RESEARCH ARTICLE

Effects of Sixteen Weeks Exercise Training on Left Ventricular Dimensions and Function in Young Athletes

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Received: 25.10.2011
Accepted: 13.06.2012

DOI: 10.5455/njppp.2012.2.152-158

ABSTRACT

Background: Exercise training-induced hemodynamic and electrophysiological changes in the myocardium lead to physiological left ventricular (LV) hypertrophy with preserved cardiac contractility and function, how much exact duration and intensity is enough for that?, is still not known. This must be known to clinician as the increasing involvement of young athletes in intensive training regimens.

Aims & Objective: To evaluate morphological changes in heart by echocardiography with sixteen weeks of exercise.

Materials and methods: Study comprises of sixteen weeks duration and was done on the students of physical education. This was a longitudinal study in which eighty-five subjects (43 male, 20.11 yrs ±1.137, 42 female, 19.81 yrs ± 1.89) were assessed using echocardiography and Medical Graphics CPX-D (for aerobic power) before the start of exercise program and at the end of exercise program. Statistical analysis was done using paired t test using Graph pad prism 5 software.

Results: No significant change was found in left ventricular morphology and ejection fraction after exercise program.

Conclusion: The results of this study suggest that the exercise training over a period of sixteen weeks doesn't influence cardiovascular morphology, but causes improvement in aerobic power.

KEY WORDS: Echocardiography; VO2max; Aerobic Exercise

INTRODUCTION

Regular participation in intensive physical exercise is associated with central and peripheral cardiovascular adaptations that facilitate the generation of a large and sustained cardiac output and enhance the extraction of oxygen from exercising muscle for aerobic glycolysis. Long-term physical exercise leads to left ventricular morphological adaptations, which vary with the kind of sport and the intensity and extent of the training. Although the echocardiographic changes related to exercise in athletes participating in various sports have been well described[1,2], longitudinal studies have been less well documented, hence we undertook a longitudinal study to assess the effect of 16-week moderate intensity endurance exercise on cardiovascular system in young healthy males and females.

MATERIALS AND METHODS

This was a longitudinal study which was done on young healthy males and females. Eighty-five subjects (43 male, 20.11 yrs ±1.137, 42 female, 19.81 yrs ± 1.89) were selected randomly from the medical college. Inclusion criteria were mainly healthy volunteer, age group between 18 – 23 yrs, and non smokers. Smokers, subjects with history cardiac, respiratory and diabetics and subjects whose clinical finding were abnormal were excluded from the study. Informed consent was taken from all the volunteers.

There exercise schedule was as follows.
Frequency: eight session /wk,
Time: 60min / session,
Type of physical activity: running (endurane)
Intensity was assessed with the help of Rating of Perceived Exertion scale. It was somewhat hard intensity (RPE scale[3]). Total duration of the exercise program was sixteen weeks. Exercise program per session were distributed as warm up for five min fairly light intensity (RPE scale), followed by running somewhat hard intensity (RPE scale), for 25 min then rest for five minutes and again running somewhat hard intensity for 25 min. They were running on the prepared track. Their exercise program was closely monitored by the author. Students were on ad libitum diet i.e. there was not any restriction on the diet and they were free to eat whatever they want.

Rating of Perceived Exertion scale is a common method, used in research studies for determining exercise intensity levels. The scale of perceived exertion is how hard you feel when your body is working, and therefore is a subjective measurement. Before the exercise program we had given education to the volunteers regarding how to use this scale. The commonly used scale is based on the research of Gunnar Borg, and is therefore also called the Borg Scale. We had used this scale as our sample size was eighty-five (43 male, 20.11 yrs ±1.137, 42 female, 19.81 yrs ± 1.89), as this scale is easier to use when sample size is large.[3]

Volunteers were evaluated within before exercise program and after 16-week moderate intensity endurance exercise and these findings were compared with previous findings.

For Echocardiography: PHILIPS ie 33, S5-1 (Company - Philips Healthcare, Philips Electronic India limited. Technopolis Knowledge Park, Mahakali Caves Road, Chikala, Andheri (E), Mumbai) - sector array transducer was used.

Appointments were given to eight subjects daily. Subjects were examined and conventional two-dimensionally (2D) guided M-mode recording were recorded. At rest, left ventricular end diastolic and end systolic diameters, interventricular septum and left posterior wall thicknesses were measured from the parasternal long and short-axis view, just below the mitral valve level according to the recommendations of the American Society of Echocardiography.[4,5] Cardiologist was following the same guidelines..

