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Effect of yoga on endothelial function, vascular compliance and sympathetic tone in elderly subjects with increased pulse pressure

[1]**Dr Suwaibah Fatima Samer**, Assistant Professor, Department of Physiology, Bhaskar Medical College.
[2]**Dr. Mohammed Anwaar Ahmed**, Assistant Professor, Department of Physiology, Dr. Patnam Mahender Reddy Institute of Medical Sciences.
[3]**Dr. Mohammed Abrar Hassan**, Professor, Department of Physiology, Bhaskar Medical College.

Corresponding Author: Dr Suwaibah Fatima Samer

ABSTRACT

Introduction: Yoga is known to reduce arterial stiffness; however, high-intensity resistance exercise is associated with increased arterial stiffness. Yoga comprises of various domains of practices such as physical postures, regulated breathing, meditation and several other related techniques. Arterial compliance (AC) describes the ability of an artery to distend in response to a change in intravascular pressure; and its impairment is strongly associated with cardiovascular disease (CVD). Thus, AC may be an important risk factor for CVD as well as an early marker to prevent subsequent cardiovascular events. AC can be measured by noninvasive methodologies such as pulse wave velocity (PWV), a technique that determines the change in artery diameter relative to distending pressure using ultrasound and applanation tonometry; and the assessment arterial pressure waveforms.

Materials and method: This study sought to determine the effects of yoga on endothelial function, vascular compliance and sympathetic tone in elderly subjects with increased pulse pressure. The study consisted of one treatment group. The treatment group was used to measure blood pressure, supine blood pressure. The study consisted of one visit where all pre and post measurements took place, as well as yoga. Men and women between the ages of 20 and 75 years were recruited. All participants must have had at least three months of yoga experience in order to qualify for the study to ensure the likelihood of proper execution of the postures.

Result: In our study in Yoga group, Systolic Blood pressure at Baseline was 150.99 mmHg and after 3 months 137.81 mmHg. Whereas Diastolic Blood pressure was 78.20 mmHg and after 3 months 77.20 mmHg. Moreover, Pulse pressure at Baseline was 76.93 mmHg and after 3 months 64.72 mmHg. Whereas, Mean arterial pressure was 102.40 mmHg and after 3 months 97.44 mmHg. In our study in control group, Systolic Blood pressure at Baseline was 149.92 mmHg and after 3 months 150.99 mmHg. Whereas Diastolic Blood pressure was 79.68 mmHg and after 3 months 78.73 mmHg. Moreover, Pulse pressure at Baseline was 74.44 mmHg and after 3 months 76.33 mmHg. Whereas, Mean arterial pressure was 102.99 mmHg and after 3 months 102.69

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mmHg. While comparison between Baseline versus after 3 months in Yoga group statistical Significant and in control group statistical not Significant.

Conclusion: Increased NOx level due to long term yoga may reflect the improved functional status of the vascular endothelial layer. Reduced resting HR, SBP & DBP also indicate the cardiovascular response modulating efficacy of regular yoga training. This also suggestive of improved cardiac endurance and fitness. Elevated NO level is the indicator of improved endothelial functional status. Therefore, it may be concluded that, yoga as a complementary exercise modality to reduce the risk of CVDs in healthy adult individuals.

Keywords: Elasticity, arteries, Endothelial function, vascular compliance, sympathetic tone, Pulse pressure

INTRODUCTION

Yoga is a form of mind-body fitness that involves a combination of muscular activity and an internally directed mindful focus on awareness of the self, the breath, and energy. [1] Four basic principles underlie the teachings and practices of yoga's healing system. The first principle is the human body is a holistic entity comprised of various interrelated dimensions inseparable from one another and the health or illness of any one dimension affects the other dimensions. [2] The second principle is individuals and their needs are unique and therefore must be approached in a way that acknowledges this individuality and their practice must be tailored accordingly. The third principle is yoga is self-empowering; the student is his or her own healer. [3]

