■ *Original Article*

EFFECT OF YOGA ON CARDIOVASCULAR AUTONOMIC REACTIVITY IN ESSENTIAL HYPERTENSIVE PATIENTS

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Abstract

Background and objective: We aimed to investigate the effect of yoga on cardiovascular autonomic reactivity in essential hypertensive patients. **Methods:** The study was conducted on 14 essential hypertensive patients, who were on salt–reduction and similar anti-hypertensive drugs. They were randomized into two groups; control (n=7; age 42.2±11.9 years) and yoga (n=7; age 44.9±10.8 years). The yoga group practiced yoga for ½ h/d, 6 d/ week for 6 weeks. The control group did not practice any type of yogic exercises or relaxation techniques. Autonomic function tests consisting of deep breathing, Valsalva maneuver, handgrip (HGT), and head-up tilt (HUT) tests of all patients were assessed at 0 week and every two weeks for 6 weeks. The data were analyzed using Friedman test followed by multiple comparisons. **Relusts:** In yoga group significant reduction in resting heart rate, SBP, and DBP were found after 4 weeks of yogic practices as compared to baseline recording; HR [84(78-94.5) Vs 72(67.5-77); p=0.028], SBP[144(140-165) Vs 130(125-144); p=0.018], and DBP[98(94-101) Vs 88(78-90); p=0.018]. Similarly, significant reduction in SBP was found after yogic practices in response to HGT and HUT although the magnitude of changes was increased or comparable to control. There was significant increase in Valsalva ratio after yogic practices [1.17(1.12-1.4) Vs 1.33(1.29-1.55); p=0.018]. **Conculsion:** Yoga combined with anti-hypertensive drugs is effective in reducing BP in resting condition and increasing parasympathetic reactivity. It is also found to normalize cardiovascular autonomic function in hypertensive patients.

Keywords: Yoga, essential hypertension.

Introduction

Hypertension is one of the most prevalent cardiovascular disorders affecting 20% of world's population.[1] Eighteen percent of it is essential hypertension. The central venous pressure as well as arterial blood pressure is increased in essential hypertensive patients. The elevated central venous pressure is due to decrease in compliance of either the venous bed of left ventricle or both; and it is amplified with age and baseline vascular resistance.[2] Sympathetic nervous hyper-tonicity may be responsible for activation of the renin-angiotensin system, and both of these together may play an important role in the elevation of BP.[3] Release of nor-epinephrine from central nervous system (CNS), presumably in the forebrain, mediates increased sympathetic nerve firing in patients with essential hypertension.[4] Studies on heart rate variability have shown decreased parasympathetic activity in essential hypertensive patients.[5,6]

Stress has been implicated as one of the major causes of essential hypertension by producing large amount of vasoconstrictor hormones that increase BP.[7] Persistent increase in arterial BP may result in cardiovascular (ventricular hypertrophy, myocardial infarction, and stroke) and other complications.

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As the exact causes of the disease is yet to be known and the nature of the disease is multi-factorial, many patients have to take anti-hypertensive drugs lifelong for the management of the essential hypertension. Long-term treatment and multiple drug requirements make the patients' compliance poor. Despite long-term normalization of BP by anti-hypertensive drugs, there exists autonomic dysfunction.[8] Therefore, there is a continuous search for newer alternative methods of therapeutics.

Based on limited scientific research, yoga (meditation, asanas, and pranayama) including relaxation therapy is known to improve cardiovascular autonomic functions. Meditation is associated with reduced sympathetic adrenergic receptor sensitivity, which might affect cardiovascular response during stress.[9] During meditation appearance of frontal midline theta rhythm in electroencephalogram reflects mental concentration as well as meditative state of relief from anxiety and is correlated negatively with sympathetic activation. This suggests a close relationship between autonomic functions and activity of medial frontal neural circuitry and possibility of controlling CNS functions through yoga and meditation.[10] Transcendental meditation (TM) practice improves mood state, adrenocortical activity and kidney functions; and believed to reduce stress[11] and shows significant reduction in average ambulatory diastolic BP.[12] Its effect is additive in reducing BP in patients treated with â-blockers and Ca^{++} channel blockers.

