Use of Electrocardiogram as Part of the Preparticipation Examination

Kelly Chain, MD; and Andrew Gregory, MD

ABSTRACT

A sudden cardiac event or death in a young athlete is a traumatic and memorable event. These tragic events have long-lasting and widespread influences that not only affect the person's immediate family, but also have profound effects on the team, school, and entire community. Over the past several decades there has been a significant research effort in the area of sudden cardiac death (SCD) in athletes in hopes of decreasing preventable deaths. One area of research and discussion that has emerged is the use of electrocardiograms (EKGs) in preparticipation screening examinations as a tool to help identify athletes at risk for SCD. The use of an EKG in addition to a detailed history and physical examination is a controversial and frequently debated topic. To help sort through some of the controversy, this article discusses some of the pros and cons of incorporating the EKG as a screening modality in the preparticipation evaluation for clearance to participate in sports. **[*Pediatr Ann.* 2016;45(1):e26-e29.]**

Sudden cardiac death (SCD) is the leading cause of death in young athletes during sports participation. During preparticipation evaluation (PPE) visits, clinicians are receiving more questions about incorporating electrocardiogram (EKG) screening to detect potentially lethal heart conditions. Many families are aware that several countries in Europe routinely use EKG screening and wonder why the United States has not instituted this recommendation.

What are the pros and cons of preparticipation EKG screening in the US, and how might athlete-specific criteria assist in reviewing EKGs conducted in young athletes?

INCIDENCE RATE OF SUDDEN CARDIAC DEATH

To help determine if the implementation of an EKG would be a useful tool to include in a PPE, a first step is to determine the actual incidence rate of SCD in athletes. Reliable data in this area have been lacking, and it is difficult to determine due to poor-reporting techniques. Early studies looking at the incidence rate of SCD in young athletes have relied on media reports, surveys, voluntary registers, or insurance claims to determine the number of cases in any given time period. This has led to widely ranging results, varying from 1 in 23,000 to 1 in 300,000 athletes.[1-7]

A more recent study[8] looking at SCD in National Collegiate Athletic Association (NCAA) athletes aimed to provide a more precise estimate of SCD and used data from the NCAA database. The incidence rate of SCD was found to be 1 in 43,770 per year for all NCAA athletes, with the highest risk for occurrence being black male basketball athletes—1 in 5,743; that is a 3-fold higher risk than that for white male basketball athletes.[8] When compared to previous estimates, this study found that SCD was much more prevalent than previously estimated in collegiate athletes, which lends support for the use of EKGs to detect cardiac abnormalities and to prevent deaths in this particular population.

Several other studies have found the incidence rate to be much lower. If the incidence rate was estimated to be 1 in 200,000 as found in previous studies, 200,000 athletes would have to be screened with EKGs to detect 1,000 athletes who may be a risk for SCD, and only one of whom would actually die.[9] Until more data are published that yield more accurate incidence results of SCD involving middle school, high school, and college athletes, the overall rate would still be considered low.

When more data are available, if the incidence rate is found to be higher than what's currently estimated and more consistent with the NCAA data, then EKGs may have greater support for

Kelly Chain, MD, is a Clinical Instructor, Department of Pediatrics and Orthopaedics, Vanderbilt University School of Medicine. Andrew Gregory, MD, is an Associate Professor of Orthopedics, Neurosurgery & Pediatrics, Vanderbilt University School of Medicine.

Address correspondence to Kelly Chain, MD, Vanderbilt Orthopaedic Institute Medical Center East, South Tower, 1215 21st Avenue South, Nashville, TN 37232; email: kelly.f.chain@vanderbilt.edu.

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use in the school-aged population. At this time, given that EKG sensitivity is only 51% and specificity is only 61% and the estimated SCD incidence rate is low, the value of adding an EKG to the PPE has not been recommended.[10] Given the low frequency and the large number of competitive athletes, the use of an EKG may result in a significant number of false-positives tests that would far outnumber the true positive results.[9] Thus, because of the low frequency of SCD and the high rate of false-positive results, the American Heart Association (AHA) has not included EKGs as part of the routine PPE.

