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

[1]Dr. Suri Srinivasa Ravikiran
Assistant Professor Maheswara Medical College, Hyderabad
[2]Dr. P. Jayanth Kumar,
Associate Professor, Department of Physiology, ASRAM Medical College, Eluru.
[3]Dr. Katta Sreenivas Reddy,
Assistant Professor, GSL Medical College Rajahmundry
Corresponding Author: Dr. P. Jayanth Kumar,
Associate Professor, Department of Physiology,
ASRAM Medical College, Eluru.

ABSTRACT

Introduction: Yoga is known to reduce arterial stiffness; however, high-intensity resistance exercise is associated with increased arterial stiffness.

Materials and methods: We determined the role of habitual exercise on the age-related decrease in central arterial compliance by using both cross-sectional and interventional approaches. First, we studied 151 healthy men aged 18 to 77 years: 54 were sedentary, 45 were recreationally active, and 53 were endurance exercise–trained. Central arterial compliance (simultaneous B-mode ultrasound and arterial applanation tonometry on the common carotid artery) was lower (P,0.05) in middle-aged and older men than in young men in all 3 groups.

Result: In a frequency domain analysis of HRV, we found a significant decrease in LF component from 80.85 nu to 78.42 nu (p=0.015) and LF/HF ratio from 6.02 to 5.49.

Conclusion: Twelve weeks of yoga or stretching video classes promoted positive changes in several outcomes generally regarded as cardiovascular risk factors in HPMWs, and these changes were even more pronounced by the association with respiratory technique.

Keywords: hypertension, arterial stiffness, endothelial function, yoga, breathing, oxidative stress

INTRODUCTION

Yoga comprises of various domains of practices such as physical postures, regulated breathing, meditation and several other related techniques. One study found that gray matter volumes were higher in those who were practicing hatha yoga and meditation for a long time as compared with controls not practicing yoga. [1] There is some evidence that meditation alone too provides neuroprotective effects by the way of increasing cortical thickness and that older people have advantage in getting this benefit of meditation. [2] We found elevations in serum brain-derived neurotrophic factor (BDNF), a neuroprotective chemical, after 3-month Yogāsana and Prāṇāyāma therapy in adults with depression. [3] BDNF is highly expressed in the hippocampus. [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]

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 [12] 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. [13] On the other hand, a previous meta-analysis has shown that resistance exercise does not decrease arterial stiffness in middle-aged subjects. [14]

MATERIALS AND METHODS

This is a prospective study was conducted in the Department of Physiology, Tertiary Care Teaching Hospital over a period of 1 year. We studied a total of 151 healthy men. Subjects were older (aged 50 to 77 years). For at least the previous 2 years, subjects were either sedentary (no regular physical activity), recreationally active (light to moderate exercise 3 times per week), or endurance-trained (vigorous aerobic-endurance exercise $5 times per week and active in local road running races). For protocol II, 20 healthy older sedentary subjects were studied before and after 3 months of Yoga training.

Inclusion Criteria

All subjects were normotensive (140/90 mm Hg), nonobese, and free of overt chronic diseases as assessed by medical history, physical examination, and complete blood chemistry and hematological evaluation (eg, Plasma Glucose concentration 140 mg/dL, Total cholesterol 240 mg/dL) were included. Men aged 50 years were further evaluated by ECG at rest and, along with blood pressure, during incremental treadmill exercise performed to exhaustion.

ISSN:0975 -3583,0976-2833 VOL14, ISSUE 03, 2023

Exclusion Criteria

Candidates who smoked in the past 4 years, were taking medications, or had significant intima-media thickening, plaque formation, and/or other characteristics of atherosclerosis were excluded.

All subjects gave their written informed consent to participate. All procedures were reviewed and approved by the Human Research Committee.

