

**AMSSM Position Statement on Cardiovascular Preparticipation Screening in Athletes:
Current Evidence, Knowledge Gaps, Recommendations and Future Directions**

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ABSTRACT

Cardiovascular screening in young athletes is widely recommended and routinely performed prior to participation in competitive sports. While there is general agreement that early detection of cardiac conditions at risk for sudden cardiac arrest and death (SCA/D) is an important objective, the optimal strategy for cardiovascular screening in athletes remains an issue of considerable debate. At the center of the controversy is the addition of a resting electrocardiogram (ECG) to the standard preparticipation evaluation using history and physical examination. The American Medical Society for Sports Medicine (AMSSM) formed a task force to address the current evidence and knowledge gaps regarding preparticipation cardiovascular screening in athletes from the perspective of a primary care sports medicine physician. The absence of definitive outcomes-based evidence at this time precludes AMSSM from endorsing any single or universal cardiovascular screening strategy for all athletes, including legislative mandates. This statement presents a new paradigm to assist the individual physician in assessing the most appropriate cardiovascular screening strategy unique to their athlete population, community needs and resources. The decision to implement a cardiovascular screening program, with or without the addition of ECG, necessitates careful consideration of the risk of SCA/D in the targeted population and the availability of cardiology resources and infrastructure. Importantly, it is the individual physician's assessment in the context of an emerging evidence-base that the chosen model for early detection of cardiac disorders in the specific population provides greater benefit than harm. AMSSM is committed to advancing evidenced-based research and educational initiatives that will validate and promote the most efficacious strategies to foster safe sport participation and reduce SCA/D in athletes.

BACKGROUND

Cardiovascular (CV) screening in competitive athletes is recommended by most major medical organizations and sports governing bodies;¹⁻⁶ however, agreement on the most appropriate screening protocol remains a topic of considerable controversy. Within both the primary care sports medicine and sports cardiology communities, this topic has created a highly charged debate specifically regarding the addition of a resting 12-lead electrocardiogram (ECG) to the preparticipation history and physical examination. This polarized environment has limited a productive discussion of the current evidence, the identification of knowledge gaps, and the development of research and educational priorities to improve the CV care of athletes.

AMSSM Charge

The AMSSM Board of Directors appointed a task force to address the issues surrounding the CV screening of young competitive athletes (age 12-35) in the United States. The objective of the task force was to examine the current evidence and knowledge gaps relevant to CV screening in athletes and provide a framework for the AMSSM membership to assess screening recommendations and future research directions. This statement is unique in providing an assessment of CV screening from the perspective of a primary care sports medicine physician. While it may assist other healthcare professionals with CV screening in athletes, conclusions may not necessarily apply to physicians from other disciplines.

Writing Group Selection and Process

The AMSSM President appointed co-chairs (JAD and FGO) to assemble a task force to address the topic of CV preparticipation screening. The task force was carefully selected to include a balanced panel

of primary care sports medicine physicians with demonstrated leadership and expertise in athlete CV screening to represent the different perspectives of CV preparticipation screening. This panel focused specifically on issues relevant to the potential addition of ECG to the preparticipation physical evaluation (PPE) and did not address the utility of other potential screening modalities, such as echocardiography.

A survey of the task force members was used to identify key discussion areas and generate an initial outline. The panel subsequently engaged in a series of conference calls, literature review, and written communications to discuss and analyze specific areas relevant to CV screening in athletes, followed by an in-person meeting in Atlanta, GA, on February 21-22, 2016. An Executive Summary from this panel is presented in Box 1.

THE PPE AND CARDIOVASCULAR SCREENING

The Role and Objectives of the PPE

The overall role of the PPE is to evaluate the health of the athlete to optimize safe sports participation and provide an opportunity to assess current and future health risks and quality of life matters.^{1,5,6} Although studies have not shown the PPE to prevent morbidity or mortality in athletes, there is general agreement and acceptance that the primary objective of the PPE is to detect conditions that predispose athletes to serious injury, illness, or sudden death.¹ The current PPE model employs a comprehensive history questionnaire and physical examination. While pragmatic and widely practiced, this model has shown limited effectiveness in screening for conditions associated with sudden death or catastrophic injury. In 2004, an evidence-based review questioned the PPE format as an effective method for health risk screening prior to participation in exercise and sport.⁷ As currently practiced, the PPE may have fallen short of achieving its desired purpose, and its primary goals may need to be reevaluated and refocused.

