Hypertension Research (2015) 38, 48–55

www.nature.com/hr

ORIGINAL ARTICLE

Additional benefit of yoga to standard lifestyle modification on blood pressure in prehypertensive subjects: a randomized controlled study

Ramkumar Thiyagarajan[1], Pravati Pal[1], Gopal Krushna Pal[1], Senthil Kumar Subramanian[1], Madanmohan Trakroo[2], Zachariah Bobby[3] and Ashok Kumar Das[4,5]

High blood pressure (BP) is a known risk factor for cardiovascular disease morbidity. Considering the growing evidence of nonpharmacological interventions in the management of high BP, we designed a randomized, parallel active-controlled study on the effect of yoga and standard lifestyle modification (LSM) on BP and heart rate in individuals with prehypertension (systolic BP 120–139 mm Hg and/or diastolic BP 80–89 mm Hg). Volunteers (20–60 years) of both genders without any known cardiovascular disease were randomized into either LSM group ($n=92$) or LSM + yoga group ($n=92$). Before the intervention, age, waist circumference, physical activity, BP and fasting plasma glucose and lipids were comparable between the groups. After 12 weeks of intervention, we observed a significant reduction in the BP and heart rate in both the groups. Further, the reduction in systolic BP was significantly more in LSM + yoga group (6 mm Hg) as compared with LSM group (4 mm Hg). In addition, 13 prehypertensives became normotensives in LSM + yoga group and four in LSM group. The results indicate efficacy of nonpharmacological intervention and the additional benefit of yoga to standard LSM. Further research in this field may add to the level of evidence on the benefit of yoga, in the reduction of BP in high BP subjects, in the scientific literature.
Hypertension Research (2015) **38,** 48–55; doi:10.1038/hr.2014.126; published online 4 September 2014

Keywords: blood pressure; lifestyle modification; prehypertension; yoga therapy

INTRODUCTION

Cardiovascular disease (CVD) is a major health problem in developing countries.[1] One of the major risk factors contributing to increase in CVDs is high blood pressure (BP).[2] Even a mild increase (starting from 115/75 mm Hg) in BP is considered a threat, leading to CVDs.[3] In the society, this level of rise in BP is often ignored and is not considered as a health risk, as it is asymptomatic. Therefore, in 2003, the seventh report of Joint National Committee for prevention, detection, evaluation and treatment of high blood pressure (JNC 7) emphasized the term 'prehypertension,' that is, systolic BP of 120–139 mm Hg and/or diastolic BP of 80–89 mm Hg.[4] Individuals with prehypertension hold more than threefold risk for developing hypertension and CVD in the future when compared to individuals with normal/optimal BP.[5] Recent studies have reported increased cardiovascular risk in prehypertensive subjects, in Indian population.[6,7]

After considering the CVD risk in individuals with prehypertension and the direct correlation of level of BP with CVD mortality, JNC 7 also emphasized the use of standard lifestyle modification (LSM), as a preventive strategy, to prehypertensive individuals without the use of any anti-hypertensive drugs.[4] Standard LSM includes weight reduction, salt restriction, DASH (dietary approach to stop hypertension) eating plan, brisk walking and moderation of alcohol.[4] Many studies have reported the reduction in BP after LSMs[8–11] as compared with the unhealthy lifestyle, which in turn may lead to CVD mortality.

Yoga being a form of lifestyle intervention is socioculturally acceptable to Indians.[12] Previous studies have demonstrated improved BP and overall CVD risk in both healthy and CVD risk subjects, after yoga intervention.[13–19] However, no randomized controlled studies in the literature included prehypertensive subjects (without known CVDs) alone, to demonstrate the effect of yoga therapy along with standard LSM on BP reduction. Therefore, in the present study, we investigated the effects of standard LSMs and yoga therapy on BP and heart rate (HR) in prehypertensive subjects, and the additional efficacy of yoga therapy over standard LSMs.

[1]Department of Physiology, Jawaharlal Institute of Postgraduate Medical Education and Research, Puducherry, India; [2]Department of Physiology, Mahatma Gandhi Medical College and Research Institute, Puducherry, India; [3]Department of Biochemistry, Jawaharlal Institute of Postgraduate Medical Education and Research, Puducherry, India; [4]Department of Medicine, Jawaharlal Institute of Postgraduate Medical Education and Research, Puducherry, India and [5]Department of Endocrinology, Jawaharlal Institute of Postgraduate Medical Education and Research, Puducherry, India
Correspondence: Dr Professor P Pal, Department of Physiology, Jawaharlal Institute of Postgraduate Medical Education and Research (JIPMER), Puducherry 605 006, India.
E-mail: drpravatipal@gmail.com
Received 6 January 2014; revised 2 April 2014; accepted 13 June 2014; published online 4 September 2014

METHODS

The study was commenced after approval from the Jawaharlal Institute of Postgraduate Medical Education and Research (JIPMER) Scientific Advisory Committee and JIPMER ethics committee for human studies. This is a parallel active-controlled, randomized, unblinded study.

