Preparticipation Cardiovascular Screening — Finding the Middle Ground

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The electrocardiogram (ECG) screening conversation has dominated the preparticipation physical evaluation (PPE) for more than a decade. Like many controversial topics, there are two sides and sometimes little movements (4). Both arguments are outlined in this issue of *Current Sports Medicine Reports* (*CSMR*). The American Heart Association and American College of Cardiology (ACC) have jointly published their recommendations over the past year (9), the ACC Sports Cardiology Section has weighed in on protecting the heart of the American athlete (8), and the National Collegiate Athletic Association (NCAA) has developed a recommendation for cardiovascular (CV) care of college athletes specific to that age group that is soon to be released. The American Medical Society for Sports Medicine is currently developing a statement to guide primary care sports medicine physicians through the decision matrix.

A good clinical outcome requires an honest patient working with a knowledgeable and reasonably astute clinician in shared decision making. The current PPE CV screening program in the United States requires both, as it is designed to capture symptomatic and familial causes of exercise-related sudden cardiac death (SCD). Although the PPE for U.S. athletes has been in use since the 1960s, attempts to standardize the examination across the country with the *Preparticipation Physical Evaluation* monograph, now in its fourth edition, have fallen short (2). In addition, a retrospective study of young athletes who died during exercise showed that a large percentage had positive responses to the usual CV screening questions that were not considered significant or were confused with other organ system dysfunctions by examining physicians (3). Improvements in the process are clearly needed. In the electronic age, the use of computerized, secure data formats may make this possible.

There are accepted screening criteria to guide decision making for public and individual health. The World Health Organization (WHO) criteria seem most often quoted, although there are several iterations available in the literature. The criteria are meant to be linked, like a chain. If any single criterion in a screening proposal is not met, the proposal should not be instituted.

Here is one version of the "WHO criteria for screening:

1. The screening program should respond to a recognized need.
2. The objectives of screening should be defined at the outset.
3. There should be a defined target population.
4. There should be scientific evidence of screening program effectiveness.
5. The program should integrate education, testing, clinical services, and program management.
6. There should be quality assurance, with mechanisms to minimize potential risks of screening.
7. The program should ensure informed choice, confidentiality, and respect for autonomy.
8. The program should promote equity and access to screening for the entire target population.
9. Program evaluation should be planned from the outset.
10. The overall benefits of screening should outweigh the harm" (1).

There are inherent limitations of screening that should also be considered in the decision process. Three may apply to the ECG PPE screening: 1) screening can involve the cost and use of medical resources on a large group of people who do not need treatment, 2) unnecessary investigation and treatment of false-positive results, and 3) an unwarranted sense of security caused by false negatives. Screening decisions are visibly complex and can have unintended consequences.

We have learned much about screening in the past four decades. Many of our nationwide screening programs, such as a prostate-specific antigen for prostate cancer and mammography for breast cancer in some age groups, were initiated with good intentions but without outcomes data. As outcomes are studied, we are finding limited or no change in deaths and significant harms from some programs. We can no longer initiate a screening program based on good intentions; this is especially true of low-frequency events like sudden cardiac arrest in athletes. We need ECG outcomes data before committing to mass screening initiatives that have potential to do harm from inadvertent exclusion from activity or the evaluation and potential interventions that may ensue.

As seen from two articles in this issue of *CSMR*, when it comes to cardiac screening, what constitutes an event is part of the controversy. How we determine the SCD rates depends on who is included in the numerator (number of deaths and/or cardiac arrests) and matching those cases with a concordant denominator (number of athletes screened). Some studies include only deaths, whereas others include all cardiac arrests (probably the better measure but more difficult to track). Some studies include only athletes who collapse during or within an

hour of sport participation (exercise-related cardiac deaths), whereas others include all athletes who collapse at any time or even die during sleep (all athletes who die of cardiac causes). The broader inclusion criteria begin to drift into cardiac deaths in the general population and skew the risk assessment. The denominators are also tricky. The National High School Federation data are often cited, but the database reports athlete seasons and not athlete years. In Minnesota, unduplicated athlete years are recorded in the catastrophic insurance database, so there is a reasonably accurate count of individuals at risk each year in varsity programs (12). Most Minnesota high school athletes participate in two or three sports each year, so athlete seasons do not accurately reflect high school athlete years (12). In addition, there are many high school age athletes participating in community programs outside the high schools, so a high school age denominator is elusive. In colleges, it may be safe to assume that most of the athletes are involved in a single sport, so the total number of college athletes may be a concordant denominator for that age group. How many people are involved in one or more community-based sport programs each year is unknown and an estimate at best.

The age range of athletes should be considered in the screening decision process (11). There is a difference in duration and intensity, and potentially cardiac risk of exercise as athletes transition through the pre-high school, high school, college, and post-college age groups. Extrapolating from one age group to another may not lead to the best solution for each. The broad age range of 5 to 35 years old is fraught with problems as coronary artery disease starts to play a role in athlete SCD beginning in the early 20s. Even the 12 to 25 age group is likely too broad for a uniform screening recommendation. Each age group deserves individual attention when considering CV screening elements beyond history and physical examination (H&P).

Athletes at all levels seem to be in the spotlight, and SCD in this group commands public attention. But do we really know how SCD affects "nonathletes" who collapse out of the public eye? Among high school students on campus, the relative risk of cardiac arrest in athletes compared with nonathletes was 3.6 (1.14 vs 0.31 per 100,000 person years) (14). However, nonathletes are on campus less total time per day on average than athletes training and competing with high school teams, and for the most part, nonathletes, other than gym class, exercise off campus where they are at greater risk for sudden cardiac arrest (SCA) (work, home chores, and community-based sports). We need a better understanding of SCD across the general population in each age group before we make the decision that athletes need more screening.