Ideally, the PPE is performed in the primary care setting (i.e. physician's office) as part of the continuous care of the athlete, creating an entry point for young athletes into the health care system and affording opportunities to provide education, counseling, and intervention for both general wellness and injury prevention. Within this context, screening questionnaires serve as an expanded checklist to guide the physician during the preparticipation evaluation of a young athlete. This panel supports the PPE as a mechanism for the general health assessment of the athlete and to establish a minimum standard to evaluate multiple organ systems that may impact safe sports participation. This panel also supports the development of additional strategies to promote the overall and CV well-being of both young athletes and non-athletes.⁶

The Role and Objectives of Cardiovascular Screening

The primary goal of CV screening in competitive athletes is to identify underlying cardiac disorders predisposing to sudden cardiac arrest and death (SCA/D) with the intent to reduce morbidity and mortality by mitigating risk through individualized, patient-centered, and disease-specific medical management.^{2,8} Cardiovascular screening is one component of a comprehensive PPE, although CV screening can also be performed independently.

Cardiovascular screening in young athletes is challenging, and all potential screening tools have limitations. This panel proposes that a "one size fits all" model of CV screening is not warranted or justified. It is important that the goals and expectations of CV screening based on history and physical examination alone be reevaluated and that considerations for more intensive CV screening be defined. Factors to consider in selecting a CV screening strategy include: estimates of risk for SCA/D in the individual or athlete population; available sports cardiology resources and expertise; the potential benefits and harms of the screening process; and existing sport association directives.

Considerations for the Team Physician

Team physicians maintain a unique role and often function as the primary care provider for many of the athletes under their care. Team physicians also recognize that many athletes have a primary care provider independent of the team who performs the required PPE and is integral in managing both acute and chronic problems that confront the individual athlete. In these circumstances the team physician has the additional challenge and responsibility for shared decision-making, and open communication between the primary care provider, team physician, and athlete is essential for optimizing care. Furthermore, the PPE and CV screening protocol implemented by team physicians may be driven by institutional standards or sport governing body requirements.

INCIDENCE OF SCA/D IN YOUNG ATHLETES

Current Evidence

Estimates of the rate of SCA/D in athletes vary widely and are affected by study methodology, the means for case identification, age range, the inclusion or exclusion of cardiac arrest with survival, and cases occurring at rest or outside of exercise.⁹⁻²¹ (Table 1) Based on available U.S. studies and a systematic review of the literature, a generally accepted annual incidence of all SCA/D is approximately 1 in 80,000 in high school athletes and 1 in 50,000 in college athletes.²² Studies indicate that 56-80% of SCA/D in young athletes occurs during exercise with the remainder considered non-exertional (i.e. at rest or during sleep).^{12,17,21}

Evidence supports that athletes display a differential risk for SCA/D based on age, sex, race, sport, and level of play.^{9,10,14-21} Incidence rates are consistently higher in male and African-American athletes. Male college basketball players have the highest reported overall risk of sudden cardiac death (SCD) at 1 in 9,000 per year, and male African-American college athletes have a reported SCD risk of 1 in 16,000

per year.²¹ In addition, studies consistently report that two sports alone, male basketball and football, account for 50-61% of all identified cases of SCA/D.^{12,17,21} Studies with mandatory reporting systems in other active young adult populations, such as military personnel and firefighters, have demonstrated comparable rates of SCA/D as in college male athletes.²³⁻²⁵

Knowledge Gaps

Without a mandatory reporting system for SCA/D in athletes, cases may go undetected and current incidence estimates may not represent the true risk. In addition, current epidemiologic studies do not provide a complete understanding of the comparative risk of SCA/D in athletes versus non-athletes as the estimated incidence range of SCA/D in the general population of adolescents and young adults overlaps with the estimated incidence range of SCA/D in adolescent and young adult athletes.^{18,25-29} (Table 1) In a prospective study monitoring SCA in U.S. high schools, student athletes were 3.6 times more likely to suffer SCA while on school campus than non-athlete peers.¹⁸ However, this study did not account for activities off campus and did not allow an absolute risk comparison between the groups. In contrast, a recent retrospective study comparing the risk of SCD in adolescent and young adult athletes versus non-athletes from Hennepin County, Minnesota, found a higher incidence of sudden CV-related death in non-athletes.³⁰ This study was limited by estimates of the athlete and non-athlete populations at risk and by unclear methodology to confirm if cases participated in an organized sport.

