ORIGINAL ARTICLE

ATHLETE'S HEART: THE LEFT VENTRICULAR REMODELING IN PAKISTANI ELITE ENDURANCE ATHLETES

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ABSTRACT

Background: Top-level physical training is often associated with morphological changes in heart including increased left ventricular cavity dimension, wall thickness and mass. The objective of this study was to find out the differences in ventricular chamber size and wall thickness in Pakistani elite endurance athletes as compared to age and Body Mass Index matched controls.

Material & Methods: This comparative cross-sectional study was conducted in Department of Physiology, Army Medical College, Rawalpindi from May 2003 to November 2004. A sample of 44 male subjects was selected, comprised of 22 elite endurance athletes (group 1) and 22 age and BMI matched healthy sedentary volunteers as controls (group 2). All those with cardiopulmonary diseases or having family history of these diseases were excluded. M-mode echocardiography was carried out. Age, weight, height and Body Mass Index were demographic variables while left ventricular end-diastolic internal diameter, diastolic interventricular septal thicknesses, left ventricular posterior wall thickness, and left ventricular mass were research variables. All these data were of ratio type, hence described by mean and standard deviation. The significance of the mean differences for all the variables was derived by student *t* test. Alpha value of 0.5 was considered as statistically significant.

Results: The mean LVIDd was 54.63±1.79 mm, IVST 9.86±0.89 mm, PWTd 8.63±0.73 mm, and LVM 196.36±22.86 gm in athletes and 40.63±2.08, 8.52±0.37, 8.04±0.32, 102.5±11.01 in controls respectively. The values in athletes were signifcantly higher as compared to controls.

Conclusion: Regular and extensive endurance training results in significantly greater left ventricular mass and volume.

KEY WORDS: Left Ventricular Hypertrophy; Echocardiography; Athletes; Left Ventricular Remodeling.

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INTRODUCTION

Top-level training is often associated with morphological changes in heart including increased left ventricular (LV) cavity dimension, wall thickness and mass.[1] It is assumed that the dimensional changes affect all cardiac cavities to the same extent and result in a balanced cardiac hypertrophy[2] which is called the "athlete's heart".[3] First demonstrated in 1935,[4] the enlarged heart of athletes is a beneficial adaptation enabling the athlete to perform more work.[5] The athlete's heart sustains an increased hemodynamic load which leads to the myocardial cellular stretch and strain.[6] In response to pressure overload, there increase in myocyte width, which in turn increases wall thickness.[7] Aerobic exercise results in increased left Ventricular mass (LVM), increased heart rate during exercise (decreased resting heart rate), increased ventricular stroke volume, and increased cardiac output, among other effects.[8] In regularly trained healthy subjects, both isotonic and isometric exercise cause cardiac changes resulting in modifications of the ventricular chamber, called physiological hypertrophy or athlete's hypertrophy.[9] Another major component of cardiac performance during exercise is the enhancement of sympathetic activity, which causes an increase in heart rate and contractility and mediates the cardiovascular and metabolic responses to exercise.[10] Echocardiographic studies reveal typical morphologic changes

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in athlete's heart, whose geometric pattern is much complicated.[3] Strength-trained athletes with isometric exercise or static exercise (weight lifting, body-building) reportedly tend to develop concentric Left Ventricular Hypertrophy (LVH).[11] Endurance-trained athletes with isotonic and dynamic exercise (long distance-runners, tri-athletes, marathon runners) tend to develop eccentric LVH and larger cavity dimensions.[12] Combined endurance-training and strength-training (cycling, field hockey, swimming) lead to both eccentric and concentric LV changes, showing a significant increase in wall thickness and corresponding increase in internal diameter.[13] The magnitude of the physiologic increase in cardiac mass vary according to the sport; extreme changes in cavity dimensions and wall thickness have been reported most commonly during training for rowing, cross-country skiing, cycling, and swimming.[14] In elite athletes marked LV morphological alterations (believed to be physiological adaptations to systematic athletic conditioning) are reversible after cessation of training and competition.[15] The increase in cardiac volume makes the heart more compliant with a larger stroke volume.[16] On the other hand 'bed rest' leads to the reversal of these changes and reduction in volume has been noted in two weeks.[17]

The objective of this study was to find out the differences in ventricular chamber size and wall thickness in Pakistani elite endurance athletes as compared to age and Body Mass Index (BMI) matched controls.

MATERIAL AND METHODS

This comparative cross-sectional study was carried out in the Department of Physiology, Army Medical College, Rawalpindi with collaboration of Armed Forces Institute of Cardiology (AFIC), Rawalpindi, Pakistan from May 2003 to November 2004.

A sample of 44 male subjects was selected by purposive non-probability technique from Pakistan Army personnel. These comprised 22 elite endurance athletes (group 1) and 22 age and BMI matched healthy sedentary volunteers as controls (group 2), both with age range of 18 to 35 years. All those with cardiopulmonary diseases or having family history of these diseases e.g. coronary artery disease, cardiomyopathy, severe arrhythmias, or any other disabling cardiovascular disease were excluded.

After complete medical history and physical examination, M-mode echocardiography[18] was carried out by Toshiba Power Vision 6000 Echocardiograph (Toshiba Medical Systems, Tokyo, Japan) with a 3.7 MHz transducer for all these subjects in AFIC by a single consultant cardiologist (Aziz S).

