ORIGINAL ARTICLE

Selective use of the electrocardiogram in pediatric preparticipation athletic examinations among pediatric primary care providers

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Objectives: Recent literature examining insurance administrative data suggests that a selective approach, with concurrent history and physical exam (H&P), for obtaining an electrocardiogram (ECG) as a part of a preparticipation examination (PPE) for pediatric athletes is commonly used in the primary care setting demonstrating a high rate of disease detection. We sought to understand practice patterns of providers with regard to usage of ECG as a part of PPE.

Methods: Utilizing an online survey, we queried primary care providers regarding their practice patterns, rationale, and concerns regarding use of ECGs as a part of the PPE.

Results: A total of 125 pediatricians completed the survey; 73.7% selectively use the ECG, 24.6% never use the ECG, and only 1.7% always obtain an ECG as part of the PPE. The most common rationale for selectively or never using the ECG is the belief that the H&P is sufficient to identify cardiac disease (70%). The most common H&P findings that lead to ECG screening include chest pain or syncope with exertion, family history of sudden cardiac death, an irregular heart rate, and a diastolic murmur. Among the diseases associated with sudden cardiac death, most pediatricians fear missing hypertrophic cardiomyopathy.

Conclusion: Based on a survey of primary care providers, most practitioners are utilizing a selective approach of obtaining an ECG as a part of a PPE for athletic participation, which is in agreement with the current American Heart Association guidelines. Significant practice variation continues to exist, and may represent an area for future resource optimization.

KEYWORDS

history and physical, primary care providers, sudden cardiac death, survey

1 | INTRODUCTION

Sudden cardiac death (SCD) is a rare, but devastating outcome for young athletes throughout the world. Historic epidemiological data placed the rate of sudden unexpected death between 1.3 and 4.6 per 100,000 person-years in United States populations (Driscoll & Edwards, 1985; Neuspiel, 1985). More recent data from international centers have shown somewhat lower rates, ranging between

0.78 and 1.5 per 100,000 person-years (Pilmer, Kirsh, Hildebrandt, Krahn, & Gow, 2014; Winkel et al., 2014). While the data suggest that SCD in the young is a rare event, the potential impact on a family and community is significant. While many approaches have been used or proposed, the optimal strategy for the detection of cardiac disease associated with SCD remains elusive. The situation is further complicated by the complex interactions of cost-benefit, false positives and negatives, and the potential burden of unnecessary testing.

TABLE 1 AHA/ACC recommendations for pre-participation screening of competitive athletes⁵

Personal medical history ^a	Family history	Physical examination
1. Chest pain/discomfort/tightness/pressure related to exertion	8. Premature death (sudden and expected, or otherwise) before 50 years of age attributable to heart disease in ≥ 1 relative	11. Heart murmur ^b
2. Unexplained syncope/near-syncope (judged to not be vasovagal)	9. Disability from heart disease in close relative <50 years of age	12. Femoral pulses to exclude aortic coarctation
3. Excessive and unexplained dyspnea/fatigue or palpitations, associated with exercise	10. Hypertrophic or dilated cardiomyopathy, long QT syndrome, or other ion channelopathies, Marfan syndrome, or clinically significant arrhythmias; specific knowledge of genetic cardiac conditions in family members	13. Physical stigmata of Marfan syndrome
4. Prior recognition of a heart murmur		14. Brachial artery blood pressure (sitting position) preferably taken in both arms
5. Elevated systemic blood pressure		
6. Prior restriction from participation in sports		
7. Prior testing for the heart, ordered by a physician		

^aParental verification recommended for middle school and high school athletes.

^bMurmurs judged likely to be organic and unlikely to be innocent; auscultation should be performed in both the sitting and standing position, specifically to identify murmurs of dynamic of left ventricular outflow tract obstruction.

The current American Heart Association (AHA)/American College of Cardiology recommendations for preparticipation examination (PPE) include 14 elements covering history, physical examination, and family history. Universal mass electrocardiogram screening is not recommended (Table 1) (Maron et al., 2007). While it is not the current standard in the United States, other countries have instituted mandatory athlete electrocardiogram (ECG) screening with varying results. In 1982, Italy launched a nationwide screening program and saw a decrease in the incidence of SCD in screened athletes from 3.6/100,000 person-years to 0.4/100,000 person-years (Corrado et al., 2006). Conversely, data from Israel did not show a significant change in the rate of SCD (2.54/100,000 to 2.66/100,000 person-years) after a mandatory pre-screening ECG program was instituted in 1997 (Steinvil et al., 2011).