The yogic asanas influence various organs physiologically, exert neuro-physiological stability by lowering level of cholinesterase and catecholamines, and show certain significant trends of endocrine restoration and metabolic correction.[13] The *Shawasana*- a relaxation exercise probably influence the hypothalamus- can establish a psycho-physiological relaxation in a short period. Therefore, we aimed to investigate the effect of yoga (meditation, pranayama and certain easy asanas) on cardiovascular autonomic responses in essential hypertensive patients.

Material and methods

The study was conducted on 14 ambulatory essential hypertensive patients, age ranging from 30 – 60 years of either sex. They were newly diagnosed and follow-up cases, previously not engaged in any type of relaxation therapy. Patients with concomitant diseases (diabetes mellitus, secondary and severe hypertension) were excluded from the study. All the recruited patients were taking â-blocker as well as Ca^{++} channel blockers and were on salt reduction. Patients were systematically randomized into control and yoga groups. The control group was on conventional drug therapy and salt reduced diet. The yoga group was on similar anti- hypertensive drugs and salt reduction, and also practiced certain selected yogic practices for half an hour per day, 6 days in a week for 6 weeks. They practiced yoga under the supervision of trained yoga instructor at Yoga and Life Style Clinic, Department of Physiology, BPKIHS. The study was conducted from 2000-2002.

The yoga group practiced the following yogic practices

1. **Strenthening exercise (for 5 min):** consisted of Manibadha, Shakti Vikash, Ardhabhuja Shakti Vikash, Purna Shakti Vikash, Anjuli Shakti Viksh, Kamar Chakrasana, Vakshasthal Shakti Vikash and Uder Shakti Vikash. Each exercise was done for 40 sec.
2. **Yogic asanas (for 6 -7 min):** consisted of Tarasana, Trikonasana, Gomudhasana, Shashankasana, Padmasana, Bhujangasana, Hardhayastambhasana, Naukasana and Makarasana. Each was done for 40 sec.
3. **Shavasana,** a relaxation exercise, was done for 5 min.
4. **Meditation** was done in a comfortable posture (desired by patients) for 5 min.
5. **Pranayama:** consisted of Anuloma-biloma and Nadisuddi pranayama. Both are breathing exercises. Each was done for 2 min.

The assessment of autonomic function test (AFT) was performed in both the groups before randomization and at every two weeks for 6 weeks between 8:30 to 11:00 AM at room temperature 26±1°C after 2 hours of breakfast. The AFT consisted of deep breathing test, Valsalva maneuver, handgrip test (HGT) and head-up tilt test (HUT).[14] During all these tests simultaneous ECG and respiration were recorded continuously. Deep breathing, Valsalva maneuver and HGT were done as recommended by Ewing (1982).[15] For head-up tilt test patients were asked to lie down supine on a tilt table for 15 min and then table was tilted at 60° in 15 sec and the patients were remained tilted for 6

min. Baseline BP was recorded in supine position at the end of supine rest and subsequent BP was recorded at ½ min, 1 min, 2 min, 4 min, and 6 min in the tilted position. After 6 min patients were brought to the horizontal position.

Statistical analysis

The data were tested for normal distribution. The data of general characteristics was analyzed using unpaired student t test. The Friedman test followed by multiple comparisons was used to study the changes within the group over the period of time and Mann Whitney U test was used for inter group comparison. A p value of <0.05 was considered statistically significant.

Results

There were no significant differences between yoga and control groups in terms of their age, sex, height, weight, and blood pressure (Table 1). The yoga group showed significant reduction in weight and body mass index (BMI) after four weeks of yoga practice as compared to baseline recording and control group (Table 2). The yoga group also showed significant reduction in resting HR, SBP, and DBP after 4 weeks of yoga practice as compared to baseline recording and further reduction after 6 weeks of yoga practice (Table 2). After six weeks of yoga practice all these variables were significantly reduced as compared to control group also. No such significant changes were found in the control group over the study period in within-group comparison (Table 2). In yoga group, during HGT also there was significant reduction in SBP as compared to baseline recording (Table 3), whereas, ÄSBP (change in SBP during HGT i.e. SBP during HGT minus SBP before start of HGT) increased after 4 weeks of yoga practice and further increased after 6 weeks of yoga practice (Table 3). The yoga group showed reduction in DBP also during HGT, however, it was not statistically significant. The increase in ÄDBP (change in DBP during HGT i.e. DBP during HGT minus DBP before start of HGT) was > 10 mmHg at 0-week recording and at subsequent 4-weeks and 6-weeks of recordings. There were no significant changes over the study period. The control group showed no significant changes in SBP or DBP during HGT in within-group comparison over the study period.

