Electrocardiogram in Preparticipation Athletic Evaluations among Insured Youths

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Objective To retrospectively characterize electrocardiogram (ECG) use among preparticipation history and examinations (PPEs).

Study design Using the 2005 to 2010 MarketScan insurance database, we identified subjects aged 5-21 years with either a PPE with an ECG or a PPE alone, excluding those with known cardiac diagnoses. We described cardiology referrals and subspecialty testing within 180 days and cardiac diagnoses within 1 year of the PPE, and the costs of testing in each group.

Results From 2005-2009, 503 304 PPEs occurred in 419 456 subjects, of which 8621 (2%) included an ECG. ECG use increased from 12-20 per 1000 PPEs from 2005-2009. Females, lower socioeconomic status, and rural settings were associated with fewer ECGs. Thirteen percent of PPEs with ECG and 0.5% of PPEs alone led to a cardiology referral. After PPEs with ECG, cardiac disease was identified in 18% (2% sports-limiting); after PPEs alone, cardiac disease was identified in 0.5% (0.03% sports-limiting). The PPE had a sensitivity of 44% and a specificity of 98.6% of identifying cardiac disease. The total reimbursement cost of PPEs plus testing was $80 396 464 ($160 per PPE).

Conclusions These real-world data demonstrate that community providers selectively use the ECG as part of the PPE with a high rate of identification of cardiac disease. Mass ECG screening would need to be more efficient at identifying disease than this selective approach. *(J Pediatr 2015;167:804-9)*.

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Sudden cardiac death in young athletes is a rare but catastrophic event that propels families, providers, and communities to action to prevent such future tragedies. One prevention approach entails preparticipation screening of competitive athletes. An Italian program of preparticipation athletic screening that included an electrocardiogram (ECG) is purported to have reduced annual mortality by 89% over 25 years,[1,2] prompting some to advocate for adding an ECG to the preparticipation history and examination (PPE) screening in the US.[3] Experiences in other countries have not shown similar results.[4] Proponents note that adding an ECG increases the yield for identifying diseases associated with sudden cardiac death,[5] whereas critics of ECG screening highlight the differences between US and Italian demographics and disease distribution and note that the reduced mortality rate in Italy after implementation was comparable with the US death rate without systematic screening.[6-8] Critics also cite the limitations of the ECG, with its high false positive rate and inability to detect some diseases associated with sudden death.[9] The debate about the cost effectiveness of adding an ECG to the PPE involves variable assumptions and has produced conflicting results.[10-12]

European and US guidelines differ in their recommendations of whether to use the ECG in the context of mass screening of athletes.[13-16] The American Heart Association (AHA) and the American College of Cardiology (ACC) do not recommend the use of systematic ECG screening of US athletes because of a lack of resources and a high rate of false positive ECGs.[15,16]

Editorials,[17] cost-effectiveness analyses,[10,11] and guidelines[13,15,16] frame the ECG screening debate as a dichotomous decision: mass ECG screening vs PPE alone. Yet, alternative strategies, such as selective use of the ECG, are rarely discussed. Therefore, the purpose of this study was to use a large insurance database to determine the frequency of ECG use as part of the PPE and to describe the subsequent medical testing, diagnostic yield, and associated costs.

ACC	American College of Cardiology
AHA	American Heart Association
ECG	Electrocardiogram
HCM	Hypertrophic cardiomyopathy
ICD-9	*International Classification of Diseases, Ninth Revision*
PPE	Preparticipation history and examination

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Methods

Data were obtained retrospectively from The Truven Health Analytics MarketScan Commercial Claims and Encounter Database. Created by the Medstat Group, Inc (Ann Arbor, Michigan), this database contains insurance claims data on 49 million employees, spouses, and dependents, ages 0-64 years, covered through large employers in various private health care plans. The geographical distribution roughly follows the US population distribution (39% of the sample is from the South, 21% from the West, 25% from the North Central region, and 15% from the Northeast). Data on race and ethnicity are not included. Information from inpatient and outpatient settings is integrated at the patient level, allowing for tracking of patients through the medical continuum. Complete payment information, including reimbursement, is captured, and patient- and provider-level data are deidentified to protect privacy. Clinical data, such as ECG and testing results, are not available in the database.[18] Because this study used deidentified data from an existing database, it was not considered human subjects research.