For Maximal Oxygen Consumption: Subjects underwent measurement of maximal oxygen consumption (VO_2max) performed by open circuit spirometry using a progressive treadmill walking protocol to volitional fatigue using a Medical Graphics CPX-D with Breeze Ex 3.06 software. Requirements to assure subjects reached their maximal oxygen consumption by this protocol included at least two of the following three criteria: (1) maximal heart rate>200 beats per minute; (2) respiratory exchange ratio (VCO_2/VO_2) >1.0; and (3) a plateau in oxygen consumption. All subjects reached their maximal oxygen consumption according to the above criteria.

For Fat Mass and Fat %: OMRON BF (Company - Test Medical Symptom @, Inc, 6633, Ashman road, Maria Stein OH.45860 PH 888-595-3136) 300 was used. It works according to Bioelectrical impedance analysis method (BIA). BIA is the most simple, quick, and inexpensive method to know the of fat mass and fat %.[6]

Body Surface Area: was calculated by DuBois formula. [BSA (m^2) = 0.007184 x Height (cm) $^{0.725}$ x Weight (kg) $^{0.425}$]

For Heart Rate: long lead II ECG was used. Cardiart 108-T-MK-VI, a single channel, 12-lead electrocardiograph was used to record the ECG (BPL Manufacturing Company,BPL limited, Banglore, India).

The subject was told to lie comfortably in supine position on the bed. Any metallic object such as watch, rings, necklace and coins were removed. Clothes were removed in a manner to expose chest, legs, and forearm. The cardio jelly was applied and long lead II was recorded on a thermo-sensitive paper 50-mm width with a speed of 25 mm/sec.

Blood Pressure: The resting blood pressure was measured with the help of mercury sphygmomanometer of Diamond company in right arm in supine position by palpatory and auscaltatory method. Pulse pressure (PP) was measured by deducting diastolic blood pressure (DBP) from systolic blood pressure (SBP) i.e. (SBP-DBP). Mean blood pressure was calculated by (DBP + 1/3 PP)

Approval for the above study was taken from institutional ethics committee.

Then the data of the observation for all parameters were statistically analyzed by calculating mean and standard deviation. The data was analyzed using Graph pad prism5 software. Statistical difference between the data obtained in various groups was evaluated by paired t test and p value <0.05 was considered as statistically significant.

RESULTS

Eighty-five subjects (43 male, 20.11 yrs ±1.137, 42 female, 19.81 yrs ± 1.89) were evaluated. Mean height was 1.701 ± 0.04568 in case of males and in females, it was 1.681 ± 0.5332. There was no significant change in weight of the volunteers with sixteen weeks moderate intensity endurance exercise. [Male (Pre exercise: 60.61 ± 5.873, Post exercise: 60.47 ± 5.516, Females (Pre exercise: 52.61 ± 6.495, Post exercise: 52.51 ± 5.465)]. There were no changes in body composition of the subjects with sixteen weeks of exercise. Body compositions of the subjects were within normal limits in both males and females. Aerobic power of all the subjects increased very significantly (Table 1). There were no significant morphological changes in heart in male as well as in females with sixteen weeks of exercise. Also there was no change in the left ventricular function as assessed by ejection fraction (Table 2).

Table-1: Result of Sixteen Week Endurance Exercise on Body Composition and Aerobic Power

Parameters	Pre Exercise Male (n=43)	Post Exercise Male (n=43)	Pre Exercise Female (n=42)	Post Exercise Female (n=42)
Fat Mass%	10.77 ± 4.64	10.78 ± 4.45	20.14 ± 4.55	20.67 ± 4.82
Fat Mass (kg)	6.59 ± 3.20	6.27 ± 2.89	10.83 ± 3.03	10.88 ± 2.96
LBM (kg)	54.24 ± 4.811	54.35 ± 4.96	41.32 ± 5.00	41.62 ± 4.79
BSA (M^2)	1.70 ± 0.081	1.711 ± 0.077	1.514 ± 0.085	1.513 ± 0.091
VO_2max (ML/KG/M)	45.14 ± 5.88	50.11 ± 4.15***	37.41 ± 3.28	41.15 ± 2.44***

Values are Mean ± SD; *** p<0.001, very highly significant; comparison between pre exercise and post exercise

Table-2: Result of Sixteen Week Endurance Exercise on Echocardiographic Dimensions

