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Effect of Aerobic Versus Isometric Exercise Training on Blood Pressure in Young Pre-Hypertensive Individuals

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ABSTRACT

OBJECTIVES: Pre-hypertension is an independent risk factor for major cardiovascular events. Aerobic exercise (AE) and Isometric exercise (IE) are well known measures for reducing the resting blood pressure (BP). The effect of whole-body IE on BP has not been studied well. In this paper, we tried to compare the effectiveness of AE and whole-body IE on BP among young pre-hypertensives.
MATERIALS AND METHODOLOGY: In this prospective observational study, 60 patients with prehypertension aged between 18 to 30 years were included. They were given exercise protocol for four weeks (3days/week) as per (the) allotted group. Demographic data, resting pulse rate, systolic and diastolic blood pressure were recorded before and after exercise each day.
RESULTS: The mean age was 23±1.26 years. Both groups were comparable in baseline characteristics. In both the groups, there was a statistically significant reduction of systolic and diastolic BP as well as pulse rate post intervention ($p<0.05$). On comparison, there was a more significant reduction of systolic BP, diastolic BP & pulse rate (119.93±3.48 vs 124.14±4.03, p=0.000, 79.31±1.95 vs 81.03±2.11, p=0.002 & 75.31 ± 5.47 vs 74.62 ± 6.44, p=0.00) in IE group.
CONCLUSION: Both aerobic and whole-body isometric exercise lead to reduction in systolic as well as diastolic blood pressure and resting pulse rate which may lead to prevention of risk of future cardiovascular events in young pre-hypertensives. Whole body isometric exercise is more effective than aerobic exercise in reducing blood pressure in observed young pre-hypertensives and should be introduced in routine practice.

Key words: Aerobic Exercise, Isometric Exercise, Pre-Hypertension

INTRODUCTION

Hypertension affects nearly 26 percent of the adult population worldwide and is an important independent predictor of cardiovascular disease, cerebrovascular accidents and death[1-4]. The seventh and eight report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC7-8) [5] as well as ACC/AHA[6] guideline defines normotensive individuals as those with systolic blood pressure under 120 mm Hg and diastolic blood pressure under 80 mm Hg. Hypertension is defined as blood pressure >140/90 mmHg (JC7-8) or as blood pressure of >130/>80 mm Hg (ACC). Patients having blood pressure between the 'normal' and 'hypertension are said to have 'Pre-hypertension (JCC7-8) or 'elevated BP' (ACC).

Pre-hypertensive individuals generally remain symptomless and undiagnosed.[7] Pre-hypertensives are more prone to develop hypertension and it has been well proven to be an independent risk factor for major cardiovascular events[8, 9].

Prehypertension is associated with a 27% increase in all-cause mortality and a 66% increase in cardiovascular disease mortality when compared to normotensives[8-12]. Lifestyle changes, such as reducing alcohol consumption and tobacco smoking, developing appropriate eating habits, and controlling body weight, are suggested as non-drug measures for preventing and treating hypertension [13]. Other means to reduce resting blood pressure (BP) is doing regular exercise [14]. Regular exercise leads to potential reduction in resting BP which is termed as post-exercise hypotension (PEH) [15] but it might take several days. PEH can be considered as an important strategy to help control resting BP, especially in hypertensive individuals.

Among different varieties of exercise, Aerobic physical exercise is the most preferred and recommended modality to promote PEH in hypertensive and pre-hypertensive individuals [16, 17]. There is less data for the mechanisms responsible for blood pressure reduction after aerobic training. A possible mechanism is the reduction in cardiac output due to a decrease in stroke volume, probably due to a pre-load reduction or it may be due to reduction in peripheral vascular resistance. Nevertheless, a meta-analysis[18] has concluded that a reduction in peripheral vascular resistance is responsible for reduction in blood pressure due to aerobic exercises. The other form of therapeutic exercise which can be used as an alternate therapy in treatment of increased blood pressure is 'Isometric exercise'.

