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Original article

Comparison of yoga and walking-exercise on cardiac time intervals as a measure of cardiac function in elderly with increased pulse pressure

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ABSTRACT

Objective: Arterial aging along with increased blood pressure(BP) has become the major cardiovascular (CV) risk in elderly. The aim of the study was to compare the effects of yoga program and walking-exercise on cardiac function in elderly with increased pulse pressure (PP).
Methods: An open label, parallel-group randomized controlled study design was adopted. Elderly individuals aged $\geq$60 years with PP $\geq$ 60 mmHg were recruited for the study. Yoga (study) group (n = 30) was assigned for yoga training and walking (exercise) group (n = 30) for walking with loosening practices for one hour in the morning for 6 days in a week for 3 months. The outcome measures were cardiac time intervals derived from pulse wave analysis and ECG: resting heart rate (RHR), diastolic time(DT), ventricular ejection time(LVET), upstroke time(UT), ejection duration index (ED%), pre-ejection period (PEP), rate pressure product (RPP) and percentage of mean arterial pressure (%MAP).
Results: The mean within-yoga group change in RHR(bpm) was 4.41 (p = 0.031), PD(ms): −50.29 (p = 0.042), DT(ms): −49.04 (p = 0.017), ED%: 2.107 (p = 0.001), ES(mmHg/ms): 14.62 (p = 0.118), ET(ms): −0.66 (p = 0.903), UT(ms): −2.54 (p = 0.676), PEP(ms): −1.25 (p = 0.11) and %MAP: 2.08 (p = 0.04). The mean within-control group change in HR (bpm) was 0.35 (p = 0.887), PD (ms): 11.15(p = 0.717), DT (ms): 11.3 (p = 0.706), ED%: −0.101 (p = 0.936), ES (mmHg/ms): 0.75 (p = 0.926), ET(ms): 2.2 (p = 0.721), UT (ms):4.7(p = 455), PEP (ms): 2.1(p = 0.11), %MAP: 0.65 (p = 0.451). A significant difference between-group was found in RHR (p = 0.036), PD (p = 0.02), ED% (p = 0.049), LVET (p = 0.048), DT (p = 0.02) and RPP (p = 0.001).
Conclusions: Yoga practice for 3 months showed a significant improvement in diastolic function with a minimal change in systolic function. Yoga is more effective than walking in improving cardiac function in elderly with high PP.

1. Introduction

Arterial aging along with increased blood pressure (BP) has become the major cardiovascular (CV) risk in elderly. Structural and functional changes take place in heart and blood vessels with advancing age. The reduction of vascular compliance with age due to stiffening of arteries is the major contributor for elevation of BP, especially systolic pressure resulting in isolated systolic hypertension (ISH) in elderly[1,2]. Systolic BP increases and diastolic BP falls with age leading to widening of pulse pressure (PP). Pulse pressure is a best tool for measuring vascular aging and a good marker for CV risk in elderly. Pulse pressure is an independent indicator of arterial stiffness[3]. It is more closely associated to CV events than systolic BP or diastolic BP alone[4].

Age-associated stiffening of aorta and increased systolic pressure increases left ventricle (LV) after-load. Increased ventricular load causes LV hypertrophy and increases LV oxygen demand. Due to these changes, LV contract and relax slowly, so that systolic time is increased while diastolic time is reduced[5]. Left ventricle becomes stiff with decreased compliance and impaired relaxation, leading to increased end diastolic pressure and diastolic dysfunction. Age associated major changes in heart function occurs mainly in left ventricular diastolic function. So, elderly individuals (especially hypertensive patients) often manifest diastolic dysfunction[6].

Although physical training programs are recommended for CV prevention and rehabilitation[7], their effects on cardiac function in

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elderly individuals remain unclear. Few authors demonstrated a beneficial effect of exercise training program on left ventricular function in elderly[8–10] while others reported either least change[11] or no change[12–16]. Moreover, most of these studies are done on trained athletes and healthy elderly individuals.

Yoga is emerging as an effective life-style modality and mind-body medicine. It is a skill to control mind and involuntary functions voluntarily. Many studies have showed beneficial effects of yoga program on CV health in young and older adults[17–20]. Again, most of the studies have either included young and middle aged individuals or mixed population with wide range of age. We did not find any studies investigating the effect of yoga on cardiac function in elderly individuals with hypertension. In the present study, we compared the effects of yoga program and walking-exercise on cardiac function in elderly with increased PP (as mentioned previously that PP is a better predictor of CV events than SBP or DBP in elderly).