Measurements

Before they were tested, subjects abstained from caffeine and fasted for at least 4 hours (a 12-hour overnight fast was used for determination of metabolic risk factors). Subjects were studied 20 to 24 hours after their last exercise training session to avoid the immediate (acute) effects of exercise, but they were still considered to be in their normal (ie, habitually exercising) physiological state.

Statistical Analyses

Two-way (age physical activity status) ANOVA was used to assess the results of protocol I. Repeated-measures ANOVA was used to examine the results of protocol II. In the case of a significant F value, a post hoc test using the Newman-Keuls method identified significant differences among mean values. Univariate regression and correlation analyses were used to analyze the relations between variables of interest. All data are reported as mean6SE. Statistical significance was set a prior at P<0.05 for all comparisons.

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)	80.85	8.13	78.42	8.63	-4.515	0.015**
HF (nu)	23.25	8.13	25.88	8.71	-4.835	0.009**
LF/HF ratio	6.02	3.15	5.49	1.92	-4.493	0.000***

P<0.05. P<0.01. P<0.001

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)	79.99	11.25	82.40	6.35	-2.788	0.090
HF (nu)	23.09	11.63	21.65	6.38	2.015	0.35
LF/HF	6.15	3.61	6.35	2.28	-1.915	0.43

ISSN:0975 -3583,0976-2833 VOL14, ISSUE 03, 2023

ratio						

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)	19.60	6.42	18.25	5.58	-5.510	0.000***
c-f PWV (m/s)	13.69	4.53	12.78	4.15	6.510	0.000***
AIx@75 (%)	34.99	15.82	32.08	12.58	-4.85	0.005**
Basi	32.35	11.85	30.35	8.45	2.730	0.099
aASi	47.9	12.88	40.99	12.45	6.066	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)	18.95	5.18	19.7	6.07	-2.315	0.210
c-f PWV (m/s)	13.41	4.12	13.75	4.68	-2.283	0.215
AIx@75 (%)	31.7	13.48	31.75	4.68	-2.283	0.860
Basi	33.6	10.58	33.8	10.95	-1.299	0.775
aASi	46.29	12.79	47.8	12.73	-2.099	0.289

P<0.05. P<0.01. P<0.001

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)	148.99	7.75	135.79	8.89	-6.75	0.000***
DBP (mmHg)	76.15	6.63	75.15	6.05	-2.05	1.315
PP (mmHg)	74.88	7.73	62.68	8.63	13.40	0.000***
MAP(mmHg)	100.35	6.33	95.38	6.25	9.55	0.000***

P<0.05. P<0.01. P<0.001

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)	147.88	8.5	148.90	8.36	-0.79	0.50
DBP (mmHg)	77.63	7.55	76.68	6.43	2.60	0.15

ISSN:0975 -3583,0976-2833 VOL14, ISSUE 03, 2023

PP (mmHg)	72.38	7.85	74.28	8.55	-2.83	0.09
MAP(mmHg)	100.99	7.22	100.65	6.05	0.73	0.55

P<0.05. P<0.01. P<0.001

DISCUSSION

The benefits of yoga and **endothelial function, vascular compliance and sympathetic tone** are well-known.[15] The underlying mechanisms of the observed beneficial effects of yoga on vascular function remain speculative; however are likely to happen through at least two pathways.[16]

Despite this fact that yoga cannot prevent or treat diseases itself, it relaxes muscles, regulate blood circulation and help patients feeling better in general. Yoga exercises reduce diastolic blood pressure and resting heart rate. It may be largely because of the reduction of sympathetic nervous system activity. Pranayama also seems to be an efficient method for balancing the autonomic nervous system and has a powerful influence on stress release, [17] as a significant risk factors of vascular dysfunctions.

Other important causes of vascular dysfunctions may be high blood pressure and loss of oxygen.[18] Pranayama leads to more oxygen delivery into the whole body including heart, brain and cells.[19] It is a commonly held belief that doing exercises consciously seems to play a key role. It reduces peripheral vascular resistance and regulates vessels' tone, the event which may help vessel walls related disorders. In addition, yoga asanas also improve the body's strength and flexibility which may help control blood pressure, respiration and heart and metabolic rates.[25]

On the other hand, yoga training helps patients to cope with stress and Anxiety, the factors which are known to be the common causes of vascular diseases.