Isometric exercise involves sustained contraction against an immovable load or resistance with no or minimal change in length of the involved muscle group. Due to association with exaggerated hypertensive responses, isometric activity has not been favoured generally but recently many researchers have reported the importance of isometric activity as a non-pharmacological measure for reduction of BP [19-21]. Recent reviews and meta-analysis have also shown superiority of single muscle group isometric exercise compared to other modalities [21-24]. Most of the studies have used only isolated hand grip or leg extension isometric exercise to see its effect on blood pressure. The effect of whole body isometric exercise on BP has not been studied well in literature. Since pre-hypertensive individuals are at risk for hypertension, it is important to examine the post-exercise effects of whole body isometric exercise and compare it with aerobic exercise in pre-hypertensive individuals. Such comparison would help us determine the potential benefits associated with these modes of exercise, if any. In this study, we aimed to determine individual effectiveness of aerobic and isometric exercise on reducing BP in pre-hypertensives. We also aimed to compare the effectiveness of both on reducing BP in them.

METHODS

Between January-2018 and July -2018, 60 (Sample size calculated was 58, according to a similar study carried out at College of Applied Health Sciences, University of Illinois at Urbana-Champaign, Urbana, IL, USA and University City Boulevard, Charlotte, NC, USA with α risk 5% and power 95, the minimum expected sample size in each group comes to 24 considering non-responsive rate 20%, the total minimum sample size comes to 58) individuals diagnosed as pre-hypertensive at S.S.G.H., Vadodara were included in this prospective observational study. The study has been approved by the ethics committee of the institute and written consent was taken from patients for the study. The healthcare providers working at S.S.G.H, Vadodara were initially screened for prehypertension by the registered physician according to standard guideline [25]. The ones diagnosed as pre-hypertensives and falling under inclusion criteria were included. The inclusion criteria of the study were: patients aged between 18-30 years of any gender diagnosed with prehypertension. The exclusion criteria for the study were: 1) Those who were unable to perform exercise due to any reason. 2) Individuals with

respiratory problems, neurological and musculoskeletal disorders. 3) Individuals diagnosed with hypertension or taking anti-hypertensive drugs. 4) Individuals with diabetes, obesity and/or high cholesterol. 5) Those who do not understand the protocol. 6) Those who currently smoke or drink or have a history of smoking/drinking.

Data collection

The patients whose blood pressure fell into pre-hypertensive range on 3 or more occasions during regular hospital visits, usually over a 1- to 3-week period were included in the study. All were screened for other cardiovascular risk factors and none met the National Cholesterol Education Program (NCEP) guidelines for lipid-lowering therapy (that is, low- density lipoprotein 4190mmol/l in the absence of any risk factors) except their new borderline hyper- tension. Also, none had diabetes (based on two fasting blood glucose 127mmol/l or greater). None of the subjects were taking any medication, including antihypertensive or aspirin, and all were non- smokers and non-alcoholic. All subjects underwent a standardized interview including details about him/her. Name, age, gender, medications, personal habits, routine physical activity (none used to follow specific routine of activity) and any associated conditions.

Anthropometrics

Weight and height were measured with the subject's being barefoot and wearing light clothes only. Weight was measured to the nearest 0.1 kg using a weighing scale. Height was measured to the nearest 0.1 cm using a wall fixed stadiometer.

Waist circumference was measured at a level midway between the lowest rib margin and the iliac crest in a horizontal plane using a measuring tape with subject wearing minimal clothing. Hip circumference was measured at the widest point over the buttocks. Waist Hip Ratio (WHR) was calculated as waist circumference divided by hip circumference.[9,11]

All subjects underwent prehypertension screening and measurement of blood pressure with the mercury sphygmomanometer was done on the left upper arm after at least 15 minutes of rest. Resting pulse rate was measured in sitting position in the left hand after the participant had rested for at least 15 min with fingertip pulse oximeter.