A recent study evaluated real-world practice on use of an ECG as a part of a PPE from 2005 to 2010 from a large insurance database (Burns, Encinosa, Pearson, & Kaltman, 2015). A total of 503,304 PPEs were performed during that time period, 2% of which included a screening ECG. The identification of cardiac disease was much higher in the group that included screening ECG; 18% of PPE with ECG identified disease (2% was sports limiting) versus 0.5% of PPE only (0.03% was sports limiting) (Burns et al., 2015). The authors inferred that practitioners are selectively using the ECG as a part of a PPE with relatively high rate of disease detection. Unfortunately, since this data was compiled using an insurance database, the authors could not evaluate the practitioners' decision-making process regarding the use of a screening ECG as a part of the PPE.

Therefore, we sought to further understand practice patterns of primary care providers with regard to usage of ECG as a part of preathletic participation evaluation. Given the relatively high rate of disease detection among the providers in the insurance database, we believe that it is important to understand the rationale of the individuals who are performing PPEs. We hope to provide a more robust understanding of the decision-making process of practitioners when it comes to determining whether to include the ECG as part of the PPE.

2 | METHODS

Utilizing a 20-question online survey, we queried primary care providers within our regional health system regarding their practice patterns,

rationale, and specific concerns with regard to their performance of PPEs and their usage of screening ECG. The survey questions are provided in the Appendix. The survey was sent to 1460 primary care providers within the Children's National Health System network over a 3-month time span; during the response period, multiple reminders and personal correspondence were sent given the overall low response rate. The surveys were performed anonymously and each respondent gave their consent prior to the initiation of the survey. A selective approach to obtaining an ECG as a part of PPE was defined as using an ECG in cases where there were concerning findings as a part of a routine history and physical examination. Individuals that did not perform PPE as a part of their practice were not able to answer any further questions and did not count toward the final count of respondents. Chi-square tests were used to test association between provider responses and provider experience (years of experience, number of annual PPEs performed, and practice setting). This study was granted exempt status by the Institutional Review Board at the Children's National Health System.

3 | RESULTS

A total of 125 providers (8.5% response rate) completed the survey, representing a mix of providers in academic pediatrics (24%), private practice (54%), and community health settings (10%); though different specialties were queried, all respondents were pediatricians. Sixty-five percent reported at least 10 years of experience and only 26% reported <5 years of experience. The majority of responding providers (90%) perform at least 25 PPEs per year and most screen predominantly middle-school and high-school participants (Figure 1), though >50% of respondents reported performing PPEs on college and elementary school athletes as well. Approximately, 50% of the respondents reported that they themselves participated in competitive athletics as a child.

While performing a PPE, 73.7% of responding providers selectively use the ECG, 24.6% never use the ECG, and only 1.7% always obtain an ECG as part of the PPE. Provider experience and practice setting were not associated with their use of ECG as part of the PPE. The decision to use an ECG as part of the PPE for the majority of

FIGURE 1 Age/class of athlete screened by surveyed practitioners

FIGURE 2 History and physical elements that lead practitioners to obtain a screening ECG as a part of a preparticipation examination

responding providers (84%) was not dependent on the level of athlete screened (varsity or collegiate athletics vs recreational sports).

The most common rationale for selectively or never using the ECG is the belief that the H&P is sufficient to identify cardiac disease (70%). In addition, respondents were concerned about the utility of ECG for PPE screening with 52% of providers reporting concerns over the diagnostic accuracy (low specificity) or implications of false positives associated with a screening ECG. Provider experience and practice setting were not associated with the rationale for not using the ECG or with their concerns about using the ECG as part of the PPE.

The most common H&P findings that lead to ECG screening include chest pain or syncope with exertion, family history of sudden cardiac death or arrhythmia, an irregular heart rate, and diastolic murmur (Figure 2). Most responding practitioners would still refer to cardiology with concerning H&P findings despite a normal ECG; only 3% of respondents would never refer in this scenario. Among the diseases associated with sudden cardiac death, most responding providers fear missing hypertrophic cardiomyopathy (HCM), with long QT syndrome a distant second (Figure 3). The two individuals that always obtain an

ECG with PPE reported an overarching fear of their patients dying suddenly as a reason to obtain the ECG irrespective of history or physical findings. Fear of litigation (10%) or parental request (24%) did not significantly influence decision-making about whether to obtain ECGs for most providers.

Most responding providers (74%) send their patients to a pediatric cardiologist for an ECG, whereas a minority have the capability to perform an ECG in their office (4%) or will send patients to an alternate location (21%). Of those ECGs that are performed at an alternate location, 76% will be sent to a cardiologist for an official reading.

