Spor Hekimliği Dergisi
Cilt : 39, S. 43-50, 2004

CARDIAC MORPHOLOGY IN GYMNASTS ASSESSED BY ECHOCARDIOGRAPHY*

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SUMMARY

The purpose of the present study was to investigate the morphological adaptations of the heart to athletic training in competitive young gymnasts. Cardiac morphology of gymnasts (n=83) and controls were (n=45) compared. Artistic and rhythmic gymnasts aged 8.8 ± 1.5 (7-12) years had been training regularly for 4 years, at an average of 10 h/week. Sixty-one percent of the athletes were females and the rest were males. An athlete diagnosed with atrial septal defect was excluded from the study. The control group was similarly ($p>0.05$) composed. Subjects were evaluated by means of two-dimensional transthoracic echocardiography. Left-ventricle end-diastolic diameter (LVEDD), left ventricle end diastolic posterior wall thickness (LVEDPWT), interventricular septum thickness (IVST) and left ventricle mass (LVmass) were measured in the athletes as 37.6 ± 3.9 (28.3 - 46.7) mm, 6.3 ± 0.8 (4.4 - 8.3) mm, 6.2 ± 0.8 (4.3 - 9.7) mm, and 63.0 ± 20.7 (29 - 111) g, respectively. These figures were significantly higher ($p<0.001$) than the ones obtained for the controls. Increase in LVEDD and LVmass was more prominent in male athletes. To conclude, physical training in young gymnasts affects heart morphology by increasing LVEDD, LVmass, IVST, and LVEDPWT. Any athlete with suspect ECG changes, physical exam findings, and family history should be evaluated with

* Part of this research was presented as a poster presentation during the 12th International Congress on Physical Education and Sport, on 21-23 May 2004, Komotini, Greece.

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echocardiography for early detection of congenital heart diseases and hypertrophic cardiomyopathy.

Key words: Hypertrophic cardiomyopathy, echocardiography, athlete's heart, exercise, gymnastics

ÖZET

JİMNASTİKÇİLERDE KARDİYAK MORFOLOJİNİN EKOKARDİYOGRAFİ İLE DEĞERLENDİRİLMESİ

Bu çalışmada, yarışmacı genç jimnastikçilerin kalplerinde düzenli antrenmanlar sonucunda oluşan morfolojik adaptasyonların incelenmesi amaçlandı. Sporcu grubun (n=83) %61'i kız, %39'u erkekti ve yaş ortalamaları 8.8 ± 1.5 (7-12) yıl idi. Artistik ve ritmik jimnastikçilerden oluşan sporcu grup ortalama olarak 4 yıllık düzenli antrenman yaşına sahipti ve ortalama haftalık antrenman saatleri 10 idi. Atriyal septal defekt saptanan bir sporcu çalışma dışı bırakıldı Kontrol grubu (n=45) benzer yaş grubunda (p>0.05) oluşturulmuştu. Ölçümler için iki boyutlu (2D) transtorasik ekokardiografi kullanıldı. Sporcuların; sol ventrikül diyastol sonu çapları (LVEDD), sol ventrikül diyastol sonu posterior duvar kalınlıkları (LVEDPWT), ventrikül iç septum kalınlıkları (IVST) ve sol ventrikül kütleleri (LVmass) sırasıyla 37.6 ± 3.9 (28.3 - 46.7) mm, 6.3 ± 0.8 (4.4 - 8.3) mm, 6.2 ± 0.8 (4.3 - 9.7) mm ve 63.0 ± 20.7 (29 - 111) g bulundu. LVEDD ve LV kütlesindeki artışlar erkek sporcularda daha belirgindi. Kontrol grubuyla kıyaslandığında, bu parametrelerde sporcular lehine anlamlı (p<0.001) farklılıklar saptandı. Sonuç olarak, çocuk jimnastikçilerde düzenli antrenmanın kalp morfolojisi üzerindeki etkileri LVEDD, LV kütlesi, IVST ve LVEDPWT'de artışlar şeklinde ortaya çıktı. Şüpheli EKG değişiklikleri, fiziksel muayene bulguları ve aile özgeçmişi bulunan her genç sporcu, konjenital kalp hastalıklarının ve hipertrofik kardiyomyopatinin erken teşhisi için ekokardiografik yöntemlerle de muayene edilmelidir.

***Anahtar sözcükler**: Hipertrofik kardiyomyopati, ekokardiyografi, sporcu kalbi, egzersiz, jimnastik*

INTRODUCTION

Cardiovascular health clearly benefits from physical activity (11). Long-term athletic training is associated with cardiac morphological changes, increased left ventricular cavity dimensions, wall thickness, and mass, a state shortly described as athlete's heart (3).

The distinction between athlete's heart and cardiac disease has particularly important implications, since identification of cardiovascular disease in an athlete may be the basis for disqualification from athletic training and competition, in an effort to minimize life-threatening risks (3).

The purpose of this study was to investigate the morphological adaptations of the heart to athletic training in competitive young gymnasts, and to compare them with age-matched controls.