Subjects were classified into two groups randomly by envelop method after being diagnosed as pre-hypertensive:

A. Aerobic exercise group.
B. Isometric exercise group

The first visit consisted of group randomization, health history and anthropometric measurements and subjects rested in a supine position for 15min, followed by BP and pulse rate measurements in sitting position. All subjects were given the aerobic training (treadmill) or isometric exercise training for 4 weeks: 3 days a week and blood pressure and pulse rate measurements were taken post training. To avoid diurnal variation, all measurements were repeated at the same time of day and in the same order as pre-measurements.

Aerobic training

The aerobic training (AE) training consisted of 30 minutes of treadmill exercise, 3 days per week for 4 weeks. The intensity of the aerobic exercise was determined according to Karvonen protocol.

Heart Rate Reserve (HRR) = [(HRmax – HRrest) 60% intensity +HRrest]

Maximal HR=220- age.

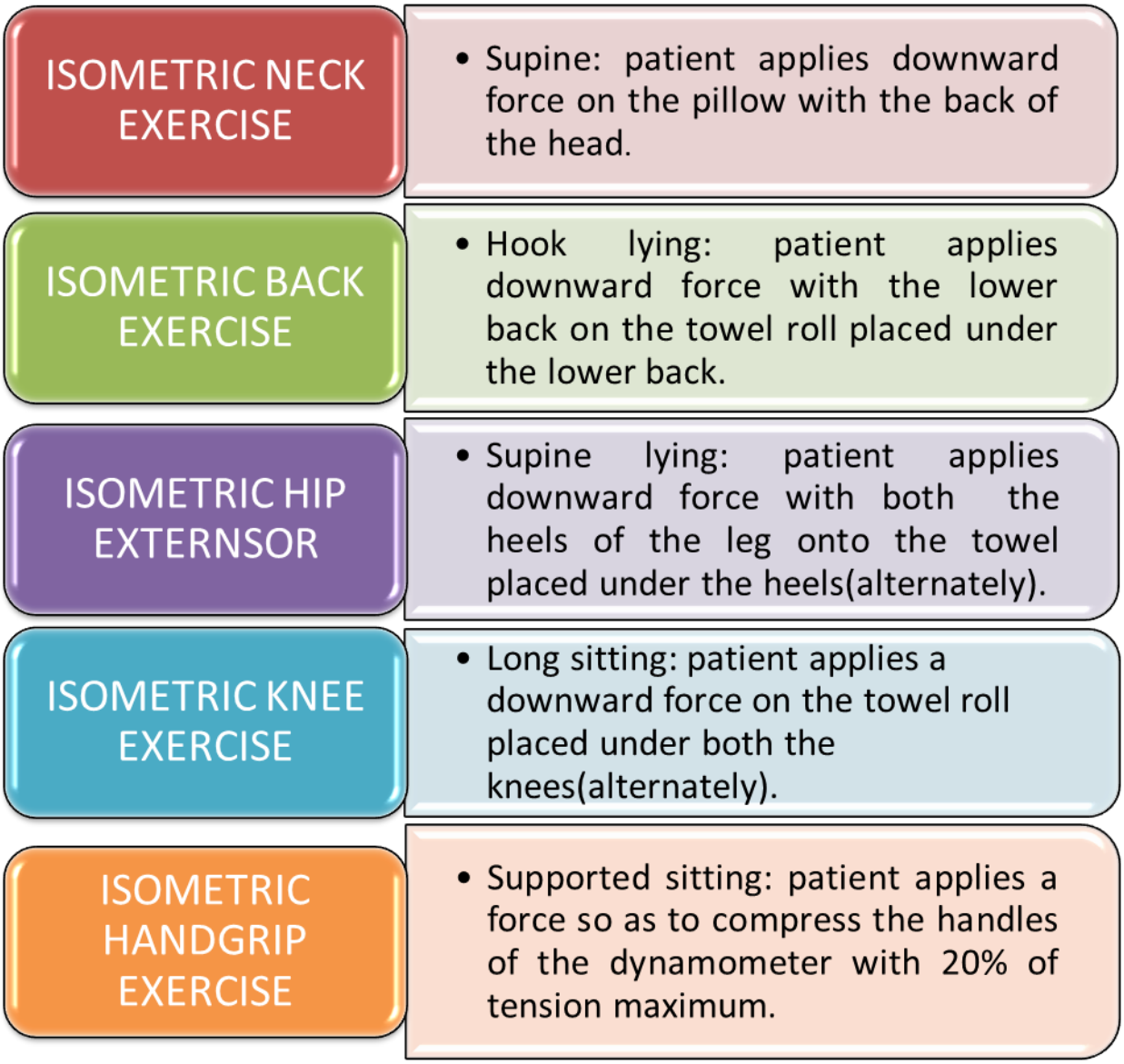
Moderate (40-60%) intensity training is set for all subjects. [26, 27]

