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Effects of eight week yoga therapy program on cardiovascular health in hypertensives

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Yogic practices may aid in the prevention and management of Hypertension (HT) and reduce cardiovascular complications in the population. The present study was undertaken to evaluate the effects of a comprehensive eight week yoga therapy programme on anthropometric, cardiovascular, biochemical parameters and wellness scores in patients of essential HT. 15 patients receiving standard medical treatment for essential HT were recruited and anthropometric, cardiovascular and biochemical investigations were done before and after a comprehensive yoga therapy programme comprising of three times a week sessions for 8 weeks. A post intervention, retrospective wellness questionnaire was used to evaluate the comparative feelings of the patients after the therapy programme. There was a statistically significant decrease in weight, BMI and all resting cardiovascular parameters such as heart rate and blood pressure indices. Total cholesterol (TC), triglyceride (TG), low density (LDL) and very low density (VLDL) lipoproteins reduced significantly while high density (HDL) lipoprotein increased significantly. All the cholesterol based ratios such as TC/HDL, LDL/HDL and showed healthy improvements. Post intervention overall wellness scores of the participants indicated that 9% attained complete relief and total satisfaction after the therapy programme while 29% were much better than before. 36% were better than before while 25% had no change in their condition. The main strength of the present study is excellent compliance and regularity of yoga practice by our participants both during directly supervised sessions and at home. Very few yoga studies have reported such excellent compliance and hence our study stands out as a special case. Hence, the all round benefits obtained in our study can be attributed to the dedicated and regular practice of the comprehensive yoga therapy programme that reports a significant improvement in anthropometric and cardiovascular parameters coupled with healthy lipid profile changes in patients of essential HT. It is concluded that a comprehensive yoga therapy programme has potential to enhance the beneficial effects of standard medical management of essential HT and can be used as an effective complementary or integrative therapy programme.

Keywords: Hypertension, Yoga therapy, Lipid profile, Cardiovascular risk

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Hypertension (HT) is one of the most common health disorders prevalent worldwide and is a major risk factor for stroke, coronary artery disease and organ failure. Increased sympathetic activity, enhanced cardiovascular reactivity and reduced parasympathetic tone have been strongly implicated in the pathogenesis of atherosclerosis, cardiovascular disease and insulin resistance which are leading causes of death and disability worldwide[1].

Yoga can be an effective adjunct therapy in HT and various studies have demonstrated the scientific basis of using it as a therapy and as an effective lifestyle modification measure [2,3,4]. Yoga is a popular means of relieving stress and improving fitness as it decreases stress and anxiety and improves health status. Yoga as a therapy is simple and inexpensive and can be easily adopted in most patients without any complications [5]. Yoga therapy encompasses the use of *asans*, *pranayams* and relaxation techniques along with dietary advice and yogic counseling that address the root cause of the problem rather than merely providing symptomatic relief [6].

Multiple simultaneous modifications of lifestyle are seen to provide the greatest lowering of blood pressure (BP) coupled with a reduced overall cardiovascular risk status. Though it may be difficult, it is of great value as even a small persistent reduction in BP can have a major protective effect on cardiovascular disease[7].

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It has been reported that autonomic deregulation underlies initiation and maintenance of HT and arterial baroreflex mechanisms operate in hypertensives albeit at a higher BP range [8]. A previous study from our laboratory reported that yoga training optimizes sympathetic response to stressful stimuli like isometric handgrip and restores autonomic regulatory reflex mechanisms in hypertensive patients and that this occurs with just 4 weeks of training[5].

In view of the above, the present study was undertaken to evaluate the effects of a comprehensive eight week yoga therapy programme on anthropometric, cardiovascular and biochemical parameters in patients of essential HT.

