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Research Article

Opt-in Electrocardiogram Screening at High-School Physicals Does Not Identify Those at Highest Risk for Sudden Cardiac Death

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ABSTRACT

Pre-participation examination (PPE) is mandatory for United States high school athletes. Despite evidence suggesting increased detection of cardiac disease associated with sudden cardiac death (SCD), obtaining a resting 12-lead electrocardiogram (ECG) is not required for pre-participation evaluation. We queried local high school athletes undergoing PPE between 2017-2019 to gauge interest in having an ECG performed during their PPE. We also evaluated willingness to pay for an ECG and potentially other tests if screening ECG is abnormal. There were 149 respondents, of whom 104 (70%) were male. 18 (12%) respondents were African American (AA) and 30 (20%) played basketball. Regarding interest in ECG, 77 (52%) were unsure, 41 (28%) responded 'yes' and 31 (21%) responded 'no'. Of those not interested in ECG, 11 (35%) played basketball, 23 (74%) were male and 5 (16%) were AA. Basketball players were less likely to want an ECG (p-value 0.002). 48 athletes responded that they would pay for an ECG, 3 (6%) of whom were AA. 46 responded that they would not pay, 13 (28%) of whom were AA (p-value 0.005). Most athletes and parents were unsure about ECG screening. Among athletes considered highest risk for SCD (males, AA and basketball players), there was disproportionately lower interest in screening or paying for an ECG. Lack of interest might be for many reasons, including lack of knowledge regarding the utility of ECG screening and financial considerations. Our study showed that opt-in ECG screening at PPE would miss many high school athletes at highest risk.

Introduction

The pre-participation examination (PPE) is mandatory for United States (US) high school athletes. However, despite evidence suggesting increased detection of cardiac disease associated with sudden cardiac arrest and sudden cardiac death (SCA/SCD), application of the resting 12-lead electrocardiogram (ECG) in pre-participation screening of these athletes is not required in the US [1]. In contrast to US recommendations, the European Society of Cardiology (ESC) and International Olympic Committee (IOC) advocate screening that includes a resting 12-lead ECG [2]. PPEs are a primary method of screening student athletes for risk of SCA/SCD. Of the various cardiovascular diseases responsible for SCD, hypertrophic cardiomyopathy (HCM) is most common. SCD has an overall low incidence in athletes [3]. It has been reported that HCM accounts for approximately 40% of sudden deaths in the athletic population [4]. Of young athletes affected by HCM, subgroups at most risk include males, African American (AA) ethnicity and basketball players [5, 6]. Harmon *et al.* stated that the overall incidence of SCD was 1:53,703 athlete-years, with the highest prevalence noted in black athletes compared to white athletes [7].

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Given most European countries and international sports governing bodies include ECG in their PPEs, use of 12-lead ECG in pre-participation screening in the US is an ongoing topic of discussion. Multiple factors have contributed to the debate, including widely variable reported prevalence of SCD in US athletes, cost of following up abnormal ECG findings, and challenges interpreting ECGs in at-risk athletes [8-10]. The purpose of this study was to assess whether high school athletes would have interest in undergoing ECG testing as part of a routine PPE if presented as an opt-in decision. We also assessed their willingness to pay for an ECG and potentially other tests if the screening ECG appeared abnormal. We were specifically interested in assessing populations at highest risk for SCD.

Materials and Methods

Surveys were distributed to local high school athletes undergoing their routine sports PPE during a free, community-based event for local high schools. Surveys were completed by either the student athlete or the student athlete and their parent(s). Figure 1 shows the survey used for this study. The data collection period included events from 2017 through 2019. The North Carolina High School Athletic Association Sport Pre-Participation Examination Form was also completed for each student. We also collected information from this form including sex, age, history of illnesses and family history. The survey collected demographic information including sport, ethnicity and type of health insurance. The survey also asked two questions assessing interest in ECG screening (Figure 1).

Please select the sports in which you participate at school: Please select all

- o Cheerleading
- o Cross Country
- o Golf
- o Football
- o Soccer
- o Tennis
- o Volleyball
- o Basketball
- o Swimming and Diving
- o Wrestling
- o Baseball
- o Softball
- o Track and Fiedl
- o Lacrosse
- o Other (please write)

What is your ethnicity of origin (or race)?: Please select all

- o White
- o Hispanic or Latino
- o Black or African American
- o Native American or American Indian
- o Asian / Pacific Islander
- o Other (or prefer not to say)

What type of health insurance do you have? Please select all

- o Private or Employee-based
- o Government Issued (Medicare/Medicaid/Veterans or Military)
- o Uninsured
- o Unsure or I prefer not to say

There is some evidence that indicates that an electrocardiogram (ECG, EKG) can detect some heart conditions that can predispose an athlete to sudden cardiac death that a physical exam can otherwise not detect. If available, would you be interested in having an ECG performed at future physicals?

