

“Study of Impact of Yoga on Physiological And Biochemical Parameters in Hypertensive And Normal Subjects.”

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Abstract : Stress is found to be an important factor in the etiology or precipitation of hypertension. Yoga controls the stress. In the present study we aim to study the degree of effect that yoga brings in normal subjects as compared to hypertensive subjects, in terms of various physiological cardio-respiratory parameters and biochemical parameters.

Type of trial: - This was the prospective; follow up, multiple comparison groups, non-cross over 90 days trial.
Study design:- The study included three different groups. The control and the study group underwent yogic session daily of 1.5-hour duration for a total period of 90 days. Physiological parameters studied at the beginning of the study and thereafter, every 30 days, till the end of the study i.e. 90 days were, Pulse rate, Respiratory rate and Blood pressure. Biochemical parameters assessed at the start and completion of the study were Serum total cholesterol ,Serum triglyceride ,Serum HDL-cholesterol, Serum LDL cholesterol . Statistically significant decrease was observed in all the physiological and biochemical parameters in all the study groups. It was concluded that in hypertensive subjects whether newly diagnosed or already diagnosed, there is restoration of the altered parameters towards normal.

Keywords: Yoga ,Hypertension,Lipid profile

I. Introduction

Hypertension is the major risk factor for many non-communicable diseases like cardiovascular diseases, stroke, renal failure and diabetes mellitus.^{1,2} Apart from the developed countries with aging population, now the developing countries like India with a younger population are showing rising trends in the prevalence of hypertension.Hypertension is estimated to cause 4.5% of current global diseases⁴ and about one billion people suffer from it worldwide.⁵ Recent data suggest that hypertensive persons are more predisposed to the development of diabetes than the normotensive persons. Stress is found to be an important factor in the etiology or precipitation of these conditions. Therefore, along with many other diseases hypertension and diabetes are also included under psychosomatic diseases. Lifestyle modifications are to be seriously considered as an adjunct to the drug interventions.⁸ Yoga influences the body as well as controls the stress (external or internal) in the individual, promotes well being, improves quality of life and its safety profile is excellent. We aim to study the degree of effect that yoga brings in normal subjects as compared to hypertensive subjects, in terms of various physiological cardio-respiratory parameters and biochemical parameters.

II. Materials And Methods

Setting: - Present trial was carried out in the Department of Physiology Government Medical College and Hospital (GMCH), Nagpur, India and the biochemical analysis was done in the laboratory of department of Biochemistry, GMCH, Nagpur. The subjects were trained in yogic practices at Shree Janaradan Swami Yogabhyasi Mandal, Ramnagar, Nagpur.

Type of trial: - This was the prospective; follow up, multiple comparison groups, non-cross over 90 days trial.

Planned Study population: -

Control group fulfilling the following criteria: -

1. Normal healthy adult volunteers more than 40 years of age, of both genders.
2. Non-smoker, non-alcoholic.
3. Not doing yoga previously.
4. Not on any medication.

A. Inclusion criteria for study group;-

1. Subjects above 40 yrs of age of both the genders.
2. Subjects having essential hypertension which included,

- ❖ Subjects with newly diagnosed Stage-1 hypertension and are not on any medication.
- ❖ Subjects with hypertension diagnosed within last 5 yrs and are on medication.
- 3. Not doing Yoga previously.
- 4. Subjects who are nonalcoholic and nonsmokers.

Exclusion criteria: -

1. Subjects with Stage-2 hypertension.
2. Subjects with hypertension with cardiovascular or cerebral complications.
3. Subjects with secondary hypertension.
4. Subjects already practicing yoga.
5. Subjects on medication altering lipid profile.
6. Pregnant women.

B. Ethics clearance and informed consent: -

Study was approved by institutional ethics committee. Informed consent was obtained from the subjects after explaining the study design.

Sample size: - The sample size was calculated by the statistician on the basis of previous study.

Study design: -

The study included three different groups.

Group I - Normal healthy controls.

Group II - Subjects with newly diagnosed Stage-1 hypertension and are not on any medication.