According to the HRR obtained, the subjects were asked to walk at a gradually increasing speed maintaining their heart rate reserve which remained the same throughout the training. Post-intervention blood pressure and pulse rate were measured after 15 minutes of rest.

Isometric Exercise training

The isometric training exercises consisted of ankle press, knee press, head press, static abdominis and sustained hand grip - all performed under the physiotherapist's supervision. The subjects were asked to hold the handgrip dynamometer (Jamar dynamometer, Sammons Preston Inc., Boling-brook, IL, USA) in the dominant hand to get full grip, asked to compress the handles of it by maximal force for 3-4 seconds. The procedure was repeated thrice with rest and maximal isometric tension was recorded (Tmax.) Same procedure was repeated with pressure biofeedback using the stabiler^{TM} pressure biofeedback unit (2006 Encore Medical L.P.). Each contraction was sustained for 10 seconds of 20% of MVC (measured using handheld dynamometer for IHG and pressure biofeedback for other IE.) and each subject completed three sets of 10 repetitions, 3 days per week for 4 weeks. Each IE session took approximately 25-35min to complete. Figure 1 shows details of Whole-Body Isometric Exercise protocol. Subjects were asked to refrain from any exercise outside of their aerobic or resistance prescription. Post-intervention blood pressure and pulse rate were measured after 15 minutes of rest.

Figure 1: Whole Body Isometric Exercise Protocol



Statistical Analysis

Statistical analysis was performed using SPSS version 20 software (SPSS, Inc., Chicago, IL, USA). All data was expressed as mean±standard deviation or percentages, as appropriate. To evaluate differences between the groups, the paired and unpaired Student's t test for continuous variable was used. To control the post-intervention variables for the differences in pre-intervention value, a two-way ANCOVA was performed between the groups after intervention. A p value<0.05 (for a two-sided test) was considered significant.

RESULTS

The mean age of the study population was 23 ± 1.26 years. There are 36 (62%) females and 22(38%) males. The height, weight and waist to hip ratio of the study population were 169.4 ± 9.68 cm, 61.74 ± 12.06 Kg and 0.79 ± 0.03 respectively. The mean systolic blood pressure, diastolic blood pressure and pulse rate before and after intervention is showed in Table 1.

Table 1: Characteristics of the Study population

Variables	Value (Mean ±SD)	Range
Age (Years)	23± 1.26	21-26
Height (cm)	169.4 ±9.68	150-184
Weight (Kg)	61.74 ±12.06	41-84
Waist to Hip Ratio	0.79± 0.03	0.71-0.86
Pre- Intervention		
Systolic Blood Pressure (mm Hg)	131.34 ±4.68	124-138
Diastolic Blood Pressure (mm Hg)	87.1±2.31	82-90
Pulse Rate (/min)	83.26±5.77	69-92
Post- Intervention		
Systolic Blood Pressure (mm Hg)	122.03±4.3	114-130
Diastolic Blood Pressure (mm Hg)	80.17±2.19	76-84
Pulse Rate (/min)	74.97±5.93	60-85

As shown in Table 2, in Aerobic exercise group, there was a statistically significant reduction of systolic and diastolic blood pressure from 131.45 ± 4.87 mm Hg and 87.03 ±2.42 mm Hg to 124.14 ±4.033 mm Hg and 81.03 ± 2.11 mm Hg respectively (p =0.000). The pulse rate was also significantly reduced (82.69 ± 5.66 vs 75.31 ±5.47, p=0.000, Table 2). In Isometric exercise group, the similar findings were noted i.e. significant reduction of systolic blood pressure (131.24 ±4.58 mm Hg vs 119.93 ± 3.48 mm Hg, p=0.000), diastolic blood pressure (87.17± 2.24 mm Hg vs 79.31 ± 1.95 mm Hg, p=0.000) and pulse rate (83.83 ± 5.92 vs 74.62 ± 6.44, p=0.004) (Table 2).