Similarly the yoga group showed significant reduction in both SBP (Fig 1 & 2) and DBP (Fig 3) during head-up tilt test after 4 weeks of yoga practice as compared to baseline recording and further reduction after 6 weeks of yoga practice. The control group showed no significant changes in SBP or DBP during HUT in within-group comparison over the study period. The Valsalva ratio significantly increased in yoga group after 2 weeks of yoga practice (Table 2). Such increase was not found in control group. No significant difference was found in E:I ratio both in within- and between-group comparisons over the study period.

Dose of the anti-hypertensive drugs was reduced in four of the patients of yoga group. In one patient, dose of propranolol was reduced from 40 mg to 20 mg after 2 weeks of yoga practice and further the dose was reduced to 10 mg after 4 weeks of yoga practice and in another

patients dose of both propranolol 40 mg and nifedipine 10 mg was reduced to half after 6 weeks of yoga practice. In the similar way dose of the propranolol was reduced to half in another two patients.

Table 1. General characteristics of essential hypertensive patients

Parameters	Control (n=7) (mean±SD)	Yoga (n=7) (mean±SD)	p value
Age (years)	42.20±11.88	44.86±10.76	NS
Height (cm)	162.4±6.95	160.9±9.79	NS
Weight (kg)	64.80±4.87	63.14±7.63	NS
BMI (kg/m^2)	24.86±2.73	24.63±3.09	NS
SBP (mmHg)	152.86±11.13	152.5±13.89	NS
DBP (mmHg)	102.14±3.93	102.0±10.85	NS
HR (beats/min)	75.2±10.3	84.57±18.43	NS
RR (breath/min)	16±2.1	15±3.6	NS

BMI=body mass index, SBP=systolic blood pressure, DBP=diastolic blood pressure, HR=heart rate, RR=respiratory rate, p<0.05, considered as statistical significance. NS= no significant differences.

Table 2. Comparison of resting variables and Valsalva ratio between yoga and control groups over the study period, n=7 in each group

Variables	Groups	0-week values	2-week values	4-week values	6-week values	In intra-group comparisons				
		Median (inter quartile range)				p1	p2	p3	p4	p5
Weight	Control	64(63-69)	64(63-68)	64(64-68)	64(63-68)	NS	NS	NS	NS	NS
kg	Yoga	65(56.5-68)	63(56-67)	63(56-66.5)*	60(55.5-65.5)*	NS	0.026	0.027	NS	0.041
BMI,	Control	24.7(24.2-26.5)	24.4(24.2-26.5)	24.7(24.2-26.5)	24.6(24.4-26.9)	NS	NS	NS	NS	NS
kg/m²	Yoga	24.8(22.6-26)	24.69(22.3-25.5)	24.5(22.3-24.7)	23.7(22.1-24.5)*	NS	0.028	0.028	NS	0.043
HR,	Control	75(74-76)	69(68-73)	73(72-75)	74(70-91)	NS	NS	NS	NS	NS
bpm	Yoga	84(78-94.5)	76(74.5-87)	72(67.5-77)	72(66-74.5)*	NS	0.028	0.028	NS	0.034
SBP,	Control	140(120-146)	130(130-140)	132(124-142)	128(126-144)	NS	NS	NS	NS	NS
mmHg	Yoga	143(136-155)	120(120-138)	126(122.5-135)*	122(117-129)*	NS	0.042	0.018	NS	NS
DBP,	Control	86(80-90)	90(90-92)	88(88-96)	86(86-92)	NS	NS	NS	NS	NS
mmHg	Yoga	98(94-101)*	90(86-94)	88(78-90)	80(78-85)*	0.027	0.018	0.018	0.017	0.028
Valsalva	Control	1.06(1.06-1.09)	1.2(1.06-1.21)	1.38(1.25-1.5)	1.26 (1.16-1.5)	NS	NS	NS	NS	NS
ratio	Yoga	1.17(1.13-1.4)	1.27(1.21-1.72)	1.33(1.29-1.55)	1.46(1.38-2.25)*	0.032	0.018	0.018	NS	0.018