Parameters	Pre Exercise Male (n=43)	Post Exercise Male (n=43)	Pre Exercise Female (n=42)	Post Exercise Female (n=42)
LVPWs (cm)	1.44 ± 0.32	1.38 ± 0.25	1.34 ± 0.19	1.38 ± 0.25
LVPWD (cm)	1.031 ± 0.161	1.021 ± 0.160	0.981 ± 0.171	0.985 ± 0.161
IVSs (cm)	1.311 ± 0.33	1.312 ± 0.24	1.281 ± 0.207	1.283 ± 0.296
IVSd (cm)	0.981 ± 0.13	0.971 ± 0.14	0.898 ± 0.10	0.90 ± 0.12
LV Mass (gm)	154.55 ± 29.21	155.11 ± 29.36	121.12 ± 21.17	123.86 ± 23.14
LVIDs (cm)	2.87 ± 0.31	2.89 ± 0.35	2.38 ± 0.35	2.39 ± 0.36
LVIDd (cm)	4.461 ± 0.38	4.469 ± 0.40	4.115 ± 0.36	4.123 ± 0.44
EF (%)	62.19 ± 9.75	63.11 ± 8.121	65.58 ± 7.715	67.41 ± 8.87

Values are Mean ± SD; No significant change; comparison between pre exercise and post exercise

Table-3: Result of Sixteen Week Endurance Exercise on Echocardiographic Dimensions

Parameters	Pre Exercise Male (n=43)	Post Exercise Male (n=43)	Pre Exercise Female (n=42)	Post Exercise Female (n=42)
Systolic BP	116.27 ± 7.04	114.1 ± 4.90*	111.2 ± 9.67	110.61 ± 7.41*
Diastolic BP	74.74 ± 7.87	73.06 ± 5.99*	72.69 ± 8.93	71.51 ± 7.13*
Pulse Pressure	41.53 ± 9.15	41.88 ± 7.34	37.51 ± 5.81	37.1 ± 5.56
Mean Pressure	88.58 ± 6.27	89.02 ± 4.46	85.19 ± 8.76	85.87 ± 6.74
Resting Heart Rate (beats/min)	71.12 ± 11.25	62.14 ± 12.65 *	72.86 ± 10.25	64.58 ± 9.77*

Values are Mean ± SD; * p<0.05 significant change; comparison between pre exercise and post exercise

Significant decrease was observed in systolic, diastolic blood pressure and resting heart rate at the end of sixteen-week moderate intensity endurance exercise program (Table 3).

DISCUSSION

In present study, volunteers were involved in 16-week moderate intensity endurance exercise program. Endurance training is associated with an increased cardiac output and volume load on the left and right ventricles, causing the endurance-trained heart to generate a mild to moderate dilatation of the left ventricle combined with a mild to moderate increase in left ventricular wall thickness which is called eccentric left ventricular hypertrophy.[7] We expected such eccentric LVH, but there was no change in left ventricular dimension as well as function with the 16-week moderate intensity endurance exercise program.

No change was found in left ventricular posterior wall thickness in systole and diastole by some (LVPWs & LVPWd)[1,8] whereas some studies noted significant increase.[2,10] Improvement in LV function was seen by some authors.[1,2,9] This improvement was associated with morphological changes in some[2,9] while some exercise programs did not alter the cardiac structure.[1] McDonald MP et al[1] demonstrated that moderate exercise training results in an enhancement in the ability to reflexly adjust heart rate with spontaneous changes in arterial pressure within the operating range and this occurred independently of any changes in carotid-cardiac baroreflex function over the full response range in cardiopulmonary baroreflex function or in cardiac structure.

Left Ventricular Internal diameter at end-diastole (LVIDs) and at end-systole (LVIDd) does not change significantly in several studies[1,2,8,9] while in some it changed significantly.[10,11] Inter ventricular septal thickness at end-diastole (IVSd) and at end-systole (IVSs) remains unchanged[1,12] but increased in some studies.[2,9,13] In eccentric left ventricular hypertrophy, there is hypertrophy of all parameters i.e. left ventricular posterior wall thickness, left ventricular internal diameter and inter ventricular septal thickness. Eccentric LVH was not shown in this study. This difference may be because of less intensity of our exercise program.

EF %: Ejection fraction (EF) indicates the contractile status of heart. Some got improvement in EF[15] while some found no improvement in ejection fraction.[2,15,16] Systolic function as indicated by ejection fraction is mainly increased during the exercise not during the rest. These changes were secondary to increases in end-diastolic volume, which increased significantly at each exercise work rate following training. End-systolic volumes were unchanged after endurance training.[15] Bjornstad H et al concluded that the systolic function at rest is similar in age matched top athletes, athletic students and control.[17]

LV Mass: Wolfe LA et al found no significant change[19] while some got significant improvement in LV mass.[2,11,13,14]

Rodrigues A C et al[2] concluded that the physiologic increase in LV mass in response to regular exercise in healthy young men occurs in parallel with a decrease in atrial contribution to flow and LV function is improved despite the lack of changes in standard echocardiographic indexes.