Group III - Subjects with hypertension diagnosed within last 5 yrs and are on medication

Planned intervention: -

The control and the study group underwent yogic session daily of 1.5-hour duration from 6 to 7.30 am in the morning for a total period of 90 days. The session started with Awayawa-dhyana and a short prayer followed by various asanas, pranayama, meditation and ended with a short prayer.

Physiological Parameters assessed were,

Pulse rate, Respiratory rate and Blood pressure

Biochemical Parameters estimated were: -

- ❖ Serum total cholesterol by enzymatic method.
- ❖ Serum triglyceride by enzymatic method.
- ❖ Serum HDL-cholesterol by phosphotungstate precipitation followed by enzymatic method.
- ❖ Serum LDL cholesterol by Friedwald formula

Statistical analysis:

Continuous variables were presented as mean \pm SD. The continuous variables were compared at different time intervals within the group and also between the groups. Statistical analysis of data was performed either using a one way analysis of variance (ANOVA) followed by Bonferroni's multiple comparison test or unpaired t-test for continuous variables. Two tailed p value of less than 0.05 was judged statistically significant. Statistical calculations were done by using statistical software STATA version 8.0.

III. Results And Observations

Table 1: Group I- Change in physiological parameters.

Parameters	II. DAY				p ANOVA
	0	30	60	90	
A. PR	70.8 \pm 3.23	70.5 \pm 3.91	70.1 \pm 3.13	68.3 \pm 3.49**	<0.05
B. RR	14.56 \pm 1.92	14.06 \pm 2.16	13.4 \pm 1.71**	12.86 \pm 2.55***	<0.05
SBP	116.67 \pm 2.42	115.06 \pm 2.86**	113.86 \pm 2.77***	111.6 \pm 2.57***	<0.001
DBP	77.06 \pm 2.91	76.8 \pm 1.94	75.06 \pm 2.21***	74.6 \pm 2.47***	<0.001
MBP	90.27 \pm 2.05	89.55 \pm 1.76	87.99 \pm 1.79***	86.93 \pm 2.11***	<0.001
PP	39.6 \pm 3.91	38.27 \pm 3.09	38.8 \pm 3.42	37.0 \pm 2.81***	<0.05

Values expressed in mean \pm SD of per min values for PR and RR,

Values expressed in mean \pm SD of mm of Hg for SBP, DBP, MBP and PP,

**p<0.01 Vs O value,

***p<0.001 Vs O values,

p as determined by one way ANOVA with Bonferroni's multiple comparison post test,

PR=Pulse Pressure, RR= Respiratory rate, SBP=Systolic Blood Pressure, DBP=Diastolic Blood Pressure, MBP=Mean Blood pressure, PP=Pulse pressure,

Table 2: Group II- Change in physiological parameters.

Parameters	Day				p Value
	0	30	60	90	
C. PR	76.78±4.27	75.82±3.49	75.25±2.82*	73.75±3.43**	<0.05
D. RR	17.14±2.43	16.53±2.71	15.60±2.16**	15.21±3.40**	<0.05
SBP	147.92±6.83	140.57±6.71** *	135.29±6.31** *	128.42±6.89***	<0.001
DBP	92.57±5.60	91.28±5.42*	88.5±4.37***	83.92±3.79***	<0.001
MBP	111.02±5.03	107.71±4.73** *	104.09±4.12** *	98.76±3.58***	<0.001
PP	55.35±7.05	49.28±7.40***	46.78±6.35***	44.5±7.51***	<0.001

Values expressed in mean±SD of per min values for PR and RR,

Values expressed in mean±SD of mm of Hg for SBP, DBP, MBP and PP,

*p<0.05 Vs O Value,

**p<0.01 Vs O value,

***p<0.001 Vs O values,

p as determined by one way ANOVA with Bonferroni's multiple comparison post test,

PR=Pulse Pressure, RR= Respiratory rate, SBP=Systolic Blood Pressure, DBP=Diastolic Blood Pressure, MBP=Mean Blood pressure, PP=Pulse pressure,

Table 3: Group III- Change in physiological parameters.

