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Novice interpretation of screening electrocardiograms and impact of online training

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Abstract

Introduction: It is not known whether there is a specific training method that improves the accuracy of physician interpretations of pre-participation electrocardiograms (ECGs).
Methods: Participants took an online test and interpreted a series of normal, normal variant and abnormal ECGs. They then reviewed the BMJ's ECG interpretation online learning module and completed a post-test and a follow-up examination three months later.
Results: 28 fellows enrolled. The average correct for the pre-test was 63.57%, which increased to 81.19% for the post-test ($p \leq 0.0001$). When evaluating for retention, the average fell to 73.33% ($p = 0.0116$) but was still significantly improved from baseline ($p = 0.0253$).
Conclusions: This study demonstrated that the accuracy of fellows' interpretation of ECGs significantly improved after completion of BMJ modules. Results of this study will likely impact the training of future sports medicine fellows and should encourage fellowship directors to incorporate the BMJ's ECG interpretation module as part of their curriculum.

Keywords: Sudden cardiac death; Pre-participation screening; Interpretation of electrocardiograms

Introduction

Sudden cardiac deaths (SCD) of athletes are tragic and have a significant impact on communities. The majority of these deaths are due to unexpected cardiovascular disease [1]. Although the incidence of athlete deaths is not known, it has been estimated in the range of 1:53000 NCAA athletes per year to 1:200,000 young people of high-school age per year [2,3].

The most common causes of sudden cardiac death in athletes are hypertrophic cardiomyopathy followed by congenital coronary artery anomalies. In the older athlete, generally defined as over 35 years of age, the most common cause of death is coronary artery disease [4].

Pre-participation cardiovascular screening is an established method for evaluating large populations of athletes in order to distinguish those with disorders that would put them at risk for sudden cardiac death. These include Wolff–Parkinson–White, hypertrophic cardiomyopathy, long QT syndrome Brugada syndrome, and arrhythmogenic right ventricular dysplasia. Discovery of these disorders can frequently prevent these deaths from occurring by modifying the athlete's activity or by the insertion of an implantable defibrillation device. The timing of these evaluations is also important as most of the deaths occur during sports training or competition thus implying that there is a relationship between intense physical activity and arrhythmia-based sudden cardiac death [5,6].

Since 1996, the American Heart Association (AHA) has consistently recommended a 12-item personal and family history as well as physical examination with referral for cardiovascular evaluation if the athlete has any positive responses and has recommended against mandatory nation-wide electrocardiogram (ECG) screening for athletes [1]. However, pre-participation screening by history and physical examination alone does not have sufficient sensitivity to guarantee detection of cardiovascular abnormalities. [7] Observational data from the Veneto region in Italy suggests that ECG screening can identify and reduce the incidence of sudden cardiac death in competitive athletes [7,8]. ECGs are abnormal in >90% of patients with hypertrophic

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cardiomyopathy (and arrhythmogenic right ventricular cardiomyopathy) and can also detect ion channelopathies such as long-QT syndrome and Brugada syndrome. In their most recent consensus expert panel statement, the AHA states that ECG screening may be considered for small cohorts of athletes from 12 to 25 years of age. However, the AHA continues to recommend against routine ECGs because of the large number of athletes in the United States, the low frequency of diseases leading to SCD, the low rate of SCD itself, and the frequent false-positives [4].

Despite the recommendations, ECGs are more frequently being incorporated in pre-participation evaluations and recent survey data indicate that close to half of all Division-I athletic programs screen their athletes with ECGs [9]. However, there is controversy as to whether or not physicians evaluating these ECGs are doing so accurately. In a 2011 study of pediatric cardiologists published in the *Journal of Pediatrics*, respondents achieved a sensitivity of 68% and a specificity of 70% for recognition of any abnormality. The false-positive and false-negative rates were 30% and 32%, respectively [10]. These findings are concerning and indicate that there is a need for further training of physicians in evaluating pre-participation ECGs.