Overall, definitive evidence that U.S. athletes as a whole are at higher risk of SCA/D than the general population of similar age is lacking. This uncertainty has generated ethical concerns about limiting a screening program for unsuspected genetic and/or congenital heart disorders to only competitive athletes.^{30,31} However, systematic preparticipation screening is currently required by sports governing bodies for high school, college, and professional athletes in the U.S., and there is substantial evidence that some athlete groups, especially in the college age range, have higher rates of SCA/D than estimates

for the general population. A standardized approach to the evaluation and reporting of SCA/D in athletes has been proposed and may lead to more precise data moving forward.³²

PREVALENCE OF DISORDERS ASSOCIATED WITH SCD

Current Evidence

Exercise is a known trigger and can unmask occult cardiac disease to precipitate SCA/D.³³ The prevalence of cardiac conditions associated with SCA/D in young athletes is approximately 0.3%.² This estimate is supported by multiple studies using non-invasive cardiac evaluation tools to identify cardiac disorders at potential risk of SCA/D in young athletes.³⁴⁻⁴¹ The most commonly reported causes of SCA/D in athletes include hypertrophic cardiomyopathy (HCM), anomalous coronary arteries, idiopathic left ventricular hypertrophy, arrhythmogenic right ventricular cardiomyopathy, dilated cardiomyopathy, myocarditis, long QT syndrome (LQTS), ventricular pre-excitation / Wolff-Parkinson-White (WPW), aortic dissection, and atherosclerotic coronary artery disease (CAD).^{12,21,42-45} Notably, up to 44% of athletes with SCD have no structural cardiac abnormalities identified on post-mortem examination.^{21,43-47} These cases, known as autopsy-negative sudden unexplained death, may be due to primary electrical diseases and inherited arrhythmia syndromes. Structurally normal hearts are also reported in up to 41% of active military personnel with non-traumatic sudden death.^{23,24} (Table 2)

HCM represents 8-36% of cases in U.S. athletes depending on the study.^{12,21} While the reported prevalence of HCM in the general adult population is 1 in 500 or possibly higher,⁴⁸⁻⁵⁰ studies in young athletes have not identified a similar prevalence. This is perhaps due to variable morphological expression of HCM during adolescence and young adulthood or functional limitations leading to self-selection out of competitive sports. Based on existing studies, the detected prevalence of HCM in a young athletic population is approximately 1 in 800 to 1 in 2,600.^{38,41,51-54} Atherosclerotic CAD as a cause

of SCA/D in athletes increases with age and is also the most common identified cause of SCD in studies of the general population under age 35.^{29,55-59}

Knowledge Gaps

The lack of standardized autopsy protocols and wider expertise in forensic CV pathology present challenges to a more precise understanding of the etiology of SCA/D in athletes. However, even with such protocols, many of these conditions remain challenging to diagnose at autopsy. Current datasets largely involve review of autopsy results that may be limited by inadequate quality or information. In cases with negative or borderline autopsy findings, post-mortem genetic testing for CV conditions with known genetic mutations may provide additional insights into the causes of SCA/D.^{60,61}

A better understanding of the prevalence and natural history of conditions leading to SCA/D in different athlete populations will help predict the frequency of screening abnormalities and the potential value of different screening modalities. In addition, while high risk features for some CV disorders have been defined, a number of detectable conditions present an uncertain risk of SCA/D in athletes. More information is needed to fully understand which conditions or subsets of conditions will most likely lead to SCA/D.

CARDIOVASCULAR SCREENING IN ATHLETES

Current Assessment

History and physical examination has been the traditional standard for CV preparticipation screening in the U.S.^{1,2,62,63} The addition of a screening ECG has both potential benefits and potential risks. Regardless of the screening strategy, the optimal age and frequency to conduct CV screening in athletes is uncertain, but generally begun between the ages of 12 and 14 and repeated every 1-3 years. Ideally,

preparticipation CV screening should take place with adequate time prior to the start of a sports season to perform secondary testing of screening abnormalities.