2. Methods

2.1. Participants and study design

A total of 60 elderly individuals aged ≥60 years with increased PP ≥ 60 mmHg were recruited for the study. Volunteers were screened from geriatric health camp and Geriatric clinic of Shri B. M. Patil Medical College, Hospital & Research Centre. An open label, parallel-group randomized controlled study design was adopted. Exclusion criteria includes subjects with SBP > 159 mmHg and DBP > 99 mmHg; CV risk factors such as diabetes mellitus, hypercholesterolemia and high triglyceride level; history of secondary hypertension, neuromuscular disorders, alcoholism; practicing yoga for one hour/day for three days in a week and on any medications. Participants were instructed for not to consume any vitamin supplements or herbal drugs during the study period. This criterion for selection of elderly subjects with high PP for life-style changes intervention for three months was as per the 2007 guidelines of the task force for the management of arterial hypertension of the European Society of hypertension and of the European Society of Cardiology[21].

During visit 1–3 (three consecutive days), volunteers were screened and their BP was measured. Baseline investigation, randomization and allocation of subjects were done at their 4th visit. They were randomly allocated to Yoga group (YG; n = 30) and exercise group (EG; n = 30) by using random number table. At visit 5, post-intervention investigations were made. All the investigations were done in the morning between 8.00 h to 11.00 h after supine rest for 10 min. No intervention was given on the day of investigation. Persons handling data analysis were kept blinded.

2.2. Ethics statement

A prior study approval has been obtained from the Institutional ethical committee of Shri B.M. Patil Medical College, Hospital and Research Centre, BLDE University, India, as per the guidelines of Indian Council of Medical Research (ICMR)[22]. The declaration of Helsinki has been followed during the entire study. Informed written consent was obtained from the participants.

2.3. Intervention

The yoga program included loosening practices, Asanas (maintaining postures), Pranayama (breathing exercises) and cyclic meditation (Table 1). Asanas were practiced for 15–20 min while pranayama and relaxation technique/meditation for 40–45 min. Emphasis was placed on practicing slow and paced breathing with asanas (maintaining postures) and other techniques of Yoga program. Cyclic meditation (CM) is a cycle of alternating stimulation and relaxation that used to go into deep silence. It is a guided relaxation technique of about 23 min. During the practice of CM, the subjects followed the instructions with eyes closed. It includes stretching and relaxing the muscles consciously (in various postures) with internal awareness by observing changes in the system. The sequence of practice is as follows: (1): It began by chanting a verse (40s) in supine position with Namaskar Mudra followed by isometric contraction of the muscles from toe to head and relaxation with awareness (1 min); (2) Linear awareness was observed in standing posture (Tadasana) and balancing the weight on both feet at ease (2 min); (3) slowly moving to the next posture (ardhakatichakrasana): bending to the right (1 min 20 s) followed with instructions about relaxation and awareness (1 min 20 s); then bending to the left (1 min 20 s) followed with relaxation (1 min 20 s); (4) slowly lied down in supine posture, right arm stretched, turned to right side with head on the right biceps, (linear awareness) then rested on back, observed the abdominal movements and breathing (3 min); (5) moved to the sitting posture (vajrasana) and observed the changes (1 min 20 s); (6) chanted (MMM.) M-Kara in another sitting posture (Sasankasana) (1 min 20 s); (7) chanted (AAA.) A-Kara in backward bending on knees posture (Ustrasana) (1 min 20 s); (8) Relaxed in supine posture (Shavasana) and chanted A, U, M –kara (7 min). The postures were practiced slowly, with awareness of all the sensations that are felt[23].

Table 1
Integrated yoga module for elderly subjects with increased pulse pressure.

Sl. No	Practice		Duration
1.	Opening Prayer		1 min
2.	Sukshma Vyayama (Loosening Practices)	Loosening of Fingers Loosening of Wrist Shoulder rotation Ankle stretch/rotation Drill walking	5 min
3.	Breathing Practices	Hands in and out breathing Ankle stretch breathing Straight leg raising breathing Lumbar stretch breathing	5 min
4.	Asana (Maintaining Postures)	Utkatasana Padhastasana Ardhachakrasana Shashankasana Ardha Ustrasana Bhujangasana Ardha Salabasana Trikonasana	15 min
5.	Pranayama	Anuloma Viloma Pranayama Brahmari Pranayama	5 min
6.	Cyclic Meditation [CM]		23 min
7.	Devotional Session – Chanting/songs		5 min
8.	Closing prayer		1 min

The protocol for the walking-exercise group consisted of loosening practices like neck rotation, shoulder and hip rotation, wrist and ankle rotation, forward and side bending; and walking (40–50 min) followed by rest (10 min). Intervention for both the groups was given for one hour/day for 6 days in a week in the morning from 06:00 h to 07:00 h for twelve weeks under the supervision of experienced authorized instructor.

