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Original Article (Pages: 17135-17143)

Tissue Doppler Echocardiographic Indices in Athletic Teenagers

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Abstract

Background: The term "athlete's heart" is used to describe physiological changes occurring in the heart of a sportsperson. In contrast to young athletes, there is little data on the physiological changes in children during sport activities. The present study was conducted to compare tissue Doppler echocardiographic indices in adolescent athletes and controls.

Methods: In a case-control study done in Mashhad, Iran in 2018, 60 male adolescent athletes and 60 healthy individuals as controls were entered. All subjects were examined by a pediatric cardiologist using echocardiography to compare tissue Doppler Echocardiographic indices between case and control groups. Data analysis was done Using SPSS.20 .The significance level was<5%.

Results: Age, weight, height, heart rate and fractional shortening at baseline were not different between the two groups. In the athletes group, Ejection fraction (EF) was greater compared to the control group, while Systolic Blood Pressure (SBP) and Body Mass Index (BMI) were lower. Univariate analysis of Mitral waves showed that athletes presented greater A, E and E/E` ratio than controls and E` and S are greater in controls than in athletes. In relation to septal waves, only E` was higher in controls. In relation to tricuspid waves A, E, E`/A`ratio and E/E` ratio were higher in athletes as compared to the controls.

Conclusion: As a useful imaging tool, echocardiography can be employed to detect underlying heart disorders that may threaten people who exercise. However, better identification of individuals at risk of heart attack or other irreversible cardiac damages requires greater knowledge of the pathophysiology of cardiac adaptation to training.

Key Words: Adolescent, Athlete's heart, Pediatric athlete, Pediatric exercise, Sport cardiology, Tissue Doppler.

<u>* Please cite this article as</u>: Abtahi S, Mostafavian Z, Nikrouh E, Seifi A. Tissue Doppler Echocardiographic Indices in Athletic Teenagers. Int J Pediatr 2022; 10 (12):17135-17143. DOI: **10.22038/ijp.2022.67189.5022**

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Received date: Aug.09,2022; Accepted date: Nov.24,2022

1- INTRODUCTION

Childhood is the time of activity, and healthy children are normally more active compared to adults. Physical activity and exercise play an important role in physical and mental development of children during childhood, and prevent them from chronic diseases. Although cardiovascular fitness has been declining in children for many years, this decline has stabilized steadily since 2000 in the countries with low income equality.(1,2) International recommendations for activity of children and adolescents emphasize the importance of integrating exercise and physical activity into children's daily lives.(3,4) Despite the high prevalence of inactivity in population, the world is witnessing an increase in the number of children and adults who are trained at high levels of sports. According to estimations, the number of people who exercise has increased fivefold during the last 30 years.(5) There is strong evidence on the association between physical activity and a variety of health benefits such as bone health, muscle fitness, heart function, weight status, etc., among children and adolescents. (6) It is clear that exercise improves cardiovascular health. (7) On the other hand, many studies have indicated an increase in cardiovascular events during exercise. (8) The term "athlete's heart" refers to the changes occurring on the structure and function of the heart during exercise and has attracted the attention of physicians and scientists for about a century.(9) Henschen was the first who described enlargement of the heart caused by athletic activity using cardiac auscultation and percussion.(10) As defined by Prior and La Gerche, athlete's heart is a set of structural, electrical and functional remodelings in response to athletic exercise".(11) Although there is limited knowledge on the association between athletic training, cardiac adaptation, and physiological changes in childhood, a meta-analysis study indicated that cardiac adaptation can take place in athletes with only 12 years of age. (12) Unlike for young adults, there is little knowledge on the physiological changes occurring in children during sport activities, especially in pediatric athletes. (13) Although not a primary screening tool, echocardiography is still applied in pediatric cardiology as a primary diagnostic imaging technique. The results of studies evaluating morphological cardiac adaptation indicate that exercise has a significant effect on the left ventricle (14) and a lesser effect on the right (15). As far as we know, there is no study evaluating the effect of training volume and intensity, ethnicity, gender and age on the echocardiographic data in the pediatric age group. (16) According to the above, there is a need to study an athlete's heart not only to differentiate the athlete's heart from unpleasant states with potentially similar morphologic characteristics, but also to gain a better knowledge on the way cardiac adaptation contributes to improved athletic performance. This study is aimed to evaluate tissue Doppler echocardiographic indices in the male adolescent athletes in comparison to their controls.