Subject recruitment

We conducted seven hypertension screening camps in Puducherry, India, during the period of August 2010 to February 2013 to recruit prehypertensive subjects. In the camp, after a period of comfortable rest, BP was recorded three times with 5 mins interval between the recordings, using an automatic BP monitor (CH432B, Citizen Systems Japan, Tokyo, Japan). The average of these three recordings was considered as the final reading. Prehypertensive subjects in the age group 20–60 years of both genders without any known CVD ($n = 266$) were asked to report to our lab.

Laboratory measurement

The volunteers reported to Autonomic lab in the Department of Physiology, JIPMER, Puducherry, between 0700 and 0900hours, after overnight fasting. The BP was recorded once again in the lab with the same instrument used in camp, in sitting position after comfortable rest. Two readings were taken with 5 mins interval and the average of the readings was considered for categorizing the volunteers. A total of 192 prehypertensives were included in the study after considering the inclusion (systolic BP 120–139 mm Hg and/or diastolic BP 80–89 mm Hg) and exclusion (history of chronic illness, CVDs, diabetes, primary autonomic insufficiency, kidney diseases, sports person, under medication for prehypertension and chronic disease) criteria and after obtaining the written informed consent. The details of subject recruitment and categorization are depicted in Figure 1.

Their personal history like alcohol and smoking habits (number of packs per month), occupational status, medical history and family history of hypertension and diabetes (first-degree relatives) were also recorded. The calorie intake of each was calculated with the help of a dietitian using the dietary guidelines for Indians.[20] The physical activity of the participants was recorded, based on their activity at work, travel to and from places and recreational activities, using the Global Physical Activity Questionnaire. Physical activity was analyzed in terms of metabolic equivalent, a ratio between the work metabolic rate and the rest metabolic rate. One metabolic equivalent is defined as 1 kcal kg^{-1} h^{-1}.

Anthropometric measurements. Waist circumference was measured mid-way between lower costal border and top of the iliac crest using steel, nonelastic tape (CESCORF Equipamentos para esporte ltda me, Rio Grande do Sul, Brazil). Body mass index (BMI) was calculated using body weight and height of the individual.

Biochemical analysis. The fasting plasma glucose was estimated by glucose oxidase–peroxidase method (Genuine Biosystem, Tamilnadu, India) and the

