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EDITORIAL COMMENT

Routine ECG Screening of Young Athletes

Can This Strategy Ever Be Cost Effective?*

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"He who saves a single life saves the whole world."
—Talmud Sanhedrin 4:5 (1)

Serious cardiovascular disease (CVD) and particularly sudden cardiac death (SCD) in a young person, including an athlete, is a rare, but tragic event with far-reaching implications for families and communities (2,3). Families who are directly affected by these relatively rare events struggle to comprehend why more effective screening strategies are not routine and standardized in most of the Westernized World, including the United States and Europe. Besides the devastating blow to the families involved, these tragic events are also devastating to the community, which often calls for more vigorous screening of athletes, regardless of the cost.

However, the incidence of SCD among young athletes is vigorously debated, with wide estimates ranging from 1 per 3,000 athlete-years (AY) in National Collegiate Athlete Association (NCAA) Division I (DI) male basketball athletes to as low 1 per 919,000 AY reported in Minnesota high school athletes, a difference of >300-fold (3–5). The wide range of reported incidence is largely due to the study methodology. An accurate incidence requires a precise numerator (cases identified) and denominator (population studied). Studies with mandatory reporting and known populations report higher incidence rates than those examining media reports or estimating denominators. In addition, inclusion criteria differ between studies, with some studies including only SCD while exercising, some including SCD at any time, and some including both sudden cardiac arrest (SCA) and SCD. Moreover, emerging evidence demonstrates a much higher incidence of SCD in some specific populations: 1 in 38,000 AY in college males, 1 in 21,000 AY in African Americans (AAs), 1 in 9,000 AY in male basketball players, and 1 in 5,000 NCAA DI AA basketball athletes (3).

Although it is generally accepted that the primary purpose of the pre-participation examination (PPE) is the identification of CVD, which predisposes to SCA/SCD, a debate has developed regarding the best method to screen: history and physical examination (H&P) either alone or with the addition of a 12-lead electrocardiogram (ECG). Italian investigators have promoted mandatory 12-lead ECG screening in addition to H&P (6), and Israel also has required screening with H&P and ECG (7). In the United States, H&P alone is recommended, whereas Denmark has repeatedly rejected screening of any type for CVD on the basis of low event rates (8,9). In contrast, the National Basketball Association goes to the other extreme, requiring an exercise echocardiogram and Color Flow Doppler study yearly, although the extremely high franchise incomes and players' salaries do not suggest a need for "cost-effectiveness."

Concerns regarding this addition of ECG to H&P include (but are not limited to) the false-positive rates of routine 12-lead ECG, as well as the cost of the ECG and downstream testing (8). The Italian data suggesting that ECG screening reduced mortality in

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athletes, performed in a population from Veneto with a high prevalence of right ventricular cardiomyopathy, was not replicated in either the United States or Israel (**Figure 1**) (5-7). Therefore, the American Heart Association (AHA) and American College of Cardiology (ACC) have recommended PPE with H&P alone, and do not support the addition of mandatory ECGs. However, the AHA/ACC do support, in concept, the addition of ECG provided there is close physician involvement and sufficient quality control (8).