2- MATERIALS AND METHODS

This is a case-control study performed in Mashhad city, Iran, in 2018. The participants included 60 male adolescent athletes (group I) studying in a professional Sports high school, and 60 healthy individuals (group II) who matched group1 in terms of age, weight and height. They were selected through convenience sampling. The participants in group I were from students who practiced in their specific sport branch over 5 hours a week for at least 1 year, while the participants in group II studied in a non-sports high school and their sports activities were limited to 2 hours of regular sports per week. All participants were between 14 and 16 years old. They were screened through history and physical examination, and had no heart disease. Subjects with anabolic steroid misuse and a history of systemic disease were excluded from the study. After learning about the procedure of the study, written consents were obtained from the participants. Sample size was calculated according Simsek`s study (17) in which the mean and standard deviation of Em (early diastolic) peak (cm/s) of lateral annulus in two groups of subjects including athletes and controls were 18.8 ± 4.1 and 15 ± 3.5, respectively. And according to a formula for comparing means in two independent groups with a significance level of 0.05 and a power of 80%, at least 16 people were specified as the required sample per group. Finally, 60 people were entered in each group.

Data collection tool was a checklist for each subject including demographic characteristics like group, age, weight, height and findings of tissue Doppler echocardiography. All subjects were examined by a pediatric cardiologist using a General Electric vivid 3 echocardiography.

2-1. Data analysis

Data were analyzed using SPSS V. 20 software. Qualitative data were represented as frequency and percentage while quantitative data were expressed as mean ± SD. Student's t-test was applied to compare continuous variables with normal distribution between the two groups (group I and group II).

The effects of independent variables on dependent variables were examined simultaneously using Analysis of Covariance test (ANCOVA). P-values less than 0.05 were considered as statistically significant.

3- RESULTS

The two studied groups were similar regarding age, weight, height, heart rate and fractional shortening. The BMI and SBP in athletes were lower than that of the control group and Ejection fraction (EF) was found to be notably greater in athletes than in the controls **(Table 1**). The difference in EF remained significant between the two groups, after adjusting for variables of age, SBP, and BMI.

Univariate analysis of Mitral waves, showed that athletes presented greater A, E and E/E` ratio than controls and E` and S are higher in controls than in athletes. These differences remained significant after adjusting the effects of age, BMI, BP and group by ANCOVA test. In contrast, A`, E/A, and E`/A` ratios were similar between the groups.

Table-1: Demographic and echocardiographic findings of athletes and controls

Variable	Athletes	Controls	p-value
Age (yrs)	15.28 ± 0.61	15.32 ± 0.62	0.768
Weight (kg)	60.13 ± 9.7	61.43 ± 5.19	0.361
Height (cm)	172.6± 6.5	170.8 ± 3.3	0.051
BMI (kg/m2)	20.07± 2.35	21.07 ±1.8	0.01
Systolic Blood Pressure (mmhg)	107.58 ±7.83	112.17± 5.55	<0.0001
Heart rate	71.1 ± 10.6	69.5 ± 10.4	0.332
Ejection fraction	65.88 ± 4.5	62.33± 1.49	<0.0001
fractional shortening	36.08 ± 3.55	36.36 ± 1.32	0.57

Table-2: Comparing the Standard transmitral Doppler velocities between athletes and controls

Mitral waves	Athletes	Controls	p-value
A	0.58 ± 0.12	0.45 ± 0.06	<0.0001
E	1.1 ± 0.21	0.9 ± 0.08	<0.0001
A\`	0.06 ± 0.015	0.07 ± 0.002	0.318
E\`	0.18± 0.03	0.21± 0.004	<0.0001
S	0.09 ± 0.02	0.12 ± 0.003	<0.0001
E/A	1.96 ± 0.49	2.04± 0.31	0.249
E\`/A\`	2.89 ± 0.78	3.09 ± 1.35	0.054
E/E\`	6.27 ±1.21	4.42 ± 0.37	<0.0001

In relation to septal waves, only E\` was greater in controls than in athletes and after adjusting the effects of age, BMI, BP and group by ANCOVA test, this difference remained. The differences between A1, S velocity and **E\`/A\`** ratio were not significant between groups (**Table 3**).