- o Yes
- o No
- o Unsure

Many insurances do not cover electrocardiograms (ECGs, EKGs) and other tests that would need to be done if abnormal. If your insurance does not cover these tests, would you be willing to pay for them out-of-pocket?

- o Yes
- o Yes but only if less than $1000
- o Yes but only if less than $500
- o Yes but only if less than $100
- o Yes but only if less than $50
- o No I would not

Figure 1: Survey.

Statistical analysis of the data was performed with p-value comparisons across treatment groups for categorical variables based on chi-square test of homogeneity, and with p-values for continuous variables based on ANOVA or Kruskal-Wallis test for median.

Results

Table 1 shows demographic information for this study. There were 149 total participants. 70% of respondents were male. The age ranged from 10 to 18 years old. 70% of respondents were White and 12% were Black or African American. The three most highly represented sports were soccer (25%), football (23%) and basketball (20%). There were patients that reported multiple ethnicities or reported participating in multiple sports.

Table 1: Demographics.

Total participants = 149	Number	Percentage		Number	Percentage
Sex			*Sport*		
Male	104	70%	**Cheerleading**	15	10%
Female	45	30%	**Cross country**	20	13%
Ethnicity			**Golf**	2	1%
White	105	70%	**Football**	34	23%
Hispanic or Latino	8	5%	**Soccer**	37	25%
Black or African American	18	12%	**Tennis**	12	8%
Native American or American Indian	5	3%	**Volleyball**	8	5%
Asian/Pacific Islander	11	7%	**Basketball**	30	20%
Other (or prefer not to day)	10	7%	**Swimming & diving**	7	5%
Primary care doctor			**Wrestling**	12	8%
Yes	131	88%	**Track and field**	22	15%
No	18	12%	**Lacrosse**	11	7%
Age (Years)			**Other**	5	3%
Median	15				
Minimum	10				
Maximum	18				

Table 2 shows the characteristics of participants by interest in ECG. Regarding interest in ECG, 41 (27%) responded 'yes', 31 (21%) responded 'no' and 77 (52%) were unsure. We found a statistically significant association between playing basketball and interest in undergoing ECG screening (p-value = 0.002). We can see that 37% of basketball players responded no to interest in ECG screening compared to 24% of football players, 14% of soccer players and 18% of other athletes. There was no other statistically significant difference found between interest in ECG and age, gender, ethnicity, type of insurance or insurance status. Specifically, there was no statistically significant difference comparing gender and interest in ECG screening (p-value = 0.62) and comparing Black or African American ethnicity to all others (p-value = 0.71).

Table 2: Characteristics of the participants by interest in ECG.

	Yes (N = 41)	**No (N = 31)**	**Unsure (N = 77)**	**p-value**
Age (years)				
Mean +/- SD	15.2 +/- 1.4	15.2 +/- 1.4	15.1 +/- 1.3	0.92
Median (25th, 75th)	16.0 (14.0, 16.0)	15.0 (15.0, 16.0)	15.0 (14.0, 16.0)	
Gender				0.62
Female	11 (24%)	8 (18%)	26 (58%)	
Male	30 (29%)	23 (22%)	51 (49%)	
Ethnicity				0.50
White	26 (25%)	20 (19%)	55 (52%)	
Hispanic or Latino	3 (60%)		2 (40%)	
Black or African American	3 (21%)	4 (29%)	7 (50%)	
Native American or American Indian	1 (25%)	1 (25%)	2 (50%)	
Asian/Pacific Islander	4 (50%)		4 (50%)	
Other/Prefer not to say	4 (24%)	6 (35%)	7 (41%)	
Black or African American				0.71
Yes	5 (28%)	5 (28%)	8 (44%)	
No	36 (27%)	26 (20%)	69 (53%)	
Sport				
Basketball	12 (40%)	11 (37%)	7 (23%)	0.002
Football	10 (29%)	8 (24%)	16 (47%)	0.82
Soccer	12 (32%)	5 (14%)	20 (54%)	0.42
Other	15 (23%)	12 (18%)	38 (58%)	0.34
Location of school				0.31
Chatham county	14 (19%)	18 (24%)	43 (57%)	
Other	15 (31%)	10 (20%)	24 (49%)	
Insurance				0.15
Private or Employee-based	25 (38%)	12 (18%)	29 (44%)	

Government issued	3 (25%)	3 (25%)	6 (50%)	
Uninsured or Unsure or Prefer not to say	13 (18%)	16 (23%)	42 (59%)	
Insurance or not				0.054
Private or Employee-based or Government issued	28 (36%)	15 (19%)	35 (45%)	
Uninsured or Unsure or Prefer not to say	13 (18%)	16 (23%)	42 (59%)	

Table 3 reports the characteristics of participants by willingness to pay for an ECG. 55 participants did not respond to this question. Of those who responded (n = 94), 48 responded 'yes' and 46 responded 'no'. A statistically significant relationship was found between willingness to pay for ECG and ethnicity (p-value = 0.03). Specifically, athletes identifying as Black or African American were less likely to report being willing to pay for ECG screening compared to a composite of all other ethnicities (p-value = 0.005). We can see that 81% of those who identify as Black or African American were not willing to pay for an ECG compared to 42% of all other ethnicities. There was no statistically significant relationship identified between willingness to pay for an ECG and age, gender, sport, location of school, type of insurance or insurance status.