Yoga engages the student in the healing process; by playing an active role in their journey toward health, the healing comes from within, instead of from an outside source and a greater sense of autonomy is achieved. The fourth principle is that the quality and state of an individuals mind is crucial to healing. When the individual has a positive mind-state healing happens more quickly, whereas if the mind-state is negative, healing may be prolonged. [4] Other potential mechanisms of action may include decreases in sympathetic nervous system activity or reductions in inflammatory markers. [5] Yoga creates not only inner, physical and emotional balance through the use of postures, called asanas, combined with breathing techniques or pranayama, but also has diverse clinical and non-clinical applications as a result of the degree of complexity and multidimensionality of these exercises. Yoga also may be helpful through reducing anxiety and depression of individuals deal with the emotional aspects of chronic pain. [6]

Arterial compliance (AC) describes the ability of an artery to distend in response to a change in intravascular pressure; and its impairment is strongly associated with cardiovascular disease (CVD). [7] Thus, AC may be an important risk factor for CVD as well as an early marker to prevent subsequent cardiovascular events. [8] AC can be measured by noninvasive methodologies such as pulse wave velocity (PWV), a technique that determines the change in artery diameter relative to distending pressure using ultrasound and applanation tonometry; and the assessment arterial pressure waveforms. [9]

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Vascular aging results in stiffer arteries and vascular endothelial dysfunction, and may have a role in the development of cardiovascular disease. [10] In particular, excess reactive oxygen species production by mitochondria is a key mechanism of aging and age-related vascular dysfunction. [11]

Physical inactivity is an independent risk factor for the deterioration of vascular function, atherosclerosis, and cardiovascular diseases Regular exercise training leads to the prevention of cardiovascular diseases and mortality. Aerobic exercise is known to significantly reduce large artery compliance, one of the parameters of arterial stiffness, in middle-aged and older humans. [12] On the other hand, a previous meta-analysis has shown that resistance exercise does not decrease arterial stiffness in middle-aged subjects. [13]

MATERIALS AND METHODS

This study sought to determine the effects of yoga on endothelial function, vascular compliance and sympathetic tone in elderly subjects with increased pulse pressure. The study consisted of one treatment group. The treatment group was used to measure blood pressure, supine blood pressure. The study consisted of one visit where all pre and post measurements took place, as well as yoga.

Inclusion Criteria:

Men and women between the ages of 20 and 75 years were recruited. All participants must have had at least three months of yoga experience in order to qualify for the study to ensure the likelihood of proper execution of the postures.

Exclusion Criteria: From this study was based upon the following criteria: i) any known CVD; ii) uncontrolled hypertension; iii) personal history of a stroke; iv) and insulin dependence.

Procedures: Potential participants were prescreened via health history questionnaires and information about past medical history, current medication use, smoking history, and weekly physical activity was obtained. Testing procedures and study involvement was described by the investigator or a member of the research team. Participants reported to the Cardiovascular Physiology Research Laboratory for one testing session.

Each session included: 6 seated blood pressure measurements (3 before the yoga session and 3 following the session); and 2 supine blood pressure measurements (1 before and 1 after the yoga session). Seated blood pressure was measured after 5 minutes of rest with the participant seated and their legs uncrossed. Once completed, the following ensued: completion of PANAS (Positive and Negative Affect Schedule) survey; height and weight measurements; body mass index (BMI) calculation; and augmentation index and pulse wave velocity assessments.

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For vascular measures, participants lay down for a minimum of 5 minutes. PWV and AIx, two indices of AS were measured non-invasively using the SphygmoCor CvMS device. For AIx, a tonometer was placed over the radial artery in order to obtain continuous blood pressure measurements. For PWV, proximal and distal measurements in millimeters was completed. The proximal measurement was the distance between the carotid artery and the sternal notch and the distal measurement was the distance between the sternal notch and belly button, plus the distance from the umbilicus to the femoral artery.