MATERIAL AND METHODS

Athletes

Eighty-three competitive young gymnasts from Izmir (61% females), aged 8.8 ± 1.5 years, underwent two-dimensional (2D) echocardiography during the peak competitive season. Written consent for cardiovascular evaluation was obtained from a parent/guardian. All athletes had competed at the regional level for 4 years (range 1 to 7 years) and 85% were competing at the national level at the time of this study. The number of hours of intensive training averaged 10 h/week (range 7 to 15 h). No athlete had symptoms of underlying cardiovascular disease. An athlete later diagnosed with atrial septal defect was excluded from the study.

Controls

Forty-five healthy sedentary controls participated voluntarily in the study. They were students at a primary school. They led a relatively sedentary lifestyle, defined as <2 h of organised physical activity per week. Controls had similar (p>0.05) age and gender distribution as the athletes: 8.6 ± 1.3 years (7-12), 64% females.

Echocardiography

A paediatric cardiologist performed two-dimensional (2D) echocardiography, using the Hewlett-Packard Sonos 1000 System equipped with a 3.5-Mhz transducer. Images of the heart were obtained in the standard parasternal long-axis and short-axis, and apical four-chamber planes, as previously described (16). The left ventricle (LV) end diastolic posterior wall thickness was measured from 2D short-axis views at end-diastole, with the largest measurement within the (LV) wall defined as the maximal wall thickness. M-mode echocardiograms derived from 2D images in the parasternal long axis were used for the measurement of LV end-diastolic dimensions, and interventricular septum diameter (13).

Statistical Analysis

Statistical analyses were performed using the Systat statistical software (version 9.0 for Windows; SPSS Inc., Chicago, IL, USA). Univariate analysis of variance, Student's t-test, and chi-square analysis were applied to data. Level of statistical significance was accepted as $p<0.05$. All data is presented as mean ± SD.

RESULTS

Demographic and echocardiographic parameters are given in Table 1. There were no significant differences ($p>0.05$) between the two groups in terms of gender, age and body mass index (BMI) distribution. Controls were heavier and taller ($p<0.05$) than the gymnasts.

Table 1. Demographic and echocardiographic parameters (as mean ± SD, and min-max) in gymnasts and non-athletic controls.

	Gymnasts (n=82)	Controls (n=45)	P
Age (year)	8.8 ± 1.5 (7-12)	8.6 ± 1.3 (7-12)	>0.05
Gender (F/M)	50/32	29/16	>0.05
Weight (kg)	23.9 ± 4.6 (15-35)	26.7 ± 5.8 (19-42)	<0.05
Height (cm)	124.9 ± 11.0 (106-168)	130.0 ± 11.0 (106-165)	<0.05
BMI (kg/m^2)	15.2 ± 1.5 (11.4-22.3)	15.7 ± 3.0 (11-24)	>0.05
LVEDD (mm)	37.6 ± 3.9 (28.3-46.7)	33.6 ± 4 (25.6-40.9)	<0.001
LVEDPWT (mm)	6.3 ± 0.8 (4.4-8.3)	5.5 ± 0.5 (4.4-6.8)	<0.001
IVST (mm)	6.2 ± 0.8 (4.3-9.7)	5.6 ± 0.6 (4.2-7.0)	<0.001
LV mass (g)	63.0 ± 20.7 (29-111)	44.0 ± 16.3 (20-81)	<0.001

BMI: body mass index; LVEDD: left ventricle end-diastolic diameter;
LVEDPWT: left ventricle end-diastolic posterior wall thickness;
IVST: interventricular septum thickness; LV mass: left ventricle mass

During echocardiography, all athletes were evaluated for the presence of atrial septal defect, ventricular septal defect, patent ductus arteriosus and aortic coarctation. None of the subjects had the latter three pathologies. But in one of the male athletes, although he was free of any cardiac symptoms, a large secundum type atrial septal defect was detected. He was later operated and the atrial septal defect was closed with dacron patch. Following operation, he has discontinued sports activity. His echocardiographic measurements were excluded from the study.

Functions of the atrio-ventricular and semilunar valves were evaluated with echocardiography. Neither regurgitation nor stenosis was detected in these valves. There were no coronary artery anomalies in any subject.

The systolic function of the left ventricle was evaluated with ejection fraction and fractional shortening. No statistically significant differences were found between the groups for these parameters. Ejection fraction and fractional shortening were above 65 % in both the study and control groups. Statistically significant differences ($p<0.001$) were observed between the groups for LVEDD, LVEDPWT, IVST, and LVmass (Table 1). As the controls were heavier, this significance would become even more prominent, if corrected for body weight.

When the two genders were compared, there were no differences in LVEDPWT and IVST. However, LVEDD and LVmass were found to be higher ($p<0.001$) in the male athletes compared with their female counterparts (Table 2).

Table 2. Comparison of echocardiographic findings between female and male athletes (as mean ± SD, and min-max).