BMI=body mass index, HR=heart rate, SBP=systolic blood pressure, DBP=diastolic blood pressure; p1= 0-week vs. two-week, p2= 0-week vs. four-week, p3= 0-week vs. six-week, p4= two-week vs. four-week, p5= two-week vs. six-week; asterisk mark (*) = significant differences, control vs. yoga group; $p<0.05$, considered as statistical significance, NS= no significant differences.

Table 3. Comparison of SBP (mmHg) responses in HGT between yoga and control groups over the study period, n=7 in each group

HGT	Groups	0-week values	2-week values	4-week values	6-week values	In intra-group comparisons				
Variables		Median (inter quartile range)				p1	p2	p3	p4	p5
Baseline	Control	132(130-140)	140(140-142)	136(132-140)	134(132-138)	NS	NS	NS	NS	NS
SBP	Yoga	144(140-165)	140(131-145)	130(125-144)	120(118-145)	0.042	0.018	0.039	NS	0.039
SBP at	Control	150(144-154)	160(158-162)	150(132-156)	146(138-160)	NS	NS	NS	NS	NS
1 min	Yoga	170(160-175)	170(146-180)	160(138-164)	148(141-155)	NS	NS	NS	NS	0.042
SBP at	Control	156(156-170)	166(160-170)	160(140-162)	160(160-170)	NS	NS	NS	NS	NS
2 min	Yoga	188(176-199)	168(157-180)	164(149-166.5)	150(146-161)*	NS	0.018	0.018	NS	0.018
SBP at	Control	170(160-172)	170(168-194)	162(160-170)	172(148-180)	NS	NS	NS	NS	NS
4 min	Yoga	188 (164-198)	178(165-183)	170(160-182)	164(160-174)	NS	NS	NS	NS	NS
ÄSBP	Control	30(30-42)	38(30-44)	26(20-38)	38(24-40)	NS	NS	NS	NS	NS
	Yoga	20(18-28)	36(26-41.5)	44(34-55)	48(30-63.5)*	NS	0.028	0.032	NS	0.028

HGT=Handgrip test, SBP=systolic blood pressure, SBP at 1', 2' & 4'= SBP during HGT at the end of 1, 2, and 4 min respectively; ÄSBP= increase in SBP during 4 min of HGT; p1= 0-week vs. two-week, p2= 0-week vs. four-week, p3= 0-week vs. six-week, p4= two-week vs. four-week, p5= two-week vs. six-week; asterisk mark (*) = significant differences, control vs. yoga group; $p<0.05$, considered as statistical significance, NS= no statistical significant difference.

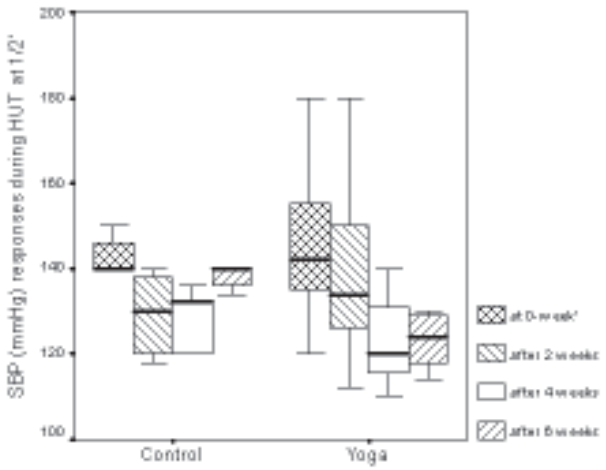

Fig 1. *Changes in systolic blood pressure (SBP) responses at 1/2 min of head-up tilt test (HUT) in control (n=7) and yoga (n=7) groups. The yoga group showed significant reduction in SBP; 0-week vs 4-week (p=0.027) and 0-week vs 6-week (p=0.027). The p<0.05 was considered as statistical significance.*