2.4. Measurement of blood pressure

As BP is more variable in older people, an average of nine BP readings (measured thrice with an interval of one minute on every visit for three consecutive days in a sitting posture) was taken using mercury sphygmomanometer (Diamond, Industrial Electronic and Allied products, India)[24]. Pulse pressure was estimated as the difference between systolic and diastolic BP. Mean arterial pressure (MAP), an average arterial pressure in an individual during single cardiac cycle was estimated by adding 1/3rd of PP to DBP.

2.5. Assessment of cardiac function

Cardiac function was assessed by measuring the cardiac time intervals using 8-channel non-invasive automatic device (Periscope, Genesis Medical Systems, India). Periscope is a real time PC-based simultaneous acquisition (200 samples per second) and analysis system. This device uses four BP cuffs and two-channel ECG leads to record arterial pressure waveforms and ECG simultaneously. The recordings were made in supine position. BP cuffs were wrapped over both upper arms (brachial artery) and legs (tibial artery) above ankle. ECG electrodes were placed on the ventral surface of both wrists and medial side of the ankles. The BP cuffs were connected to oscillometric pressor sensor and plethysmographic sensor to determine pressure waveforms and volume pulse waveform. The data obtained in 10 s was stored in the computer for further analysis. Periscope supports a sophisticated digital-signal algorithm to calculate all the results. As the device is fully automated and does not require any operator for handling any probe to record the waveforms, so it is devoid of any operator bias. It calculates cardiac time intervals using limb pressure waveforms and ECG.

2.5.1. Pre-ejection period (PEP)

It is a period of electromechanical delay and isovolumetric contraction. It is the time between the beginning of the depolarization of left ventricle and the opening of the aortic valve.

2.5.2. Left ventricular ejection time (LVET)

It is a period of ventricular emptying. It is the time from opening of the aortic valve to its closing. Ejection time may decrease with an increase in heart action. It is used as a measure of LV stroke volume.

2.5.3. Upstroke time (UT)

It is time for the pulse wave to rise from its foot to peak. This gives an indication of heart's contractibility and hence the health of left ventricular muscles. The lesser the UT, the more the contractibility of the LV.

2.5.4. Ejection duration index (ED%)

The ratio of the duration of systolic ejection to the total duration of a cardiac cycle is the ejection duration index.

2.5.5. Diastolic time (DT)

It is a period of ventricular filling. It is the duration between opening and closing of mitral valve.

2.5.6. Heart rate (HR)

It was calculated from R-R interval of ECG.

2.5.7. %MAP

It is the percentage of Mean Arterial Pressure height from diastolic pressure to the total pulse pressure. Higher the%MAP greater is the hardening of artery.

2.6. Rate pressure product (RPP

It is a sensitive index of myocardial oxygen consumption (MVO_2) or demand and cardiac workload. It is also called as cardiovascular product or double product. RPP is a product of heart rate (bpm) and systolic BP (mmHg)[25].

2.7. Estimation of biochemical parameters

The blood sample was collected in the morning with overnight fasting. Fasting blood glucose (Trinder's method), serum triglyceride level (glycerol phosphatase-oxidase method), serum cholesterol (cholesterol oxidase-peroxidase enzymatic method) and HDL cholesterol (phosphotungstic acid method) were estimated using commercial diagnostic kits (ERBA-MANNHEIM).

2.8. Statistical analysis

The obtained data was expressed in mean and standard deviation. The differences between the post-intervention and the baseline measures were calculated to determine the significant improvement in the outcome measures using paired 't' test. Within group change was determined using mean within-person change and 95% confidence intervals (95%CI). Between group differences were determined by calculating the mean between-group changes and confidence intervals. Further, Analysis of covariance (ANCOVA) was used to find the statistically significant differences in the post-intervention values between the two groups. ANCOVA determines the difference between the two treatment effects while controlling the baseline values. Statistical significance was established at $p < 0.05$. Data were analyzed by using SPSS software version 20.