HISTORY AND PHYSICAL EXAMINATION FOR THE CARDIOVASCULAR SCREENING OF ATHLETES

Benefits

Identifying athletes with potential CV symptoms (i.e. exertional syncope) or a family history of juvenile/young adult SCA/D or inheritable cardiac conditions are important elements of screening. The history and physical examination is a core skill routinely practiced by medical providers and a fundamental component of the PPE. Based on existing studies, the sensitivity of history and physical examination for the detection of cardiac disorders with elevated risk for SCA/D is about 20%,⁵⁴ representing a small but important group of athletes potentially identifiable by the customary screening model. A screening examination also can identify previously unrecognized hypertension in adolescent and young adult athletes, which is important in the prevention of long-term CV morbidity.⁶⁴⁻⁶⁶

Limitations

Approximately 80% of athletes who suffer SCA/D have no documented warning symptoms at the time of PPE screening and may be missed by an evaluation focused primarily on signs and symptoms.^{47,67-69} Standardized symptom and family history questionnaires, such as the PPE Monograph and American Heart Association (AHA) questions, also demonstrate a high positive response rate in high school (15-31%) and college (27-37%) athletes,^{40,41,70-72} requiring the medical provider to understand the purpose of the questions and the requisite pursuit of additional history to determine the need for secondary testing. Variable understanding of the PPE questions and process can create wide variation in provider follow-up and limit the effectiveness of standardized history questionnaires as a screening tool.

To be effective, PPE questionnaires require an honest patient and thus may fail to elicit a positive response to symptoms that are present but not volunteered. In addition, CV symptoms may be present in athletes with occult disorders, but misinterpreted as a normal response to vigorous exertion. Some athletes also may develop symptoms subsequent to the PPE, and thus a cardiac disorder could be missed by an evaluation performed at a single time point. Part of the PPE process should include athlete and family education on CV signs and symptoms that may develop after the examination and warrant re-evaluation.

Several studies indicate that the PPE is not implemented adequately or uniformly.^{7,73-76} This incomplete compliance and awareness of expert guidelines complicates our understanding of the potential benefit and overall feasibility of implementing systematic questionnaires as a primary screening strategy. Recent studies suggest that less than half of primary care physicians are aware of the CV screening recommendations from the AHA or the PPE Monograph.^{73,74} In a survey of CV screening practices at NCAA Division I universities, 92% of responding universities did not use PPE forms that fully meet the AHA recommendations for CV screening,⁷⁵ and in 2014 only 43% of state high school athletic associations require forms that fully address all of the PPE Monograph (4th edition) personal and family history CV screening recommendations.⁷⁶

Physical examination also presents challenges as a screening tool for the identification of CV disorders. Clinical agreement during cardiac auscultation can vary widely among medical providers, and the ability to distinguish physiologic from pathologic murmurs is difficult even among experts.⁷⁷⁻⁸¹ In one pilot study evaluating auscultation clinical agreement during a preparticipation assessment of 101 consecutive athletes, two board certified family physicians each identified six individuals requiring further investigation, but only agreed upon one, demonstrating limited agreement with a kappa of 0.114 (95% CI, -0.182 to 0.411).⁸¹ Identification and clinical agreement of the physical stigmata of

Marfan's Syndrome and related connective tissue disorders is also challenging for both primary care providers and experts.⁸²

Knowledge Gaps

Despite its use and existence for over two decades, the immediate and long-term outcomes of the customary PPE are largely unknown. In fact, no study to date has tested the ability of modern recommendations for CV screening by history and physical examination alone to detect CV conditions that pose potential risk of SCA/D in athletes. Current estimates of the sensitivity of the history and physical examination are extrapolated from studies that also utilize other screening modalities such as ECG, and thus interpretation of history or physical examination findings may be confounded when viewed in the context of a normal or abnormal ECG. Thus, the extent to which a screening evaluation using only history and physical examination can identify athletes with conditions associated with elevated risk of SCA/D is yet to be clearly established.

The potential benefit of education, continuity, and repeat assessments using a cardiac history and physical examination also requires additional investigation. Further research is needed to improve the sensitivity, specificity, positive predictive value, and reliability of screening questions and the physical examination for the identification of athletes with at risk disorders. The physician response to positive history questions remains relatively uninvestigated and non-uniform, and more research is needed to determine the clinical features and pathways for additional evaluation in athletes. Electronic PPE formats may provide a platform to better understand the current PPE process and improve question sets. Whether a PPE performs more effectively than an annual health examination with the patient's primary care physician is also unknown.

