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Research Article / Araştırma Makalesi

Can standardized criteria enhance the accuracy of the interpretation of ECGs in pre-participation screening?

Spora katılım muayenelerinde standardize edilmiş kriterlerin kullanılması EKG'lerin doğru yorumlanma oranını artırabilir mi?

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ABSTRACT

Objective: Sudden cardiac death during sports is a relatively uncommon but impactful phenomenon. Athletes frequently do not show symptoms and SCD is the first sign. The two primary approaches are pre-participation examination and broadening the use of automated external defibrillators to decrease the occurrence of this deleterious event. A critical aspect of this exam involves assessing the resting 12-lead ECG. Evaluation of ECGs in deciding for eligibility of athletes is crucial. This study assesses the impact of "abnormal ECG criteria in athletes" on the ECG interpretation by sports medicine residents in Türkiye.

Materials and Methods: A cross-sectional study was conducted by sending an online questionnaire to sports medicine residents in Türkiye. It was designed so that the same 40 ECGs were evaluated twice by the same residents. Abnormal ECG Criteria file has been delivered to participants after the initial evaluation and they were asked to assess the same 40 ECGs based on these criteria for the second evaluation.

Results: Twenty-six participants completed both parts of the questionnaire. The median score of the before one-shot education session was 30.00, with minimum and maximum scores of 18 and 35, respectively. The median score of the after one-shot education session was 31.00, with minimum and maximum scores of 26 and 37, respectively. There was a significant increase in the total score after one-shot education session, based on the Wilcoxon signed rank test (p=0.035).

Conclusion: Relying on the standardized criteria for ECG evaluation during pre-participation examination significantly improved the interpretations of sports medicine residents.

Keywords: *ECG, sudden cardiac death, athletes, one-shot education*

ÖZ

Amaç: Sporda ani kardiyak ölüm görece nadir görülen bir durumdur ancak toplumsal etkisi büyüktür. Sporcular genellikle semptom göstermezler ve ani kardiyak ölüm ilk bulgudur. Bu klinik durumu azaltmak için, spora katılım öncesi muayene ve otomatik eksternal defibrilatör kullanımının yaygınlaştırılması iki ana stratejidir. Bu muayenenin önemli bir parçası 12 derivasyonlu dinlenim EKG'nin değerlendirilmesidir. Bu EKG'lerin spora katılım için uygunluk açısından doğru değerlendirilmesi büyük önem taşımaktadır. Bu çalışmanın amacı, "sporcularda anormal EKG kriterleri"nin Türkiye'deki spor hekimliği asistanlarının EKG yorumlama doğruluğu üzerindeki etkisini değerlendirmektir.

Gereç ve Yöntem: Kesitsel bir çalışmadır. Türkiye'deki spor hekimliği asistanlarına çevrimiçi bir anket gönderilerek kesitsel bir araştırma yapılmıştır. Çalışma, aynı 40 EKG'nin aynı asistanlar tarafından iki kez değerlendirileceği şekilde tasarlanmıştır. İlk değerlendirmeden sonra katılımcılara "Anormal EKG Kriterleri" dosyası gönderilmiş ve aynı 40 EKG'yi bu kriterlere göre tekrar değerlendirmeleri istenmiştir.

Bulgular: Yirmi altı katılımcı testin her iki bölümünü de tamamladı. Tek oturumluk eğitimden önce ortanca puan 30.00, minimum ve maksimum puanlar sırasıyla 18 ve 35 idi. Tek oturumluk eğitimden sonra ortanca puan 31.00, minimum ve maksimum puanlar sırasıyla 26 ve 37 olarak saptanmıştır. Wilcoxon testi ile incelendiğinde, tek oturumluk eğitimden sonra toplam puanda istatistiksel olarak anlamlı bir artış gözlenmiştir (p=0.035).

Sonuç: Spora katılım öncesi muayenede standardize edilmiş kriterlerin kullanılması spor hekimliği asistanlarının EKG'leri daha doğru yorumlamalarını sağlamıştır.

