. Our hypothesis is supported by a recent report that the period immediately following alternate nostril breathing as well as paced breathing is marked by elevated autonomic modulation of the heart. [15]

It is to be noted that in virtually all of the short term HRV analysis, there were differences between the responses of DM and HT patients with regard to mean RR and mean HR. This may be attributed to a greater degree of cardiac autonomic neuropathy that is known to occur in patients of DM. Pre-post intra group comparisons showed significant increases in Mean RR and Mean HR in both HT and DMHT groups while there were significant increases in LFnu and LF/HF ratio with significant decrease in HFnu in DM group. The post CNP responses of DM group in Mean RR, SDNN, Mean HR, RMSSD, LF power and total power were contrary to responses in the other groups.

HRV is known to be lower in patients of DM and HT and in our study, SDNN, RMSSD, LF power, HF power and total power were much lower in the DMHT group compared to the other groups and this may be attributed to a synergetic detrimental effect on the cardiac autonomic nervous system due to concurrent DM and HT. a previous study by Sridar et al has also reported reduced baseline HRV in patients having DMHT as compared to those having only DM [16] This can be attributed to the cardiac aautonomic neuropathy in DM and HT resulting in impaired regulation of BP and HRV due to a shift in cardiac autonomic balance towards sympathetic dominance. Improvements in all HRV parameters following CNP in our patients may be attributed to a balancing of the autonomic function with a shift from the sympathetic dominant state to one of parasympathetic balance. Sridar et all had also reported that the degree of increase in HRV was greater in hypertensive diabetic patients as opposed to normotensive diabetic patients [16] and our findings are similar to some extent as there was a greater Δ% change in DMHT group.

A recent study from JIPMER assessing sympathovagal imbalance by spectral analysis of HRV reported that that autonomic imbalance in pre-hypertensives was due to proportionate increased sympathetic activity and vagal inhibition, whereas in hypertensives, vagal withdrawal was more prominent than sympathetic over activity. [17] This may explain the major differences between the groups at baseline and also the changes in DMHT group as the cardiac autonomic imbalance was of a greater degree of severity. Increased sympathetic activity, enhanced cardiovascular reactivity and reduced parasympathetic tone have been strongly implicated in the pathogenesis of insulin resistance syndrome, atherosclerosis and cardiovascular diseases. Innes and Vincent have suggested that yoga reduces this risk profile by decreasing activation of the sympatho-adrenal system and the hypothalamic-pituitary-adrenal axis and also by promoting a feeling of wellbeing along with direct enhancement of parasympathetic activity via vagus nerve. [18]

Although decreased HRV is the most powerful predictor of cardiac mortality, there are a few limitations in any study using HRV as a tool for research. It is still unclear as to which is the best HRV variable to measure as none provides significant, consistent and accurate outcome. [19] Since HRV deals with RR interval variations, its measurement is limited to subjects with sinus rhythm and to those with low number of ectopic beats. [20]

As the present study lacked an appropriate paired control group of patients, further controlled studies are planned to ascertain a deeper understanding of the mechanisms involved. Such studies can also determine how long such an autonomic modifying effect persists in clinical situations. It is recommended that this simple and cost effective technique be added to the regular management protocol of HT and DM and utilized when immediate reduction of HR and BP are required in day-to-day as well as clinical situations.

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