3. Results

3.1. Participant flow and baseline characteristics

Altogether 44 subjects (study group-24; exercise group-20) with technically successful pressure waveform and ECG recordings were included for data analysis. Out of 60 male subjects recruited for the study, data of 44 subjects were analyzed. The baseline characteristics of the participants were shown in Table 2. There was no significant difference in age, BMI, HR, BP blood glucose and lipid profile between the yoga and walking groups. These findings indicate an equal distribution of subjects to both groups. Blood glucose and lipid profile of all participants values were within normal range. All the participants recruited for the study were residing surrounding the site of study and use to visit our campus ground regularly either morning or evening. Therefore, the adherence of the participants to intervention program was good: about 91% participants attended yoga program while 89% for walking-exercise. Most of the participants were retired employees and habitual of slow nature walking.

3.2. Heart rate

There was a significant reduction in HR ($p = 0.031$) and increase in PD ($p = 0.042$) within-yoga group while no change was noticed

Table 2
Baseline characteristics of participants.

Variable	Yoga group (n = 24)	Exercise group (n = 20)	p-Value
Age (Years)	68.50 ± 4.85	69.30 ± 5.932	0.57
BMI (kg/m2)	24.64 ± 3.65	25.17 ± 3.90	0.587
Heart Rate (bpm)	70.77 ± 9.08	73.08 ± 11.40	0.389
Systolic BP (mmHg)	146.87 ± 5.72	145.83 ± 6.33	0.51
Diastolic BP (mmHg)	74.2 ± 4.60	75.57 ± 5.685	0.31
Pulse Pressure (mmHg)	72.17 ± 6.018	70.33 ± 6.321	0.255
MAP (mmHg)	98.27 ± 4.525	97.37 ± 8.364	0.606
Fasting Blood Glucose (mg/dl)	93.83 ± 11.63	91.73 ± 11.94	0.493
Serum Triglyceride (mg/dl)	93.96 ± 25.45	99.00 ± 23.15	0.426
Total Cholesterol (mg/dl)	152.5 ± 24.32	154.23 ± 19.79	0.763
HDL Cholesterol (mg/dl)	46.8 ± 4.21	46.16 ± 4.29	0.567

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Table 3
Heart rate and Cardiac time intervals: Baseline and post-interventional values in participants and within group changes.

Variables	Yoga group (n = 24)			Exercise group (n = 20)		
	Before	After		Before	After	
	Mean ± SD	Mean ± SD	p-Value	Mean ± SD	Mean ± SD	p-Value
RHR (bpm)	70.88 ± 12.39	66.45 ±7.4	0.031*	72.15 ± 11.08	71.8 ± 10.06	0.887
ED%	33.24 ± 4.59	31.13 ± 2.69	0.001**	32.83 ± 4.32	32.93 ± 4.22	0.936
PEP (ms)	151.16 ± 8.61	152.41 ± 10.2	0.385	152.05 ± 5.43	149.95 ± 7.04	0.110
Upstroke time (ms)	192.5 ±24.22	195.04 ± 22.67	0.676	184.7 ± 24.73	180 ± 20.66	0.455
LVET (ms)	284.46 ± 23.36	285.12 ±25.97	0.903	276.95 ± 25.38	274.75 ± 18.66	0.721
Diastolic time (ms)	587.04 ±126.27	636.08 ±94.42	0.017*	581.9 ± 119.85	570.6 ± 105.1	0.706
RPP	10382.12 ± 1708.72	8843.54 ± 1001.8	≤ 0.001	9504.54 ± 3378.74	9581.54 ± 3307.82	0.978

RHR = Resting heart rate; ED% = ejection duration index; PEP = pre-ejection period; LVET = left ventricular ejection time; ES = Ejection slope; RPP = Rate pressure product.
$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

within- exercise group (Table 3). A significant mean between-group change was also observed in HR (p = 0.036) and PD (p = 0.021) (Table 4).

3.3. Ventricular function

Table 3 shows cardiac time intervals in participants of yoga and walking-exercise group. Among the ventricular systolic function indices, there was no significant change in PEP, LVET and UT within-yoga and within- exercise group. Though statistically not significant but a mean increase in LVET was noticed within-yoga group while in walking group it was decreased. Ejection duration index was significantly reduced (p = 0.001) within-yoga group following yoga practice while no alteration in walking-exercise group was observed. ANCOVA showed significant between-group change in ED% and UT (Table 4).