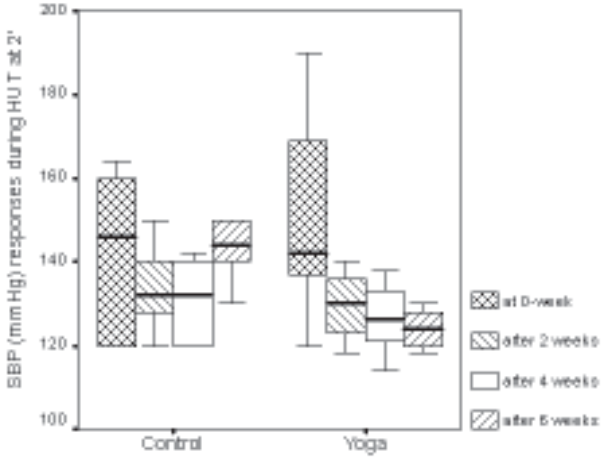

Fig 2*. Changes in systolic blood pressure (SBP) responses at 2 min of head-up tilt test (HUT) in control (n=7) and yoga (n=7) groups. The yoga group showed significant reduction in SBP; 0-week vs 4-week (p=0.042) and 0-week vs 6-week (p=0.028). The p<0.05 was considered as statistical significance.*

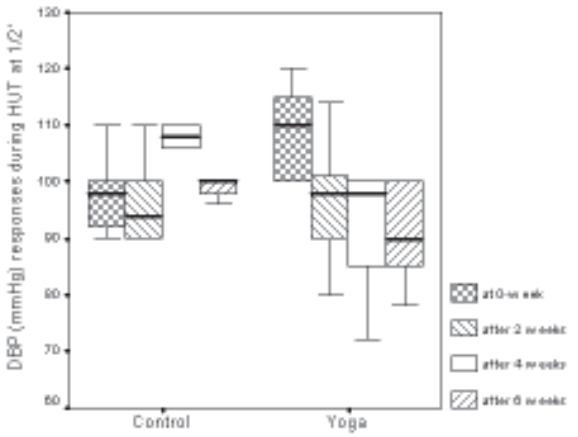

Fig 3. *Changes in diastolic blood pressure (DBP) responses at 1/2 min of head-up tilt test (HUT) in control (n=7) and yoga (n=7) groups. The yoga group showed significant reduction in DBP; 0-week vs 4-weeks (p=0.026) and 0-week vs 6-week (p=0.018). The p<0.05 was considered as statistical significance.*

Discussions

This study aimed at investigating the effect of yoga on cardiovascular autonomic reactivity in essential hypertensive patients. The study consisted of two groups; control (essential hypertensive patients on anti-hypertensive drugs) and yoga (essential hypertensive patients on similar anti-hypertensive drugs plus yogic practices). Both yoga and control groups were comparable in terms of their age, height, weight, body mass index, resting heart rate and resting blood pressure. The yoga group showed significant reduction in all these parameters (weight, BMI, HR, SBP, and DBP) after 4 weeks of yoga practice and further reduction after 6 weeks of yoga practice in within-group comparison. After six weeks of yoga practice all these variables were significantly reduced as compared to control group also, whereas, the control group showed no significant changes in weight, BMI, resting HR and resting BP within-group comparison over the study period.

In a recent study it has been reported that a 6-day yoga and diet change program decreased the BMI and the fat-free mass in healthy subjects.[16] Similar result i.e. reduction in weight and BMI after yogic practices has been found in the present study also, which indicated that yoga is effective in reducing weight and BMI also in essential hypertensive patients.

In the present study, yoga practice included combined practice of easy asanas, meditation and pranayama. The decrease in BP and HR may have been because of combined effect of components of yoga. Similar effect of decrease in SBP and DBP was reported in mild to moderate hypertensive patients.[17,18] In both of the study, patients were not on antihypertensive drugs and reduction in BP was found after long time of yogic practices. In the present study patients were treated with antihypertensive drugs along with yoga and they showed decrease in BP even after shorter period of yoga practices.

It is important to note that drugs may have mimicry action for decreasing BP by yogic practices because similar effect in drugs treated patients was observed in an earlier study[19].