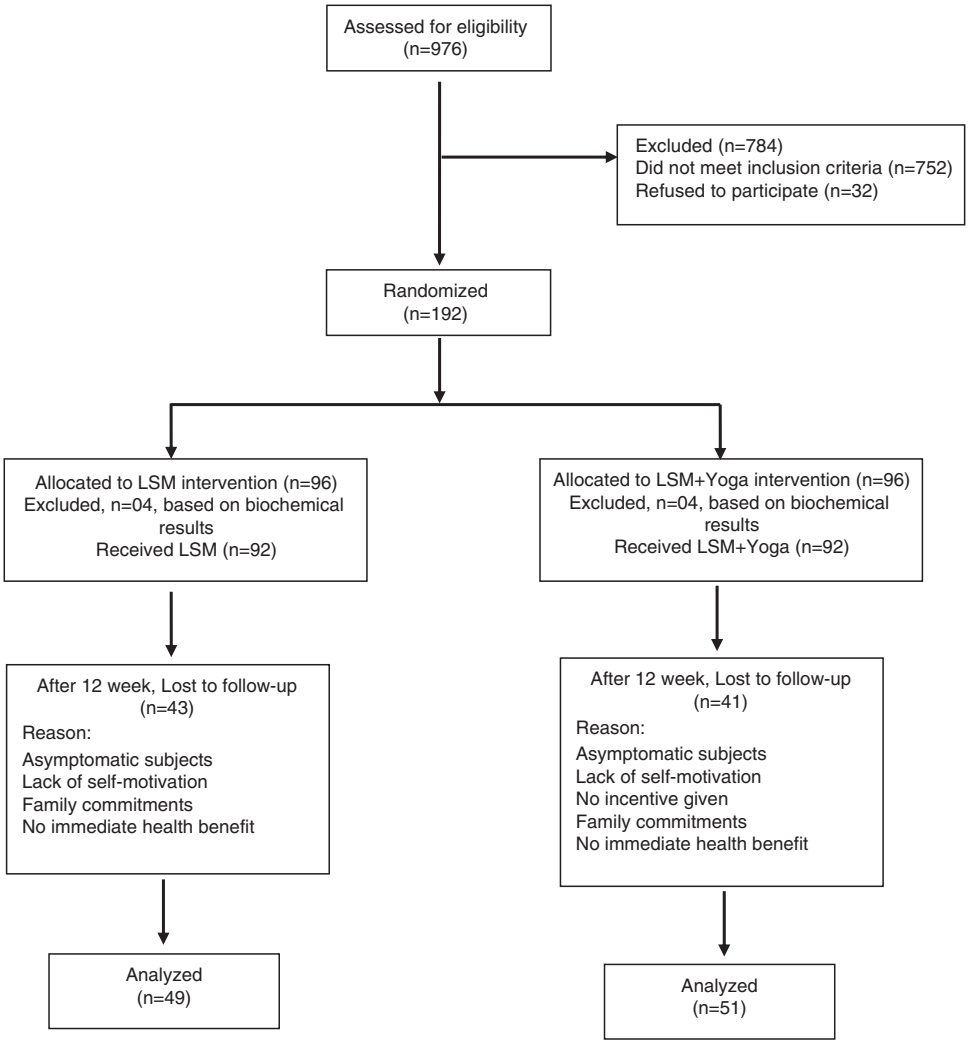

Figure 1 Summary of work.

lipid profile, total cholesterol, triglyceride and high-density lipoprotein cholesterol, was measured by diagnostic kit method (Agappe Diagnostics, Kerala, India) using fully automated clinical chemistry analyzer (AU400; Mishima Olympus Co., Ltd, Tokyo, Japan). Low-density lipoprotein cholesterol and very low density lipoprotein cholesterol were calculated using Friedwald's equation. After the biochemical analysis, eight subjects (four in LSM group and four in LSM + yoga group) who had fasting plasma glucose $>125\,mg\,dl^{-1}$ or total cholesterol $>239\,mg\,dl^{-1}$ or triglyceride $>199\,mg\,dl^{-1}$ were excluded from the study and advised to consult their family physician or referred to the JIPMER outpatient department.

Intervention. Prehypertensive subjects performed 12-week LSM or LSM + yoga intervention.

Standard LSM intervention. In accordance with JNC 7,[4] we emphasized the following to the subjects: reduce dietary salt intake ($\leqslant 6$ g per day) and alcohol consumption, increase fruit and vegetable content in diet as per DASH (dietary approach to stop hypertension) criteria, perform aerobic physical activity ($\geqslant 30$ mins per day, most of the days of the week) and reduce or maintain body weight (maintain between BMI of 18.5–24.9 $kg\,m^{-2}$). To maximize compliance, we advised the subjects to maintain a diary of their daily dietary intake and physical activity. Their doubts were clarified through phone.

Yoga therapy. Yoga therapy classes were conducted in the Advanced Center for Yoga Therapy, Education and Research (ACYTER), JIPMER, Puducherry, India, by the qualified yoga teachers who also conducted yoga classes in the community. We followed the yoga therapy protocol for hypertension designed in ACYTER, JIPMER (Table 1). Each yoga session lasted for 45 mins (see Supplementary Table), thrice a week under supervision, for 12 weeks. Subjects were motivated to do the same at home in the remaining days of the week. Attendance register was maintained, and those who had at least 80% of attendance at the end of 12 weeks of yoga therapy were considered to have completed the study.

For further details about standard LSM and yoga therapy, see Supplementary Information.

Outcomes and end point of the study

Addition of yoga to standard LSM was expected to produce additional benefits in terms of reduction in the BP. Statistically significant difference in systolic BP between LSM and LSM + yoga groups was kept as primary end point of the study.

Randomization

The prehypertensive subjects were randomized into LSM group and LSM + yoga group. Block randomization method was used to generate the allocation sequence with the ratio of 1:1 between LSM and yoga groups. Individuals were allotted to either LSM or yoga group using the serially numbered opaque sealed envelope technique.

The allocation list was prepared by one of the co-authors. The first author of this study enrolled and assigned subjects to the groups. As the comparator agent (LSM intervention) was active controlled, neither the subjects nor the yoga teachers were blinded.

Table 1 Yoga therapy class structure and components

Yoga components	*Duration (min)*
Yogic counseling	
Preparatory practices: Breath–body coordination practices and joint loosening practices	10
Asans: Talasan, Ardhakati chakrasan, Ardh chakrasan, Uttanpadasan, Ardhahalasan, Pavanmuktasan, Sarvangasan, Makarasan, Bhujangasan, Dhanurasan and Vajrasan	14
Pranayam or breathing techniques: Chandranadi, Pranav and Nadishuddhi pranayams	7
Relaxation techniques: Kayakriya in shavasana and shavasan with Savitri pranayam	14

Data analysis

Continuous data were expressed as mean ± s.d., and categorical data were expressed as frequencies. Frequency distributions between the groups were compared using the χ^2-test. Based on the distribution of the data, unpaired Student's *t*-test or Mann–Whitney *U*-test was performed to compare BP, HR and biochemical parameters between the groups before the intervention. Effect of intervention and group was analyzed using repeated measures, analysis of variance with intervention as within-subject factor and group as between-subject factor. Data analysis was performed using the Statistical Package for Social Sciences version 19.0 for Windows (SPSS, Chicago, IL, USA). $P<0.05$ was considered statistically significant.

