

## CLINICAL DECISIONS

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## Cardiac Screening before Participation in Sports

This interactive feature addresses the approach to a clinical issue. A case vignette is followed by specific options, none of which can be considered correct or incorrect. In short essays, experts in the field then argue for each of the options. Readers can participate in forming community opinion by choosing one of the options and, if they like, providing their reasons.

## CASE VIGNETTE

The director of a high school athletic program is considering implementation of a requirement that all student athletes undergo cardiac screening by a physician before participating in any school-sponsored athletic team. Several teachers at the high school have been advocating for a mandatory screening program after seeing a television news report that featured a student from a nearby high school who died from a sudden cardiac arrest while playing basketball. However, coaches have expressed concern to the athletic director that instituting such a requirement would discourage students from playing organized sports and could be a financial burden for some families.

The athletic director seeks your advice on the following two questions:

1. **Should young athletes be required to undergo cardiac screening before participating in sports?**
2. **If an athlete does undergo screening, should the screening involve only a history and physical examination, or should electrocardiography (ECG) also be required?**

What do you recommend? To aid in your decision making, four experts in the field defend the possible answers to each of these questions. On the basis of your assessment of the experts' opinions, your reading of published literature, other information sources, and your own clinical experience, make your choices and offer your comments at NEJM.org.



Choose an option and comment on your choice at NEJM.org

## QUESTION 1, OPTION 1

## Require Young Athletes to Undergo Cardiac Screening before Participation in Sports

Sanjay Sharma, M.D.

The death of a high school athlete is a highly emotional event. Apart from the devastation within a family unit, the sudden nature of the event and the loss of decades of life have a lasting impact on friends, peers, and both the lay and medical communities. Deaths are usually attributable to hereditary or congenital abnormalities affecting the cardiac structure or the electrical system of the heart. These conditions are often associated with a relatively quiescent natural history and favorable prognosis in most sedentary persons but with an increase in the risk of sudden cardiac death among athletic youth that is two to five times greater than the risk in more sedentary youth.

Approximately 100 young athletes die from sudden cardiac arrests in the United States every year. According to analysis of a series of 1866 deaths in young athletes, 65% of young athletes who die from sudden cardiac arrests are of high-school age.<sup>1</sup> Most of these young adults lose at least 50 years of normal life expectancy, representing a minimum of 5000 life-years lost annually; therefore, sudden cardiac death in young athletes may be considered to be an important public health issue. Although the incidence of sudden cardiac death among athletes is approximately 1 death in 50,000 athletes, it is well recognized that 1 in 300 young persons harbors a cardiac condition that can result in instantaneous death. The unpredictability of such catastrophes and their occurrence without previous warning symptoms are a strong and obligatory incentive in any compassionate society to support cardiac screening of all high school athletes. The obligation is magnified by the fact that most implicated diseases can be diagnosed during life

and by the fact that there are several therapeutic strategies to minimize the risk of death.

Indeed, both the American Heart Association (AHA)<sup>2</sup> and the European Society of Cardiology (ESC)<sup>3</sup> advocate preparticipation cardiac screening of young athletes. It is ironic that screening is performed in college athletes and in more than 90% of professional athletes in the United States, yet these athletes are less likely to have serious forms of primary cardiomyopathies, since rigorous training schedules in middle school and high school eliminate those with impaired myocardial function. Therefore, any reluctance to screen the most vulnerable cohort of athletes — those in high school — seems deplorable. The detection and proper management of a potentially life-threatening genetic or congenital cardiac disorder in such persons is associated with disproportionately better outcomes than those in persons with ischemic heart disease or heart failure — and at a much lower cost. Furthermore, evaluation of the family members of an athlete who has received a diagnosis of a genetic disorder provides an invaluable opportunity to identify other young relatives at risk. The early identification of a young person at risk also permits informed decisions relating to exercise and the pursuit of appropriate career paths.

There is no evidence that preparticipation cardiac screening deters young athletes from participating in competitive sports. On the contrary, promoting safe exercise is likely to achieve the most important goal of Western health care organizations: a reduction in cardiovascular disease burden. Cardiac screening of young, impressionable persons also has the potential to raise awareness of cardiac disease and to promote healthier life habits in the future. The postulated financial burden for some families is worthy of mention, but most parents already invest large sums on sports club membership, coaching, and sports equipment to help their children realize their ambitions; in contrast, the fee for minimizing the risk of an exercise-related sudden cardiac death in their child is very small. In summary, preparticipation cardiac screening should be required for all young athletes before they engage in organized competitive sports.

Disclosure forms provided by the author are available with the full text of this article at [NEJM.org](http://NEJM.org).

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## QUESTION 1, OPTION 2

## Do Not Require Young Athletes to Undergo Cardiac Screening before Participation in Sports

N.A. Mark Estes III, M.D.