Electrodes were placed on both wrists and the left hip area to obtain heart rate during this measurement. PWV was determined by dividing the distance between artery sites by transit time. Once in place, the tonometer was placed over the carotid artery in order to obtain ten consistent waveforms. The process was completed for the femoral artery as well. The combination of blood pressure 14 waveforms along with the ECG results were analyzed by the device to yield both augmentation index and carotid-femoral PWV. Once the vascular measurements were completed, the participant was taken to the yoga room, where they completed one hour of an advanced guided yoga (Strong Vinyasa Flow Yoga for Strength and Stamina with Jenni Rawlings, 2013). Following the completion of the yoga routine, the participant was escorted back to the laboratory by a member of the research team in order to obtain post-exercise measurements which included all of the procedures described above except height and weight measurements.

Statistical Analysis

Data normality was assessed using the Shapiro-Wilk test. If the data were normally distributed, paired t-tests were used to compare pre- and post-intervention means for our outcome variables. Statistical significance was set a priori at $P \leq 0.05$ for all tests.

RESULTS

Table 1 Heart rate variability: Baseline and post-intervention values of Yoga group participants

Variable	Baseline		After 3 months		t / z value	p Value
	Mean	SD	Mean	SD		
LF (nu)	82.89	10.15	80.45	10.69	-6.520	0.020**
HF (nu)	25.29	10.15	27.93	10.75	-6.840	0.010**
LF/HF ratio	8.05	5.19	7.55	2.99	-6.499	0.000***

P<0.05. P<0.01. P<0.001

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Table 2 Heart rate variability: Baseline and post-intervention values of control group participants.

Variable	Baseline		After 3 months		t / z value	p Value
	Mean	SD	Mean	SD		
LF (nu)	81.99	13.29	84.45	8.40	-4.792	0.095
HF (nu)	25.13	13.69	23.69	8.43	4.020	0.40
LF/HF ratio	8.20	5.68	8.40	4.33	-2.921	0.45

P<0.05. P<0.01. P<0.001

Table 3 Vascular stiffness: Baseline and post-intervention values in Yoga group.

Variable	Baseline		After 3 months		t / z value	p Value
	Mean	SD	Mean	SD		
baPWV (m/s)	21.65	8.44	20.31	7.63	-6515	0.000***
c-f PWV (m/s)	15.74	6.59	14.83	6.20	8.515	0.000***
AIx@75 (%)	36.99	17.88	34.14	14.63	-6.90	0.005**
Basi	34.40	13.91	32.40	10.51	4.735	0.099
aASi	49.9	14.93	42.99	14.51	8.070	0.000***

P<0.05. P<0.01. P<0.001

Table 4 Vascular stiffness: Baseline and post-intervention values in control group

Variable	Baseline		After 3 months		t / z value	p Value
	Mean	SD	Mean	SD		
baPWV (m/s)	20.99	7.24	21.9	8.09	-4.320	0.215
c-f PWV (m/s)	15.45	6.18	15.79	6.73	-4.288	0.220
AIx@75 (%)	33.22	15.55	33.79	6.73	-4.288	0.865
Basi	35.8	12.64	35.9	12.99	-2.299	0.780
aASi	48.33	14.83	49.9	14.79	-4.099	0.292

P<0.05. P<0.01. P<0.001

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Table 5 Blood pressure: Baseline and post-intervention values in Yoga participants

Variable	Baseline		After 3 months		t / z value	p Value
	Mean	SD	Mean	SD		
SBP (mmHg)	150.99	9.80	137.81	9.99	-8.80	0.000***
DBP (mmHg)	78.20	8.69	77.20	8.10	-4.10	2.320
PP (mmHg)	76.93	9.79	64.72	9.69	15.45	0.000***
MAP(mmHg)	102.40	8.39	97.44	8.30	11.60	0.000***

P<0.05. P<0.01. P<0.001

In our study in Yoga group, Systolic Blood pressure at Baseline was 150.99 mmHg and after 3 months 137.81 mmHg. Whereas Diastolic Blood pressure was 78.20 mmHg and after 3 months 77.20 mmHg. Moreover, Pulse pressure at Baseline was 76.93 mmHg and after 3 months 64.72 mmHg. Whereas, Mean arterial pressure was 102.40 mmHg and after 3 months 97.44 mmHg.