RESULTS

We included only those subjects who had completed 12 weeks of the particular intervention for statistical analysis (per protocol analysis). A total of 49 prehypertensive subjects completed LSM intervention and 51 completed LSM + yoga intervention with the dropout rate of 46% and 43%, respectively. The recruitment of participants started in August 2010 and ended in February 2013. After 12-week follow-up, final record of test parameters and data entry was completed in June 2013.

Baseline comparison of LSM ($n=49$) and LSM + yoga ($n=51$) groups (that is before intervention)

Demographic profile. Before the intervention, distribution of age (42.47 ± 9.00 and 44.08 ± 9.42), gender (male/female: 31/18 and 31/20), family history of hypertension (34.69 and 37.25%), family history of diabetes (42.86 and 37.25%), history of smoking (22.45 and 19.61%) and alcohol intake (22.45 and 19.61%) were not significantly different between LSM and LSM + yoga group. No significant difference was observed between LSM and LSM + yoga groups in the anthropometric measurements (body weight, waist circumference and BMI) and in the level of physical activity (Table 2).

Basal physiological and biochemical parameters. The basal physiological (BP and HR) and biochemical parameters (fasting plasma glucose and lipid profile) were comparable between LSM and LSM + yoga groups, as depicted in Table 2.

We did not observe a significant difference in the demographic, basal physiological and biochemical parameters in prehypertensive subjects of both groups at the start of the study ($n=184$), data not shown.

Comparison of LSM ($n=49$) and LSM + yoga ($n=51$) groups after 12 weeks follow-up

Demographic profile. Number of smokers decreased after intervention in the LSM + yoga group (19.61–15.68%). Body weight, BMI and waist circumference differed significantly in both the groups after 12 weeks of respective intervention.

Basal physiological and biochemical parameters. Systolic BP, diastolic BP, HR and mean arterial pressure significantly reduced after LSM and LSM + yoga intervention. Fasting plasma glucose and blood lipids (except high-density lipoprotein cholesterol and low-density lipoprotein cholesterol, after LSM intervention) significantly decreased after 12 weeks of LSM and LSM + yoga intervention (Table 2). The effect of both interventions on the systolic and

Table 2 Effect of 12 weeks LSM intervention and LSM + yoga intervention on blood pressure, anthropometric measures, physical activity and biochemical parameters in prehypertensive subjects

Parameters/group	*Before LSM (n = 49)*	*After LSM (n = 49)*	*Before LSM + yoga (n = 51)*	*After LSM + yoga (n = 51)*
Age (year)	42.47 ± 9.00		44.08 ± 9.42	
Gender (male/female)	31/18		31/20	
Systolic BP (mm Hg)	127 ± 5	123 ± 4***	127 ± 6	121 ± 6###
Diastolic BP (mm Hg)	85 ± 4	82 ± 3***	85 ± 4	81 ± 4###
Heart rate (b.p.m.)	77 ± 9	74 ± 8***	75 ± 10	72 ± 9##
MAP (mm Hg)	99.07 ± 3.57	95.45 ± 3.13***	98.86 ± 3.79	94.16 ± 4.40###
Body weight (kg)	69.32 ± 11.72	68.34 ± 11.52***	68.25 ± 9.83	67.12 ± 9.50###
Body mass index (kg m^{-2})	25.71 ± 3.21	25.36 ± 3.12***	25.74 ± 3.52	25.33 ± 3.44###
Waist circumference (cm)	85.49 ± 8.00	85.06 ± 8.00***	83.67 ± 6.62	82.96 ± 6.26##
Physical activity (METs)	412.24 ± 479.94	960.00 ± 443.40***	437.25 ± 411.83	943.14 ± 375.50###
FPG (mg dl^{-1})	93.57 ± 10.88	89.94 ± 7.62***	92.06 ± 13.76	85.92 ± 9.20###
Total cholesterol (mg dl^{-1})	185.14 ± 29.80	176.57 ± 29.87***	184.59 ± 27.32	174.25 ± 27.58###
Triglycerides (mg dl^{-1})	134.53 ± 33.50	118.61 ± 33.05***	133.14 ± 36.71	115.65 ± 30.62###
HDL-C (mg dl^{-1})	37.84 ± 4.28	37.98 ± 4.31	36.45 ± 4.36	37.82 ± 4.56#
LDL-C (mg dl^{-1})	120.40 ± 26.27	114.87 ± 25.96	121.51 ± 25.37	113.30 ± 24.61###

