

The Preparticipation Sports Examination of Healthy Children: When Should be Referred to Pediatric Cardiologist?

Sağlıklı Çocukların Spor Katılımı Öncesi Değerlendirilmesi: Ne Zaman Pediatrik Kardiyoloğa Yönlendirilmeli?

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ABSTRACT Objective: Sudden cardiac death (SCD) that may occur during sports activation of young healthy athletes is a painful condition and impose responsibilities on both families and physicians. Although, there is not an established standard protocol in medical screening of sports preparticipation, any of the screening procedure cannot completely rule out the presence of cardiovascular disease and prevent from SCD. The aim of this study is to evaluate the frequency of cardiac anomalies in healthy children evaluated by electrocardiography (ECG) and transthoracic echocardiography before sports participation and to question the necessity of pediatric cardiologist evaluation in the light of the available data. **Material and Methods:** All children who were admitted to Pediatric Cardiology Department of Keçiören Training and Research Hospital to get certificate to conform sports activation and underwent cardiac examination, ECG and echocardiography between October 2018 and October 2019 were enrolled in the study and findings were evaluated retrospectively. **Results:** A total of 785 children and adolescents with median age of 12 (minimum 5-maximum 18) years were enrolled in the study in one year period. A total of 27 (3.4%) participants showed abnormal findings on physical examination. ECG abnormalities were detected in 48 (6.1%) participants. Structural cardiac anomalies were observed in 53 (6.7%) participants by echocardiography. None of the echocardiographic diagnoses were hemodynamically significant. **Conclusion:** Echocardiography allows to diagnose cardiomyopathies or hemodynamically significant structural heart diseases which lead to decision of sports disqualification. However, in such a case, symptoms and ECG abnormalities may occur earlier and may be a guide for physicians for further examination. Comprehensive cardiac evaluation by a pediatric cardiologist including echocardiography should be performed in patients with suspected personal and family history, pathological findings in physical examination and/or pathological ECG findings.

Keywords: Children; electrocardiography; echocardiography; sports

ÖZET Amaç: Genç ve sağlıklı sporcuların, spor aktivitesi sırasında meydana gelebilen kayıplar olarak bilinen ani kardiyak ölüm, oldukça sarsıcı bir durumdur ve hem ailelere hem de hekimlere sorumluluklar yüklemektedir. Spora katılım öncesi medikal tarama konusunda belirlenmiş standart bir protokol olmamasına karşın, görüntüleme yöntemlerinden hiçbiri, kardiyovasküler hastalık varlığını tamamen dışlayamaz ve ani kardiyak ölümden tamamen koruyamaz. Bu çalışmanın amacı, spor katılımı öncesi, elektrokardiografi (EKG) ve ekokardiografi yöntemleriyle değerlendirilen sağlıklı çocuklarda kardiyak anomali sıklığını değerlendirmek ve mevcut veriler ışığında, pediatrik kardiyolog değerlendirmesi gerekliliğini sorgulamaktır. **Gereç ve Yöntemler:** Çalışmaya, Keçiören Eğitim ve Araştırma Hastanesi Çocuk Kardiyoloji Polikliniğine, Ekim 2018 ve Ekim 2019 tarihleri arasında spor aktivitesine katılım raporu almak için başvuran ve kardiyolojik muayene, elektrokardiografi, ekokardiografi yapılan tüm çocuklar dahil edildi ve bulgular retrospektif olarak incelendi. **Bulgular:** Ortanca yaşı 12 (minimum 5, maksimum 18) yıl olan 785 çocuk ve adolesan bir yıl süre içinde çalışmaya dahil edildi. Patolojik fizik muayene bulgusu, 27 (%3,4) katılımcıda izlendi. Elektrokardiogram anormalliyi 48 (%6,1) olguda saptandı. Ekokardiografi ile 53 (%6,7) olguda yapısal kardiyak anomali tespit edildi. Ekokardiografi ile tanı koyulan kardiyak anomalilerin hiçbiri hemodinamik olarak anlamlı değildi. **Sonuç:** Ekokardiografi, spora katılımda engel teşkil edebilecek hemodinamik olarak anlamlı yapısal kalp hastalığı veya kardiyomyopati teşhisine imkan vermektedir. Ancak, böyle bir durumda semptomlar ve EKG anormallikleri daha önce ortaya çıkabilir ve hekimler için ileri inceleme açısından yol gösterici olabilir. Bir pediatrik kardiyolog tarafından, ekokardiografiyi içeren kapsamlı kardiyak değerlendirme, patolojik EKG bulguları olan ve/veya fizik muayenesinde patolojik bulgu saptanan, şüpheli kişisel ve aile öyküsü olan hastalara yapılmamalıdır.