4 | DISCUSSION

Our study is the first to evaluate the practice patterns and rationale of primary care providers with regard to the use of ECG as a part of the PPE. Burns et al. inferred from claims data that most providers do not perform an ECG for every PPE but rather use a selective approach (Burns et al., 2015). Utilizing our survey respondent data, we are able

FIGURE 3 Most commonly feared cardiac diagnoses among surveyed practitioners that perform screening preparticipation examinations

to provide evidence of practice patterns that confirms the data from the Burns paper. Approximately 74% of the responding practitioners use a selective approach to use the ECG as a part of the PPE. The determination to use the ECG is driven by findings on the history or physical exam and not by external factors, such as level of athletic competition or fear of litigation.

The current AHA guidelines recommend a 14-point history and physical exam as a part of the PPE; universal ECG screening is not currently recommended (Maron et al., 2007). The recommendations stress the importance of a complete history, including family history, as well as a comprehensive physical examination. A majority of respondents appears to follow the current guidelines and selectively use the ECG in contrast to the universal ECG screening approach, but a small number of providers continue to utilize an all or none approach despite the guidelines. Most historical studies, including those addressing cost-effectiveness, have compared H&P to ECG in a mutually exclusive manner. Some recent studies have begun to evaluate the strategy of adding an ECG in cases of an abnormal H&P, which is more in-line with the current guidelines (Schoenbaum, Denchev, Vitiello, & Kaltman, 2012; Wheeler, Heidenreich, Froelicher, Hlatky, & Ashley, 2010). Further study on the value of adherence to the guidelines, as well the importance of comparative effectiveness studies of the incremental value of studies, is integral, and was a recommendation of a 2010 working group from the National Heart, Lung and Blood Institute on SCD in the young (Kaltman et al., 2011).

The respondents in our survey reported HCM as the most feared diagnosis as a reason to obtain a screening ECG with the PPE. This is not surprising based on the epidemiology of SCD in the United States and the high profile that these cases receive in the lay media; the reported prevalence of HCM is 0.2% or 1:500 individuals (Gersh et al., 2011). Unfortunately, HCM creates a difficult diagnostic dilemma because of the heterogeneity of the disease and the overlap of a benign diagnosis of athlete's heart with the potential for an ECG to produce false positives or negatives. Baggish et al. evaluated college athletes with and without ECG screening and found a false-positive rate of 16.9% for ECG (Baggish et al., 2010). Rowin et al. evaluated ECGs in patients diagnosed with HCM and found a 10% false-negative rate, though the patients with normal ECG did have lower maximal left ventricular wall thickness (Rowin et al., 2012). Brosnan et al. showed a significant degree of interobserver variability when three different

specialists (electrophysiologist, sports cardiologist, and sports medicine specialist) reviewed the same ECGs of competitive athletes; additionally, the only two patients that were found to have pathology were not correctly identified by all three physicians (Brosnan et al., 2015). These studies provide context of the limits of ECG screening, even in addition to a thorough screening examination.

The survey data highlight potentially important practice variations among practitioners within our center. For example, 52% of providers are screening patients in the elementary school age range, and >90% are screening middle-school age groups. In addition, 25% of the respondents reported that they either perform their own ECGs or send to another hospital or institution, instead of sending them to a cardiologist. Of those individuals, only three-quarters will send the ECG to a cardiologist for an official interpretation. Additionally, only 14% of respondents would always refer to cardiology for a concerning H&P despite a normal ECG and 3% would never refer in this situation. Importantly, the data from Corrado et al. in the Italian cohort showed that all athletes who died suddenly had obtained eligibility for competitive sports, despite 44% of those athletes having at least one abnormal finding on preparticipation evaluation (Corrado et al., 2006). Even with the institution of universal ECG screening with PPE, all of the athletes with SCD were still cleared for competitive sports. It is essential, as specified by the AHA recommendations (Maron et al., 2007) that cardiology evaluation occur for an abnormal finding on the H&P, irrespective of ECG findings. Further research to identify best practice and implementation research to ensure that these best practices saturate the community may optimize the ability of the selective ECG approach to identify at-risk patients.

There are limitations to our study. Given the makeup of our survey respondents, we were biased toward pediatric providers, although we did provide an adequate mix of individuals with community health, private practice, and academic backgrounds. Our survey is subject to response bias, although it is not clear that respondents to the survey would necessarily share similar views of ECG screening; the response bias is further complicated by our low response rate. The results are biased toward more experienced providers (73% with at least 5 years of experience), as experienced practitioners may be less likely to obtain additional testing or consultation. The low response rate does create difficulty in extrapolating our findings to the entire population of primary care providers or to other centers, though we were able to demonstrate a trend.

5 | CONCLUSION

Based on a survey of local pediatric primary care providers, most practitioners are utilizing a selective approach of obtaining an ECG as a part of an athletic preparticipation evaluation. The survey data show that a majority of providers are following the current AHA guidelines which recommend a history and physical for preparticipation sports examination, in contrast to a universal approach of ECG screening. ECG use is driven by abnormalities on the history and/or physical exam. The survey highlights significant practice variation among providers and may suggest areas for potential optimization.