Abbreviations: BP, blood pressure; FPG, fasting plasma glucose; HDL-C, high density lipoprotein cholesterol; LDL-C, low density lipoprotein cholesterol; LSM, lifestyle modification; MAP, mean arterial pressure; MET, metabolic equivalent.
Data are expressed as mean ± s.d.
P-value <0.05 considered statistically significant.
***$P<0.001$, comparison of before LSM group with before LSM + Yoga and after LSM groups.
#$P<0.05$, ##$P<0.01$ and ###$P<0.001$, comparison of before LSM + Yoga group with after LSM + Yoga group.

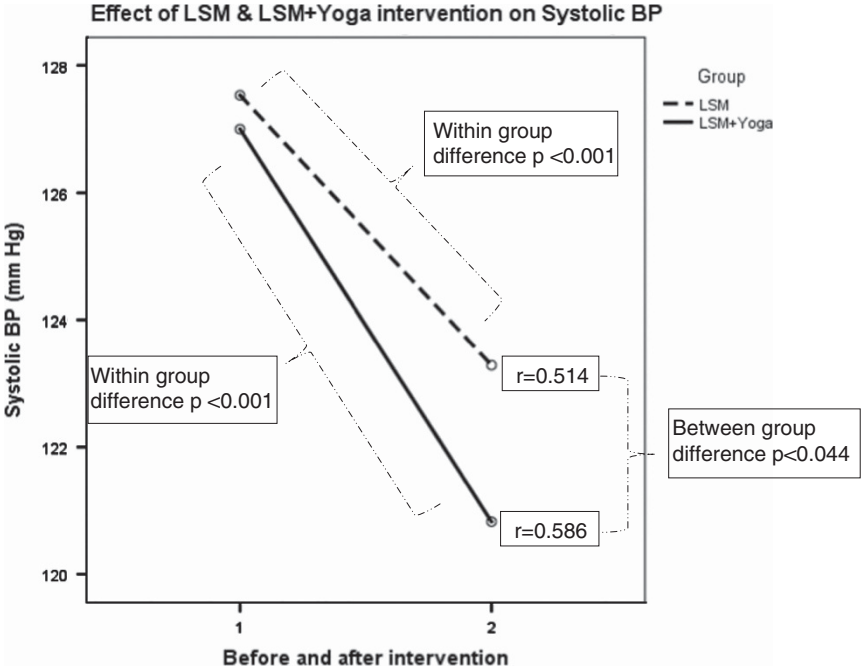

Figure 2 Comparison of effect of 12-week lifestyle modification (LSM) and LSM + yoga intervention on systolic blood pressure (BP) with effect size (*r*) and *P*-value.

diastolic BP is illustrated in Figures 2 and 3, as effect size and *P*-value. The changes in systolic and diastolic BP after 12 weeks of LSM and LSM + yoga intervention (Table 3), and the number of prehypertensive subjects whose systolic BP decreased ($\geqslant$2 mm Hg to $\geqslant$6 mm Hg) after 12-week LSM and LSM + yoga intervention are illustrated in Figure 4. The fall in systolic BP of $\geqslant$4 mm Hg was more in LSM + yoga group (75%) as compared with that in LSM group (55%).

Additional benefit of yoga intervention to LSM intervention

After 12 weeks of intervention, four subjects in LSM group and 13 in LSM + yoga group became normotensives. Systolic BP reduced in 80% and 84% of the subjects in LSM and LSM + yoga groups, respectively, and the diastolic BP reduced in 84% of prehypertensives in LSM group and 88% in LSM + yoga group. The differences in the systolic and the diastolic BP between groups (LSM and LSM + yoga) are depicted in Figures 2 and 3. But when compared with LSM group,