Anahtar Kelimeler: Çocuklar; elektrokardiografi; ekokardiografi; spor

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Participating in regular sports activities has a crucial role for cardiovascular system health. The number of children and adolescents engaged in sports is increasing day by day. There is also an increasing concern among families and even clinicians of underlying cardiovascular disease because of the news about sudden cardiac death during sports activities on media. This condition emphasizes the importance of cardiac evaluation before participation in sports.

Sudden cardiac death (SCD) is defined as unexpected death of a previously healthy person without a trauma and has an incidence ranging between 1 in 40 000 and 1 in 80 000.^{1,2}

Structural cardiac anomalies such as hypertrophic cardiomyopathy, anomalies of coronary arteries, aortic stenosis or electrical abnormalities and ion channelopathies are the cardiac predisposing factors to SCD.^{3,4} The most common cause of SCD among these cardiac anomalies is hypertrophic cardiomyopathy (HCM) with an incidence range of 0.1%-0.2%.³ Despite the rarity of cardiac anomalies in SCD of athletes, SCD is the most common cause of death during exercise at pediatric age and this condition leads to the necessity of screening of cardiac anomalies in sports preparticipation of healthy children. However, there is not still an established screening standard procedure all over the world. While American Heart Association recommends only physical examination and personal-family history, recommendation of European Society of Cardiology adds electrocardiography to screening programmes.^{5,6} Recent studies reported that limited echocardiography should be a part of screening procedure.⁷⁻⁹ However, time and cost effectiveness of screening with echocardiography is still of debate.

In Turkey, due to the absence of a standard approach and concerns of clinicians about undiagnosed cardiac anomalies, all healthy children even without a symptom, history or any positive finding are referred to pediatric cardiology departments. So, this condition becomes a daily clinical practice of a pediatric cardiologist and different clinics established their own screening procedure including different tests such as; transthoracic echocardiography, 24 hour rhythm holter monitoring or cardiovascular stress test.

The aim of this study is to present our experience in one year period as well as to assess the necessity of detailed cardiac examination by a pediatric cardiologist including echocardiography in preparticipation sports screening of healthy children.

MATERIAL AND METHODS

From October 2018 to October 2019 a total of 785 healthy children were admitted for pre participation sports screening to Pediatric Cardiology Department of Keçiören Training and Research Hospital. All these children were screened with a medical, personal and family history, cardiac examination, measurements of weight, height, blood pressure, electrocardiography (ECG) and transthoracic echocardiography.

A comprehensive history was obtained according to American Heart Association's guidelines including the following questions; exertion related chest pain; syncope or presyncope; exertion related dyspnea, fatigue, or palpitations; existence of a heart murmur; abnormalities in blood pressure; previous sports restrictions; family history of premature death, coronary artery disease before the age of 50, cardiomyopathy and ion channelopathies.⁶

Anthropometric data were obtained in all participants and weight (in kilograms) divided by the square of height (in meters) (kg/m^2) was defined as body mass index (BMI).

After a 10 min seated rest blood pressure was taken with an appropriate size of cuff using a mercury sphygmomanometer.

Supine, resting ECG was obtained from all participants with an ECG recorder (Nihon Kohden, Tokyo, Japan) set at 25 mm/s paper speed and 10 mm/mV voltage standardization. An experienced pediatric cardiologist interpreted all ECG recordings. Corrected QT (QTc) intervals were calculated using the Bazett formula, in leads II or V5.¹⁰

A standard transthoracic echocardiography was performed using Vivid 3 (General Electric, USA) echocardiography with the aid of 3 MHz probe following the American Heart Association echo guidelines.¹¹

If clinically indicated, additional tests such as 24 hour rhythm holter monitoring (CardioScan 11.0; DM Software Inc., Nevada, County, California, United States of America) and exercise stress test (CPET Treadmills; Norav Instrument Inc., Zernick-epark, Groningen, Neitherlands) were performed.