Table-3: Comparing the Standard transseptal Doppler velocities between athletes and controls

Septal waves	Athletes	Controls	p-value
A\`	0.07 ± 0.019	0.06 ± 0.001	0.291
E\`	0.14± 0.024	0.15± 0.003	0.028
S	0.087 ± 0.01	0.09 ± 0.001	0.07
E\`/A\`	2.35 ± 0.71	2.38 ± 0.07	0.768

Table-4: Comparing the Standard trans tricuspid Doppler velocities between athletes and controls

Tricuspid waves	Athletes	Controls	p-value
A	0.52 ± 0.09	0.34 ± 0.05	<0.0001
E	0.78 ± 0.16	0.6 ± 0.05	<0.0001
A\`	0.08± 0.003	0.1 ± 0.003	<0.0001
E\`	0.16± 0.03	0.17 ± 0.004	0.132
S	0.13 ± 0.02	0.14 ± 0.002	0.084
E/A	1.5 ± 0.28	1.98± 1.87	0.055
E\`/A\`	2.02 ± 0.87	1.65 ± 0.07	<0.001
E/E\`	5.01 ±1.31	3.64 ± 0.33	<0.0001

4- DISCUSSION

As a relatively new technique of cardiac function assessment, tissue Doppler imaging (TDI) can provide measurements of myocardial velocities all across the cardiac cycle (18). Previous studies have indicated that LV diastolic function is significantly associated with increased stroke volume and plays a key role in physical function and cardiorespiratory (19). E/A ratio and LV filling parameters through mitral annulus are frequently used in the case of diastolic functions (20). In the present study, the measurements taken by transmitral

Doppler velocity showed significantly higher rates of mitral annular a velocity and peak E velocity in athlete participants compared to the participants in the control group. However, both groups were found to be similar in E/A ratio and E'/A' ratio. In addition to diastolic compliance, transmitral velocity can be influenced by a variety of parameters including pre- and after-load and heart rates. The results of longitudinal studies have shown that LV diastolic function is increased in previously sedentary individuals after endurance training (21). Recently, a meta-analysis of 59 studies involving 1451 athletes was conducted. The results showed a normal or slightly higher E/A ratio in athletes in comparison to the controls, which is consistent with the findings of this study (22). Any change in athletes' E/A ratios may be attributed to a potential decrease in peak A filling velocity or to a potential increase in peak E wave velocity. Besides, it is difficult to determine whether changes in E and A velocities are indicative of enhanced intrinsic performance, changes in loading, or heart rate (23). In recent systematic reviews, increased E/A ratio in athletes has been mainly attributed to a decrease in resting HR. It is only in older athletes that HR-independent increases in diastolic flow data may be apparent (24). Similarly, athlete participants in the present study showed higher heart rates than those in the control, but the difference was not statistically significant (71 “Beat Per Minute” or BPM in the athletes' group against 69 BPM in the control). While the majority results of other studies show lower heart rates in athletes due to the augmented vagal tone in well trained athletes (24-27), it is considerable that our athletes have not been professional in sports.

Recent studies comparing septal and lateral wall motion between athletes and control subjects have reported an increase in peak early (E') and a decrease in A' tissue velocity in athletes (28, 29). However, in this study lateral E' and Septal velocities in athletes were significantly lower compared to other participants whereas A' velocities were relatively similar in both groups.