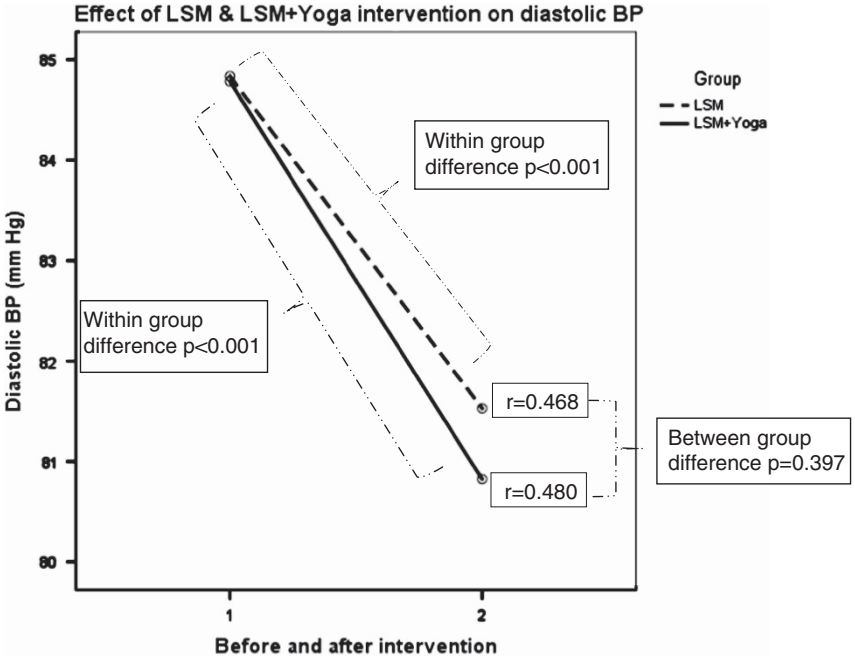

Figure 3 Comparison of effect of 12-week lifestyle modification (LSM) and LSM + yoga intervention on diastolic blood pressure (BP) with effect size (*r*) and *P*-value.

Table 3 Change in systolic and diastolic BP after 12 weeks of LSM or LSM + yoga intervention

BP	*Change in BP after intervention*	*LSM (n = 49); mean ± s.d.*	*LSM + Yoga (n = 51); mean ± s.d.*
Systolic BP	Reduced	*n* = 39; 5.64 ± 3.21	*n* = 43; 7.65 ± 4.36
	No change	*n* = 04	*n* = 02
	Increased	*n* = 06; 2.00 ± 1.10	*n* = 06; 2.33 ± 1.75
Diastolic BP	Reduced	*n* = 41; 4.19 ± 2.81	*n* = 45; 4.84 ± 3.29
	No change	*n* = 02	*n* = 03
	Increased	*n* = 06; 2.33 ± 1.37	*n* = 03; 2.00 ± 0.00

Abbreviations: BP, blood pressure; LSM, lifestyle modification.
Data are expressed as mean ± s.d.

the systolic BP alone significantly reduced in LSM + yoga group (mean difference 1.932, 95% confidence interval 0.061–3.892, $P < 0.05$).

DISCUSSION

Of note, based on the available published literature in the reduction of BP, the class of recommendation of yoga therapy as an alternative approach is 'Class III', that is, no benefit or harm to the individual, and the level of evidence is classified as 'Level C' that is, very limited population is evaluated, and the evidence is based on the consensus opinion of experts and case studies. Because of the paucity of consistent study results, the American Heart Association scientific statement did not recommend yoga as an alternative therapy in clinical practice.[21] This necessitates the need for well designed, reliable randomized controlled studies with structured yoga therapy in the reduction of BP, to augment the efficacy of yoga therapy in the literature.[22]

Novelty of the present study: A few randomized controlled studies have demonstrated the effect of yoga therapy on BP in prehypertensive and stage 1 hypertensive subjects,[13–16] and none of those studies has included the prehypertensive subjects alone. Novelty of the present study is that it explores the effect of yoga therapy on BP in JNC 7-defined prehypertensive subjects alone, without any known CVDs, that is, this is the first randomized controlled study in the scientific literature that reveals the effect of yoga therapy on BP reduction in prehypertensive subjects and explores the efficacy of yoga intervention over standard lifestyle intervention.

Before the intervention, age, waist circumference, BMI, physical activity, BP and fasting plasma glucose and lipids were comparable between the groups—with ($n = 100$) or without ($n = 184$) the dropouts. In within group analysis, we observed significant reduction in BP, HR, waist circumference, BMI, fasting plasma glucose and lipids (except high-density lipoprotein cholesterol and low-density lipoprotein cholesterol in LSM group) in both the groups after the 12 weeks of intervention. But, in the between-group analysis, systolic BP alone was significantly different between LSM and LSM + yoga group, that is, the reduction in systolic BP was more in LSM + yoga group (6 mm Hg) as compared with LSM group (4 mm Hg) after 12 weeks of intervention.