In the present study, there was no significant change in LV morphology and LV function. If we compare all studies according to frequency, intesity, time, and mode of activity, mode was predominantly dynamic as in our study, frequency is certainly more in our study, time is more or less equal, but intensity is less, so it may be the factor for no significant change. Intensity of exercise in our study was similar to studies who got result comparable to us. So the exercise of short duration must be accompanied by very hard intensity for morphological changes to occur. So while assessing the athletes in the clinic, stress has to be given on intensity of exercise, it is important to ask history of not only duration but also of intensity especially when duration of the training programme is short, so as evaluation of athlete is possible.

How does the left ventricular size increase because of the exercise. It is because of lower heart rate and increased venous return.[10,18] Most of author had got the bradycardia[1,2,18] even Goodman JM et al,[15] with 6 days of endurance training, found no significant change in heart rate but it showed decrease. Exercise training besides causing vagal dominance, decreases the intrinsic firing rate of sinoatrial pacemaker tissue.[20] Due to lower heart rate more time is allowed for ventricular filling for accommodating more volume of blood in the left ventricle, which causes stretching of myocardial fibres, this increases the end-diastolic diameter of the ventricles. Increase in the size of left ventricular chamber increases the reserve capacity of chambers as well as increase force of contraction of left ventricle to pump out more volume of blood during each stroke.[15,18]

Maximal Oxygen Consumption: In present study, highly significant rise in aerobic power was demonstrated in males as well as females. VO2max is the internationally accepted parameter to evaluate the cardio respiratory fitness. The first and foremost effect of exercise is on increased VO2max.[3] Our result is in harmony with various other longitudinal studies.[21,22] Goodman JM et al also found significant increase in aerobic power with short duration(6 days) of training.[15]

What is the role of frequency, intensity, time, and type of training? Recent studies are in favour of high intensity aerobic endurance training.[21,22] Improvement in aerobic power depends on initial level of VO2max. Wenger HA et al in his review concluded that frequencies of as low as 2 per week can result in improvements in less fit subjects but when aerobic power exceeds 50 ml/kg/min, exercise frequency of at least 3 times per week is required.[23] As the levels of initial fitness improve, the changes in aerobic power decreases regardless of the intensity, frequency or duration of exercise. Resistance training or static training has little effect on VO2max. Resistance training alone does not increase VO2max, should not be considered as primary means of training for developing VO2max.[24]

In present study, subjects were mainly doing dynamic exercise; their F.I.T.T. was adequate to cause significant increase in aerobic power. There also exists gender difference (VO2max was less in females). Women have less blood volume, fewer red blood cells, and less hemoglobin, leading to lower oxygen carrying capacity, and capability to increase their arterial – venous difference. A smaller heart result in higher resting and sub maximal heart rate, lower stroke volume and oxygen pulse. VO2max is lower in women than men primarily because of lower cardiac output. Females have lower VO2max values than males, in part, because of their higher body fat content and smaller total muscle mass.[3,24]

Blood Pressure: Beneficial effect of exercise on blood pressure is well known. According to American College of Sports Medicine[25], exercise remains a cornerstone therapy for the primary prevention, treatment, and control of hypertension. Volunteer in our study were normotensive and significant decrement in systolic as well diastolic blood pressure was seen in the present study. The exercise training seems to act on systemic vascular resistance, plasma catecholamine, PGE2 and taurine levels, renin-

angiotensin-aldosterone system[8] which result decrese in blood pressure.[26]

Thus, sixteen weeks moderate intensity endurance exercise program, is helpful in improving aerobic power but not sufficient for cardiac morphological changes. For these changes to occur, exercise program must be of very hard intensity if duration of exercise program is short. To know the duration with moderate intensity for morphological changes to occur, we would recommend more longitudinal studies, but from this study we may opine that sixteen weeks are insufficient for moderate intensity. Athletes should also be given the importance of intensity of the exercise.

Limitations of the Study: To know the intensity, we had used Rating of Perceived Exertion scale which is the subjective method as our sample size was large, in future we would recommend objective method like that depending on target heart rate. Monitoring was difficult because of large sample size; study with smaller sample size would be performed for qualitative improvement.

Possibility intraobserver variations especially during echocardiography cannot be ruled out in spite of all precautions.

CONCLUSION

The results of this study suggest that the exercise training over a period of sixteen weeks doesn't influence cardiovascular morphology, but causes improvement in aerobic power.

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Cite this article as: Hulke SM Vaidya YP, Ratta AR. Effects of sixteen weeks exercise training on left ventricular dimensions and function in young athletes. Natl J Physiol Pharm Pharmacol 2012; 2:152-158.
Source of Support: Nil
Conflict of interest: None declared