Caselli et al. reported that young white athletes showed lower E' values in a large cohort (n = 1,145) compared to the control group (30), which is in line with our findings. Adequate filling of the left ventricular in athletes does not need much expansion in its size, causing a reduction in relaxation velocities. This finding could explain the low LV ejection fraction in many athletes with large LVs, because generating sufficient stroke volume does not require large LV contraction. Although there is increasing evidence on increased diastolic function in athletes, it should be noted that TDI is load- and rate-dependent and has been used almost exclusively to evaluate longitudinal motion. The analysis of pulse tissue Doppler velocities showed that peak Sm and E'(end diastolic) velocities of septal and mitral annulus in athletes were significantly lower than those in controls, but the two groups showed similar mitral annulus A' velocities. Kneffelet al. attributed the higher E/A ratios in athletes to a lower resting heart rate (24). Baldi et al. and Zoncu et al. also reported higher levels of E’ tissue velocities in athlete subjects than in controls (23, 31). In a study by Poh et alThe researcher reported that intensive physical training increased E’ level in elite speedsters (29). According to Vinereanu et al., endurance-trained athletes showed greater improvement in LV diastolic function as compared to the strength-trained athletes (28). There are echocardiographic studies evaluating functional and morphological adaptation of the left ventricle among athletes (33-36). However, few studies have been devoted to investigating the role of physical exercise in the structure and function of the right heart (22, 37, 38).

Furthermore, we studied RV diastolic function by analyzing diastolic tricuspid annulus velocities. In this regard, previous research revealed that RV tissue Doppler peak velocities are notably higher in athletes (37, 38). However, some studies including Erol et al. failed to find any significant differences in systolic and diastolic function parameters in doppler echocardiography between the athletes and the controls. It was argued that despite significant chamber dilation, the global RV function of athletes' hearts remained unchanged (38). As our study showed that Tricuspid annulus A and E velocities in athletes were significantly greater in comparison to the controls. Both groups showed similar E' velocities of Tricuspid annulus; whereas, A' velocities of Tricuspid annulus were significantly lower in athletes. The ratio of E' to A' velocities were significantly higher in athletes but E/A ratios were similar in both groups. In this study, we used ejection fraction to determine LV systolic functions. The results showed significantly higher rates in athletes compared to the controls. This is in contrast to the finding of many previous studies which report similar and not significant differences between LV systolic functions in athletes and non-athlete adolescents (39-42).

4-1. Limitations of the study

Artifacts were the significant limitation of this study; they especially included patients' body movement and respiration, which diminish image quality in a way that the measurements are not possible at certain segments. To avoid this limitation, the images including a minimum of three cycles taken at the end of the expiration were used for the measurements. The presence of different sports disciplines were another limitation of the current research, so that it was impossible to classify the population.

Given that the population of pre-adolescent athletes who are involved in professional sports is increasing, the differentiation of physiological changes of the athlete's heart from the pathological changes of the myocardium is increasingly important from a clinical point of view. Especially because the results of some studies have shown that severe exercise can not only accelerate and aggravate the symptoms of hereditary cardiac disorders like Arrhythmogenic right ventricular cardiomyopathy (ARVC), but also causes arrhythmias through irreversible cardiac alterations.

5- CONCLUSION

As a useful imaging tool, echocardiography can be employed to detect underlying heart disorders that may threaten people who exercise. It is also a low-price, non-invasive approach for the examination of cardiac compatibility to exercise. Diagnosing exercise adaptation is as challenging as diagnosing some cardiac disorders in the early stages. Thanks to the newly developed tools, better quantification of cardiac functions has become possible today. However, better identification of individuals at risk of heart attack or other irreversible cardiac damages requires greater knowledge of the pathophysiology of cardiac adaptation to training.

6- ETHICAL CONSIDERATIONS

This study has been registered with the ethics code of IR.MUMS.REC.1400.271. Information about each patient is kept confidential and the questionnaires were delivered with a code. All Individuals entered the study with informed written consent.

7- ACKNOWLEDGEMENT

We would like to thank all people who participated in this study.

8- CONFLICT OF INTERESTS

None.

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