Anahtar Sözcükler: *EKG, ani kardiyak ölüm, sporcular, tek oturumluk eğitim*

INTRODUCTION

Sudden cardiac death (SCD) in athletes is a devastating and infrequent phenomenon. Nevertheless, it has garnered significant attention due to its publicity (1,2). This phenomenon usually affects young, seemingly healthy athletes who

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suffer a sudden and unexpected cardiac event leading to their death (3). Although these incidents are uncommon, they have a significant influence on the athletic fraternity and pose pertinent questions about the well-being and safety of athletes. There are a number of potential factors that can cause SCD in athletes, with cardiovascular diseases being the most prevalent. These diseases include hypertrophic cardiomyopathy (HCM), arrhythmogenic right ventricular cardiomyopathy (ARVC), congenital coronary artery anomalies, commotio cordis, long QT syndrome, Marfan syndrome, and drug use (4-6). Pre-participation screening, education, and emergency preparedness are recommended to prevent SCD in athletes. Athletes should receive an extensive medical examination, including cardiac screening, to detect any pre-existing cardiac conditions that may be hazardous. It is important to provide knowledge about the indications and manifestations of possible cardiac problems for coaches, athletes and their relatives, as well as the necessary emergency aid tactics. Policies against the use of performance-enhancing drugs should be implemented. It is essential that athletes undergo periodic medical examinations to monitor their health over the course of their careers (2,7,8).

The electrocardiogram (ECG) of an athlete may differ from that of a sedentary individual because of the physiological adaptations in response to regular, intense exercise. Such variations are frequent in athletes who undergo regular strenuous physical activity. An athlete's ECG commonly shows bradycardia, increased heart size, sinus arrhythmias, junctional rhythms, T-wave changes, slightly prolonged QT interval, and increased voltage of I, II, III, aVL, aVF, and aVR (4). While it's true that ECG findings are frequently found in athletes, their interpretation should only be done with the individual's medical history and physical condition in mind. Thus, any abnormal results must be assessed by a medical professional to rule out underlying cardiac problems. To ensure their heart health and safety during intense physical activity, athletes must undergo regular cardiac screening (9).

The European Society of Cardiology (ESC) and the International Olympic Committee (IOC) advise conducting a resting ECG for routine pre-participation screening. It is hence crucial for physicians to accurately interpret the ECG to avert SCD in sports. The criteria previously used by Drezner et al., based on the "Recommendations for interpretation of 12-lead ECG in the athlete" by Corrado et al., were used to standardize assessments in sports medicine outpatient clinics in Türkiye (10,11). This study aims to assess how "abnormal ECG criteria in athletes" affect the precision of ECG interpretation performed by sports medicine residents in Türkiye.

MATERIAL and METHODS

Research design and study population

This is a cross-sectional study that consists of a one-shot education session. The study was approved by the Clinical Research Ethics Committee of Süleyman Demirel University Medical Faculty (date: 31/01/2023 and number: 2/27). Informed consent was obtained from the participants. The study population consisted of sports medicine residents in Türkiye.

Methodological details of the study

An online survey was conducted using the Google Forms web design tool and sent out to sports medicine residents in Türkiye. After agreeing to participate in the study, the residents completed the survey, which comprised of two parts. It consisted of a set of 40 ECG images, with each correct response earning one point. The highest score attainable was 40 points. Participants were asked to classify the ECG shown in each image into one of two response options. Response option 1 comprises normal ECG results, indicating that no further assessment or investigation is needed. Response option 2 comprises abnormal results, necessitating further assessment and investigation. Study participants were asked to review 40 ECG images (normal ECG, n=23; abnormal ECG, n=17) of asymptomatic athletes aged 14 to 35 years. In order to answer all questions correctly, 23 normal ECGs had to be classified into response option 1 and 17 abnormal ECGs had to be classified into response option 2. Subsequently, an 'Abnormal ECG Criteria' information form was sent to the participants via email, and they were requested to re-evaluate the same ECG images by utilizing this form after one week. These criteria have been previously utilized by Drezner et al., and are based on Corrado et al.'s "recommendations for interpretation of the 12-lead ECG in the athlete" practice guideline.