ECG FOR THE CARDIOVASCULAR SCREENING OF ATHLETES

Benefits

The addition of a screening ECG to the history and physical examination increases the detection of cardiac disorders potentially at risk of SCA/D in athletes.^{39-41,54,68,70,72,83} An estimated 60% of the disorders associated with SCA/D in young individuals may have detectable ECG abnormalities.¹⁷ In studies conducted by centers with considerable experience in ECG screening, adding an ECG demonstrates improved sensitivity compared to history and physical examination in detecting previously undiagnosed and unsuspected cardiac disorders.^{34-41,51,70,83,84}

ECG is an objective test, but subject to variable interpretation. Use of modern ECG interpretation guidelines that account for physiologic adaptations in athletes have reduced the false-positive burden without a demonstrable change in sensitivity.⁸⁴⁻⁸⁷ False-positive rates have declined, ranging from 2.5-6.6%, when ECG review is conducted by clinicians experienced in applying modern interpretation standards.^{40,41,70,72,83-88}

An ECG deemed to be abnormal is typically an actionable finding in the screening evaluation of athletes. An abnormal ECG also may raise awareness to vague symptoms or relevant family history that previously went unreported or uninvestigated, or initiate a more in-depth assessment of questionable physical examination findings.

Limitations

ECG interpretation in athletes is challenging even when using modern criteria, and clinical agreement and reproducibility between physicians can be limited. Some studies have demonstrated that systematic evaluation of an athlete's ECG using standardized criteria improves interpretation accuracy.^{89,90} However, inter-observer variability and the reliability of ECG standards even among experienced physicians remains a major concern.^{91,92} In one study, pediatric cardiologists, without use of

a standardized criteria set, achieved a sensitivity of 68% and a specificity of 70% for recognition of abnormal ECG patterns that occur infrequently but may represent conditions predisposing to SCD.⁹³

The false-positive rate for ECG screening is strongly associated with the criteria used to guide interpretation and the experience of the interpreting physician.⁸³⁻⁸⁷ A false-positive ECG leads to additional testing that increases the total cost and may pose other risks to the athlete depending on the nature and timing of the test. ECG is not 100% sensitive for ECG detectable disorders (false-negatives), and the age at which some cardiac disorders manifest ECG abnormalities is variable, raising concerns about the timing of testing and requirements for repeat testing. In addition, some conditions at risk for SCA/D do not manifest ECG abnormalities and thus would not be detectable through ECG screening. Finally, like history and physical examination, some conditions which create an increased risk for SCA/D are sporadic and not present at the time the ECG is obtained.

Physician training and experience are linked to accurate ECG interpretation and limit the ability of many physicians to add ECG to the current screening process. In addition, technical standards need to be adhered to as use of poor quality, low resolution ECG instruments or improper recording techniques can also produce misleading results.⁹⁴ Physician infrastructure and resources remain major obstacles to considering quality application of ECG in the CV preparticipation evaluation of athletes.⁹⁵

Knowledge Gaps

Education in ECG interpretation is a critical step that should be accomplished before including an ECG in the athlete CV screening process. While educational modules have been developed, the impact and effectiveness of ECG interpretation training programs requires additional study. The secondary evaluation of athletes with ECG abnormalities can vary by physician experience,⁷² and the recommended evaluation of specific ECG abnormalities should be more clearly defined. Lastly, the extent to which

technology advances and computerized ECG interpretation algorithms using modern athlete-specific standards will improve physician ECG interpretation accuracy is unknown and requires investigation.

OUTCOMES FOR EARLY DETECTION OF CARDIOVASCULAR DISEASE

Current Assessment and Knowledge Gaps

Outcome studies of CV screening in athletes are limited and present conflicting evidence regarding the potential benefit to prevent SCA/D.^{35,51,96} In addition, the natural history and absolute risk of conditions associated with SCA/D in athletes identified with a cardiac disorder during preparticipation screening is largely unknown with limited outcomes-based evidence.