PREVENTION OF SUDDEN CARDIAC DEATH

The goal of adding EKG screening to the PPE is ultimately to save lives by preventing SCD. Thus, the second issue centers on the ability of the EKG to prevent SCD in athletes. Most athletes with heart problems appear healthy. About 75% of athletes with hypertrophic cardiomyopathy have no murmur on physical examination, and 80% of athletes who die of SCD from hypertrophic cardiomyopathy had no warning signs prior to the lethal event.

A study[11] conducted in Italy examined this question and looked at the rate of SCD 2 years before and 22 years after EKG inclusion as part of PPE in athletes age 12 to 35 years. Over a period of 20 years, 42,386 athletes were screened and 879 (2%) were disqualified from sport participation because of a cardiac condition.[11] With the implementation of EKG screening, the annual rate of death due to SCD declined from 3.6 per 100,000 people in the 2 years prior to the screening to 0.43 per 100,000 people 20 years after the start of EKG screening, a 90% annual reduction in SCD.[11] As a result of this study and the decline in mortality with EKG screening, the European Society of Cardiology and the International Olympic Committee have adopted the requirement of a 12-lead EKG screening as part of the PPE.

This trend of reduced SCD is not documented in other studies. Israel also mandated EKG screening for athletes and a study looked at SCD trends 12 years prior to the implementation of the screening program and 12 years afterward. In this study,[12] there was no change demonstrated in the annual incidence rate of SCD after the implementation of an EKG screening program. The annual rate of SCD was 2.54 events per 100,000 people prior to the initiation of the screening and 2.66 events per 100,000 people after screening. If the Israeli study[12] had narrowed the time period under investigation to 2 years prior to the start of the screening, as the Italy study did, they would have falsely found that EKG screening saved lives because of a peak incidence rate from 1995 to 1996 just prior to the start of the screening program. However, by looking further back in time they were able to account for natural fluctuations with time and determined that the use of EKG screening did not influence whether an athlete would die due to SCD.

Another study conducted in Minnesota reported that the SCD rate in high school-aged athletes was found to be lower than the rate reported in the Italian study[11] after screening despite the fact that there was no screening program in place for the Minnesota athletes.[13]

If the three studies are compared, all have similar rates of SCD despite the presence or lack of an EKG screening program. Thus, there are conflicting data on the effectiveness at EKG screening and its ability to save lives. More research needs to be conducted to determine if screening programs truly reduce the incidence rate of SCD in athletes and prevent mortality, or if rates fluctuate with time and are independent of clinical screening efforts.

COST-EFFECTIVENESS OF EKG SCREENING

A third point of discussion about EKG screening is whether it is cost-effective. The US generally accepts a program as cost-effective if less than $75,000 is spent per life-year saved.[14] An EKG is a relatively inexpensive test and usually costs on average about $50 per screening. Universities or other institutions that perform PPEs can purchase portable EKG machines to assist with mass cardiac screenings. These machines are also relatively inexpensive and can cost around $2,000, which in terms of medical expenses is a relatively low cost.

Conservative estimates hypothesized that approximately 2.06 life-years per 1,000 athletes are saved with EKG screening, which is a cost of $42,000 per life-year saved.[14] Thus, this estimate would meet the accepted benchmark for a cost-effective screening program.

However, the support of the cost-effectiveness of EKG screening ends there. As EKG screening numbers increase so do the eventual false-positive rates that result in further testing, doctor visits, and increased costs. The exact increased cost of adding the EKG to PPE screening is hard to identify. Cost projections range widely and have been estimated to be anywhere from $21,200 to $71,300 per diagnosis made. Some projections have even estimated as high as $1.32 million per life saved.[15] Thus, the addition of an EKG to the PPE is expensive and can be predicted to add up to a total cost of $2 billion annually to health care expenses.[16]

The limitations in the determination of the true cost-effectiveness of EKG screening are two-fold: (1) an accurate incidence rate of SCD is poorly defined

TABLE 1.

Seattle Criteria Outlining Normal Physiologic Electrocardiogram Changes Seen in the Athlete's Heart

- Relative bradycardia
- First-degree atrioventricular block (Mobitz type I)
- Incomplete right bundle branch block
- Early ventricular repolarization

Adapted from Maron et al.[16]

TABLE 2.