The Statistical Package for the Social Sciences program version 21 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis of data. Shapiro-Wilk test was used to assess the normal distribution suitability of variables. For normally distributed data, continuous variables were expressed as mean \pm standard deviation and as median (minimum-maximum) for non-normally distributed data. Statistically significance level was considered as a p value of under 0.05.

The present study was approved by a scientific committee of Keciören Training and Research Hospital comprising the hospital administration and lecturers (2019/43278876-929). The study was carried out in accordance with the principles of Helsinki Declaration. Written informed consent was obtained from all participants over the age of six and their parents.

RESULTS

A total of 785 children were enrolled in the study. Table 1 demonstrates demographic and clinical features of the participants including age, gender, BMI and blood pressure.

While most of the participants were asymptomatic at the time of admission, near syncope or syncope were the most frequent complaints reported by 9 children (1.1%). Heart murmur (not innocent) and systolic hypertension were the positive findings of

physical examination and detected in 11 (1.4%) and 16 (2%) participants, respectively.

ECG were evaluated as normal in 737 (93.8%) participants. The mean QTc interval of the study group was 393.9 ± 18.5 msec. Only two patients were detected to have prolonged QTc. Abnormal findings of ECG were detected in 48 (6.1%) participants. Excluding normal variants such as sinus arrhythmia, early repolarization pattern, incomplete right-bundle block etc., a total of 17 (2.1%) participants had pathologic electrocardiographic findings.

Transthoracic echocardiography were normal in 732 (93.2%) participants. Systolic functions were all in normal limits in the study group with mean ejection fraction of $71.54 \pm 6.04\%$ mean shortening fraction of $40.81 \pm 5.55\%$. None of the participants had hemodynamically significant structural heart disease.

A total of 23 participants had 24 hour rhythm holter monitoring and 22 had exercise stress test. Extrasystoles with different frequencies were observed in 11 (1.4%) participants. These extrasystoles were disappeared with exercise during exercise stress test and no ST-T changes were determined in the participants.

Findings from examination, electrocardiography and echocardiography were summarized in Table 2.

DISCUSSION

The aim of pre participation sports screening tests are to diagnose the underlying cardiac anomalies and to prevent athletes from SCD. However, no worldwide consensus is available on how to perform preparticipation sports medical screening.

Personal/family history and physical examination recommended by all American and European scientific committees and sports associations.^{12,13} Moreover, while American Heart Association recommends only physical examination and personal-family history, recommendation of European Society of Cardiology adds electrocardiography to screening programmes.^{5,6} ECG is reported as a more sensitive method than history or physical examination alone by European guidelines, because, the presence of lethal asymptomatic cardiac pathologies such as; genetic ar-

TABLE 1: Demographic and clinical characteristics of the participants.

	n (%), median (min-max)
Age (years)	12 (5-18)
Gender (female/male)	247/538(31.5/68.5)
Height (cm)	153(107-204)
Weight (kg)	45(16-99)
BMI (kg/m ²)	18.2 (10.5-32)
Systolic BP (mmHg)	109 (85-140)
Diastolic BP (mmHg)	60 (33-95)

BMI: Body mass index; BP: Blood pressure.

TABLE 2: Findings from screening tests.

	n (%)
Personal history	
Chest pain with exercise	9 (1.1)
Syncope/ near syncope	9 (1.1)
Dyspnea and fatigue with exercise	3 (0.4)
Family history	
Sudden cardiac death	4 (0.5)
Arrhythmia	5 (0.6)
Coronary artery disease before the age of 50	30 (3.8)
Structural heart disease	12 (1.5)
Physical examination	
Heart murmur	11 (1.4)
Hypertension	16 (2)
Electrocardiography	
Sinus arrhythmia	17 (2.2)
Sinus bradycardia	4 (0.5)
Sinus tachycardia	1 (0.1)
Incomplete RBBB	9 (1.1)
Left anterior/posterior hemiblock	6 (0.7)
Preexcitation (WPW)	1 (0.1)
Ventricular extrasystole	2 (0.3)
Supraventricular extrasystole	2 (0.3)
Early repolarization pattern	2 (0.3)
ST-T changes	2 (0.3)
Long QT	2 (0.3)
Echocardiography	
MVP	8 (1.0)
Secundum ASD	9 (1.1)
PFO	8 (1.0)
ASA	2 (0.3)
Mild-trivial valve insufficiency	21 (2.6)
Probable rheumatic heart disease	5 (0.6)