Methodology

This study was conducted as part of a larger study on the effects of yoga therapy on essential HT that had been accorded permission by the Research and Ethics Councils of the institute. Fifteen (9 male, 6 female) patients aged 25 – 65yrs (*M* = 46.60, *SEM*=2.95) receiving standard medical treatment at JIPMER were recruited for this study by accidental sampling method and prior informed consent obtained from them. None of the patients had previously engaged in yoga practice. Seven of them had coexisting diabetes mellitus, three were suffering from respiratory disorders, two from musculoskeletal disorders and one from peptic ulcer. Patients with history, signs, symptoms and/or laboratory reports suggestive of nephrologic and ophthalmologic complications were excluded from the study. The following parameters were tested before and after the 8 week study period.

Anthropometry: Anthropometric measurements were made prior to BP recording. Subjects were weighed in normal clothing to the nearest 0.1 kg (Krups, New Delhi). Their height was measured to the nearest 0.1 cm on a calibrated stature meter (Nisco, Delhi). Body mass index (BMI) was calculated as weight (Kg) / height (m^2).

Cardiovascular parameters: Recordings were taken in an air-conditioned laboratory 2 hours after a light breakfast. Basal recordings were taken in sitting posture after 5 minutes of rest in a chair. Systolic pressure (SP) and diastolic pressure (DP) and heart rate (HR) were measured with non-invasive semi-automatic BP monitor (Omron Inc., Japan). Rate-pressure product (RPP = SP × HR × 10^{-2}) and double product (Do P = HR × MP × 10^{-2}) were calculated for each recording.

Biochemical investigations: Biochemical investigations were done at the JIPMER Central Laboratory where blood was drawn from an antecubital vein in post-absorptive state. On the day of the blood collection, subjects were asked to abstain from yoga training. Lipid profile including total cholesterol (TC), triglyceride (TG), high density lipoprotein (HDL), low density lipoprotein (LDL) and very low density lipoprotein (VLDL) were requisitioned and evaluated.

Wellness questionnaire: A post intervention, retrospective wellness questionnaire compiled by ACYTER team was used to evaluate the comparative feelings of the patients after the therapy programme. Five different responses ranging from 'worse than before' to "complete relief / totally satisfied' were utilized to evaluate various physical and psychological aspects of the patient's condition. The questionnaire was finalized in consultation with a 12 member team consisting of 3 eminent medical practitioners, 2 Psychologists, 2 Yoga experts, 2 eminent yoga therapy consultants, 2 Educationists and one legal anthropologist.

Yoga therapy programme: The patients had an initial consultation session at the ACYTER Yoga OPD and were given yogic counseling and lifestyle modification advice including increased physical activity, reduction of dietary sodium, increased dietary consumption of potassium through fresh fruits and vegetables along with a diet rich in fiber[7]. They then attended the special yoga practise sessions conducted at ACYTER for HT patients. A comprehensive yoga therapy programme was imparted to the patients by qualified yoga instructors for the duration of 60 min thrice a week for 8 weeks. There was 99.17% attendance during the 24 directly supervised sessions. Patients were also motivated to practice the yoga therapy schedule at home on other days. Of the 15 patients, 5 reported a home practice of 3 days/week, 3 practiced 2 days/week and 2 practiced 4 days/week and 1 day/week at home. One patient each reported that they practiced 6 and 7 days/week at home while one reported they didn't practice at home at all. Analysis of patient feedback showed that the duration of home practice was 30 min for 7 patients, 20 min for 4 patients and 60 min for 2 patients and 40 min for one. Patients were advised to do the practices without over straining depending on their individual capacity. The schedule is given in Table 1.