	Female athletes (n=50)	Male athletes (n=32)	P
Age (year)	8.7 ± 1.7	8.9 ± 1.2	>0.05
Weight (kg)	23.5 ± 4.9	24.5 ± 4.1	>0.05
Height (cm)	124.7 ± 12	125.2 ± 8.0	>0.05
BMI (kg/m^2)	15.0 ± 1.7	15.5 ± 1.3	>0.05
LVEDD (mm)	36.1 ± 3.5	39.9 ± 3.5	<0.001
LVEDPWT (mm)	6.2 ± 0.8	6.3 ± 0.8	>0.05
IVST (mm)	5.9 ± 0.8	6.4 ± 0.6	<0.05
LV mass (g)	55.7 ± 17.7	74.5 ± 20.4	<0.001

DISCUSSION

Regular intensive physical training in endurance sports is associated with physiological increase in LVEDPWT, cavity size, and mass (1,10,14). The extent to which absolute left ventricular dimensions increase with training is usually limited, but may be substantial in elite athletes and suggestive of structural heart diseases such as hypertrophic cardiomyopathy (HCM), Marfan syndrome, congenital coronary artery anomalies, and aortic stenosis (valvular) (2). The differential diagnosis between athlete's heart and HCM represents a vital clinical dilemma since at least 10% of adolescent patients with HCM may be exposed to an unacceptably high risk of sudden death (7). HCM is the most common cardiovascular cause of sudden death in young athletes. A false positive diagnosis of HCM would result in unnecessary disqualification from sport (6), thereby potentially depriving the athlete from the many physical, psychological, and financial benefits of sports participation. Conversely, an erroneous negative diagnosis of athlete's heart could jeopardize a young life (9).

In this study, our aim was to evaluate cardiac morphology of young trained gymnasts, in comparison with a control group. LVEDD, LVEDPWT and IVST were found to be higher in athletes. Similar to our results, Monolas et al. found that left ventricular muscle mass was significantly larger in athletic males aged 11-12 (5). In the present study, LVEDD, LVEDPWT, IVST and LVmass were found to be higher than the control group both in girls and boys. In addition, LVEDD, IVST and LVmass measurements were higher in the male gymnasts, compared with the females.

Athlete's heart is the consequence of several determinants, including sport type, gender, and possibly, inherited genetic factors (12). The changes in cardiac morphology associated with long-term athletic training may be more striking in certain sports such as distance running, swimming, cycling and rowing/canoeing (8). The LV mass and LVPWT of marathon runners and judokas were found to be significantly greater than those of controls (1). There is no substantial data about the effect of athletic training on cardiac morphology in gymnasts. Gymnastics is a sport in which training starts at a very early age like 5-6 years old. So, at the age of 10, most of the athletes are in the sport for about 4-5 years. The possibility of changes in cardiac morphology associated with athletic training thus increases in this sport. In this study, it was observed that significant changes in cardiac morphology occurred by training in gymnastics.

Spirito et al. studied the morphologic adaptations of the heart to training in elite athletes representing 27 sports and found that endurance cyclists, rowers, and swimmers had the largest LV diastolic cavity dimensions. Sports such as track sprinting, field weight events, and diving were at the lower end of the spectrum of cardiac adaptation to athletic training. In isometric sports such as weight lifting and wrestling, wall thickness relative to cavity dimensions was found to be higher, but absolute wall thickness remained within normal limits (15). In our study, LV diastolic dimensions and LVmass measurements were higher in gymnasts and this was more prominent in the males.

In the study of Sharma et al., 720 elite adolescent athletes (75% males) aged 15.7 ± 1.4 years participating in ball, racket and endurance sports, and 250 healthy sedentary controls of similar age, gender and body surface area underwent echocardiography to define physiological limits of left ventricular hypertrophy. They observed that athletes had greater absolute LVPWT compared with controls. Maximum LVPWT exceeded the predicted upper limits in 5% of the athletes (14). Echocardiographic data defining athlete's heart are limited largely to adolescents (14 to 18 years old) for whom the risk of sudden death from HCM is high, with little information in younger athletes (7-14 years old). This is a reason for our selection of the 7-12 years old age group.

The efficacy of preventive screening is shown by recent studies reflecting a high prevalence (more than 70 %) of cardiac diseases as the reason for non-eligibility to participate in sport (4). Pre-participation screening by history, physical examination and electrocardiography alone may not be sufficient to identify heart disease. In this study, in one of the male athletes, a large atrial septal defect has been detected incidentally, although he was asymptomatic. He underwent surgical treatment. The two dimensional echocardiogram is the principal diagnostic tool to exclude congenital heart disease.

In conclusion, athletes' heart in gymnasts was investigated in children and it was detected that physical training in gymnastics affects heart morphology by increasing LVEDD, LVmass, IVST, and LVEDPWT. Increases in LVEDD and LVmass were more prominent in male athletes. Any athlete, especially with suspect ECG changes, physical exam findings, and family history should be evaluated with echocardiography for early detection of HCM and presence of any congenital heart disease.

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