Determining the ECGs

The ECGs used in the study were obtained from the records of athletes at the Süleyman Demirel University Sports Medicine Clinic. ECGs representing hypertrophic cardiomyopathy and Brugada syndromes were included for educational purposes, as participating athletic activities are strictly contraindicated with these very rare diagnoses. The initial assessment of ECGs' normality or abnormality was performed by a sports medicine physician (xx1), followed by a blind assessment by other sports medicine physicians (xx2, xx3) and a cardiologist (xx4).

Statistical analysis

SPSS was utilized for analysis. Demographic data was defined through the use of percentage (%), frequency (n), me–

dian (minimum-maximum), and a Wilcoxon signed rank test was employed to compare the data before and after. The p-value was determined to be significant at the 0.05 level.

RESULTS

Twenty-six participants completed both parts of the test. The test had a median score of 30.00 before one-shot education session, with a minimum and maximum score of 18 and 35, respectively. The median score for the after one-shot education session was 31.00, with minimum and maximum scores of 26 and 37, respectively. The most commonly misinterpreted ECGs were 2 normal ECGs answered as abnormal and 4 pathological ECGs answered as normal by the participants. The pathological ECGs included low atrial rhythm pattern, hypertrophic cardiomyopathy features, long QT syndrome, and inverted P wave presence in lead V3. The Wilcoxon signed rank test revealed a statistically significant rise in the total score between before and after one-shot education session (p=0.035). An investigation was conducted to identify which subgroups caused the increase. No significant difference was observed in the scores for accurately detecting abnormal ECGs between before and after one-shot education session (p=0.870). However, there was a significant difference in the total number of normal ECGs correctly detected between the before and after one-shot education session (p=0.021). Table 1 presents the scores of correctly identified abnormal and normal ECGs.

Table 1. Scores based on correct responses

	One-shot education session		
	Before	**After**	**P value**
Response 1 score	19.00 (11-22)	19.50 (14-23)	**0.021***
Response 2 score	12.50 (7-17)	12.00 (8-16)	0.870
Total score	30.00 (18-35)	31.00 (26-37)	**0.035***

Note: Response 1 score indicates number of ECGs those were accurately classified as normal, Response 2 score indicates number of abnormal ECGs those were accurately classified as abnormal. *: p<0.05

DISCUSSION

The European Society of Cardiology has reported the incidence of SCD during sports to fluctuate between 1-200 per 100,000 individuals based on different age decades. Measures are being implemented globally to minimize this comparatively uncommon incidence and guarantee safe athletic participation. The primary strategies include pre-participation screening (12). The utilization of 'Abnormal ECG Criteria' was found to have a beneficial effect on the ECG assessment of sports medicine residents as per this study. The introduction of the same standardized ECG criteria in another study resulted in an elevated rate of accurate detection in a group of 60 participants encompassing primary care physicians, sports medicine physicians, and cardiologists (10). The implementation of the criteria in this study increased the rate of correct interpretation of both normal and abnormal ECGs. There was no notable difference in detecting abnormal ECGs in our study, but there was an increase in the detection of normal ECGs. Therefore, the overall score improvement was due to the decrease in false positives after implementing the criteria. In other words, after one-shot education session, there was a more accurate detection of normal ECGs.

The causes of SCD can be categorized into two types- structural and non-structural cardiac pathologies. Examples of structural abnormalities may include HCM, Dilated Cardiomyopathy, Coronary Artery Anomaly, and Left Ventricular Hypertrophy. Examples of non-structural abnormalities may include Wolff-Parkinson-White syndrome, Long QT syndrome, Brugada syndrome (13). In that study, two ECGs were found to be most inaccurately interpreted, belonging to patients with HCM and long QT syndrome.