Parameters	Day				p ANOVA
	0	30	60	90	
E. PR	78.03±3.09	77.63±3.2	75.57±3.64*	74.96±5.54***	<0.01
F. RR	16.33±2.96	15.45±2.45	15.09±1.97*	14.27±3.66**	<0.05
SBP	138.36±8.70	135.33±9.03**	131.15±6.10***	125.39±5.51***	<0.001
DBP	84.61±3.40	83.15±3.31**	81.15±3.43***	78.42±4.09***	<0.001
MBP	102.52±4.29	100.54±4.15***	97.82±3.28***	94.36±3.18***	<0.001
PP	53.75±8.10	52.18±8.83	50.00±6.53**	46.54±7.09***	<0.01

Values expressed in mean±SD of per min values for PR and RR,

Values expressed in mean±SD of mm of Hg for SBP, DBP, MBP and PP,

*p<0.05 Vs O Value, **p<0.01 Vs O value, ***p<0.001 Vs O values,p as determined by one way ANOVA with Bonferroni's multiple comparison post test,

PR=Pulse Pressure, RR= Respiratory rate, SBP=Systolic Blood Pressure, DBP=Diastolic Blood Pressure, MBP=Mean Blood pressure, PP=Pulse pressure,

Table 4: Group 1 Change in biochemical parameters.

Parameters	Day		p ANOVA
	0	90	
a) TC	150.76±19.9	146.4±16.93	<0.01
TG	93.06±17.92	89.63±17.78	<0.05
HDL	52.96±7.42	55.3±7.75	>0.05
LDL	79.18±17.24	73.17±14.76	<0.01
VLDL	18.61±3.58	17.92±3.57	<0.05
TC/HDL	2.89±0.48	2.68±0.37	<0.01
LDL/HDL	1.53±0.43	1.35±0.34	<0.01
FBS	92.76±11.75	87.93±9.62	<0.05
PMBS	118.3±17.06	110.73±12.03	<0.05

Values expressed in mean±SD of mg/dl for TC, TG, HDL, LDL, VLDL, FBS and PMBS,

Values expressed in mean ±SD of ratio for TC/HDL, LDL/HDL,

P<0.05 is considered as significant,
 p as determined by paired 't' test. TC=total cholesterol, TG= triglycerides, HDL=high density lipoprotein, LDL= low density lipoprotein, VLDL=very low density lipoprotein, FBS= fasting blood sugar, PMBS= post meal blood sugar.

Table 5: Group II Change i

Parameters	Day		P ANOVA
	0	90	
b) TC	180.28±32.56	172.07±25.82	<0.05
TG	121.71±45.49	113.32±37.56	<0.05
HDL	44.60±9.70	49.71±13.64	>0.05
LDL	111.33±38.06	99.69±33.21	<0.01
VLDL	24.32±9.09	22.66±7.57	<0.05
TC/HDL	4.23±1.17	3.67±0.96	<0.01
LDL/HDL	2.65±1.12	2.17±0.90	<0.01
FBS	94.71±9.54	89.92±7.40	<0.05
PMBS	121.43±17.78	112.14±17.07	<0.05

n biochemical parameters.

Values expressed in mean±SD of mg/dl for TC, TG, HDL, LDL, VLDL, FBS and PMBS,

Values expressed in mean ±SD of ratio for TC/HDL, LDL/HDL,

P<0.05 is considered as significant,

p as determined by paired 't' test.

TC=total cholesterol, TG= triglycerides, HDL=high density lipoprotein, LDL= low density lipoprotein, VLDL=very low density lipoprotein, FBS= fasting blood sugar, PMBS= post meal blood sugar.

Table 6: Group III Change in biochemical parameters.