At what level of occurrence does it make sense to institute screening for SCA in athletes? The rate of 1 SCD per 100,000 athlete years seems to be accepted for high school (14) and 1 to 2 per 100,000 athlete years for college athletes (a little over half of the 79 cardiac deaths in 4,242,519 athlete years occurred during activity), although studies at the college age show subgroups with higher SCD rates in certain sports and races (5). With a risk of 1 to 2 per 100,000 athlete years, 100,000 athletes need to be screened to potentially prevent one to two cardiac deaths. In that set of athletes, there will be false positives and false negatives, which complicate the decision process and have the potential for both great cost and athlete harms. Assuming a 5% false-positive rate for ECG screening, about 5,000 of 100,000 athletes will test positive for one true-positive finding, and all will require additional testing to ferret out the false-positive examinations (10). The cost of screening is more than money; it includes opportunity costs (what will not be offered if the health care dollar is directed at a specific screening process), variables due to false-positive ECG that require additional testing to prove true versus false, and adverse effects on future insurability and employability of the athlete. There are also false-negative ECG results for coronary artery anomalies and other nonelectrocardiographic heart issues that lurk in very low frequency within the group of athletes.

The current PPE H&P is a means of detecting symptomatic conditions associated with exercise and has never been a tool for detecting asymptomatic disease. Family history also can point to increased risk and can be used to initiate case finding studies. Positive responses to the PPE questionnaire are "invitations" to direct additional questions toward the issue to determine the significance of the response. There is little doubt that an ECG can identify electrocardiographic conditions that are not detectable by H&P. However, the natural history of these asymptomatic ECG-identified conditions has not been determined. The combination of false positives and negatives leaves the routine use of ECG in question regarding good versus harm in otherwise healthy asymptomatic athletes, leaving reason to question the implementation of such programs. If ECG meets the accepted screening criteria for some athlete populations, it may be reasonable to begin a screening program limited to that group. Before embarking on that journey, a complete testing algorithm should be in place to limit false positives and to deal with the positive tests, as the ECG will find abnormalities. If individual programs within the NCAA or other sports organizations elect to start such a program, it should be initiated with very careful follow-up including the costs of evaluations (financial costs borne by the athlete and family, time to consultation, time to conclusion of the evaluation, and time away from sport) and any change in cardiac event rates. In addition, a collaborative central NCAA database should be established to compare programs that elect not to implement ECG screening.

Heart disease begins early in life, and fitness throughout a lifetime makes a difference in heart disease in later years (13). Blood pressure measurement may be the most significant CV screening portion of the PPE, especially when the statistics for heart failure by age 40 in people with ignored blood pressure problems as teens and young adults are added into the mix (6). The other often overlooked measurement in the PPE is the determination of overweight and obesity status with the subsequent health risks, because fit and fat is not healthy with a higher risk of early death even in fit obese individuals compared with unfit normal-weight individuals (6).

We do need to improve what we have, and the use of electronic PPE records may be the vehicle that will allow us to see the outcomes of the examination (cleared for participation or not) on a broad scale, improve the question sets, and track individuals over time for outcomes (11). Even across the NCAA, there is no standard form, format, or process for the examination. If the NCAA heart care recommendations are used at sites that are ready to meet the proposed college

age ECG screening criteria, the opportunity to study outcomes with a combined electronic format and institutional input into a central database could allow a comparison of the current H&P process with an ECG added process in the college age group. Given the current pretest probability of SCD and the posttest probability of a false positive or false negative, a universal mandate for ECG screening seems ill-conceived. This is clearly an area where legislative mandates for ECG screening without the funding to support a full screening and clearance protocol and fully train the work force should be avoided.

For the dollar spent, the greatest good will come from the investment in cardiopulmonary resuscitation and automatic external defibrillator (AED) training for athletes, coaches, and parents, and the purchase and maintenance of AED at all athletic practice and competition sites. With the geographical size and layout of some school campus athletic facilities, adding golf carts with AED and GPS tracking may be advantageous to reduce the time to defibrillation and give the ability to quickly locate and get to a collapsed athlete.

When it comes to bias in decision making, Paul Simon said it best, "A man hears what he wants to hear and disregards the rest." The ECG screening discussion needs to move toward best practice and shared decision making for individual athletes. There are several knowledge gaps in athlete CV care that require investigation, in addition to the basic question, "Does it make a difference in outcomes and actually reduce SCD?" We do not know the SCD rate in the general population, we do not know the significance of the "positive" ECG finding, we do not know the effectiveness of the current process, and we do not know the "readiness" of the provider knowledge base for either the current PPE process or the ECG evaluation of athletes. PPE CV screening has many forms, and the "right" answer is not clear for the entire population of young athletes. Although the NCAA database suggests increased SCD risk during and away from activity in some subgroups, it is not clear that ECG screening focused on those specific groups would reduce SCD. Across the entire group of athletes ages 12 to 25 years, the financial burden of CV ECG screening and associated evaluations on the medical dollar could be staggering, and unfunded mandates could bring the PPE process to a halt. With ongoing research, the path to CV screening with or without ECG added to the current PPE may become clear. Research into CV screening should continue, although this issue really begs for a randomized trial of current versus current plus ECG processes looking at actual outcomes with sufficient power and duration to answer the question.

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