ZKTB

ORIGINAL RESEARCH

Retrospective Evaluation of Children Applying for Athlete Licenses

Sporcu Lisansı İçin Başvuran Çocukların Retrospektif Değerlendirilmesi

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ABSTRACT

Objective: *The numbers of children and adolescents taking part in sporting activities has risen increasingly in recent years, but sudden deaths occurring during matches or training are a cause for concern among families and in society. The purpose of the study was to seek an answer to the question of whether children should be evaluated by a pediatric cardiologist for sports licenses.*

Material and Methods: *168 children aged 7-17 who had newly started sporting activities or doing sport for some time were included in the study. Participants underwent a detailed physical examination and were assessed by a pediatric cardiologist. Athletes were examined using history, physical examination, 12-channel echocardiogram and echocardiography. Children with arrhythmia were investigated using 24-h Holter monitoring.*

Results: *168 cases, 136 (81%) boys and 32 (19%) girls were enrolled. The mean age of the cases was 13 years. Pathology was determined in 4.1% of all subjects at electrocardiogram and in 11.9% at echocardiography. Effort tests were applied to 14 children with significant symptoms, in whom arrhythmia was determined or with a family history, 24-h rhythm Holter monitoring to five children and ambulatory Holter monitoring to one hypertensive child. Holter monitoring revealed frequent isolated monomorphic ventricular premature contraction in two subjects. Seven participants were eventually suspended from sporting activities.*

Conclusion: *National guidelines including presport cardiovascular evaluation have been developed in order to prevent sports-related sudden deaths. The main conclusion from our findings is that young children engaging in sports should be evaluated by a pediatric cardiologist before starting sporting activities.*

Keywords: *athletes, child, electrocardiogram, echocardiography, sudden death*

ÖZET

Amaç: *Spor faaliyetlerine katılan çocukların ve ergenlerin sayısı son yıllarda giderek artmaktadır, ancak müsabaka/ antreman sırasında meydana gelen ani ölümler aileler ve toplum arasında endişe kaynağıdır. Bu çalışmanın amacı, çocuklara spor lisansı için pediatrik kardiyolog tarafından değerlendirilmesi gerekir mi sorusuna bir cevap aramaktı.*

Gereç ve Yöntemler: *Yaşları 7-17 arasında olan spora yeni başlamış 168 çocuk çalışmaya dahil edildi. Katılımcılar detaylı bir fizik muayeneden geçirildi ve bir pediatrik kardiyolog tarafından değerlendirildi. Sporcu çocuklar öykü, fizik muayene, 12 derivasyonlu elektrokardiyografi ve ekokardiyografi ile incelendi. Aritmi saptanan hastalar 24 saatlik Holter monitörizasyonu ile araştırıldı.*

Bulgular: *Çalışmada 136 (%81) erkek ve 32 (%19) kız toplam 168 olgu mevcuttu. Olguların yaşları ortalaması 13 yıl (7-17) idi. Tüm katılımcıların % 4,1'inde elektrokardiyogramda ve % 11,9'nda ekokardiyografide patoloji saptandı. Anlamlı şikayeti olan, aritmi saptanan veya aile hikayesi olan 14 çocuğa efor testi, 5 çocuğa 24 saat ritim Holter monitörizasyonu ve hipertansif olan 1 çocuğa 24 saat ambulatuar holter monitörizasyon yapıldı. Holter monitörizasyonu katılımcıların 2'nde sık izole monomorfik ventriküler erken atımı açığa çıkardı. Yedi katılımcı profesyonel spor aktivitelerinden uzaklaştırıldı.*

Sonuç: *Spor aktivitelerine bağlı ani ölümleri engellemek amacı ile spor öncesi kardiyovasküler değerlendirmeyi içeren ulusal kılavuzlar geliştirilmelidir. Genç çocuk sporcuların spor aktivitelerine başlamadan önce bir pediatrik kardiyolog tarafından değerlendirilmesi gerektiği çalışmamızın ana sonucudur.*

Anahtar Kelimeler: *ani ölüm, çocuk, çocuk kardiyoloji, elektrokardiyogram, ekokardiyografi, sporcu*

INTRODUCTION

The numbers of children and adolescents taking part in sporting activities has risen increasingly in recent years, but sudden deaths occurring during matches or training are a cause for concern among families and in society. The definition of sudden cardiac death (SCD) includes fatalities occurring within 1-6 h after onset of symptoms. Sports-related sudden death refers to fatalities occurring during or immediately after training or matches/contests. Although it is not easy to exactly determine the number of SCDs among athletes or the general population, several studies have attempted to shed light on the subject. A SCD rate of 2.3/100,000 has been reported for all individuals engaging in sports. Ninety-five percent of sudden deaths in sport are due to cardiovascular causes (1-4).

