Effect of Yoga on Endothelial Function, Vascular Compliance and Sympathetic Tone in Elderly Subjects with Increased Pulse Pressure: A Randomized Clinical Study
1. LIMITATIONS OF THE STUDY

1.1. Though the CV risks in males are equal to females after menopause, only males have participated in the present study, which is the major limitation of the study. The female participants declined to participate in the study because of inconvenience to attend the training in the morning continuously for three months. Therefore, future studies should address the effect of yoga on both genders with hypertension.

1.2. Initially, we have incorporated pulse wave analysis (RIx) method to evaluate endothelial function including endothelial-dependent and independent vasodilation along with serum NOx. But due to technical variation in the instrument (Physiopac, Medicaid systems Ltd), we were compelled to drop pulse wave analysis method. Hence, the endothelial function was assessed by only estimation of serum NOx and AIx. Therefore, future studies should thoroughly investigate the endothelial function.

1.3. The sample size may be sufficient for an experimental design, but to infer the clinical outcomes by RCT seems to require large sample size.
2. SUMMARY AND CONCLUSION

2.1. The purpose of the study was to determine the effect of yoga on vascular function in elderly with increased PP and to explore the yoga induced benefits of mechanism on hypertension in elderly.

2.2. We hypothesized that Yoga intervention will be more effective than walking on vascular stiffness, endothelial function, cardiac autonomic nervous system activity, oxidative stress and antioxidant capacity.

2.3. The objectives of the study were evaluated in an open parallel arm randomized controlled study design. The participants were elderly subjects aged between 60 to 75 years with PP > 60mmHg (n=60). All the selected participants were mild hypertensives (Grade I hypertension). Subjects with SBP > 159mmHg and DBP > 99mmHg and subjects with CV risk factors such as diabetes mellitus, hypercholesterolemia and high triglyceride level were the major exclusion criteria.

2.4. Yoga group (n=30) was assigned for yoga training and control group (n=30) for brisk-walk with stretching exercise for one hour in the morning for 6 days in a week for three months.

2.5. The following parameters were tested before and after 3 months of intervention: Arterial stiffness measures: Brachial-ankle pulse wave velocity (baPWV), Carotid-femoral pulse wave velocity (c-f PWV), augmentation index (AIx@75), arterial stiffness index at brachial (bASI) and tibial arteries (aASI); Endothelial function indices: Total serum nitric oxide concentration (NOx), augmentation index (AIx@75); Heart rate variability (HRV) measures: Low frequency (LF), high frequency (HF) and LF/HF ratio; Oxidative stress measure: serum malondialdehyde (MDA) concentration; and antioxidant capacity: serum superoxide dismutase (SOD) activity, erythrocyte reduced glutathione (GSH), serum ascorbic acid or vitamin C.
2.6. We believe that this may be the first randomized controlled study that assessed the influence of yoga on vascular function and oxidative stress in elderly with hypertension.

2.7. We found a significant decrease in c-f PWV by 7.89% (p<0.001), baPWV by 7.74% (p<0.001), AIx@75 by 8.68% (p=0.005) and aASI@75 by 15.09% (p<0.001) in yoga group participants. These findings suggest attenuation in arterial stiffening in elderly who practiced yoga. This was the novel finding of the thesis.

2.8. A reduction in LF by 3.07% (p=0.012), LF/HF ratio by 13.46% (p<0.001) and significant increase in HF by 12.65% (p=0.008) in yoga group suggesting a shift in the autonomic balance towards the vagal dominance.

2.9. Yoga had also significantly reduced serum MDA level (p<0.001), and enhanced SOD activity (p=0.007), serum GSH (p=0.002) and vitamin C (p=0.002). While in control group, we observed a significant increase in serum MDA level (p=0.04) and reduction in serum vitamin C level (p=0.015) with no significant difference in the SOD activity and GSH level. This was also the novel finding of the study.

2.10. A significant increase in serum NOx by 23.26% (p<0.001) and AIx@75 by 8.68% (p=0.005) in the Yoga group was noticed, which is the novel finding of the study. These findings imply an increase in bioavailability of NO and an improvement in endothelial dependent vasodilation in Yoga practitioners.

2.11. A significant decrease in SBP by 9% (p<0.001), PP by 16.71% (p<0.001) and MAP by 5.08% (p=0.000), was observed in the Yoga group participants.

2.12. There were no significant changes in vascular function, oxidative stress, cardiac autonomic nervous system and BP in the participants of control group following walking exercise intervention.

2.13. Most of the participants (both group) used to do mild walking and exercise regularly before enrolment for the study. The benefits of daily physical activity might have reached to threshold level, so further walking exercise may not have induced
any beneficial changes in the participants of control group. The difference in the effect of yoga therapy and brisk-walk exercise may be also due to the fact that the elderly people usually suffer from osteoarthritis and could not exercise or walk effectively.

2.14. Yoga is spiritually based, which most of the older individuals enjoys and love to perform. They were found to be involved both physically and mentally while performing Yoga, which is most important for getting beneficial changes in overall health.

2.15. These findings suggest that yoga module tested in the present study is an effective physiological means to control hypertension along with arterial stiffness in elderly. Yoga has also induced beneficial changes in endothelial function, cardiac autonomic nervous system, oxidative stress and antioxidant defense.
3. FUTURE DIRECTIONS

3.1. Future studies should address the effect of yoga on vascular function in both genders with hypertension with large sample size.

3.2. Further studies are required to make definitive conclusions on influence of yoga on endothelial function and its regulatory genes expression.

3.3. We look forward to study the effect of different components of yoga separately on vascular function in elderly.

3.4. Further research is warranted to find out the pattern of physical activity which is most beneficial to elderly.