EDITORIAL COMMENTARY

ECG screening for athletes: Letting evidence and reason advance the debate

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Sudden cardiac death (SCD) in a young athlete, usually due to genetic cardiovascular disease, is a tragic and emotionally charged event that brings to the forefront the ongoing debate about preparticipation electrocardiographic (ECG) screening and athletic restriction. Development of a cost-effective screening strategy with a high predictive accuracy in detecting cardiovascular conditions predisposing to SCD in athletes is an intuitively attractive public heath priority.[1–5] The primary objective of preparticipation athletic screening is detection of potentially lethal cardiovascular diseases likely to manifest as SCD during athletics. In Italy, a 12-lead ECG is routinely obtained as part of a mandatory comprehensive screening program.[1] This systematic screening is associated with a decline in deaths when linked to athletic restriction.[1] Since 1982, this government-subsidized national screening program with ECGs has been performed at regional centers by highly specialized physicians with legal liability for errors.[1] In contrast, the customary practice of screening athletes in the United States is limited to history and physical examination performed by a wide range of health care professionals with varying expertise without routine inclusion of an ECG in a less accountable legal context.[3–7]

Although other European countries have adopted the Italian model and some experts have suggested that ECG screening should be added for U.S. athletes, considerable controversy remains regarding this approach.[1,2,8–12] Despite many studies evaluating the outcomes of preparticipation screening, few have evaluated the incremental value and cost of ECG to the standard screening history and physical examination.[4,5] Because the outcomes and cost of screening with ECG remain incompletely studied, many experts believe that data are insufficient to justify a U.S. national program similar to that used in Italy.[9,11,12] Issues related to cost effectiveness, false-positive screening tests, and the efficacy of athletic restriction in preventing SCD are particular concerns.

The problem with borderline or false-positive test results, commonly from ECG interpretation, is particularly relevant when evaluating the feasibility of a national athlete screening program.[7,11,12] In prior screening efforts of varied design, the percentage of false-positive examinations ranged from 10% to 25%, depending on the threshold criteria used to define an abnormal ECG.[5,13–15] ECG abnormalities occur frequently in athletes, reportedly in 10% to 40%, depending largely on their level of sports training and the criteria used for distinguishing abnormal patterns.[13,15] When identified on the primary screening examination, ECG abnormalities often trigger noninvasive diagnostic evaluations by cardiovascular specialists, including techniques such as echocardiography and cardiac magnetic resonance imaging, which add considerably to the scope and resources required for the screening program. After comprehensive evaluation, diagnostic uncertainty about the presence or absence of significant cardiovascular disease sometimes persists.

Whether athletic restriction improves outcomes in individuals identified through screening as having a cardiovascular disease predisposing to SCD in the United States remains incompletely studied. Preparticipation screening of athletes using ECG has been reported to result in a pronounced reduction in sudden death in northern Italy.[1] However, the annual death rate in Italy prior to the initiation of the mandatory screening program was high compared to the rate reported in U.S. studies.[12,14,15] The initial death rate of one per year for 27,000 athletes accounts for much of the reduction over the course of the study. The lowest annual death rate achieved in the Italian study with screening is similar to that reported for U.S. athletes between 1983 and 1993.[14] Other recent observations from a U.S. study raise similar questions about improved outcomes with screening and athletic restriction.[15] The Italian program included nonparticipation in competitive athletic activity as well as disease-specific treatment of identified athletes with heart disease. Thus, assessment of the impact of each intervention is difficult. Concurrent changes in treatment of the athletic population over time are possible and could have contributed to the reduction in events during the study.

In the final analysis, the incremental utility of ECG screening to the history and physical examination remains debatable in the United States due to the absence of sufficiently robust evidence to conclusively resolve the issue.

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Passionate arguments continue to be advanced for implementation of a U.S. national screening program with ECGs,[8,10] but those arguments are effectively countered by reason and the need to satisfy many fundamental tenets of evidence-based medicine.[9,11,12,16,17] They include ensuring that clinical practice, including screening, is based on robust data from appropriately designed clinical trials.[16] Screening is appropriate when several conditions are satisfied. Sensitive, specific, practical, cost-effective screening strategies for a condition that has significant morbidity or mortality are required.[17] The condition being screened for should have a proven treatment that can affect its outcome and not merely prematurely identify the inevitable.[17] Treatment afforded by early detection should produce results superior to those of early treatment of symptomatic results.[17] A final requisite is a sufficiently high prevalence of the condition in the population to merit screening in a cost-effective fashion.[17]

In this issue of *Heart Rhythm,* Malhotra et al[18] advance the available knowledge by providing useful observations about athletic screening by specialists. The investigators evaluated the cost and yield of a 5-year screening program at a U.S. Division I college. A total of 1,473 competitive athletes were screened with history, physical, and ECG over 5 years, with follow-up testing as dictated by clinical symptoms and ECG findings. Routine screening with history and physical examination alone uncovered five significant cardiac abnormalities. ECG screening was abnormal in 443 (30%) asymptomatic athletes, leading to 227 echocardiograms, 44 cardiac magnetic resonance images, 10 stress tests, 7 drug challenges, 6 Holter monitors, and 4 ablations.