The association between CVD and BP, starting from the BP range of 115/75 mm Hg, is well established, and the risk for developing CVD is doubled with each 20 mm Hg rise in systolic BP and 10 mm Hg in diastolic BP.[3] In previous studies, pharmacological intervention reduced BP in prehypertensive subjects but the effect was associated with adverse side-effects of drugs.[23–26] Thus, a nonpharmacological intervention without any ill effects could be a good alternative. In our study, we observed a significant reduction in both systolic and diastolic BP in both the groups after 12 weeks of intervention. This indicates that the nonpharmacological intervention might be

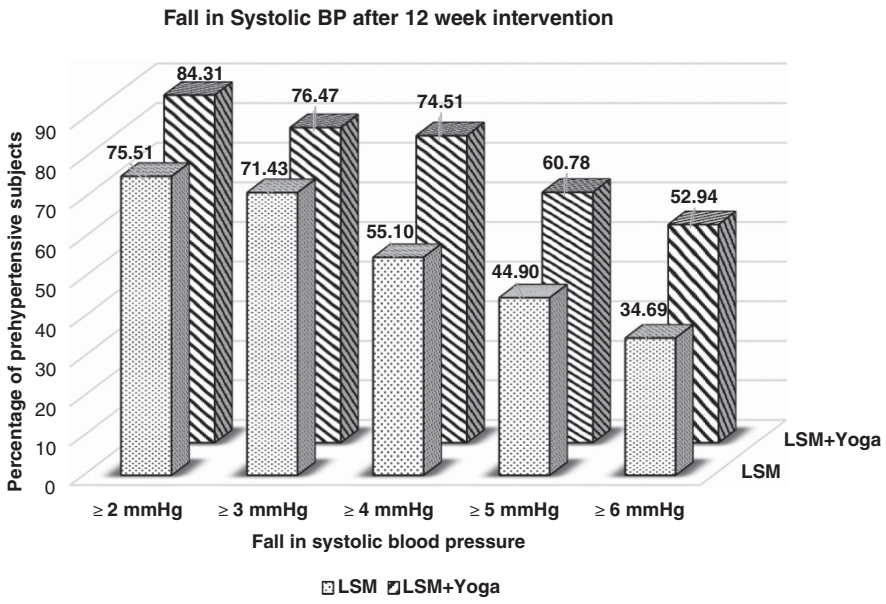

Figure 4 Comparison of fall in systolic blood pressure (BP) after 12 weeks of lifestyle modification (LSM) and LSM + yoga intervention.

adequate to reduce BP in prehypertensive subjects. Previous studies have also demonstrated a significant reduction in BP after a period of LSM[8,9,11,13,15] or yoga therapy[13–15,17–19] intervention.

Framingham's heart study showed that 18–37% individual with prehypertension progress to hypertension in 4 years and the chance increases with age.[27] Subject with prehypertension have threefold increased risk for CVD in the future when compared to subjects with normal BP.[5] In the present study, four prehypertensive subjects in LSM group and 13 in LSM + yoga group became normotensives (systolic BP <120 mm Hg and diastolic BP <80 mm Hg) following 12 weeks of respective intervention. In addition, 39 (80%) prehypertensive subjects in LSM group and 43 (84%) subjects in LSM + yoga group showed reduction in systolic BP (minimum of 1 mm Hg). But the reduction in systolic BP of $\geqslant 4$ mm Hg was more evident in LSM + yoga group (75%) as compared with LSM group (55%). After the intervention, in the LSM + yoga group, more number of prehypertensive subjects returned to normotension and the number of subjects in whom systolic BP fell $\geqslant 4$ mm Hg were more compared with LSM group. This signifies the additional benefit offered by the LSM + yoga combination as compared with LSM alone.

In our study, mean systolic BP reduced by 4 mm Hg and 6 mm Hg after LSM and LSM + yoga intervention, respectively. The number of prehypertensive subjects who showed a fall in systolic BP was consistently more in LSM + yoga group for each mm Hg fall and the difference in the number was more evident after 3 mm Hg fall (Figure 4). Lewington *et al.*[3] demonstrated that the reduction in systolic BP by 2 mm Hg lowers the risk of death due to ischemic heart disease and stroke by 7% and 10%, respectively. In the present study, 75% in LSM group and 84% in LSM + yoga group showed a fall in systolic BP of $\geqslant 2$ mm Hg and thus their risk of death due to CVD is reduced by the respective intervention.

Previous randomized controlled studies demonstrated effect of yoga on BP in subjects with prehypertension and stage 1 hypertension.[13–16] Three[14–16] out of four studies used exercise as the active control, and a study by Cohen *et al.*[13] used usual health care as a comparator arm. In these studies, the fall in systolic BP after yoga therapy was between 2 and 6 mm Hg. Similarly, previous randomized controlled studies[28–33] on the effect of standard LSM on BP was also performed in subjects with prehypertension and stage 1 hypertension, and the fall in systolic BP after the intervention was between 4 and 16 mm Hg. Studies also observed that the reduction in BP was better when LSM components were combined.[29,31,32]