The sudden cardiac death of a young athlete who was previously presumed to be healthy evokes a strong emotional response. These rare, tragic deaths receive widespread media attention and often result in initiatives for preparticipation screening for athletes, including a history and physical examination. Screening is sometimes supplemented by ECG. The evidence suggesting that any screening program saves lives is limited to a single study that has fundamental limitations.<sup>4-6</sup> Multiple gaps in evidence strongly indicate that implementing preparticipation cardiovascular screening of athletes on a large scale would be premature.<sup>4,5</sup>

Sudden death among young athletes is rare, with approximately 150 deaths occurring annually during a sports practice or game.<sup>4</sup> By contrast, every year in the United States, approximately 14,000 persons younger than 21 years of age die from accidents, 8000 die from sudden death not related to athletics, 4100 die from homicide, and 2200 die from suicide.<sup>4</sup> In fact, whether sudden death occurs more frequently during sports practices or games remains controversial. In addition, the premise that restriction of participation in sports improves outcomes remains unproven.

The argument advanced by screening advocates is based solely on one observational study conducted in Italy.<sup>6</sup> The investigators studied the effects, in a homogenous population, of a nationally mandated and funded screening program implemented by sports medicine physicians at regional centers. The screening included a history taking, physical examination, and ECG, with selective use of echocardiography and stress testing.<sup>6</sup> After implementation of the screening program, the investigators observed a reduction in deaths among athletes from 3.6 deaths per 100,000 person-years to 0.4 deaths per 100,000 person-years by comparing the only available data — data from the 2 years preceding implementation of the screening program — with data from the subsequent two decades.<sup>6</sup> How-

ever, the high baseline death rate in the short prescreening period of that study results in the erroneous conclusion that screening that includes ECG improves outcomes.<sup>6,7</sup> A similar screening program in Israel did not show any reduction in death after screening of athletes that included ECG.<sup>7</sup> In the Israeli study, the rate of sudden cardiac death peaked at 8.4 deaths per 100,000 person-years in the 2 years preceding implementation of the screening program and declined to 1.1 deaths per 100,000 person-years after implementation ( $P < 0.001$ ).<sup>7</sup> Use of the rate from the 2-year prescreening period as the baseline rate would result in the erroneous conclusion that the Israeli screening was effective.<sup>7</sup> However, in a proper analysis of the data — a comparison of the rate during the 12 years before implementation of the prescreening program with the rate for the 12-year period after implementation of the prescreening program — there was no reduction in mortality.<sup>7</sup> Marked variations in the annual rate of sudden deaths are noted in all the studies.<sup>4,6-8</sup> The rate of sudden death among high school athletes over a 23-year period in a statewide U.S. screening program that did not include ECG was 1 death per 100,000 person-years.<sup>8</sup> This rate was similar to that reported by the Italian investigators during the same period of time after the initiation of a screening program that included ECG.<sup>6</sup> The Italian, Israeli, and U.S. reports share the fundamental limitations of being retrospective, nonrandomized, observational, registry studies.<sup>4,6-8</sup>

The goal for all screening programs is to reduce the number of sudden cardiac deaths among athletes in a cost-effective manner. All screening programs, by definition, have unintended and adverse consequences. These include falsely identifying and unnecessarily restricting athletes who are free from cardiovascular disease. Whether screening of athletes while excluding other youth is ethical merits careful consideration. Data are needed on the incremental risk of sports, the false positive rate of screening performed by nonexperts in a diverse U.S. population, the cost of screening and subsequent tests, and outcomes that include restriction of athletic activities. The limited data that are available fall far short of the current standards of evidence-based medicine and health policy.<sup>4</sup> Given these considerations, the rational approach is to obtain data from appropriately designed studies and regis-

tries that robustly evaluate outcomes and cost. Advancing potentially costly and harmful athletic screening without proven benefit would be premature.

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#### QUESTION 2, OPTION 1

## Cardiac Screening for Young Athletes before Participation in Sports Should Include a History and Physical Examination Only

Victoria L. Vetter, M.D.

Preparticipation evaluation of young athletes should use a history and physical examination as the best screening method for cardiovascular conditions that can lead to sudden cardiac arrest and sudden cardiac death. The evidence regarding the merits of a history and physical examination alone, as compared with a history and physical examination plus ECG, is scarce, with no randomized trials or case-control studies comparing the two screening options.<sup>9</sup> The observational 25-year experience in Italy showed a decrease of 89% in the rate of sudden cardiac death after ECG was added to the history and physical examination, but some have questioned the generalizability of these findings to the U.S. population. A study that was based on newspaper accounts in Israel did not show a difference in the rate of sudden cardiac death after ECG was added to screening.<sup>10</sup> Other observational studies have shown that the combination of a history and physical examination is less sensitive, but more specific, than ECG.<sup>11</sup>

A history and physical examination will not identify all conditions, since only 50% of youth who have a sudden cardiac arrest report antecedent symptoms, and only 16% report a positive family history.<sup>12</sup> However, the history and physical examination will result in fewer false positive findings than will ECG. Furthermore, a history and physical examination cost less than other screening approaches, since the infrastructure for preparticipation evaluation is already in place.