Hypertrophic cardiomyopathy (HCM) constitutes the leading cause for sudden cardiac death in athletes below 35 years, rendering it a challenging condition to define definitively, even when utilizing established diagnostic criteria (13). Five HCM ECGs were assessed in our study. At least 50% of the participants correctly identified four of them. However, in both parts of the study, over 70% of participants wrongly classified one HCM ECG as 'normal', despite it was exhibiting hypertrophy criteria in the anterior and limb leads, albeit not in the lateral leads, which is commonly observed. Identification of hypertrophic cardiomyopathy (HCM) ECGs using criteria for lateral derivations may have been easier than with positive findings in the anterior precordial and limb leads. There are multiple ECG findings associated with HCM, including left ventricular hypertrophy (LVH), prominent Q wave, and T-wave inversion. These ECG abnormalities may indicate the presence of HCM. Thus, it would be helpful to bear these in mind, in addition to evaluating the ventricular hypertrophy criteria in all ECG leads.

To establish the diagnosis of prolonged QT, the QT interval is measured on an ECG. Due to the variability of QT interval with heart rate, correcting the QT interval for heart rate is essential. Various formulas can be used to adjust for heart rate variability, but the Bazett formula ($QTC = QT / \sqrt{RR}$) is the most frequently employed. The QTc is considered prolonged in men if it exceeds 440 ms, and 460 ms in women. A QTc greater than 500 indicates an increased risk of torsade de pointes. A useful hint to identify a prolonged QT interval during the initial examination of the ECG is to note that a normal QT interval should be less than half the preceding RR interval (14).

The T wave in an ECG shows ventricular repolarization. Normally, the T wave is generated at the end of the last phase of ventricular repolarization. In a typical T wave shape, a low amplitude broad hump, which is upright and follows the QRS complex, is observed. Pathological T wave inversion is defined as a negative deflection of the T-wave of at least 2 mm in at least 2 leads, except in cases of aortic valve replacement (AVR), III, and V1, and excluding changes in V1-V4 in patients of Afro-Caribbean descent when preceded by a domed ST-segment. By the age of 16 years, it was found that negatively deflected T-waves beyond V2 are present only in 0.1% of participants. Thus, PTWI is uncommon among healthy athletes and does not seem to indicate physiological adaptation to exercise (15-17).

Atrial depolarization results in the formation of the P wave on the ECG. The direction of the depolarization wave is typically towards the left and downwards, resulting in an upright P wave in leads I and II and an inverted one in lead aVR. Normally, sinus P waves are most prominent in leads II and V1. The P wave typically exhibits biphasic behavior in V1. A negative P wave in V1 may indicate superior placement of the V1-V2 electrodes. A negative P wave in lead I may be a consequence of incorrect recording, dextrocardia, or abnormal atrial rhythms (18,19).

The research involved sports medicine residents who volunteered to participate. The number of participants was limited as a result of the small population of these residents (n=55, approximately) in Türkiye. It is worth highlighting the research's strength, which is that 90% of the ECGs were obtained from data of our clinic, while the remaining 10% were taken from educational resources.

CONCLUSION

The implementation of abnormal ECG criteria has allowed sports medicine residents to more precisely identify normal athlete ECGs. Improved recognition of normal ECGs may decrease the need for cardiology consultations, ultimately alleviating the hospital's patient load and reducing the number of unnecessary investigations. Additional education may be necessary to identify pathological ECGs.

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Ethics Committee Approval / Etik Komite Onayı

The Ethics Committee of Süleyman Demirel University approved all procedures and the experimental design (date: 31/01/2023 and number: 2/27)). The study protocol is in accordance with the latest version of the Declaration of Helsinki.

Conflict of Interest / Çıkar Çatışması

The authors declared no conflicts of interest with respect to authorship and/or publication of the article.

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Author Contributions / Yazar Katkıları

Concept – GB, SFO; Design - GB; Supervision – SE,AO; Materials – Data Collection and/or Processing –GB, AÖ; Analysis and Interpretation – SE, GB; Literature Review – AO,GB ; Writing manuscript – GB,AÖ; Critical Reviews – SE, SFO. All authors contributed to the final version of the manuscript and discussed the results and contributed to the final manuscript.

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