However, CV screening is supported based on the premise that early detection of pathologic cardiac disorders is important and could make a positive difference, and disease-specific data suggests that individualized risk stratification and management lowers mortality for some conditions. For example, large cohort studies using current management strategies and therapeutic measures have demonstrated improved survival with a low HCM-related mortality in children and young adults with HCM.^{97,98} A prospective study from Italy found a 73% mortality reduction in athletes from early detection of HCM compared to unscreened non-athletes.⁵¹ In addition, individualized management and in-depth counseling of children diagnosed with LQTS have shown low cardiac event rates and no deaths in two separate cohorts of young recreational and competitive athletes.^{99,100} Expert consensus guidelines for risk stratification and management of asymptomatic athletes identified with WPW pattern also were developed in partnership between the Pediatric and Congenital Electrophysiology Society and the Heart Rhythm Society.^{101,102} In addition, the AHA and American College of Cardiology recently updated their “Eligibility and Disqualification Recommendations for Competitive Athletes with Cardiovascular Abnormalities.”¹⁰³ The language and content in these guidelines affirms from cardiology experts that

early detection of conditions at risk has the potential for individual benefit.¹⁰³ Lastly, the accurate diagnosis of an inherited cardiac condition in an individual athlete, and the appropriate guidance for participation and treatment, may benefit not only the individual athlete, but also the entire family and possibly future generations through appropriate genetic testing and counseling.

The question of whether early detection provides more benefit than harm applies to CV screening by any means and the potential risks associated with the early detection and therapeutic process. The detection of a cardiac condition associated with SCA/D statistically places an athlete in a higher risk category than an athlete without a cardiac condition detected by screening. However, data to quantify and predict individual risk is limited, and the potential harms of secondary testing of screening abnormalities must be considered.

Overdiagnosis refers to a disorder detected through screening that does not lead to symptoms or a major event.¹⁰⁴⁻¹⁰⁶ The potential for overdiagnosis can be a product of any CV screening strategy (i.e. history and physical examination with or without ECG), but will increase when using modalities with a higher sensitivity. The number of athletes detected with conditions at potential risk needed to identify one athlete that will go on to have SCA/D is affected by the accuracy of the screening procedures, the predicted prevalence of disorders at elevated risk, and the estimated incidence of SCA/D. (Table 3) The lack of definitive outcomes data and the uncertainty surrounding overdiagnosis complicates our understanding of whether the potential benefits of adding ECG to CV screening in athletes will outweigh the potential risks.

PHYSICIAN RESOURCES AND INFRASTRUCTURE

Current Assessment

An ECG screening program requires physicians knowledgeable in current athlete-specific ECG interpretation standards and adequate cardiology resources to guide the secondary investigation of ECG abnormalities. The absence of a physician workforce capable of accurate ECG interpretation in athletes and the secondary evaluation of ECG abnormalities is a major obstacle to wider application of ECG screening, even among U.S. universities and colleges.^{6,107}

Sports medicine physicians conducting or considering ECG screening as a part of a PPE are strongly encouraged to establish a close and collaborative relationship with local cardiology resources as part of a cardiovascular care team approach. Some considerations when identifying appropriate cardiology resources include: specialist availability with practice models that facilitate rapid turn around times; access to timely diagnostic testing; familiarity with contemporary athlete-specific ECG interpretation criteria; and a commitment to work in partnership following the establishment of an exercise or competition limiting diagnosis. The development of regional referral centers has also been proposed to assist in ECG interpretation and the evaluation of athletes with a suspected or known CV disorder when local expertise is not available.⁶

Likewise, CV screening strategies using a standard history and physical examination recommended for over two decades are still not uniformly implemented or practiced.⁷³⁻⁷⁶ Additional education and implementation strategies regarding best practices for history and physical examination need to be pursued.

Educational Initiatives

Consensus standards for ECG interpretation in athletes have evolved considerably over the last decade with each revised criteria set improving specificity.⁸⁴⁻⁸⁷ Online training modules are available at no cost to physicians to foster a common understanding of modern ECG interpretation standards

(<http://learning.bmj.com/ECGathlete>). This may serve as a starting point for physicians, although accurate ECG interpretation will be enhanced by additional clinical experience and ongoing education.

The PPE Monograph is available to guide a standardized preparticipation history and physical examination.¹ Additional resources are also available to aid in Marfan's Syndrome recognition and diagnosis (<http://www.marfan.org/dx/home>) and cardiac auscultation skills (<http://www.easyauscultation.com/heart-sounds>).

RECOMMENDATIONS

Moving Forward: A New Paradigm for Cardiovascular Screening in Athletes

While knowledge gaps exist between the available evidence and the evidence needed to precisely quantify and balance the potential benefits versus the potential harms associated with different models of CV screening, the lack of definitive data should not discourage reassessment of our current practices. The ECG screening debate is often framed as a choice between universal, mandatory screening or no screening at all.¹⁰⁸ These polarized options provide little guidance to explore alternative strategies for the individual physician who recognizes the limitations of the current PPE model, understands that adding an ECG has both potential benefits and risks, and recognizes a lack of clear patient-oriented outcomes evidence. The primary care sports medicine physician, however, is still responsible for the CV screening of the individual athlete and in many cases may guide decision making for at risk populations. A new framework to guide sports medicine physicians in choosing how they perform CV screening is warranted.