Parameters	Day		P ANOVA
	0	90	
c) TC	194.2±44.24	184.4±35.29	<0.05
TG	133.9±34.39	120.7±23.12	<0.01
HDL	46.24±10.51	52.18±11.85	<0.05
LDL	121.2±41.79	108.0±31.93	<0.01
VLDL	26.78±6.88	24.13±4.62	<0.01
TC/HDL	4.38±1.34	3.68±0.96	<0.01
LDL/HDL	2.77±1.22	2.18±0.84	<0.01
FBS	98.45±12.43	92.24±9.98	<0.05
PMBS	119.63±14.55	111.78±12.88	<0.01

Values expressed in mean±SD of mg/dl for TC, TG, HDL, LDL, VLDL, FBS and PMBS,

Values expressed in mean ±SD of ratio for TC/HDL, LDL/HDL,

P<0.05 is considered as significant,

p as determined by paired 't' test.

TC=total cholesterol, TG= triglycerides, HDL=high density lipoprotein, LDL= low density lipoprotein, VLDL=very low density lipoprotein, FBS= fasting blood sugar, PMBS= post meal blood sugar.

IV. Results And Observations

In the present study it was found that the pulse rate was decreased significantly ($p<0.05$) at 60 days in Group II, III .Also pulse rate was significantly reduced at 90 days in group I ,II, and group III ($p<0.001$). [Table 1-3] RR decreased significantly at 60 day in group I, and II with $p<0.01$ while in group III with $p<0.05$. This significant decrease continued at 90 days also with group II and III (<0.01) and group I ($p<0.001$). [Table 1-3]

Present study showed significant decrease in SBP beginning at 30 days. And it was very highly significant ($p<0.001$) in-group II as compared to others. At 60 and 90 days all the groups had highly significant decrease in SBP ($p<0.001$). [Table 1-3]

Present study showed significant decrease in DBP at 30 days in Group II and III ($p<0.05$, $p<0.01$ respectively) while at 60 and 90 days the entire groups showed significant decrease. [Table 1-3]

Mean blood pressure showed significant decrease at 30 days in groups II, III ($p<0.001$) and at 60 days in Group I ($p<0.001$) compared to day 0 values. [Table 1-3]

In our study it was found that only Group II had significant ($p<0.001$) reduction in PP at 30 days. The decrease in PP was significant in Group II and III ($p<0.001$ and $p<0.01$ respectively) at 60 days. At the end of the trial, all the groups had, very highly significant decrease in PP with $p<0.001$. [Table 1-3]

In present study decrease in the total cholesterol was found in all the groups at 90 days. The decrease was significant ($p<0.05$) for Group II and III while it was highly significant in Group I ($p<0.01$). [Table 4-6]

After yoga, at 90 days, the reduction in the serum triglycerides levels was found in all the groups in the present study. The decrease was significant ($p<0.05$) in Group I and II, while it was highly significant ($p<0.01$) in Group III [Table 4-6]

After 90 days of yogic practices significant ($p<0.05$) increase in the HDL level was found in Group III. Increasing levels of HDL were observed in Group II and I though the changes were not significant at 90 days. [Table 4-6]

Present study found highly significant reduction in the LDL levels after yoga therapy in Group I, II and III ($p<0.01$) [Table 4-6]

Study showed changes in the VLDL levels parallel to TG levels in all the three groups. The decrease was significant in Group I and II ($p<0.05$) and was highly significant in Group III ($p<0.01$). [Table 4-6]

The present study found higher TC/HDL ratio and LDL/HDL ratio in Group II, III as compared to Group I at baseline. Ninety days of yoga therapy resulted in significant reduction ($p<0.01$) in Group I, II and III [Table 4-6]

V. Discussion

The present study was aimed to assess the extent of impact of yogic practices in persons above 40 years having different physiological conditions i.e. in healthy subjects with normal physiology and in hypertensive subjects i.e. with altered physiology.