Table 1—Sequence and duration of yoga techniques practiced by our subjects

	Yoga technique	Duration (min)
1	Talasan	0.5
2	Ardhkati chakrasan	1.0
3	Ushtrasan	0.5
4	Balasan	0.5
5	Sashasan	0.5
6	Matsyasan	0.5
7	Pashchimottanasan	0.5
8	Pavanamuktasan	3.0
9	Dwipad uttanasan	0.5
10	Bhujangasan	0.5
11	Chandranadi pranayam	3.0
12	Vibhag pranayam	3.0
13	Pranav pranayam	5.0
14	Nadi shuddhi	3.0
15	Vyagrah pranayam	1.0
16	Bhramari pranayam	3.0
17	Savitri pranayam	3.0
18	Kayakriya	6.0
19	Shavasan	15.0
	Rest period in-between practices	10.0
	Total	60 min

Statistical analysis: 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. Data that passed normality testing by Kolmogorov-Smirnov Test was analyzed using Students paired t test. Data that failed normality testing was analyzed using Wilcoxon Matched-Pairs Signed-Ranks test. *P* values less than 0.05 were accepted as indicating significant differences between pre and post intervention data.

Results

The results are given in Tables 2, 3, 4 and Fig.1. All data are expressed as $M \pm SEM$.

Anthropometry: Wilcoxon Matched-Pairs Signed-Ranks test showed a statistically significant (p=0.0039) decrease in both weight and BMI.

Resting cardiovascular parameters: Students paired t test showed significant reductions in HR, t (14) =3.03, p=0.0089, SP, t (14) =7.78, p <0.001, DP, t (14) =4.25, p<0.001, PP (pulse pressure) t (14) =2.70, p = 0.0174, MP (Mean Pressure) t (14) =6.86, p <0.001, RPP, t (14) =7.28, p<0.001, DoP, t (14) =6.77, p <0.001.

Table 2—Effect of 8 weeks yoga therapy programme on heart rate (HR), systolic pressure (SP), diastolic pressure (DP), pulse pressure (PP), mean pressure (MP), rate-pressure product (RPP) and double product (DoP) in patients of essential hypertension. B: before and A: after the 8 week study period.

	B	A	% Change	p Value
HR (beats/min)	84.13 ± 2.79	80.53 ± 2.89	- 4.28	0.0089
SP (mmHg)	149.60 ± 3.13	132.60 ± 2.51	- 11.36	< 0.001
DP (mmHg)	95.60 ± 3.10	86.27 ± 1.78	- 9.76	< 0.001
PP (mmHg)	54.00 ± 3.75	46.33 ± 2.89	- 14.20	0.0174
MP (mmHg)	113.60 ± 2.56	101.71 ± 1.53	- 10.47	< 0.001
RPP (units)	125.95 ± 5.04	106.79 ± 4.34	- 15.21	< 0.001
DoP (units)	95.90 ± 4.40	82.07 ± 3.47	- 14.42	< 0.001

Values are $M \pm SEM$ for 15 subjects.

Table 3—Effect of 8 weeks yoga therapy programme on total cholesterol (TC), triglycerides (TG), low density lipoprotein (LDL),very low density lipoprotein (VLDL), high densitylipoprotein (HDL), TC/HDL ratio, LDL/HDL ratio, HDL/LDL ratio, weight, height and body mass index (BMI) in patients of essential hypertension. B: before and A: after the 8 week study period

	B	A	% Change	p Value
TC (mg/dl)	173.67 ± 10.23	161.07 ± 9.11	- 7.26	0.0084
TG (mg/dl)	142.33 ± 15.57	125.00 ± 13.19	- 12.18	< 0.001
LDL (mg/dl)	108.87 ± 8.75	101.73 ± 8.35	- 6.56	0.0381
VLDL (mg/dl)	30.80 ± 3.08	26.80 ± 2.62	- 12.99	< 0.001
HDL (mg/dl)	39.00 ± 2.24	41.87 ± 2.06	+ 7.36	0.0459
TC/HDL	4.67 ± 0.39	3.95 ± 0.25	- 15.50	0.0214
LDL/HDL	2.97 ± 0.35	2.50 ± 0.22	- 15.88	0.0181
HDL/LDL	0.40 ± 0.046	0.45 ± 0.048	+ 13.75	0.0062
Weight (kg)	66.60 ± 1.98	65.60 ± 1.92	- 1.50	0.0039
Height (m)	1.62 ± 0.02	1.62 ± 0.02	0.00	-
BMI	25.54 ± 1.02	25.16 ± 1.00	- 1.49	0.0039

Values are $M \pm SEM$ for 15 subjects.