RBBB: Right bundle branch block, WPW: Wolf Parkinson White, MVP: Mitral valve prolapse; ASD: Atrial septal defect; PFO: Patent foramen ovale; ASA: Atrial septal aneurysm.

rhthymias, channelopathies, can only be detected by ECG, and defends the opinion that ECG should be in routine preparticipation screening.¹⁴

The use of echocardiography in preparticipation screening and cost effectivity have been widely described recently. Nevertheless, echocardiographic examination has not yet been introduced into routine screening programmes neither in the United States nor in Europe countries. Routine use, limited use in selected sports or only during the first evaluation use

of echocardiogram is recommended as a useful and feasible screening modality by some authors.¹⁵⁻¹⁸ However, other authors declared that screening with echocardiography could not benefit to determine risk for SCD and did not find cost effective.¹⁹

In the present study, we presented our experience in a one year period. Hemodynamically insignificant abnormal echocardiographic findings were observed in 53 (6.7%) children. Cardiac anomalies detected by echocardiography in our study (mitral valve prolapse, secundum ASD, rheumatic heart disease.. etc.) necessitate periodical clinical follow up and can constitute complications over time. However, none of them were the cause of sports restriction or prohibition at the time of admission.

Pathologic electrocardiographic changes were detected in only 2.1% of the participants. Although ECG is not enough to identify the structural cardiac anomalies that most mild cardiovascular abnormalities may not be associated with detectable ECG alterations.²⁰ Our study is compatible with this previous knowledge, we found that none of the ECG findings were related to echocardiographic findings.

The absence of a standard method and increasing concerns about SCD in Turkey lead clinicians to refer healthy children to pediatric cardiology departments in order to make a comprehensive cardiac screening. Moreover, all individuals engaged in sports are at risk for SCD. Most deaths are caused by silent structural and arrhythmogenic heart diseases. SCD might be the first finding in these completely asymptomatic, previously healthy children.^{21,22} This condition also leads an ongoing debate in medical screening of sports preparticipation and lack of a standard method. In addition, there is no study for the efficacy or cost-effectiveness of different procedures applied in our country.

The total approximate cost of comprehensive pediatric cardiology examination including ECG and echocardiography for one children is 57 Turkish Liras and covered mostly by public insurance (15.5 Turkish Liras for examination, 2.25 Turkish Liras for ECG and 19.6 Turkish Liras for echocardiography). As considering that this study presented only one center's experience in one year period, total public in-

insurance expenditure including all country would be very high. So, there is a necessity to establish a standard screening protocol with a law by Ministry of Health in sports preparticipation in our country. Raised concerns of family and physicians about possible heart conditions could be minimized by education. More research is needed to provide people from these misconceptions and psychosocial impacts.

CONCLUSION

Echocardiography allows to diagnose cardiomyopathies or hemodynamically significant structural heart diseases which lead to decision of sports disqualification. However, in this case, symptoms or ECG abnormalities can occur previously and guide physicians during screening. So, we concluded that comprehensive cardiac evaluation including echocardiography by a pediatric cardiologist should be performed in patients with suspicious personal and family history, pathological findings in physical examination and/or pathological ECG findings. In addition, large, multicenter national studies should be done to determine the validity of different screening methods as a part of comprehensive cardiac evaluation.

Limitations of the presented study originate from the study's design. This study is just a retrospective ,

cross-sectional study and not planned to report the utility or costeffectivity of any method. However, this study does show that physical examination and evaluation of ECG are helpful methods which pediatricians and family physicians can do to predict any underlying cardiac disease in apparently healthy children.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: Şeyma Kayalı; **Design:** Şeyma Kayalı; **Control/Supervision:** Şeyma Kayalı; **Data Collection and/or Processing:** Nuran Belder; **Analysis and/or Interpretation:** Nuran Belder; **Literature Review:** Şeyma Kayalı; **Writing the Article:** Şeyma Kayalı; **Critical Review:** Şeyma Kayalı; **References and Fundings:** Nuran Belder; **Materials:** Şeyma Kayalı.

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