Physiological parameters were studied at the beginning of the study and thereafter, every 30 days, till the end of the study i.e. 90 days. Biochemical parameters were assessed at the start and completion of the study. In the present study the significant decrease in **pulse rate** started at 60 days in Group II and III while at 90 days in group I. [Table 1-3]. Many studies depicted changes in pulse rate with yogic practices.^{10,11,12,13,14} The decrease in pulse rate was significant except in the study of Nayar HS. Yoga brings about the behavioural change, which is the cortical influence along with influence of limbic system on hypothalamus.¹⁵ The result is increased parasympathetic tone and reduced sympathetic tone. The pulse rate decreases mainly because of increased parasympathetic tone.^{16,17} Yoga by modifying the stage of anxiety reduces stress induced sympathetic overactivity.^{17,18}

It was found in the present study that yoga causes reduction in the **respiratory rate** (RR). RR decreased significantly at 60 day in all the groups. This significant decrease continued at 90 days also. [Table 1-3] . No significant difference of change in the respiratory rate and pulse rate was found in between the groups. [Table 7-9]. The decrease in the respiratory rate shows the shift to a relative parasympathetic dominance from earlier sympathetic dominance.¹⁰ The decrease may also be due to the psychosomatic relaxation caused by the yogic practices.

Significant decrease in **SBP** was observed at the beginning at 30 days in all the groups and it was very highly significant in-group II. While at 60 and 90 days all the groups showed very highly significant decrease in SBP. [Table 1-3] . The change in the SBP from baseline at 30, 60 and 90 days is highest in group II than group I and III. Thus it can be said that yoga is more beneficial in reducing the SBP if given earlier in the course of disease. This may be because the SBP, which is prone for fluctuations due to various arousal responses, undergoes fewer alterations after yoga, as yoga decreases the sympathetic arousal response and stress induced reactions. Our findings are in consistence with many studies.^{20,10,11,12,13,14} Dhameja et al ,concluded that, yoga decreases blood pressure and oxidative stress in patients with hypertension.²¹ Jayaram et al and Mohd Noor jahan begum et al observed significant decrease in SBP and DBP in subjects who have practiced yoga along with pranayam technique^{22,23}

Yoga brings about behavioral change through its effect on hypothalamus causing increase in the parasympathetic tone and reduction in the sympathetic tone which was also confirmed by **Singh S et al**¹⁴. Dorsomedial hypothalamic nucleus plays a key role in integrating the cardiovascular response to stress.²⁰ The increase in the baroreceptor sensitivity after yoga in hypertensive subjects also shows the predominance of parasympathetic activity. There is progressive attenuation of sympatho-adrenal axis and renin-angiotensin activity after yoga.²⁴ It was suggested that insulin resistance with reactive hyperinsulinemia might lead to hypertension through mechanisms like increased sympathetic nervous system activity, enhancement of sodium retention, alteration of cation transport, hypertrophy of vascular smooth muscle cells and stimulation of renin-angiotensin system.^{25,26} The reduction in SBP may be due to decrease in the insulin resistance and associated hyperinsulinemia.

In the present study significant decrease in DBP started at 30 days in Group II, III and at 60 in Group I which further continued till the completion of study. [Table 1-3]. Others studies are also having findings similar to us^{20,10,11,12,13,14}. Yoga was found to reduce the DBP along with the SBP. It is because of the relaxation effect of yoga which decreases the sympathetic tone which in turn reduces the peripheral resistance and thereby the DBP.¹⁹ This may be due to the cognitive restructuring with sensory and motor attenuation leading to decreased arousal to external stimuli.²⁷ The decrease in the DBP after yoga in our study can be beneficial as DBP is also related to the risk of cardiac events in hypertensive subjects.²⁸

Mean blood pressure (MBP) was significantly decreased at 30 days in groups II, III and at 60 days in Group I compared to day 0 values. [Table 1-3]. The decrease in the mean blood pressure was due to decrease in the DBP along with decrease in the pulse pressure. Our results were in accordance with **Madanmohan et al**¹² And **Vijayalakshmi et al**¹³ also found significant ($p<0.001$) reduction in MBP in hypertensive subjects after yoga training.

The reduction in **pulse pressure** (PP) was seen at different time periods in different groups. The decrease started at 30 days in Group II, at 60 days in Group III and continued at 90 days. The decrease in PP may be due to more reduction in the SBP than the DBP. While **Madanmohan et al**¹² stated non significant change in PP in normal healthy volunteers. **Vijayalakshmi et al**¹³ found significant ($p<0.0001$) reduction in the PP in hypertensive subjects after yoga training. Pulse pressure which is the pulsatile blood pressure index is an independent risk factor for cardiac events in essential hypertension.^{28,29} The greater reduction in PP in Group II may indicate the salutary effect of yoga in the earlier phases of the course of the disease.