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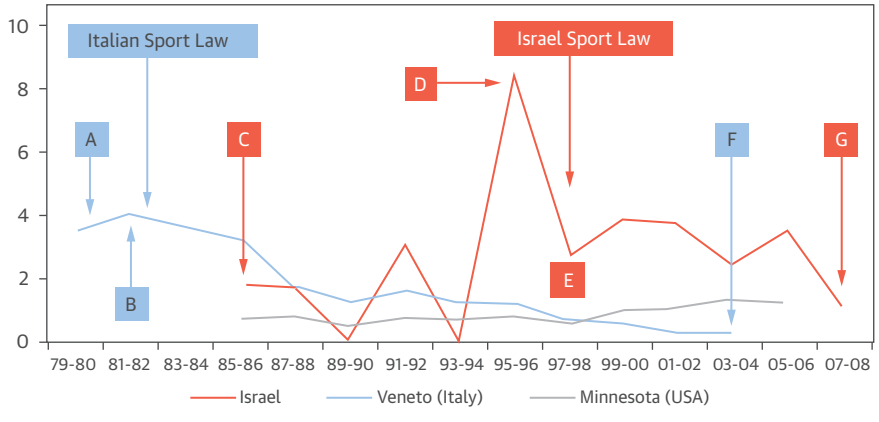
In this issue of the *Journal*, Dhutia et al. (10) investigated the cost of ECG screening from 2011 to 2014 in 4,925 previously unscreened athletes (age 14 to 35 years) from the United Kingdom using the 2010 European Society of Cardiology (ESC) recommendations and the Seattle and refined ECG interpretation criteria. Using the 2010 ESC recommendations, the average cost per athlete was $110 and was $35,993 per significant CVD diagnosis, which was reduced to $92 and $87 per athlete screened and $30,251 and $28,510 per significant CVD diagnosis using the Seattle and refined criteria, respectively (10). Clearly, the cost of SCD prevention would likely be considerably higher. Nevertheless, these investigators suggest that more contemporary ECG interpretation criteria will reduce costs and improve cost-effectiveness, which may make this testing more cost-permissive, at least for some sporting organizations.

Although the incidence of SCA/SCD is debated, the prevalence of CVD in young people is about 1 in 300 (11). Clearly, ECG significantly increases the likelihood of detecting CVD; however, the very high false-positive rates in the past made its use impractical. This study demonstrated dramatically reduced false positive rates using modern criteria to interpret the ECG (to 4.3%) (10). This study did not compare the cost per diagnosis of H&P to H&P with ECG or ECG alone, perhaps because in this cohort, the H&P did not diagnose any of the potentially lethal CVDs. This finding is similar to a recent meta-analysis of 47,000 athletes, which found that ECG had a sensitivity/specificity for CVD of 94%/93%, whereas history had a sensitivity/specificity of 20%/94% and physical examination of 9%/97% (12). Obviously, H&P have extremely low sensitivities as supported in the present study.

This study demonstrates that ECG screening and appropriate secondary testing can potentially be accomplished cost-effectively to identify CVD (10). The current U.S. recommendation of screening with H&P is the least cost-efficient manner to identify CVD because of its poor sensitivity. Perhaps, a "one size fits all" model for PPE may not be appropriate. Potentially, screening strategies should be tailored

FIGURE 1 Sudden Cardiac Death in Athletes



An Italian study **(blue)** (6) concluded that electrocardiography (ECG) screening (started in 1982) significantly reduced the incidence of sudden cardiac death by comparing the sudden death in the 2-year pre-screening period **(A to B)** with the post-screening period **(B to F)**. The study by Steinvil et al. (7) is depicted by the **red graph**, which compared the 12 years before screening **(C to E)** with the 12 years after the onset of mandatory ECG screening **(E to G)**. Had they limited comparison of the post-screening period to the 2-year period preceding the enforcement of screening in Israel (**D to E** vs. **E to G**, as performed in the Italian study), they would have concluded erroneously that screening saved the lives of athletes in Israel. The study from Minnesota **(gray)** (5) shows a low mortality rate in a population of athletes not undergoing systematic ECG screening. Reproduced with permission from Steinvil et al. (7).

to the population being screened and the available resources. For a start, it seems that at least ECG screening of NCAA DI male basketball players, who have a high incidence of SCD, could be done cost-effectively using modern ECG interpretation standards (13). This could potentially later be extended to other higher-risk athletes in places with available resources. As emphasized by the quotation from Talmud Sanhedrin (1), saving lives is a priority, and whether we practice general family practice/internal medicine, sports medicine, sports cardiology, or general CVD, saving lives is what we always must strive to do.

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