Diastolic time was significantly increased (p = 0.017) within-yoga group while no significant difference was noticed within-walking-exercise group (p = 0.706). Further, ANCOVA showed significant between-group change in DT indicating that yoga is effective in inducing favorable changes in diastolic function in elderly (Table 4).

3.4. Rate pressure product (at rest)

Within-group analysis has shown a significant decrease in RPP in yoga group while no significant change was noticed in exercise group (Table 3). Between-group analysis showed a significant difference in post-intervention RPP between yoga and exercise group indicating that yoga is better than walking-exercise in improving myocardial performance (Table 4).

3.5. Arterial stiffness

Fig. 1 shows mean change in%MAP in Yoga and walking group. Within-yoga group, a significant reduction in mean%MAP (p = 0.004) was observed with no change within- walking-exercise group. Between-groups, there was no significant change in%MAP.

4. Discussion

To our knowledge, influence of yoga on cardiac function in elderly with hypertension has not been studied previously. We believe that the present study may be the first randomized controlled study on influence of yoga on cardiac function in elderly with increased PP. First part of our study related to yoga effects on vascular function has been reported[26]. Present study has shown that yoga practice can induce favorable modulation in cardiac function in elderly with mild hypertension. Twelve weeks of yoga training have significantly increased diastolic time; reduced HR and increased PD; decreased RPP and arterial stiffness. Minimal change was noticed in systolic function with yoga practice. Yoga can be used as a physiological approach for improving the efficiency of cardiac function in elderly.

Increased resting HR is an independent CV risk factor[27] and is associated with higher mortality and morbidity[28,29]. Higher resting HR has been attributed to sympathetic overactivity, impaired myocardial oxygen delivery, elevation in BP and increased arterial stiffness[30–32]. Koskela et al. shown that lower resting HR is associated with a more beneficial hemodynamic profile[32]. Higher HR affect cardiac function by increasing left ventricular work load and myocardial oxygen demand. In addition, age-associated increase in aortic stiffness and BP in elderly increases after load on left ventricle leading to left ventricular hypertrophy and cardiac failure[5]. Heart rate reduction is a choice of treatment in patients with coronary artery disease, which reduces myocardial oxygen consumption and improves subendocardial blood flow[33]. In the present study, we found that yoga program has effectively reduced resting HR (6.25%; p = 0.031) and increased PD (unlike beta blockers), which may be attributed to reduction in sympathetic overactivity and central arterial stiffness[26]. We and other researchers have shown that yoga can induce beneficial

Table 4
Change (gain) Scores in cardiac time intervals and rate pressure product.

Variables	Yoga group Mean change (95% CI)	Exercise group Mean Change (95%CI)	Between group change P-value
RHR (bpm)	4.42 (0.43, 8.4) *	0.35 (−4.71, 5.41)	0.036*
ED%	2.12 (0.92, 3.28) *	−0.1 (−2.7, 2.5)	0.049*
PEP (ms)	−1.25 (−4.17, 1.67)	2.1 (−0.52, 4.72)	0.102
Upstroke time (ms)	−2.54 (−14.95, 9.87)	4.7 (−8.19, 17.59)	0.048*
LVET (ms)	−0.66 (−11.89, 10.55	2.2 (−10.5, 14.9)	0.245
Diastolic time (ms)	−49.04 (−88.47, −9.61) *	11.3 (−50.56, 73.16)	0.02*
Rate pressure product	−1538 (999.49, 2077.67)	−10.45 (−796.95, 776.05)	≤ 0.001

RHR = Resting heart rate; ED% = ejection duration index; PEP = Pre-ejection period; LVET = left ventricular ejection time; RPP = Rate pressure product.
$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

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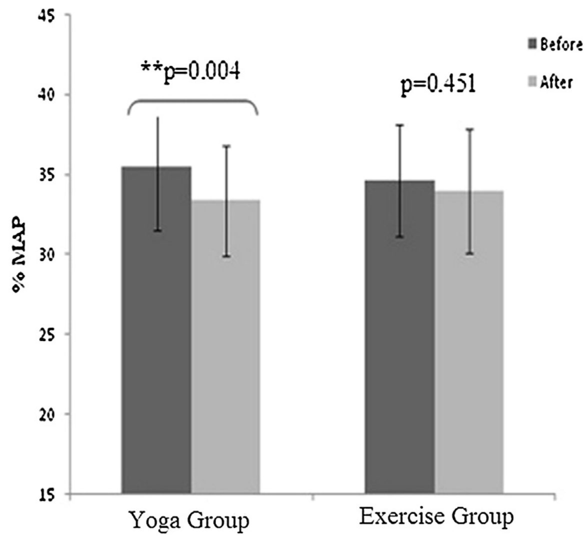