Table 4—Post intervention % responses of participants to retrospective wellness questionnaire

	Worse than before	Same as before	Better than before	Much better than before	Complete relief / Totally satisfied
Ability to concentrate	-	33.34	40	26.67	-
Control of anger / loss of temper	-	20	46.67	26.67	6.64
Appetite	-	23.07	46.15	23.07	7.69
Confidence level	-	20	26.67	20	6.64
Ease of breathing	-	20	40	26.67	13.34
Energy levels	-	38.46	23.07	30.76	7.69
Enjoyment of life	-	33.34	26.67	26.67	13.34
Feeling calm & fresh	-	26.67	33.34	26.67	13.34
Feeling of hopelessness	-	20	40	33.34	6.64
Feeling of loneliness	-	33.34	26.67	33.34	6.64
General flexibility	-	20	53.34	13.34	13.34
General mood	-	14.28	35.71	35.71	14.28
General sense of relaxation	-	13.34	40	33.34	13.34
General wellbeing	-	14.28	42.85	42.85	-
Joint mobility	-	28.57	35.71	28.57	7.14
Nervousness	9.09	14.28	50		9.09
Pain levels	-	46.15	30.76	15.38	7.69
Performance of day-to-day Activities	-	35.71	35.71	28.57	-
Sleep quality / duration	6.64	26.67	13.34	33.34	20
Stress levels	-	26.67	26.67	40	6.64
Total wellbeing score	0.79	25.41	35.67	28.68	8.67

Biochemical parameters: Wilcoxon Matched-Pairs Signed-Ranks test showed a statistically significant decrease in TC, p=0.0084 and TG, $p < 0.001$. Students paired t test showed significant reductions in LDL, t (14) = 2.29, p = 0.038, VLDL, t (14) =4.27, p <0.001 and significant increase in HDL, t (14) =2.19, p= 0.046. Wilcoxon Matched-Pairs Signed-Ranks test showed a statistically significant decrease in LDL/HDL, p=0.018 while Students paired t test showed significant decrease in TC/HDL, t (14) = 2.59, p = 0.021 and increase in HDL/LDL, t (14) = 3.21, p = 0.006.

Wellness questionnaire: The post intervention overall wellness scores of the participants are given in Fig. 1 and the detailed breakup of % responses to each question is given in Table 4. Overall responses to the retrospective wellness scores indicated that our patients felt a sense complete relief and total satisfaction (9%), they were much better than before (29%), they were better than before (36%) or felt no change in their condition (25%). The condition of 1% was reported to be worse than before the therapy programme.

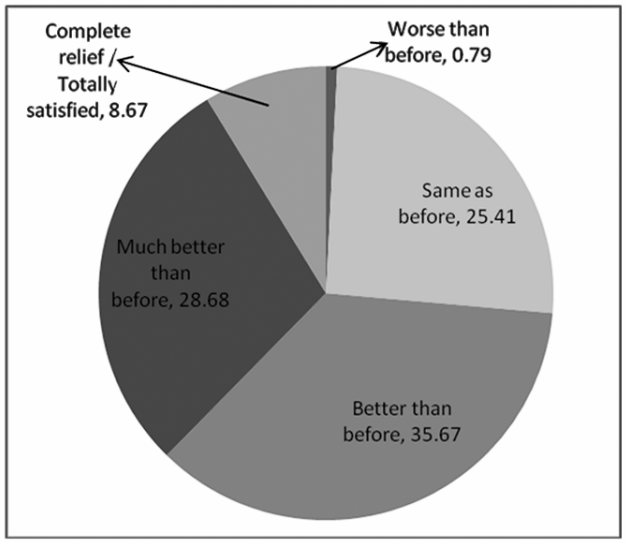

Fig.1—Post intervention overall % responses of the participants to the wellness questionnaire