Table 2: Effect of Intervention on Study Population

Variables (Mean ± SD)	Pre- Intervention (Mean ± SD)	Post- Intervention (Mean ± SD)	p value
Aerobic Exercise Group			
Systolic Blood Pressure (mm Hg)	131.45 ± 4.87	124.14 ± 4.033	0.000
Diastolic Blood Pressure (mm Hg)	87.03 ± 2.42	81.03 ± 2.11	0.000
Pulse Rate (/min)	82.69 ± 5.66	75.31 ± 5.47	0.000
Isometric Exercise Group			
Systolic Blood Pressure (mm Hg)	131.24 ±4.58	119.93 ± 3.48	0.000
Diastolic Blood Pressure (mm Hg)	87.17± 2.24	79.31 ± 1.95	0.000
Pulse Rate (/min)	83.83 ± 5.92	74.62 ± 6.44	0.004

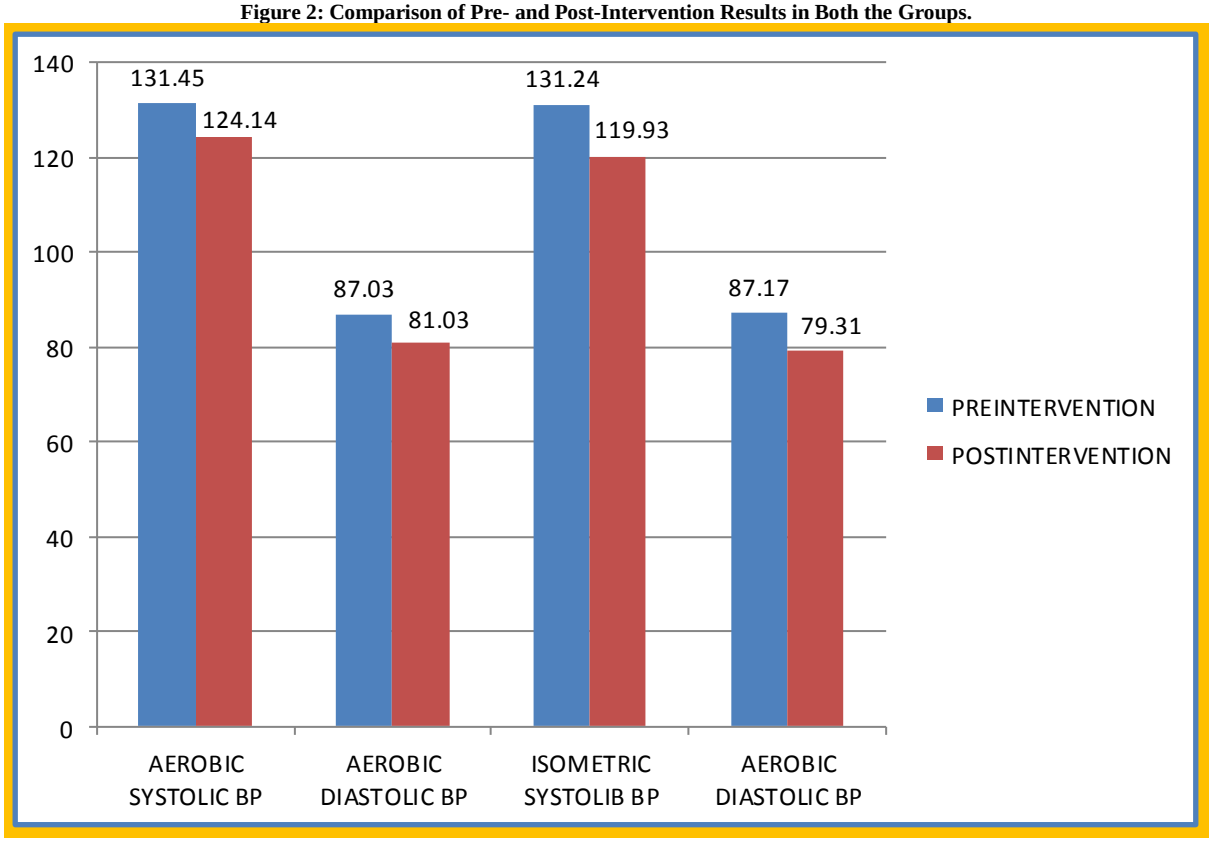
Both Aerobic exercise and Isometric exercise groups were comparable in terms of age, height, weight and waist to hip ratio (p>0.005, Table 3). The pre intervention systolic blood pressure (131.45 ± 4.87 vs 131.24 ± 4.58, p=0.868), diastolic blood pressure (87.03 ± 2.42 vs 87.17 ± 2.24, p=0.823) and pulse rate (82.69 ± 5.66 vs 83.83 ± 5.92, p=0.457) were also not statistically different between the groups (Table 3, Figure 2). We found a statistically significant difference in post-intervention systolic and diastolic blood pressure between both groups. When pre-