Other studies[20,21] also found reduction in BP after yogic practices. In these studies patients practiced meditation, pranayama, easy asanas and also few difficult asanas like Chakrasana, Halasana, and Sarbhangasana but in present study patients practiced meditation, pranayama and few easy asanas but not the difficult asanas. Thus the present study showed that combined practice of even easy asanas, meditation, and pranayama for shorter duration is effective in reducing BP in essential hypertensive patients. The duration as short as two weeks was sufficient to detect significant desirable physiological effects.

Specifically the yogic posture influences various physiological organs in the body rather than producing simple skeletal muscle action.[22] A combined practice of several important asanas has shown considerable improvement in cardio-respiratory functions, adrenocortical functions and a number of metabolic correlations in addition to remarkable psychological and neurophysilogical improvements.[23] It is one of the possible mechanisms for reduction of BP in hypertensive patients. The Shavasana, a relaxation exercise probably influences the hypothalamus through the continuous feedback of slow rhythmic proprioceptive and enteroreceptive impulses[24] that can establish a psycho-physiological relaxation and reduce the physiological stress in shorter time.[25] It is known that stress can cause hypertension through repeated blood pressure elevations as well as by stimulation of the nervous system to produce large amounts of vasoconstrictor hormones that increase blood pressure.[26] Reduction in stress after yogic practices might be other possible mechanism for reduction of resting HR and BP in the present study. It is reported that yogic practices that appear to exert neuro-physiological stability is evident from lowered level of cholinesterase and catecholamines.[27] It might lead to reduction in BP because lowered level of cholinesterase and catecholamines cause reduction in sympathetic activation and increase in parasympathetic activity. We also found increase in parasympathetic activity in our study after yoga practice. The Vlasalva ratio, which is a marker of parasympathetic reactivity and baroreflex function, was found to be increased after yogic practices, indicating increase in parasympathetic reactivity and baroreflex sensitivity. Another marker of parasympathetic reactivity; E:I ratio showed increasing trend. Increase in parasympathetic activity/or reactivity has obvious relation possibly reciprocally decreasing sympathetic activity. This may be one of the reasons for reduction of resting HR and BP in the present study.

Regarding BP changes in an earlier study it has been reported that the total peripheral resistance and average ambulatory DBP decreased significantly during meditation.[28] The decrease in vasoconstrictor tone during meditation might be the hemodynamic mechanism responsible for reduction in DBP in the present study.

In the present study during handgrip test the control group showed no significant changes in SBP and DBP responses in within-group comparison over the study period, whereas the yoga group showed significant reduction in SBP during handgrip test after yogic practices. However, ÄSBP (change in SBP during HGT i.e. SBP during HGT minus SBP before start of HGT) was significantly increased after yogic practices. Similar result was obtained by Vijyalaxmi et al (2004).[21] The result possibly indicates an improvement in the cardiac autonomic regulation by improving the sympathovagal balance. As a result there was reduction in SBP during rest and HGT as well and ÄSBP increased during HGT. This mechanism might make the body capable of coping up with exercise stress.

There was reduction in DBP during HGT and increase in ÄDBP over the study period, however, it was not statistical significant. The ÄDBP was > 10 mmHg in baseline recording and it was maintained over the study period. The ÄDBP > 10 mmHg is

considered to be normal[14] in healthy individuals. Thus, yoga might have not changed it because yoga is known to effect autonomic function for normalization. This fact need to be studied further.

In this study during head-up tilt both SBP and DBP were reduced after yogic practices both in supine and tilted positions and no patients showed significant postural fall during the test. In an earlier study[29] progressive change in BP and HR responses to tilt during 3-week course of yogic practices was observed indicating the gradual improvement in baroreflex sensitivity. Similar mechanism might have been working in the present study.

In the present study dose of the anti-hypertensive drugs was reduced in majority of the patients of yoga group, which is supported by an earlier study.[30]

Conclusion

We conclude that yogic practices combined with anti-hypertensive drugs were found effective in reducing BP in resting condition and during stimulus-induced conditions as well in mild to moderate essential hypertension. It reduced the requirement of the dose of antihypertensive drugs in majority of the essential hypertensive patients. Specifically it was found to affect cardiovascular autonomic regulation and tends to normalize it. Further studies are suggested on larger sample size and with some more biochemical and stress related variables.

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