Table 3: Characteristics of the participants by willingness to pay for ECG.

	Yes (N = 48)	**No (N = 46)**	**p-value**
Age (years)			
Mean +/- SD	15.2 +/- 1.4	15.4 +/- 1.1	0.44
Median (25th, 75th)	15.5 (14.0, 16.0)	15.5 (15.0, 16.0)	
Gender			0.30
Female	15 (60%)	10 (40%)	
Male	33 (48%)	36 (52%)	
Ethnicity			0.03
White	35 (57%)	26 (43%)	
Hispanic or Latino	4 (80%)	1 (20%)	
Black or African American	3 (25%)	9 (75%)	
Native American or American Indian		2 (100%)	
Asian/Pacific Islander	4 (80%)	1 (20%)	
Other/Prefer not to say	2 (22%)	7 (78%)	
Black or African American			0.005
Yes	3 (19%)	13 (81%)	
No	45 (58%)	33 (42%)	
Sport			
Basketball	13 (62%)	8 (38%)	0.26
Football	11 (46%)	13 (54%)	0.55
Soccer	13 (57%)	10 (43%)	0.55
Other	20 (51%)	19 (49%)	0.97
Location of school			0.70
Chatham county	14 (47%)	16 (53%)	
Other	19 (42%)	26 (58%)	
Insurance			0.53
Private or Employee-based	24 (52%)	22 (48%)	
Government issued	3 (33%)	6 (67%)	
Uninsured or Unsure or Prefer not to say	21 (54%)	18 (46%)	
Insurance or not			0.65
Private or Employee-based or Government issued	27 (49%)	28 (51%)	
Uninsured or Unsure or Prefer not to say	21 (54%)	18 (46%)	

Discussion

This study aimed to assess interest in obtaining a screening ECG during routine PPEs in high school student athletes, along with willingness to pay for this screening. We were specifically interested to see whether an opt-in approach would likely capture those at highest risk for sudden cardiac death: young males, African Americans and basketball players. In our study, only 27% of athletes reported strong interest in opting into ECG screening, while most were unsure. We did not address our respondents' reasoning, but we hypothesize that multiple factors likely contribute to the relatively low opt-in rate. These may include a lack of knowledge about the comfort with ECG screening and financial concerns.

While males are at higher risk for SCD than females, we did not see a difference in interest in screening ECG or willingness to pay for ECG and subsequent testing by gender. African Americans are at higher risk for SCD than other ethnicities, and while we found no significant

difference in interest in undergoing screening ECG based on ethnicity, we did find a statistically significant difference in willingness to pay for screening and possible additional testing. This raises the concern that if an opt-in screening protocol were developed, athletes in this high-risk group would be captured at a lower rate than other groups. Again, while not directly assessed in our study, decreased willingness to pay for testing might be due to financial concerns or not seeing value in ECG screening.

Basketball players were overrepresented in the group expressing disinterest in ECG screen, accounting for 35% of the 'no' responses while only making up 20% of the overall study population. This again raises concerns about the efficacy of an opt-in screening ECG strategy, as it suggests that members of this high-risk group may be less likely to receive screening.

Conclusion

Perhaps the most important goal of the PPE is to identify athletes at high risk for SCD. ECG screening can detect cardiac disease associated with SCD, and outside of the US there is agreement that ECG is an important tool for screening athletes. While perhaps raising the profile of ECG screening in PPE, an opt-in ECG screening approach would likely miss many athletes at highest risk. It is highly unlikely that an opt-in screening programme will effectively capture all athletes at high risk of SCD. Understanding of ECG screening and financial considerations could be barriers to such a programme being effective. Education about the value of ECG screening for student-athletes could be important at a community level as a means of better identifying athletes at high risk for SCD.

Highlights

i. High school athletes at highest risk of sudden cardiac death include young males, African American ethnicity and basketball players.
ii. Opt-in electrocardiogram screening for sudden cardiac death would likely miss many athletes at highest risk.
iii. Barriers include understanding ECG screening as well as financial considerations.
iv. Education regarding the value of ECG screening would be important at the community level.

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