Discussion

Anthropometric parameters: The yoga therapy programme resulted in a small yet significant (p=0.0039) reduction of weight and BMI. The lesser magnitude of change may be attributed to a lower initial BMI of our participants (25.54 ± 1.02 kg/m^2) and gentle and relaxed practice schedule appropriate for patients of HT. This provides an insight into a positive trend towards normalcy even though the magnitude of change may not be great. The reduction

of 0.38 kg/m^2 in the present study (Table 3) is comparable to other studies that have reported significant reductions in BMI following yoga training. Recent studies have reported reductions of 0.5 kg/m^2 after 3 months [9] and 0.57 kg/m^2 after a 6-day residential yoga programme in patients whose initial BMI was > 30 kg/m^2 [10]. A reduction of a greater magnitude (0.62 kg/m^2) was reported in patients whose initial BMI was > 30 kg/m^2 [11]. A normalization of BMI is significant since it has been reported that women over 18 with an initial BMI of 24 developed diabetes 5 times more often and HT twice more often than women with BMI </=21 [7].

Cardiovascular parameters: Increased sympathetic activity, enhanced cardiovascular reactivity and reduced parasympathetic tone have been strongly implicated in the pathogenesis of atherosclerosis and cardiovascular diseases[12]. Innes and Vincent 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 the vagus nerve[12]. *Balasan*, *matsyasan* and *sashasan* may be altering the hemodynamics in the thoracic cavity and thus influencing the vagus nerve. In an earlier study from our laboratory, it has been reported that 3 months of *pranayam* training results in modulation of ventricular performance by increasing parasympathetic activity and decreasing sympathetic activity[13]. As *nadishuddhi*, *pranav* and *savitri pranayams* were part of that study as well as the present study, they may have produced a similar effect in our subjects. In their review, Innes and Vincent have suggested that yoga provides a positive source of social support that may also be one of the factors reducing risk for cardiovascular diseases [12]. All of the above factors are applicable in our study and may explain the positive changes produced following strict adherence to the comprehensive yoga therapy programme.

It has been reported earlier that yogic training including inverted posture produces an improvement of baroreflex sensitivity and attenuation of the sympathetic and renin angiotensin activity[14]. The reduction in HR and BP seen in our study (Table 2), may be attributed to a similar mechanism as we have included "head below the heart" postures like *balasan*, *sashasan* and *dwipad uttanasan* in our yoga therapy schedule. Reduction in RPP and Do P (Table 2) implies a reduced load on the heart due to reduced oxygen consumption[15] and this correlates with a previous study in our laboratory that reported a consistent and significant reduction in oxygen consumption and psychosomatic relaxation with *shavasan* and *savitri pranayam*[16] that is one of the practices used in our therapy programme.

Sympathetic activation is known to increase HR and RPP and decrease overall heart rate variability (HRV) and this is evident in our pre-training values. The RPP provides a simple measure of overall HRV in hypertensive patients and is a surrogate marker in situations where HRV analysis is not available[8]. It has been previously reported that standard deviation of normal-to-normal RR intervals (SDNN), an index of overall HRV is reduced in hypertensive patients[8]. It has also been shown that SDNN and total power of HRV are inversely correlated with mean HR and RPP [17]. Hence, the significant post-training decrease in HR and RPP in our study indicates a better autonomic regulation of the heart with decreased oxygen consumption and load. This can be attributed to the pranayam practices used in our study.

Biochemical investigations: The significant decreases in TC, TG, LDL and VLDL values coupled with significant increase in HDL in our participants implies a better lipid profile having good prognostic value. A study on yogic practises on lipid profile and body fat composition in patients of coronary artery disease reported insignificant reductions of TC, TG and LDL after 6 months [18]. However, Innes and Vincent reported that all 12 studies reviewed by them suggested that yoga improves lipid profile [12]. Reductions in TC, TG, LDL and VLDL and an increase in HDL in our subjects are comparable with the findings of their review. Upon analysis of the different relative cholesterol ratios, it is apparent that the yoga therapy programme improved the 'heart friendly' status of lipid profile in our subjects. Normally the 'safe' TC/HDL ratio should be less than 4. This was initially 4.67 ± 0.39 in our patients and decreased (16%) to a safe level of 3.95 ± 0.25 after the 8-week yoga therapy programme. A healthy LDL/HDL ratio should be less than 3. Though the initial pre-training level in our subjects was a higher normal value it also reduced (16%) to a lower normal value. HDL/LDL ratio should normally be more than 0.3 but it is preferable to maintain it above 0.4. This also increased (14%) to a higher normal value implying better prognosis of cardiovascular health.