Age in years, weight in kilograms, height in meters and Body Mass Index (BMI) were demographic variables. BMI was calculated by weight in kg/ height in meters (kg/m^2). The research variables were left ventricular end-diastolic internal diameter (LVIDd) in mm, diastolic interventricular septal thicknesses (IVSTd) in mm, left ventricular posterior wall thickness (PWTd) in mm, and left ventricular mass (LVM) in grams. The left ventricular mass (LVM) was calculated by using the Devereux formula.[16]

$$LVM = 0.8\,[1.04\,(LVIDd + PWTd + IVSTd)^3 - (LVIDd)^3] + 0.6\ g$$

All these data were of ratio (continuous) type, hence descriptive statistics were shown by mean and standard deviation. The inferential statistics were carried out for significance of the mean differences for all the variables by applying independent samples student t test. Alpha value of 0.5 was considered as statistically significant.

RESULTS

All the 44 subjects were male, 22 in group 1 (study group) and 22 in group 2 (control group).

Table 1: Comparison of demographic variables between elite athletes and controls. (The values of age and BMI are given as mean ±SD)

Demographic variables	Elite Athletes (n=22)	Controls (n=22)
Age (years)	22.73 ±3.89	22.5 ± 2.48
Weight (kg)	61.48 ±2.40	63.58 ± 4.47
Height (m)	1.74 ± 0.05	1.76 ± 0.07
BMI (kg/m2)	20.36 ± 1.56	20.89 ± 0.96

None of the differences is statistically significant ($p>0.05$).

Table 2: Comparison of research variables between elite athletes and controls.

(The values are given as mean ± SD)

Research variables	Elite Athletes (n=22)	Controls (n=22)
LV end-diastolic internal diameter (LVIDd) (mm)	54.63 ± 1.79	40.6364 ± 2.08
Diastolic interventricular septal thickness (mm) (IVSTd)	9.86 ± 0.89	8.52 ± 0.37
Diastolic posterior wall thickness (PWTd) (mm)	8.63 ± 0.73	8.04 ± 0.32
Left Ventricular Mass (LVM) (gm)	196.36 ± 22.86	102.5 ± 11.01

*The difference is statistically significant at $p<0.05$

**The difference is statistically highly significant at $p<0.001$.

Table 1 presents the descriptive and inferential statistics of the demographic variables of the sample. The difference of means between none of these variables is statistically significant as the controls were carefully matched.

Table 2 presents the descriptive and inferential statistics of the research variables of the sample in elite athletes and controls. All of these are significantly higher in elite athletes as compared with the controls ($p < 0.001$ and $p < 0.05$ on independent samples student t test).

DISCUSSION

It is an established fact that left ventricular end-diastolic internal diameter (LVIDd) in athletes is increased as compared to sedentary person. Therefore, it was not surprising that in this study the LVIDd was found to be 54.63 mm ±1.79 mm in elite athletes, which is significantly higher as compared to the sedentary controls in whom it was found to be 40.63 mm ±2.08 mm. Pelliccia et al in 2013 found that LV end-diastolic internal diameter ($p<0.01$) were greater in endurance trained athletes.[19] Zdravkovic et al reported that the mean LVIDd was 53 ±0.5 mm in elite football players.[20] Similarly La Gerche et al also observed the same pattern that is Left ventricular end-diastolic internal diameter (LVIDd) of 56±5.6.[17] Pela et al found that the athletes had significantly greater LVIDd (55 ± 4.8 mm) than controls.[21] These values are close to what we found in our study. In the absence of systolic dysfunction, this cavity dilatation is most likely an extreme physiologic adaptation to intensive athletic conditioning. In our study diastolic posterior wall thickness (PWTd) was significantly more in elite athletes than that in controls. The means (±SD) of our elite athletes definitely showed an increased PWTd. The Mean ± SD PWTd in this study was calculated to be 8.63 ± 0.73 which is significantly higher than controls 8.04 ± 0.32 ($p <0.05$). The results closest to ours as far as PWTd is concerned are those of Sharma et al.[22] In their study mean PWTd levels in elite athletes were 9.5±1.7 mm and in controls were 8.4 ± 1.4 mm ($p< 0.0001$), while Abernethy et al reported the maximal wall thickness 11.2 ± 0.2 mm as compared to our study in which the maximal PWTd was observed to be 11 mm.[23] Nagashima et al found in 291 male100-km ultramarathon participants that IVSTd was 10.2 ± 1.9 mm, the PWTd was 10.0 ± 1.4 mm.[24] While Pellicia et al in their study of 2002 on 40 elite male athletes measured the PWTd to be 9.3±1.4mm, the level close to what we found in present study.[25] These high values are probably because of racial difference as Caucasian populations have more body surface area as compared to Asians. Bossone et al reported increased PWTd.[26] Similarly diastolic Inter-ventricular septal thickness (IVSTd) was also significantly more in elite athletes than that in controls, mean IVSTd in athletes was measured to 9.86 ± 0.89 mm as compared to controls 8.56 ±0.37 mm ($p<0.001$). Kasikcioglu et al, reported increased IVSTd in endurance athletes as compared to sedentary controls.[27] Palazzuoli et al concluded that IVSTd, were significantly higher in runners compared to controls ($p< 0.001$).[28]

This indicates that LVM depends upon PWTd, IVSTd and LVIDd. As we observed that in athletes included in our study all these parameters are higher than what they are in sedentary controls. Thus the LVM is also high in athletes (196.36 ± 22.38g) included in our study as compared to controls (102.5 ± 11.01g). This is in agreement to the studies conducted in Western world and Far East (Japan). Scharhag et al calculated the LVM in endurance trained athletes to be 200 ± 20 g[29] which is very near to our calculated value. Kasikcioglu et al stated that Left ventricular mass and mass index was higher in the athletes than in control subjects.[30] Dzudie et al in 2007 noted that the echocardiographic determination of LVM and volume is of importance for the interpretation of cardiac adaptations and risk-stratification. They observed increased LVM for the athlete's heart.[31]

CONCLUSION

Regular and extensive endurance training results in significantly greater left ventricular mass and volume.

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