Biochemical Parameters: -

Various parameters included in lipid profile are associated with the risk of cardiac events in subjects of essential hypertension.³⁰ After yogic practices for 90 days the lipid profile shifted toward favourable site in all the groups i.e. there was significant decrease in total cholesterol (TC), Triglycerides (TG), low density lipoproteins (LDL), very low density lipoprotein (VLDL) while in Group III there was significant increase in high density lipoproteins (HDL). [Table 4-6]

Variable effects of yoga on lipid profile were observed in many studies. Yoga decreased serum cholesterol levels in normal and hypertensive subjects in our study. In accordance to our findings **Khare et al**³¹ found significant ($p<0.005$) decrease in diabetic subjects after yoga. **Damodaran et al**¹⁰ and **Bhagal et al**³¹ found decrease in the cholesterol and TG levels after yoga in hypertensive subjects and meditation in normal subjects respectively but the results were not significant.

Increased levels of plasma cortisol and blood glucose and increased levels of atherogenic lipids, serum TGs and TC occur in essential hypertension.³³ This is due to the response of hypothalamo-pituitary axis to stress. As yoga causes balance between the components of the autonomic nervous system, the exaggerated response of the hypothalamus and the limbic system to stress is blunted leading to favorable change in the cholesterol levels.

Regular exercise reduces plasma total and unesterified cholesterol and adipose tissue phospholipids. This may be due to increased plasma lecithin-cholesterol acyl transferase (L-CAT) playing an important role in the cholesterol transport.³⁴

TGs can act as an independent risk factor for CHD. It is also called as ugly fat.³⁵ The reduction in the TGs and increase in the HDL cholesterol found in our study could be due to hydrolysis of TG rich lipoproteins that simultaneously replace intramuscular fat used during pranayama and yogic practices.³⁶ It seems quite probable that increased physical activity leads to lower plasma TG concentration and ultimately increased plasma HDL cholesterol. Physical activity and HDL appear to be linked via HDL's role in TG metabolism.³⁶ The psychosomatic stress or the oxidative stress causes decreased HDL levels due to its increased utilization in scavenging the free radicals.³⁷ The subjects who are already having the disease i.e. Group III may be under more stress which is relieved after the yoga therapy and hence the concentration of HDL increased significantly in these groups after yoga. Group II and I, which showed increasing levels in the HDL, may have significant increase with further continuation of yoga.

There are very few studies showing the consistent effects of yoga on LDL. **Prasad KKK et al**³⁶ showed significant reduction in TGs, VLDL and significant elevation of HDL cholesterol in men after yoga training while in women there was significant decrease in serum cholesterol TG, LDL and VLDL. The results were attributed to the gender difference by the author. **Bijalani et al**³⁸ had found significant decrease in all components of lipid profile after yoga except HDL which was elevated significantly. Moderate physical activity and not severe one can reduce the LDL cholesterol. Yoga postures that are equivalent to moderate exercise caused decreased LDL. Present study showed changes in the VLDL levels parallel to TG levels in all the three groups. The total cholesterol (or LDL cholesterol) to HDL cholesterol ratio represents a simple, efficient way to help estimate coronary disease risk. The present study found higher TC/HDL ratio in Group II, III as compared to Group I at baseline. Ninety days of yoga therapy resulted in significant reduction ($p<0.01$) in Group I, II and

III [Table 4-6] . Thus yoga causes reduction in the risk for CHD in these subjects. Similar to TC/HDL ratio ,the LDL/HDL ratio was also found to be significantly decreased ($p<0.01$) in Group I, II and III ,further confirming the reduction in the risk of CHD after yoga. [Table 4-6] In hypertension whether newly diagnosed or already diagnosed, there is restoration of the altered parameters towards normal. We can conclude that yoga is beneficial not only in normal persons but also in newly diagnosed stage 1 hypertensive subjects or previously diagnosed hypertensives.

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