Table 6 Blood pressure: Baseline and post-intervention values in control group participants Variable

Variable	Baseline		After 3 months		t / z value	p Value
	Mean	SD	Mean	SD		
SBP (mmHg)	149.92	9.7	150.99	9.40	-0.84	0.55
DBP (mmHg)	79.68	9.60	78.73	8.49	4.65	0.20
PP (mmHg)	74.44	9.90	76.33	9.60	-4.88	0.10
MAP(mmHg)	102.99	9.28	102.69	8.10	0.79	0.60

P<0.05. P<0.01. P<0.001

In our study in control group, Systolic Blood pressure at Baseline was 149.92 mmHg and after 3 months 150.99 mmHg. Whereas Diastolic Blood pressure was 79.68 mmHg and after 3 months 78.73 mmHg. Moreover, Pulse pressure at Baseline was 74.44 mmHg and after 3 months 76.33 mmHg. Whereas, Mean arterial pressure was 102.99 mmHg and after 3 months 102.69 mmHg.

DISCUSSION

We found, highly significant increase in post-yogic NOx level and reduction in resting HR, SBP & DBP compared to their respective baseline values. Further, correlation showed significant. Further, correlation showed significant (p reduction in resting SBP & DBP with post-yogic NOx. Significant increased level of total plasma NO level after long term yoga practice was one of the novel finding of our study. The outcome of this study is in accordance with the finding of Preethi Bangalore Lakshmangowda, et.al.[14] Patil SG et.al[15] had reported the significant increase in NO level in yoga practicing elderly subjects which resulted in reduction in arterial stiffness. Another study has reported the NO elevating effect of Bhramari Pranayama.[16] A range of studies showed exercise stimulates NO release from the endothelial cells. [17]

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Increased blood flow through vessels is identified as the root cause of endothelial release of NO. [18] The exact mechanism behind the elevated post-yogic NOx remained unclear. However, we presume that it is most likely the stimulation to increased blood flow due to yoga practice have caused the sheer force over the endothelium. As a consequence, it releases more NO than normal. Our finding regarding significant reduction of Resting HR was consistent with the findings of various researchers. [19] According to theme, that was probably due to stronger vagal activation and balance in autonomic activities caused by yoga practice. On that context, we attribute the reduction in post-yogic Resting HR to increased vagal tone, deep psychosomatic relaxation and reduction in exercise induced stress on cardiovascular system over the period of yoga training.

The Our findings i.e. significant reduction in postyogic Resting SBP & DBP compared to their respective baseline values were similar with the outcomes of various studies. [20] It is suggested that the arterial stiffness causes not only elevation of resting BP but also influence BP responses to exercise. [21] Arterial stiffness not only decided by the structural components but also by vascular tone and endothelial functional status. It is implied that NO and vascular tone are the key components in the regulation of arterial stiffness therefore they are vital determinants for exercise induced BP response. A study reveals that, pharmacological inhibition of NO synthase increases BP during sub-maximal level of exercise. [22]

Hence, it may be assumed that, reduction in Resting SBP & Resting DBP might by due to increased parasympathetic activity, reduced vascular tone; increased cardiopulmonary endurance, blood flow to the muscles at rest; elevated post-yogic NOx might have increased vasodilatory effect, decreased arterial stiffness which collectively have caused significant reduction Resting SBP & DBP after long term yoga training.

Conclusion

Increased NOx level due to long term yoga may reflect the improved functional status of the vascular endothelial layer. Reduced resting HR, SBP & DBP also indicate the cardiovascular response modulating efficacy of regular yoga training. This also suggestive of improved cardiac endurance and fitness. Elevated NO level is the indicator of improved endothelial functional status. Therefore, it may be concluded that, yoga as a complementary exercise modality to reduce the risk of CVDs in healthy adult individuals.

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