Although there is agreement on the need for pre-sport screening in order to prevent sudden deaths, there is no consensus on how this should be done. Many physicians in Turkey encounter large numbers of individuals presenting to clinics to obtain 'fitness for sports' reports in day-to-day practice. Since there is no standard approach on the basis of laws and/or general regulations for such requests in Turkey, clinics seek to respond to this demand by performing various examinations in the light of their own particular practice and experience (5).

Sport-playing children, previously assessed by a pediatrician using history and physical examination and referred to the pediatric cardiology clinic for fitness for sport reports, were evaluated retrospecti-

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vely in terms of existing heart diseases in this study. We investigated how many children were prohibited from taking part in sport due to existing heart disease. The purpose of the study was to seek an answer to the question of whether children should be evaluated by a pediatric cardiologist for fitness for sport reports.

MATERIAL AND METHOD

One hundred sixty-eight children aged 7-17 newly started on sporting activities or doing sport for some time and presenting to the pediatric cardiology clinic for sports licenses between January 2016 and May 2017 were included in the study. Subjects' records were examined retrospectively. Children with chronic disease or long-term drug use were excluded. Detailed histories for each child, detailed physical examination findings, 12-channel electrocardiogram (ECG) and echocardiography (ECHO) and, when required, 24-h rhythm Holter and ambulatory blood pressure monitoring and exercise tests were investigated. Ethical committee approval was granted from the Biochemical Research Ethical Committee for the study (Approval no. 2017/3-8).

Symptoms of angina-like chest pain, palpitations, premature fatigue, fainting or respiratory difficulty were regarded as representing positive personal history. Myocardial infarction at an early age, severe arrhythmia, cardiomyopathy, valve disease or congenital heart disease in close relatives was regarded as positive family history.

Positive physical examination findings included arrhythmic cardiac sounds, systolic or diastolic murmur, weak or no femoral pulse and blood pressure >95th percentile.

Table 1: 12-channel Electrocardiogram Criteria (1).

P wave	left atrial enlargement: negative portion of the P wave in lead V1≥0.1 mV in depth and ≥0.04 s in duration; right atrial enlargement: peaked P wave in leads II and III or V1≥0.25 mV in amplitude.
QRS complex	frontal plane axis deviation: right ≥+120° or left –30° to –90°; increased voltage: amplitude of R or S wave in in a standard lead ≥2 mV, S wave in lead V1 or V2≥3 mV, or R wave in lead V5 or V6≥3 mV; abnormal Q waves ≥0.04 s in duration or ≥25% of the height of the ensuing R wave or QS pattern in two or more leads; right or left bundle branch block with QRS duration ≥0.12 s; R or R′ wave in lead V1≥0.5 mV in amplitude and R/S ratio ≥1
ST-segment, T waves, and QT interval	ST-segment depression or T-wave flattening or inversion in two or more leads; prolongation of heart rate corrected QT interval >0.44 s in males and >0.46 s in females
Rhythm and conduction abnormalities	premature ventricular beats or more severe ventricular arrhythmias; supraventricular tachycardias, atrial flutter, or atrial fibrillation; short PR interval (<0.12 s) with or without 'delta' wave; sinus bradycardia with resting heart rate ≤40 beats/mina; first (PR≥0.21 sb), second or third degree atrioventricular block

Twelve-channel ECG and ECHO were applied to all children. One or more finding defined by the European Society of Cardiology was regarded as positive ECG1 (Table 1). Twenty-four hour rhythm Holter and ambulatory blood pressure monitoring and exercise tests were applied to all children with pathological characteristics determined in histories, physical examination or ECG.

STATISTICAL ANALYSIS

Data were evaluated using Statistical Package for Social Sciences (SPSS) for Windows version 22.0 software (SPSS Inc., Chicago, IL, USA). As a first step, normal distribution of the sample was analyzed with the Shapiro-Wilk test. Normal distribution was expressed as mean and standard deviation (SD) and skewed distribution as median and minimum-maximum values. The unpaired t test or Mann–Whitney U test were used in two-groups of gender. Categorical variables in proportions or percentages were analyzed using the chi-square test or Fisher's exact test when appropriate. Associations between variables were assessed with Spearman's rank correlation analysis when appropriate. p values <0.05 were regarded as statistically significant.

RESULTS

The mean age of the 168 children enrolled in the study was 13 years (range: 7-17); 136 were boys (81%) and 32 were girls (19%). Mean length of engagement in sporting activity was 13 months. Eighty-two (48.8%) children played football, 24 (14.2%) athletics, 17 (10.1%) basketball, 12 (7.1%) volleyball, 11 (6.5%) swimming, 9 (5.3%) handball, 8 (4.7%) martial arts, 3 (1.8%) cycling, and 2 (1.2%) wrestling. Positive family history was determined in 10 (5.9%) children. Heart disease was detected in only four of these. Dilated cardiomyopathy was determined in one child and mitral valve prolapse in three. Data concerning personal history, physical examination, ECG, ECHO, 24-h rhythm Holter and ambulatory blood pressure monitoring and exercise test data are given in tables 2 and 3.