interventional variables were adjusted using ANCOVA, there was more significant reduction of systolic blood pressure (119.93 ± 3.48 vs 124.14 ± 4.03, p=0.000, Table 4), diastolic blood pressure (79.31 ± 1.95 vs 81.03 ± 2.11, p=0.000, Table 5) as well as pulse rate (74.62 ± 6.44 vs 75.31 ± 5.47, p=0.000, Table 6) in the isometric exercise group as compared to the aerobic exercise group.

Table 3: Comparison of Aerobic Exercise Group with Isometric Exercise Group

Variables (Mean ± SD)	Aerobic Exercise Group	Isometric Exercise Group	p value
Age (Years)	22.90 ± 1.26	23.1 ±1.26	0.534
Height (cm)	168.91 ± 10.48	169.88 ± 8.97	0.708
Weight (Kg)	61.19 ± 12.8	62.19 ±11.47	0.731
Waist to Hip Ratio	0.79 ± 0.02	0.79 ±0.03	0.758
Pre- Intervention			
Systolic Blood Pressure (mm Hg)	131.45 ± 4.87	131.24 ±4.58	0.868
Diastolic Blood Pressure (mm Hg)	87.03 ± 2.42	87.17± 2.24	0.823
Pulse Rate (/min)	82.69 ± 5.66	83.83 ± 5.92	0.457
Post- Intervention (ANCOVA Tests)			
Systolic Blood Pressure (mm Hg)	124.14 ± 4.033	119.93 ± 3.48	0.000
Diastolic Blood Pressure (mm Hg)	81.03 ± 2.11	79.31 ± 1.95	0.002
Pulse Rate (/min)	75.31 ± 5.47	74.62 ± 6.44	0.662

Figure 2: Comparison of Pre- and Post-Intervention Results in Both the Groups.



DISCUSSION

A continuous and consistent relationship exists between blood pressure and risk of cardiovascular disease events which is independent of other risk factors[6].Simply, the higher the blood pressure, the greater the chance of myocardial infarction, heart failure, stroke, and kidney disease. Exercise training is an intervention that can decrease cardiovascular risk factors without negative side effects. Previous studies have shown mixed results examining the effects of resistance training on resting BP in a pre- or stage-1 essential hypertensive cohort, but few used a drug-free pre-hypertensive population.[28,29] The present study demonstrates the decrease in blood pressure and heart rate in 4 weeks of aerobic as well as whole body isometric exercise training in un-medicated pre-hypertensives.