The sample included all outpatient encounters between 2005 and 2010 for more than 12.3 million subjects, 5-21 years of age. We identified subjects with an *International Classification of Diseases, Ninth Revision* (ICD-9) code for a PPE (medical examination for sports competition, V70.3) between 2005 and 2009. Subjects with a PPE in 2009 were followed into 2010 to allow time for referrals and testing. We excluded subjects with previous known diagnoses of arrhythmia (ICD-9 code: 426-427), valve disease (394-397, 424), congenital heart disease (745-747), or cardiomyopathy (425).[19]

An ECG was considered to be part of the PPE if it occurred within 90 days after the PPE but before the cardiologist visit. In those with a PPE and an ECG, we calculated the time interval between the PPE and ECG. We analyzed temporal changes in the number of PPEs with ECG and identified factors associated with increased likelihood of undergoing a PPE with ECG. In the absence of clinical detail in the database, to understand possible indications for the ECG or cardiology referral, we identified PPEs that were coded with cardiac history or symptoms, including palpitations, murmur, chest pain, dyspnea, syncope, dizziness, and family history of sudden cardiac death or other cardiovascular diseases. We characterized how many PPEs led to a cardiology referral and additional testing within 180 days of the PPE, and cardiac diagnoses and therapeutic procedures within 1 year after the PPE. To calculate costs, we assessed reimbursements in 2012 dollars for PPEs and testing among those who were referred to a cardiologist. Therapeutic procedures were not included in the cost analysis. Data are presented at the level of the PPE unless specified otherwise.

An ECG was considered to be additional testing if it occurred on the day of the cardiologist visit. Additional testing was defined as a subsequent ECG, echocardiogram, exercise stress test, Holter monitor, electrophysiology study, cardiac catheterization, or cardiac magnetic resonance imaging study following a cardiology visit. Therapeutic procedures included catheter ablation, placement of an implantable cardioverter-defibrillator, and coronary artery reimplantation.

We categorized cardiac diagnoses broadly by ICD-9 code as arrhythmia, valve disease, congenital heart disease, and cardiomyopathy. Based on their association with an increased risk of sudden cardiac death, we designated these specific cardiac diagnoses as sports-limiting: aortic/subaortic stenosis (ICD-9 code 746.3, 746.81, or 747.22), coronary artery anomalies (746.85), hypertrophic cardiomyopathy (HCM) (425.1), other cardiomyopathy (425.4), long QT syndrome (426.82), ventricular tachycardia (427.1), and Wolff-Parkinson-White syndrome (426.7).[19]

We calculated the sensitivity, specificity, and false positive rate of the PPE for identifying cardiac disease. For this calculation, we assumed that the act of ordering an ECG was in response to positive findings during the PPE. Therefore, the PPE was considered to be positive if the decision was made to obtain an ECG. A diagnosis of cardiac disease in the PPE with ECG group (regardless of whether the subject was referred to a cardiologist) was considered to be a true positive, and a cardiac diagnosis in the PPE alone group (regardless of cardiology referral) was considered to be a false negative. We also calculated the number needed to screen (number screened/diagnoses made) for the PPE with ECG group and the PPE alone group.

Statistical Analyses

Descriptive statistics (frequencies, percentages, means, medians, and IQRs) were used to characterize PPEs, ECGs, symptoms, testing, diagnoses, therapeutic procedures, and costs and to calculate the sensitivity, specificity, false positives, and number needed to screen. Logistic regression multivariable modeling was used to determine the likelihood of undergoing an ECG with the PPE. The model included age, year, sex, rural setting, region, and payer (fee for service, preferred provider organization, point of service, health maintenance organization, and high deductible plan). We also included in the model "parents with hourly wage" (as opposed to salaried positions) as a proxy for lower socioeconomic status. A P value of $<.05$ was deemed statistically significant. Analyses were performed using Stata 12 (StataCorp, College Station, Texas).

Results

From 2005 to 2009, 503 304 PPEs were performed in 419 456 subjects, and 65 679 (16%) subjects had more than 1 PPE during the study period. The mean age was 14.3 ± 3.4 years, and 84% of subjects were ≥12 years of age. An ECG was associated with 8621 (2%) PPEs. The median time between the PPE and ECG was 2 days (IQR: 0-38 days). ECG use increased from 12-20 per 1000 PPEs from 2005-2009 (**Table I**).

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