Table 2: Children's Clinical Characteristics (n=168).

Age, years	13.26 (7-17)
Sex, male/female	136/32
Fatigue, n (%)	3 (1.8)
Palpitation, n (%)	1 (1)
Chest pain, n (%)	7 (4.1)
Family history, n (%)	10 (6)

Table 3: Subjects' Physical Examination, Electrocardiography and Echocardiography Findings (n=168).

	n	%
Murmur	11	6.5
Dysrhythmia	1	1
ECG abnormalities	7	4.1
EcHO abnormalities	20	11.9
HOLTER abnormalities	6	3.6

Abnormal ECG was determined in 6 (4.1%) of the children in the study. Wolf-Parkinson White (WPW) rhythm was observed in one, corrected QT interval > 0.45 sec in one, left ventricular hypertrophy (LVH) findings in one, ventricular extrasystole (VES) in one and right bundle branch block (RBBB) in one.

Anomalies were determined at ECHO in 19 (11.9%) children. Dilated cardiomyopathy (DCMP) was determined in one, secundum type wide atrial septal defect (ASD) in one, moderate width patent ductus arteriosus (PDA), silent PDA in one, moderate pulmonary hypertension in one, hypertrophic cardiomyopathy (HCMP) in one, patent foramen ovale in one, mild mitral valve insufficiency in nine and mild mitral valve prolapse in four. Four children (with WPW rhythm, long QT interval and VES at ECG) underwent 24-h rhythm Holter monitoring and one hypertensive child received 24-h ambulatory blood pressure monitoring, while exercise tests were applied to three children with WPW and long QT syndrome and frequently isolated VES determined at Holter monitoring. Correlation findings between ECG and ECHO results and symptoms are shown in tables 4 and 5. Secundum type wide ASD was observed in the child with RBBB at ECG, DCMP in the child with biatrial dilation findings and HCMP in the child with LVH findings.

Table 4: Correlations of Symptoms in Children with ECG Findings (n=168).

	ECG positive	ECG negative	p
Fatigue (n=3)	1	2	0.68
Palpitation (n=1)	0	1	0.72
Chest pain (n=7)	1	6	0.58
Family history (n=10)	1	9	0.70
Murmur (n=11)	1	10	0.65

ECG: Electrocardiogram.

Table 5: Correlations of The Symptoms in Children with ECHO Findings (n=168).

	ECHO positive	ECHO negative	p
Fatigue (n=3)	1	2	0.68
Palpitation (n=1)	0	1	0.72
Chest pain (n=7)	2	5	0.61
Positive family history (n=10)	4	6	0.58
Murmur (n=11)	5	6	0.54

ECG: Electrocardiogram.

Anomalies were determined at both ECG and ECHO in one of the three children with premature fatigue. No statistically significant variation was determined when ECG and ECHO findings were compared between children with and without premature fatigue (p>0.05). Anomalies were determined at ECG in one of the seven children with chest pain and at ECHIO in two. No statistically significant variation was determined when ECG and ECHO findings were compared between children with and without chest pain (p>0.05). ECG and ECHO findings were normal in one child with palpitations.

Abnormalities were detected at ECG in one of the 10 children with positive family histories and at ECHO in four. No statistically significant variation was determined when ECG and ECHO findings were compared between children with and without positive family histories (p>0.05). Abnormalities were determined at ECG in one of the 11 children with cardiac murmur and at ECHO in five. No statistically significant variation was determined when ECG and ECHO findings were compared between children with and without cardiac murmur (p>0.05).

Seven of the 168 children enrolled in this study were prohibited from sporting activities on the basis of ECG, ECHO, 24-h rhythm Holter monitoring and ambulatory blood pressure monitoring. One of these children was diagnosed with dilated cardiomyopathy, one with moderate pulmonary hypertension, one with secundum type wide ASD, one with moderate PDA, one with WPW syndrome, one with congenital long QT syndrome and one with HCMP.

DISCUSSION

The content and effectiveness of cardiovascular evaluation before participation in competitive sports has been the subject of debate for many years. Most findings observed in athletes and regarded as abnormal are in fact a variant of normal findings. In addition, a major cardiac problem may rarely be encountered in an entirely asymptomatic athlete. The essential aim of pre-sports examinations must therefore be to reveal an underlying and previously undetected cardiovascular abnormality that may lead to sudden cardiac death. However, there is no consensus regarding how pre-sports screening should be performed (5).