In our study, for the aerobic exercise group, the reduction in resting systolic and diastolic blood pressure was 7mmHg and 6mmHg respectively. This finding is consistent with other reported studies [30, 31]. Various mechanisms responsible for effect of aerobic training were: reduction in peripheral vascular resistance due to improvement in endothelial function, increased sensitivity of insulin, reduction in sympathetic tone and improving tolerance to ischemia [32, 33].

A significant reduction in systolic and diastolic blood pressure (11 mmHg and 7 mmHg respectively) was noticed in individuals after a full body large muscle group isometric exercise. This finding is consistent with other reported studies which shows similar results [19-21]. At initiation, isometric exercise leads to initial rise in BP, mostly due to the increase in cardiac output which returns quickly to baseline levels after completion of the exercise [34] but repeated performance of isometric exercise leads to reduction in BP in the long-term, and may enhance the action of antihypertensive drugs [21-24]. Additional benefits of the isometric or resistance exercise are the increase in muscle bulk, upper and lower body strength, decrease in body fat, increase in bone density, decrease in bone fractures, and increase in quality of life, especially in older individuals[20, 34.] Thus, both aerobic and isometric exercises leads to significant decrease in blood pressure. The reductions in BP found in the present study are clinically relevant, as a significant reduction in SBP of 4 mmHg for prehypertensives has been shown to reduce cardiac morbidity by greater than 5%, stroke by 8–14% and all-cause mortality by 4%.[6,13]

In the present study, there is a reduction in resting pulse rate after AE (p=0.000) and IE (p=0.004) training. A similar result was observed in the study conducted by Anthony W.Baross et al.[35] The mechanisms responsible for the attenuated resting heart rate observed in the handgrip isometric group were not easily explained. Various factors may be responsible, including resetting of central body leading to reduced sympathetic nerve activity and a decrease in muscle mechano-/metabo-receptor afferent activity [34, 35]. Huang G et al.[3036] found reduction in heart rate post aerobic training. After aerobic exercise training, it has been reported that resting HR decreases due to greater venous return to the heart and increases in autonomic control. There are emerging evidences on negative effects of increased heart rate on cardiovascular health and mortality with Aune et al [37] reporting 17% increase in mortality if resting heart rate increases by 10 beat per minute. Thus AE and IE help in decreasing cardiac as well as all-cause mortality by reducing the resting heart rate.

Our study also demonstrated that the reduction in blood pressure was more in the whole body isometric exercise group as compared to the aerobic exercise group. Interestingly, we have shown that after modest isometric exercise training, both the systolic and diastolic blood pressure returns to the normal values. Patients who performed aerobic exercise also showed reduction in systolic and diastolic blood pressure but post exercise their blood pressure failed to return to normal level. This is in contrast to various studies and reports which show that there is no difference in the magnitude or duration of the observed hypotension between exercise modalities.[38-40] However, most studies used only one group of muscle isometric training exercises while in this study whole body isometric training exercise was used. This might have led to a difference in the results. The mechanism responsible for a greater fall in blood pressure after whole body isometric exercise might be a greater reduction in vascular resistance due to involvement of more than one muscle group. Other reasons postulated in literature are: change in autonomic function control and improving oxidative stress response [34, 41]. Whatever may be the reason, the return of high blood pressure to normal level is an important finding for preventing the major

cardiovascular events in young pre hypertensives.

Limitations

The main limitation of the study is the small sample size which should be revised to a large sample size for future studies. The study population is young so these results might not be applicable in older individuals. Also no long term effect of both exercise methods was monitored. A randomised study of larger cohorts including both young and old individuals and comparing both exercise modalities in them would be ideal to draw definitive conclusions.

CONCLUSION

Both aerobic and whole body isometric exercises lead to a reduction in systolic and diastolic blood pressure and the resting pulse rate. This reduction may prevent or reduce the risk of future cardiovascular events in pre-hypertensives.

Whole body isometric exercise is more effective than aerobic exercise in reducing blood pressure and pulse rate in observed young pre-hypertensives and should be introduced in routine practice.

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Ethical Approval: Approved

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