Our finding suggests that yoga practice can improve the efficacy of cardiac function with less utilization of energy. Another study has showed that Yoga based cyclic meditation and relaxation technique can reduce oxygen consumption. However, oxygen consumption may vary among the various yoga based practices or techniques. [20]

Due to age associated changes in heart such as stiffness and hypertrophy, left ventricle contract and relax slowly, so that systolic time is increased and of diastolic time is reduced (impaired relaxation) leading to increased end diastolic pressure and diastolic dysfunction. [21] Aging has least impact on systolic function. Yoga induced reduction in HR might have given more time for cardiac relaxation or diastole. Further, improvement in diastolic function in yoga practitioners can also be probably attributed to reduction in central arterial stiffness, BP and oxidative stress. We found minimal change in the systolic function with yoga practice. [22]

CONCLUSION

Yoga practice for 12 weeks has showed a significant enhancement in left ventricular relaxation period suggesting an improvement in diastolic function. A minimal change in systolic function has been observed. It is effective in reducing HR and SBP, DBP. Yoga is more effective than walking in improving cardiac function in elderly with high PP. Yoga practice can induce favorable changes in cardiac function possible by reducing HR and ventricular after-load through reduction in arterial stiffness and BP.

REFERENCES

1. Perloff D, Grim C, Flack J, et al. Human blood pressure determination by sphygmomanometry. Circulation. 1993;88:2460–2470.
2. Seals DR, Silverman HG, Reiling MJ, et al. Effect of regular aerobic exercise on elevated blood pressure in postmenopausal women. Am J Cardiol. 1997;80:49–55.
3. Vaitkevicious PV, Fleg JL, Engel JH, et al. Effects of age and aerobic capacity on arterial stiffness in healthy adults. Circulation. 1993;88: 1456–1462.
4. Nichols WW, O'Rourke MF. McDonald's Blood Flow in Arteries: Theoretical, Experimental and Clinical Principles, Fourth Edition. 4th ed. London, UK: Arnold; 1998.
5. Bruel A, Ortoft G, Oxlund H. Inhibition of cross-links in collagen is associated with reduced stiffness of the aorta in young rats. Atherosclerosis. 1998;140:135–145.
6. Barenbrock M, Spieker C, Witta J, et al. Reduced distensibility of the common carotid artery in patients treated with ergotamine. Hypertension. 1996;28:115–119.
7. Boutouyrie P, Locolley P, Girerd X, et al. Sympathetic activation decreases medium-sized arterial compliance in humans. Am J Physiol. 1994;267:H1368–H1376.
8. Zanzinger J. Role of nitric oxide in the neural control of cardiovascular function. Cardiovasc Res. 1999;43:639–649.
9. Higgins, J.P.; Deeks, J.J.; Altman, D.G. Chapter 16: Special topics in statistics. In Cochrane Handbook for Systematic Reviews of Interventions, Version 5.1.0 (Updated March 2011); Higgins, J.P., Green, S., Eds.; The Cochrane Collaboration: London, UK, 2011; Available online: http://www.handbook.cochrane.org (accessed on 10 January 2020).
10. Kim,S.Y.;Park,J.E.;Lee,Y.J.;Seo,H.J.;Sheen,S.S.;Hahn,S.;Jang,B.H.;Son,H.J.Testingatool forassessingthe riskofbiasfornonrandomizedstudiesshowedmoderatereliabilityandpromisingvalidity. J. Clin. Epidemiol. 2013, 66, 408–4
11. [CrossRef] [PubMed] 14. Higgins, J.P.; Thompson, S.G. Quantifying heterogeneity in a meta-analysis. Stat. Med. 2002, 21, 1539–1558. [CrossRef] [PubMed]
12. Wong, A.; Figueroa, A. Eight weeks of stretching training reduces aortic wave reflection magnitude and blood pressure in obese postmenopausal women. J. Hum. Hypertens. 2014, 28, 246–250. [CrossRef]
13. Wong, A.; Sanchez-Gonzalez, M.; Kalfon, R.; Alvarez-Alvarado, S.; Figueroa, A. The eff ects of stretching training on cardiac autonomic function in obese postmenopausal women. Altern. Ther. Health Med. 2017, 23, 20–26.
14. Boonpim, H.; Wanpen, S.; Chanavirut, R.; Apaijit, K.; Kukongviriyanpan, U.; Nakmareong, S. Reduced arterialstiff nessandanklebloodpressurefollowingstretchingexerciseinpostmenopausalwomen. J.Physiol. Biomed. Sci. 2017, 30, 47–51.