These positive changes in lipid profile may be attributed to the twisting and compression-relaxation effects of postures such as *paschimottanasan*, *pawanamuktasan* and *bhujangasan*. The decrease of 'bad' cholesterol and increase in 'good' cholesterol has significance when viewed in light of the cardiovascular risk profile of diabetic patients as 7 participants had concomitant DM. It has been previously reported that *hatha yoga* decreases oxidative stress and improves antioxidant status [19] and this could also be the mechanism behind the positive changes in lipid profile of our subjects. It has been reported that a short lifestyle modification and stress management education program leads to favorable metabolic effects and that yoga reduces risk factors for cardiovascular disease and DM[20]. The improved healthier 'heart friendly' lipid profile evidenced in our study may be the biochemical mechanism by which such risk profiles are reduced.

Wellness questionnaire: It has been reported that a short lifestyle modification and stress management educational program leads to remarkable improvement in subjective wellbeing scores and can therefore make an appreciable contribution to primary prevention as well as management of lifestyle diseases[2]. A majority of the patients in our study reported an improvement in ability to concentrate, control of anger, appetite, confidence levels, ease of breathing, energy level, enjoyment of life with calm and fresh feeling (Table 4 and Fig.1). They also reported a reduced feeling of hopelessness, nervousness and loneliness. They reported improvements in general flexibility and joint mobility along with improved general mood, sense of relaxation and well being. There was decrease in pain with improvement in their ability to perform their day-to-day activities. They also felt a reduction in their stress levels with improved quality and duration of sleep. Yoga may be improving mental and emotional components of the personality and the subjective well being reported by our participants may be a contributing psycho-physiological factor in the healthy improvements shown by our patients and this aspect needs further exploration.

Our findings can be correlated with those of an earlier study on patients with mild to moderate essential HT that reported decreased VMA catecholamine and MDA levels suggestive of decreased sympathetic activity and oxidant stress after 3 months of yoga training. They also reported decreased BP, TC and TG with overall improvement in subjective wellbeing and quality of life [21].

The main strength of the present study is the excellent compliance and regularity of the yoga practice by our participants both during the directly supervised sessions (99%) and at home, where all expect one patient practiced regularly for an average of 3 days/week for a minimum duration of 30 min. Hence, the all round benefits obtained in our study can be attributed to the dedicated and regular practice of the comprehensive yoga therapy programme. Very few yoga studies have reported such excellent compliance and hence our study stands out as a special case.

As all of our participants were simultaneously also receiving medication, it is difficult to determine 'actual' benefits of the therapy intervention and differentiate them from the benefits of better medical management in the same period. The main drawback of our study is the accidental sampling method used and the lack of a control group. However, as there was no change in the medical management protocol that had already stabilized their clinical status, we can reasonably conclude that any additional benefits were due to the yoga therapy programme. It is suggested that further randomized control studies can be done to confirm these findings and facilitate a deeper understanding of the mechanisms underlying these beneficial results.

Conclusion

It is evident that a comprehensive 8-week yoga therapy programme produces significant improvement in anthropometric and cardiovascular parameters and lipid profile in patients of essential HT. It is also concluded that a comprehensive yoga therapy programme has potential to enhance the beneficial effects of standard medical management of essential HT and can be used as an effective complementary or integrative therapy programme. This study provides a scientific basis for further applied research on the effects of yoga therapy in hypertensives.

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