Fig. 1. Arterial stiffness (%MAP): Baseline and after-intervention values in Yoga and walking-exercise group participants.

modulation in age-associated cardiac autonomic changes and reduce sympathetic tone in elderly with hypertension[26] and healthy individuals as well[34].

Further, reduction in RPP at rest in participants of yoga group (present study) demonstrates a decrease in myocardial oxygen demand and improvement in myocardial performance. Rate pressure product is the amount of oxygen required by the myocardium to perform a given activity[25]. 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[35]. However, oxygen consumption may vary among the various yoga based practices or techniques.

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[5,6]. Aging has least impact on systolic function. Hypertension is also the most common cause of diastolic dysfunction and failure in elderly[21]. Therefore, hypertension along with aging becomes the powerful risk for diastolic dysfunction in older individuals. Diastole is the time for cardiac perfusion. Decrease in DT reduces myocardial perfusion and its performance. Availability of time for ventricular relaxation, diastolic filling and cardiac perfusion is determined by heart rate[6]. The present study has shown a significant increase in DT (8.35%; $p = 0.017$) in study group participants following yoga practice indicating an improvement in the diastolic function (or relaxation). Increase in DT also enhances coronary blood flow or cardiac perfusion. Enhancement in left ventricular diastolic filling is an important factor for adequate cardiac output and working/exercise capacity. 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[26], BP and oxidative stress[36]. We found minimal change in the systolic function with yoga practice. Among the systolic function markers, ED% was significantly reduced with no change in PEP, LVET and UT in yoga group.

Walking is a simple and effective physical exercise. However, our study has not found any beneficial modulation in cardiac function in participants of walking-exercise group. The pattern, duration and dosage of physical exercise for cardiac health in elderly are still not clear. Galetta et al., has demonstrated that the expected pattern of left ventricular diastolic function changes normally seen in response to age is modified in the elderly trained athletes and suggested that exercise training can effectively prevent aging effects on heart in older individuals[10]. Arbab-Zadeh et al., evaluated left ventricular compliance in master athletes and sedentary seniors by echocardiography and has shown that prolonged, sustained endurance training preserves ventricular compliance with aging[9]. While in another study, Doppler measures of diastolic function were compared in older athletes with age matched sedentary seniors and found that lifelong endurance training can only partially minimize age-associated changes in myocardial filling and relaxation[8]. On the contrary, other studies showed that regular aerobic-endurance exercise does consistently modulate the age-associated changes that occur in left ventricular structure and diastolic function[12,13]. An exercise training program for 6 months in elderly has showed a significant improvement in diastolic function in healthy during rest and exercise[37] while in hypertensive subjects minimal favorable change was noticed[11]. Ehsani et al. has demonstrated that endurance exercise training for one year can enhance left ventricular systolic performance at peak exercise in healthy older men[38].

As most of our study participants were habitual of slow walking (mentioned earlier), so benefits of physical activity on cardiac health might have reached to threshold level and therefore, probably there was no change in cardiac function with walking-exercise intervention. However, it is also important to note that there was no further deterioration in cardiac function in walking group subjects of our study, indicating that walking-exercise has improved the coping ability of heart to sustain the effects of increased BP and aging. A combined program of physical and mental exercise associated with slow breathing; and relaxation techniques (meditation) for longer duration could induce more beneficial modulation in cardiac function in elderly.

5. 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 RPP. 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.

6. Limitations

Pulse wave derived indices provide relevant information about cardiac function and moreover it is economical, easy to handle and does not require any operator for handling any probe, so it is devoid of any operator bias. However, echocardiography measures may provide more detailed information on cardiac function than pulse wave derived indices. So, further studies using echocardiography are essential to confirm and explore more information about the yoga effects on cardiac function with large sample size in elderly with hypertension. Another limitation of the study is, although, participants have practiced either yoga or walking under the supervision of authorized instructors for one hour daily, their involvement in other activity (other practices) has not been observed.

Financial disclosure

The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Conflict of interest

None

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