15. Kato, M.; Masuda, T.; Ogano, M.; Hotta, K.; Takagi, H.; Tanaka, S.; Kamada, Y.; Akiyama, A.; Kamekawa, D.; Shimizu, R.; et al. Stretching exercises improve vascular endothelial dysfunction through attenuation of oxidative stress in chronic heart failure patients with an implantable cardioverter defibrillator. J. Cardiopulm. Rehabil. Prev. 2017, 37, 130–138. [CrossRef]
16. Hotta,K.;Batchelor,W.B.;Graven,J.;Dahya,V.;Noel,T.E.;Ghai,A.;Katopodis,J.N.;Dixon, W.C.;Andrews,R.; Pragle, A.; et al. Daily passive muscle stretching improves flow-mediated dilation of popliteal artery and minwalktestinelderlypatientswithstablesymptomaticperipheralarterydisease. Cardiovasc. Revasc. Med. 2019, 20, 642–648. [CrossRef]
17. Nishiwaki, M.; Yonemura, H.; Kurobe, K.; Matsumoto, N. Four weeks of regular static stretching reduces arterial stiff ness in middle-aged men. Springerplus 2015, 4, 555. [CrossRef]
18. Kim, D.J.; Kim, J.H. Eff ects of 8-week rehabilitation exercise on vascular health. Medico-Legal Update. 2019, 19, 648–653. [CrossRef]
19. Jia, G.; Aroor, A.R.; Jia, C.; Sowers, J.R. Endothelial cell senescence in aging-related vascular dysfunction. Biochim. Biophys. Acta. Mol. Basis Dis. 2019, 1865, 1802–1809. [CrossRef] [PubMed]
20. Green, D.J.; Hopman, M.T.; Padilla, J.; Laughlin, M.H.; Thijssen, D.H. Vascular adaptation to exercise in humans: Role of hemodynamic stimuli. Physiol. Rev. 2017, 97, 495–528. [CrossRef] [PubMed]
21. Awolesi, M.A.; Sessa, W.C.; Sumpio, B.E. Cyclic strain upregulates nitric oxide synthase in cultured bovine aortic endothelial cells. J. Clin. Investig. 1995, 96, 1449–1454. [CrossRef] [PubMed]
22. Hotta, K.; Behnke, B.J.; Arjmandi, B.; Ghosh, P.; Chen, B.; Brooks, R.; Maraj, J.J.; Elam, M.L.; Maher, P.; Kurien, D.; et al. Daily muscle stretching enhances blood flow, endothelial function, capillarity, vascular volume and connectivity in aged skeletal muscle. J. Physiol. 2018, 596, 1903–1917. [CrossRef] [PubMed]
23. Pardo, P.S.; Mohamed, J.S.; Lopez, M.A.; Boriek, A.M. Induction of Sirt1 by mechanical stretch of skeletal muscle through the early response factor EGR1 triggers an antioxidative response. J. Biol. Chem. 2011, 286, 2559–2566. [CrossRef]