Outline of Pros and Cons for Inclusion of Electrocardiogram into the Preparticipation Examination

Pro	Con
• Reduce risk of sudden cardiac death in higher prevalence populations • Identify high-risk people that would not be discovered with history and physical examination alone • EKG screening itself is low cost, portable, and meets criteria for being cost-effective • False-positive rates may be reduced with use of athlete-specific EKG interpretation guidelines	• Actual sudden cardiac death incidence in school-aged athletes is currently thought to be too low to warrant mass EKG screening • Uncertain if EKG screening has the ability to save lives • False-positive rates may create significant financial and emotional costs • Lack of agreement on EKG interpretation may lead to additional cardiac evaluation and increased costs

Abbreviation: EKG, electrocardiogram.

due to incomplete data and (2) the effectiveness of EKG screening in preventing death is unknown.[14] Ultimately, the basis of a cost-effective screening program can only be demonstrated if the screening program is proven to be clinically effective.[14] Thus, it is impossible to truly determine the cost-effectiveness of mass EKG screening programs until there are better data to determine if the EKG is a clinically effective method to prevent death from SCD.

ATHLETE HEART FINDINGS ON EKG

Lastly, if EKG screening does become a routine part of the PPE then it is important to understand how regular exercise and conditioning lead to changes in the heart and EKG that are considered normal for trained athletes but would be viewed as abnormal if found in an unconditioned person. Awareness of these changes could reduce false-positive EKG readings that would result in further unwarranted testing. **Table 1** lists normal physiologic changes that are routinely seen in the athlete's heart.[17]

The sensitivity and specificity of EKG interpretation have been shown to be significantly improved when the EKGs were read by cardiology clinicians with experience in sport cardiology and athlete EKG interpretation.[18] EKG interpretation by a cardiologist helped the sensitivity improve to 93.3% and the specificity to 89.8% with a false-positive rate of 10%.[18] Another study demonstrated that history alone had a sensitivity of 44% and specificity of 75.2% for detecting a cardiac abnormality, which improved to a sensitivity of 88.9% and specificity of 69.6% with the addition of an EKG to the PPE.[19] However, there is significant variation in false-positive rates when using EKG for PPE screening. In one study, the addition of an EKG was found to have a false-positive rate of 24.7%.[19] Another recent meta-analysis of 15 pooled studies found that using an EKG was the most accurate screening test and had an overall pooled sensitivity of 94% and specificity of 93% for identifying a cardiac abnormality.[20] The false-positive rate in this study was only 6%. This was less than the false positives for both history and physical at 8% and 10%, respectively.[20]

The actual difficulty of interpreting the EKG was demonstrated in another study[21] that had a sports medicine physician, a sports cardiologist, and an electrophysiologist look at 440 EKGs from asymptomatic athletes. If the EKG was normal, agreement between any two readers was 87.5% to 94.8%[21] but if the EKG was abnormal the agreement percentage decreased dramatically. Agreement on Q waves was poor and the presence of right ventricular hypertrophy and prolonged QTc was poor to moderate.[21] Overall, underlying cardiac pathology was correctly identified in only 50% of cases (3 of 6),[21] which helps to demonstrate that although abnormalities on EKGs are rare, even people that are well trained to read EKGs have significant disagreement. This can lead to further testing for the athlete, leading to increased cost.

SUMMARY

The role of preparticipation EKG screening for prevention of SCD is complex and continues to be unclear at this time. See **Table 2** for a review of the arguments both in favor and against EKG screening in the PPE.

Given the available data, the current AHA recommendation not to include an EKG as part of the PPE screening seems reasonable. As more evidence is collected and more research completed, these recommendations may change. The focus at this time is to obtain a good history and perform a thorough cardiac examination, only obtaining EKGs on those who are identified as high risk after the history and physical examination.

Regardless of EKG screening status, physicians need to discuss emergency action plans for an athletic-related collapse and the importance of training to initiate immediate cardiopulmonary resuscitation and use of automated external defibrillators with coaches, athletes, and their families. Ultimately, no matter how careful any screening and testing that is performed to identify athletes at risk for SCD, it is impossible to identify every athlete that could suffer SCD.

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