ACKNOWLEDGMENT

None.

CONFLICT OF INTEREST

The authors report no conflicts of interest.

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How to cite this article: Clark BC, Hayman JM, Berul CI, Burns KM, and Kaltman JR. Selective use of the electrocardiogram in pediatric preparticipation athletic examinations among pediatric primary care providers. *Ann Noninvasive Electrocardiol*. 2017;22:e12446. <https://doi.org/10.1111/anec.12446>

APPENDIX

- I have read the above information and voluntarily agree to participate in this survey
 - I have read the above information and I do not wish to participate in this survey
1. Do you perform preparticipation examinations (PPEs) as part of your practice?
- Yes
 - No
 - If no, please go to question 16

2. If yes, approximately how many PPEs do you perform per year?

- 1–25
- 25–100
- >101

3. What ages of patients do you screen for PPE (choose all that apply)?

- 18 (College Sports)
- 14–18 (High School Sports)
- 10–13 (Middle School Sports)
- <10 (Elementary School Sports)

4. How often do you obtain an electrocardiogram (ECG) as part of the PPE?

- Never
- Sometimes (selectively)
- Always (with every PPE)

5. If you obtain an ECG sometimes with the PPE, what findings on history push you toward obtaining ECG as part of PPE (choose all that apply)?

- None
- Chest pain at rest
- Chest pain with exercise
- Shortness of breath
- Palpitations
- Dizziness/presyncope
- Syncope at rest
- Syncope with exertion
- Family history of sudden cardiac death
- Family history of congenital heart disease
- Family history of arrhythmia syndrome (e.g., long QT syndrome, hypertrophic cardiomyopathy, etc.)
- Family history of drowning
- Family history of death in car accidents
- Other (please specify): _____

6. If you obtain an ECG sometimes with the PPE, what physical findings push you toward obtaining ECG as part of PPE (choose all that apply)?

- None
- Systolic murmur
- Diastolic murmur
- Gallop
- Rub
- Irregular heart rate
- Bradycardia
- Tachycardia
- Other (please specify): _____

7. Does the level of sports activity (recreational, junior varsity, varsity, Collegiate Division I/II/III) affect your decision to obtain an ECG?

- Yes
- No

8. Where do you send patients to obtain an ECG?

- My office has the capability to perform an ECG
- Local hospital
- Local Internal Medicine/Family Practice office

- Adult cardiologist's office
- Pediatric cardiologist's office
- Tertiary care hospital

9. If an ECG is ordered for a PPE and performed at a location other than a cardiologist's practice, do you refer to cardiology for an official reading?

- Yes
- No
- Not applicable

10. How often do you refer to cardiology for a concerning history/physical exam despite a normal ECG?

- Never
- Rarely
- Sometimes
- Frequently
- Always

11. What cardiac diagnosis worries you the most when performing PPE with or without ECG?

- Hypertrophic cardiomyopathy
- Coronary artery anomalies
- Commotio cordis
- Arrhythmogenic cardiomyopathy
- Dilated cardiomyopathy
- Myocarditis
- Long QT syndrome
- Catecholaminergic polymorphic ventricular tachycardia
- Brugada syndrome
- Wolff-Parkinson-White syndrome
- Congenital heart disease
- Other (please specify): _____

12. If you obtain an ECG always as part of the PPE, what factors contribute to you ordering ECGs (choose all that apply)?

- Concern that one of my athletes will die suddenly
- Desire to identify undiagnosed cardiac disease in my patients
- Fear of litigation
- Request by parent

13. How many times does a parent request an ECG as part of the PPE each year?

- <1
- 1-10
- 10-20
- >20

14. If you sometimes or never obtain an ECG as part of the PPE, what factors contribute to that decision (choose all that apply)?

- The history and physical exam is sufficient for identifying cardiac disease
- The ECG has poor diagnostic accuracy (poor sensitivity and/or specificity)
- False positives from the ECG cause significant and unnecessary stress in my patients and their families
- Sudden cardiac death in young athletes is so rare that it is not a significant concern
- Other (please specify): _____

15. What is your area of medical specialty?

- Pediatrics
- Internal Medicine
- Family Practice
- Other (please specify): _____

16. What type of provider are you?

- Physician
- Nurse Practitioner
- Physician's Assistant
- Other (please specify): _____

17. How many years have you been in practice?

- Currently in training
- <5 years after training
- 5–9 years after training
- 10–20 years after training
- >20 years after training

18. In what kind of setting do you practice?

- Academic/University based
- Private practice
- Private practice with a close affiliation with an academic institution (i.e., adjunct academic appointment)
- Community health center
- Tertiary care center
- Other (please specify): _____

19. Did you play competitive sports when you were a child/adolescent?

- Yes
- No