The fall in BP after the intervention is influenced by the level of derangement present in the individuals recruited, that is, the systolic BP fall is more evident in the hypertensive individuals as compared with the group that contains both prehypertensive and hypertensive individuals.[32] The BP is known to be associated with conventional cardiovascular risk factors like age, gender, family history of hypertension and diabetes, physical inactivity, overweight/obesity, hyperglycemia and dyslipidemia. Therefore, in the present study, age, gender distribution and family history of hypertension and diabetes and physical activity were matched between the groups, and the participants with high BMI (obese), high fasting glucose (>125 mg dl^{-1}), high fasting plasma lipids (total cholesterol >239 mg dl^{-1} and triglycerides >199 mg dl^{-1}) were excluded from the study. Nonetheless, previous yoga-based randomized controlled studies[13–16] included both prehypertensive and stage 1 hypertensive subjects, and less number of subjects were studied in each group. The subjects recruited were either in young age or in middle age but not in older age group, except a recent study by Hagins *et al.*[16] Also, the BMI of the subjects recruited were in overweight/obese[13,16] range, and the BMI was not defined in other two studies.[14,15]

Increased HR is directly associated with CVD and mortality, and the chance for cardiovascular events and mortality increases (10–30%) with increasing HR (10 b.p.m.) from basal HR.[34–37] At the same time reduction in HR (10 b.p.m.) decreases the chance of cardiovascular events or mortality by 30%.[38] Clustering of abdominal obesity increased fasting plasma glucose, total cholesterol, triglycerides and low-density lipoprotein cholesterol, and decreased high-density lipoprotein cholesterol increases the prevalence of cardiovascular events and mortality[39] and the acceleration of atherosclerosis. We observed 3 b.p.m. fall in HR in both the groups

after intervention. The reduction in resting HR is significant in terms of possibility of decreased susceptibility to CVD. We also found a significant reduction in the waist circumference, plasma glucose and lipids after 12 weeks of intervention in both the groups.

The mechanism whereby lifestyle intervention lowers BP remains unclear. Probable mechanisms that lower BP through yoga are: relaxation techniques reduce feeling of stress or response to stress or physiological arousal, thereby producing favorable effects on the autonomic nervous system balance[40,41] and slow deep breathing (6 cycles min^{-1}, 0.1 Hz) synchronize with the central nervous firing (vagal nuclei) or entrains with central nervous system nuclei in which respiratory and cardiovascular centers crosstalk, thus favorably altering autonomic outflow (parasympathetic outflow to the heart and/or rhythmic sympathetic outflow to the vasculature).[42] Increased transient bouts of shear stress produced due to aerobic exercise confer a 'vascular conditioning' effect[43] by increasing endothelial nitric oxide synthase levels, which lead to increased bioavailability of nitric oxide, a powerful vasodilator that reduces BP.[44]

Yoga in the form of breathing exercises, breathe synchronized comfortable postures, relaxation practices and meditation is socio-culturally acceptable in many countries. This could be a simple, inexpensive and effective lifestyle intervention in the management of prehypertension.

Limitations

Increased dropout observed in our study in both the groups was in accordance with previous study.[13] The increased dropout may be due to lack of awareness about the disease concern, lack of self-motivation, no obvious symptoms, no immediate health benefits and family commitments. The pathophysiological mechanism and effect of lifestyle intervention and yoga therapy, especially a specific form of breathing practice or asana or relaxation technique, may further be explored at the cellular level and at higher level (functional magnetic resonance imaging). No structured classes were conducted for the subjects who practiced LSM because the study was also intended to improve self-motivation, which could modify their lifestyle after the intervention period, and the change in salt intake or fruit and vegetable consumption were only qualitatively assessed. Therefore, the magnitude of LSM may vary between subjects and groups; even then a significant improvement was observed in most of the parameters studied. Importantly, 24-h ambulatory BP monitoring could have added more information in the clinical setting about the BP of the subjects.

CONCLUSION

In prehypertensive subjects, 12 weeks of standard LSM or LSM + yoga therapy resulted in the reduction of BP, HR, waist circumference, fasting plasma glucose and lipids that are known to be associated with CVD prevalence and mortality. The reduction in systolic BP was significantly more in LSM + yoga group as compared with LSM group. Further research on the beneficial effect of yoga therapy (at behavioral and molecular levels) are warranted to validate the use of yoga therapy as an adjunct to standard LSM, to prevent disease progress, in routine clinical practice.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENTS

We thank Revathi Srinivasan, Senior Dietician, Department of dietetics, JIPMER, Puducherry, for helping us in calculating calorie intake of subjects. We also thank our subjects for participating in this study. The Department of Science and Technology, New Delhi, India, funded the first author through INSPIRE fellowship. I would also like to thank the ACYTER team for their constant support throughout the study.

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Supplementary Information accompanies the paper on Hypertension Research website (http://www.nature.com/hr)