What is unknown at this time is whether there is a specific training method that improves the accuracy of physician interpretations of athlete ECGs. This study was designed to determine if novice physicians, specifically sports medicine fellows, would improve their accuracy after completing the British Journal of Medicine's (BMJ) online "ECG interpretation in athletes" module (http://learning.bmj.com/learning/course-intro/.html?courseId=10042239) and whether their knowledge was retained three months afterwards.

Materials and methods

The study was limited to physicians participating in a sports medicine fellowship in either the 2013–2014 or 2014–2015 academic year. Participants were asked to join the study via an email to either their fellowship directors or to a national fellows list serve which contained a link to the online survey and test. The initial phase of the study ran between September 11, 2014 and October 31, 2014. The participants had the duration of the study period to complete the tests and the modules. It was estimated that a total of 16 participants for phase one and 55 for phase two were needed to reach significance. The study was approved by our institutional review board.

Phase one of the study involved a pre-questionnaire where the participants were asked what residency they participated in, an estimate of how many pre-participation ECGs they have read in the past, whether they have taken the British Medical Journal's online module in the past, and whether their program regularly performs pre-participation ECGs. The participants were then asked to complete a pre-test. The pre-test consisted of 15 ECGs: 7 normal or normal variant, and 8 abnormal. The normal or normal variants group included 2 normal ECGs without variants, and 1 ECG each of high voltage, ST elevation with early repolarization, T wave inversions in V_1–V_4 in African-American athletes, second degree Mobitz type 1 block, and low atrial rhythm. The abnormal ECGs included one each of the following: T wave inversion, HOCM represented by T wave inversion with ST depression, Wolf–Parkinson–White (WPW) pattern, long QT, Q waves, arrythmogenic right ventricular cardiomyopathy (ARVC), premature ventricular contractions (PVCs), and right atrial ectopy. The ECGs were sample ECGs used for teaching from the investigators' archives and interpretation was confirmed by all investigators. The participants were asked whether the ECG was a normal or normal variant and the athlete can be cleared for participation or whether the ECG was abnormal and the athlete required further evaluation.

The participants then took the British Medical Journal's online course on ECG pre-participation interpretation. The course is offered for free on the BMJ's Learning website (http://learning.bmj.com/learning/course-intro/.html?courseId=10042239) and involves six interactive modules on interpretation of normal and abnormal ECGs. The modules are divided into sections that address each variant tested and each section had a representative ECG of the variant. After the modules, participants took a post-test and read 15 new ECGs, again 7 normal or normal variant and 8 abnormal. The distribution of the ECG diagnoses was the same as the pre-test. ECGs were substituted with alternate ECGs depicting the same diagnosis.

In phase two, the participants were emailed the post-test again three months later and asked to retake it to evaluate retention. Since this was the same post-test, the distribution of diagnoses was maintained. Phase two occurred from February 1, 2015 to March 1, 2015. Participants were asked how many pre-participation ECGs were read in the interim and whether or not they repeated the modules.

For phase one, 28 participants were recruited. 21 participants opted to complete phase two of the study. The participants were given a $25 Starbucks gift card for the completion of phase one, a $10 gift card for the completion of phase two, and one participant received a FitBit after a raffle.

The Wilcoxon signed-rank test was used to compare physicians' test scores at various phases in the study namely, initial assessment, after completion of British modules and 3 months later. A multivariate linear regression was performed to determine the affects of pre-participation factors including practice specialty, completion of British modules prior to study period, number of ECGs read prior to study, and programs that actively screen athletes with ECGs. Physician performance regarding discrete ECG findings (i.e. T-wave inversion, long QT, early repolarization) was analyzed with paired t-tests. A P value of < 0.05 was considered statistically significant. All analyses were performed on SAS 9.2.

Results

28 fellows enrolled in phase one of the study. Of those, 21 were from family medicine residencies, two from internal medicine, two from physical medicine and rehabilitation, one from medicine-pediatrics, one from pediatrics, and one from emergency medicine. 22 fellows were current sports