The findings ultimately resulted in athletic restriction in only two athletes identified by ECG screening alone. This included one athlete with a low ejection fraction with frequent polymorphic premature ventricular contractions and one athlete with asymptomatic long QT syndrome.[18] The total cost of the screening program including follow-up tests was $894,870 to diagnose five symptomatic and eight asymptomatic findings, or $68,836 per diagnosis. The cost of standard screening alone with history and physical was $343,725, or $68,745 per finding. The marginal cost of adding ECG screening including resulting tests and procedures was $551,145, or $68,893 per additional finding. Only when the marginal cost of the screening ECGs is evaluated in the context of the total cost of additional procedures resulting from the ECGs is a minimal increase seen in the cost per additional finding. However, it should be logically evident that without the ECG screening, the costs of the additional testing would not have been incurred.

Based on these observations, the authors conclude that ECG screening of U.S. collegiate athletes can uncover significant cardiac pathology not discovered by screening without ECG. They also note that ECG screening results in many false-positive results, leading to additional tests.[18] Despite this finding, they note that the overall cost of diagnosis with the addition of ECG screening is similar to that of history and physical screening alone. The authors indicate that their study suggests that an ECG plus history and physical is as cost effective as history and physical alone when cost effectiveness is defined as cost per diagnosis.

These findings should be considered in the context of prior studies and the ongoing debate surrounding the optimal approach to screening young competitive athletes for occult cardiovascular disease to minimize SCD. The initial evaluation with a history and physical examination was performed by a team of physicians, including two internists with input from a cardiologist. ECG, echocardiography, and other tests were performed in asymptomatic athletes and were not interpreted in a blinded fashion. ECGs were overread by a cardiac electrophysiologist, and echocardiograms were interpreted by two experienced echocardiographers. The findings ultimately resulted in athletic restriction in only two asymptomatic athletes identified by ECG screening alone: one athlete with a low ejection fraction with frequent polymorphic premature ventricular contractions and one with asymptomatic long QT syndrome. It is evident that this screening program was conducted at a specialized center by experienced physicians with access to a wide range of specialized testing.

The lack of detection among any patients with hypertrophic cardiomyopathy, which typically is found in 1:500 athletes when all are screened with echocardiograms, raises the probability that the strategy of screening ECGs of all athletes and selective echocardiograms resulted in missing some athletes with the condition. The study does not present data assessing whether the screening saved any lives, so determination of the true cost effectiveness per life-year saved is not possible based on the data presented. Thus, a reasoned argument can be made from this study that the addition of screening ECG led to multiple tests and therapies in asymptomatic athletes with considerable additional cost and some risks, but without symptom or survival benefit. Exclusion of this possibility with additional studies is essential before this screening strategy can be used on a widespread basis.

This study does extend prior observations on the utility[19] and costs[20] associated with athletic screening, which have suggested that screening young athletes with 12-lead ECG plus cardiovascular-focused history and physical examination may be cost effective based on decision-analysis, cost-effectiveness modeling.[20] As in previously published studies, the study by Malhotra et al is based on a prospective population-based observational design with inherent limitations. The limitations include absence of actual data on incremental health care cost per life-year gained. This study provides an analysis of cost effectiveness defined as the cost of the total program divided by the total number of significant cardiac findings, or cost per diagnosis. Although these results are provocative, they do not prove the incremental value of ECG screening or provide any data indicating that addition of an ECG prevents SCD in athletes. To date, prospective randomized studies evaluating the actual costs

and mortality outcomes of screening with and without ECG have not been conducted. Data are insufficient to conclude that ECG screening effectively reduces SCD in athletes or that this strategy is cost effective when analyzed by the standard metric of cost per life-year gained.

To advocates of a U.S. screening program with ECGs, the notion that any well-intentioned screening program could have prohibitive cost and risk is an anathema.[12] Unnecessarily excluding athletes from participation and labeling them for a lifetime with a cardiovascular condition that they do not have is an inherent risk of any screening program. Perfectly sensitive and specific screening strategies and techniques that can serve as a "gold standard" to establish the presence or absence of a cardiovascular condition do not yet exist. Safety can be used as a smoke screen for the economic interests of organizations with a profit motive while promoting preparticipation screening. When benefits are emphasized, risks trivialized, and costs minimized for athletic screening, the public interests are not well served.

Before moving forward with any large-scale U.S. national program, smaller-scale projects definitively addressing the many gaps in our knowledge related to screening and athletic participation are needed. Until these studies are performed, inclusion of ECG in the preparticipation screening of young athletes will remain controversial because of concerns about cost effectiveness, predictive accuracy, and efficacy of interventions. The frequency and nature of cardiovascular conditions predisposing to SCD in athletes, the sensitivity and specificity of screening programs, the efficacy of interventions, and the patterns of sudden death vary based on demographic differences among countries and the expertise of the specialists conducting the screening.

The report by Malhotra et al is laudable and does provide useful information on cost per diagnosis of a screening strategy with routine ECGs and selective additional tests interpreted by experts in a nonblinded fashion. However, it is evident that although this and other studies have advanced our knowledge about ECG screening of athletes, much remains unknown. In this respect, the available data from Italy can reasonably be interpreted as supporting the efficacy of athletic screening in that country. However, the current evidence remains insufficient to conclude that preparticipation screening using ECG is cost effective or lifesaving in the United States. Continued study and collaboration are needed to develop a well-reasoned and rigorous screening program based on robust evidence from prospective data. Optimal screening strategies can only be developed using directly measured outcomes and costs. Based on these considerations, those involved in screening athletes or developing policies on screening in the United States can learn many valuable lessons from the Italian experience, prior studies, and the current study by Malhotra et al.

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