Congenital cardiac conditions are the main factors involved in sudden cardiac death among athletes under 35, with HCMP and anomalous origin of a coronary artery being the two most common causes reported in the United States of America (USA). Among athletes over 35, the majority of sudden cardiac deaths result from acquired atherosclerotic coronary artery disease. HCMP has been identified as the main cause of sports-associated cardiac arrest, constituting over one-third of sudden deaths in the USA. Other causes include anomalous origin of coronary artery from the wrong coronary sinus, arrhythmogenic right ventricular cardiomyopathy/ dysplasia (ARVC/D), myocarditis, premature coronary atherosclerosis, conduction system abnormalities and Marfan syndrome. No sudden deaths associated with hypertrophic cardiomyopathy have been observed thanks to sports screening programs operated in Italy for many years, and the most common cause of death in this region is reported to be arrhythmogenic right ventricular dysplasia/cardiomyopathy, which is also more prevalent in genetic terms (6-9).

In a study Maron et al. (10, 11) reported that SCD was linked to HCPM in 46% of cases and coronary artery disease in 19%. Another study reported that 40% of sudden deaths occurred in subjects aged under 18, and that 33% were in young people under 16. The male/ female ratio was reported at 9/1.

Arrhythmias are another common cause of sudden cardiac deaths in athletes. Bradyarrhythmias and atrial and ventricular extrasystoles are very common among athletes, but are generally benign. Other more rare potential causes of sudden death are WPW syndrome, long QT syndrome, Brugada syndrome, atrial fibrillation and nodal reciprocal re-entry tachycardia (12). We also determined ECG positivity in 4.1% of the subjects in our study, and two children were prohibited from sporting activities.

Sudden death in athletes exhibits a marked gender predilection strongly favoring males (male to female ratio as high as 10:1). This predominance of mortalities in males has been linked to greater participation in competitive sports compared with females, and to the fact that men generally undertake more intensive training and have a higher level of athletic achievement. Male gender has recently been identified as an independent risk factor for sports-associated sudden death. This is probably caused by a higher prevalence and/or phenotypic expression of cardiac diseases among young males at risk of arrhythmic cardiac arrest, including cardiomyopathies and premature coronary artery disease (13-18). Males also took part in competitive sports more frequently in the present study.

According to the American Heart Association (AHA) guideline revised in 2012, athletes should take part in sporting activities only after evaluation with a detailed personal and family history and physical examination. The sensitivity of screening based on history and physical examinatıon is quite low, because many individuals with no known heart disease have no symptoms and the first finding occurring in athletes is sudden cardiac death. In terms of laws governing screening for the purpose of eligibility to take part in sporting activity, Italy introduced these first and has applied them the longest. The Italian experience has shown that the addition to screening of ECG increases the sensitivity of screening. A decrease in mortality has been achieved by determining potentially fatal cardiomyopathies such as HCMP and ARVD at pre-screening. The AHA has not approved the routine use of ECG in pre-participation screening programs for reasons such as the low incidence of the diseases, low sensitivity, a high false positive rate (approximately 10-40%), the cost burden and concerns over the results needing specialist evaluation. This idea has not been confirmed by the European Society of Cardiology (ESC), which is still discussing whether screening prior to taking part in sporting activities is required. The AHA recommends the use of tests such as ECG and ECHO for monitoring purposes in case of suspicion of cardiovascular disease. The ESC also regards ECG as necessary for athletes taking part in high-intensity sports such as marathons, cycling and triathlon, and for those with an increased risk of sudden cardiac death (11, 19-22).

Two- and three-dimensional ECG is very useful in the diagnosis and follow-up of structural heart diseases such as HCMP. ECHO is the main technique employed in the diagnosis of HCMP, although the use of ECHO among large populations is impracticable and involves high costs. One study from Italy reported an incidence of HCMP of 0.07% in athletes identified using history, physical examination, and 12-channel ECG. That figure is also in agreement with the incidence in the USA (0.1%) where ECHO was employed. This finding suggests that ECG, as employed in the Italian screening program, is as sensitive as ECHO in identifying HCMP. In a study Pelliccia et al. (23) applied ECHO to athletes with normal ECG findings and determined no cases of HCMP. This seems to corroborate the hypothesis that ECG is as sensitive as ECHO in terms of identifying HCMP. In the present study, we diagnosed HCMP with ECG and ECHO in one subject (24, 25).

CONCLUSION

The number of children and adolescents taking part in sporting activities has risen continuously in recent years, but sudden deaths occurring during matches or training are a cause for concern among families and in society. National standardization and guidelines must be developed for presport cardiac assessments. This study reveals the need for athletes to go through a screening program based on detailed history, physical examination and 12-channel ECG cardiovascular evaluations before taking part in sports and that ECHO should also be performed when suspicion of cardiovascular disease arises.

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