The most valid reasons for not performing ECG universally at this time include the lack of infrastructure, the lack of educated personnel for interpretation of the ECGs and for the evaluation and care of athletes identified as potentially at risk for sudden cardiac death, and the lack of evidence-based ECG standards for young athletes that reflect the diversity of the population with respect to age, sex, race, and ethnic group. Without these standards and educated interpreters, the false positive level will remain unacceptably high. The so-called modern standards for interpretation of ECG that have been developed by consensus groups may or may not apply to young athletes.

Proper use of the history and physical examination is essential. AHA recommendations propose a comprehensive history and physical examination with 8 history elements and 4 physical-examination elements.<sup>2</sup> To achieve the best results, screening physicians should be experts in recognizing the potential presence of conditions that confer a predisposition to sudden cardiac death. The 12 history and physical-examination elements should be assessed in a quiet environment, with the use of a standardized form. The examiner must understand the warning signs and symptoms that suggest the possibility of serious cardiac conditions — notably, dizziness, fainting, chest pain, shortness of breath and palpitations during or after exercise, or a change in exercise tolerance. These are common symptoms in youth and result in false positive findings unless the examiner knows how to distinguish relevant symptoms from those that are benign. Most families affected by sudden cardiac arrest and associated inherited conditions are unaware of their own family's pertinent medical history, despite its importance. Education of physicians and the public is critical to improving the effectiveness of screening by means of a history and physical examination.

The value of a one-time screening assessment changes when new information becomes available. Therefore, families should be instructed to report new symptoms or new clinical events in family members that occur after a screening evaluation. The limitations and advantages of any screening method should be disclosed to all athletes and their families.<sup>9</sup> All screening must be linked to the comprehensive evaluation and care of persons with identified conditions.

A meticulous history and physical examination should be performed in every young athlete by an experienced practitioner. There is no single screening strategy that is capable of identifying all persons at risk for sudden cardiac death, since many distinct structural and electrical disorders that affect the heart contribute to that risk. Continued research is essential to determine the best screening methods to ensure the safety of our young athletes.

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#### QUESTION 2, OPTION 2

## Cardiac Screening for Young Athletes before Participation in Sports Should Include a History, Physical Examination, and ECG

Domenico Corrado, M.D., Ph.D.

Consensus statements of the AHA and the ESC agree on the need for cardiovascular evaluation of young athletes before they participate in competitive sports.<sup>2,3</sup> However, there is vigorous debate regarding the inclusion of 12-lead ECG in the screening protocol, in addition to a medical history and physical examination.

The risk of sudden cardiac death among adolescents and young adults engaged in regular training and athletic competition has been estimated to be approximately three times the risk among their nonathletic counterparts. It is noteworthy that sports activity per se is not responsible for the increase in the rates of sudden cardiac death; rather, arrhythmic cardiac arrest may be precipitated by the interaction between exercise-induced adrenergic stimulation and underlying cardiovascular diseases, such as cardiomyopathies (mostly hypertrophic cardiomyopathy and arrhythmogenic right ventricular cardiomyopathy) and cardiac ion-channel disorders. A positive family history, an abnormal physical examination, or premonitory symptoms are present in only a minority of young competitive athletes who die suddenly — with sudden cardiac arrest often the first manifestation of previously un-



suspected heart disease. Thus, preparticipation screening that relies solely on medical history (personal and family) and physical examination is of only marginal value for the detection of athletes at risk for sudden cardiac death.<sup>3,13</sup> The addition of ECG substantially enhances the power of screening for early detection of the leading causes of sudden cardiac death, which are commonly manifested as ECG abnormalities.<sup>13,14</sup>

Under a nationwide program established in 1982, young competitive athletes in Italy undergo systematic ECG screening. This experience over the course of more than 30 years has provided solid scientific evidence that preparticipation ECG may prevent sudden cardiac death in the athlete. The screening program reduced the incidence of sudden cardiac death among young competitive athletes of the Veneto region of Italy by almost 90%, from 3.6 deaths per 100,000 athlete-years before the implementation of screening to 0.4 deaths per 100,000 athlete-years two decades later.<sup>6</sup> In contrast, the rate of sudden cardiac death did not change significantly among the control population of unscreened nonathletes during the same period. The reduction in death rate among screened athletes was due primarily to fewer cases of sudden cardiac death from cardiomyopathies, and there was a parallel increase in the number of asymptomatic athletes in whom cardiomyopathies were diagnosed at preparticipation screening during the same period.

Concerns regarding the implementation of preparticipation ECG screening relate predominantly to the high number of false positive findings, which result in additional, expensive investigations or even unnecessary disqualification from competitive sports. The prevalence of false positive results depends largely on the criteria used to define an ECG as abnormal. Recently, important advances have been made in the interpretation of ECG findings in athletes, and modern criteria have been proposed with a goal of improving the ability to distinguish physiologic from pathologic ECG changes.<sup>15,16</sup> The application of modern criteria for ECG interpretation offers the potential to dramatically reduce the traditionally high number of false positive findings.

On the basis of the available data, the students in the vignette should undergo a preparticipation cardiovascular evaluation including ECG — the only screening strategy that has been proved to be effective.

Disclosure forms provided by the author are available with the full text of this article at NEJM.org.

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This article was published on November 19, 2013, at NEJM.org.

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DOI: 10.1056/NEJMcld1311642

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