This AMSSM task force, in moving forward with this position statement and new paradigm, reviewed and reflected upon guiding ethical principles and core concepts as applied to evidence based

medicine. The group acknowledged two key ethical principles that guide medical decision-making: beneficence and non-maleficence. Ultimately the benefit of any intervention must exceed the risks for the intervention to be ethical. In addition, while the physician functions as an educator in informing patients about benefits and risks, in the end it is the patient who assigns them weight. The task force additionally recognized that evidence based medicine is “the conscientious, explicit and judicious use of current best evidence in making decisions about the care of the individual patient. It means integrating individual clinical expertise with the best available external clinical evidence from systematic research.”^{109,110} Thus, a context for clinical decision-making for CV screening must be developed that accounts for the individual skills and expertise of the physician, as well as the individual characteristics of the patient or patient population.

At this time, this task force recognizes that there is not conclusive evidence to make a universal recommendation for or against the incorporation of ECG screening during the preparticipation evaluation. However, this task force additionally recognizes that the current PPE has substantial limitations for detecting occult cardiac disorders, the ECG provides increased sensitivity for detecting some cardiac disorders, a discordance exists between the prevalence of cardiac disorders and the rate of SCA/D, and evolving data supports that some athletes are at considerably higher risk of SCA/D than others. Accordingly, the cornerstone of this document’s recommendations is respect for the autonomy of individual physicians to assess the current evidence, evaluate their unique clinical situation, and decide what they believe to be the best decision for their patient or patient population. In this scenario it is understood that some physicians may decide to implement a strategy for CV screening that incorporates an ECG, while others may not. Any ECG screening program if implemented, however, should have a strong infrastructure, high quality control, and consider informed consent that outlines the potential benefits and risks with the athlete (and/or parent/guardian). Optimally, the decision to

incorporate or exclude an ECG from the preparticipation evaluation is one of shared decision making between a patient and a provider.

Risk, Resources, and Opinion on Early Detection

Where does the risk/benefit ratio change so that adding an ECG is beneficial to the athlete? The primary considerations to add ECG include: 1) individual risk based on age, sex, race, sport, and level of play; 2) physician expertise and available cardiology resources to conduct an ECG screening program with high quality; and 3) physician assessment that the utilization of ECG for the individual athlete provides more benefit than harm (Figure 1). Recognition of the differential risk in athletes may lead to an approach that more closely reflects individualized risk. For example, a physician may not add ECG for high school female athletes but choose to use ECG screening in male, African-American college basketball players. Given the uncertainty and the desire to balance potential harms with the potential benefit of early detection, differential risk, as well as the availability of cardiology resources, may have a substantial impact on the risk/benefit ratio and thus the choice of screening strategy.

In centers where ECG screening is conducted by clinicians trained in athlete ECG interpretation using modern standards and with adequate cardiology resources for secondary investigations of ECG abnormalities, ECG screening can increase detection of athletes potentially at risk for SCA/D with lower false-positive rates. However, this may not apply to sites with less experience or those without adequate cardiology infrastructure and support. A major challenge to adding ECG is improved training in athlete ECG interpretation and the presence of cardiology expertise for the secondary evaluation of ECG abnormalities.

The foundation of CV screening relies on the premise that early detection is important and prioritized. If one determines that early detection of occult cardiac disorders is of questionable benefit or outweighed by the potential risks of a particular screening strategy and lack of definitive outcomes

data, then this stance argues for less screening or perhaps no screening. Some countries endorse a paradigm with no preparticipation CV screening of any sort.^{44,111}

Weighing the Risks versus the Benefits

All screening risks the identification of disorders that may not become symptomatic or cause significant morbidity or mortality (overdiagnosis). If the threat (or evidence) of harms from early detection with potential overdiagnosis using a specific screening strategy are large, then screening by that means should be questioned.

The use of ECG will lead to increased detection and thus potentially a greater risk for overdiagnosis, misdiagnosis, unnecessary disqualification, or even adverse events or outcomes from activity restrictions, medical management or evaluation and/or treatment procedures. In accepting an additional test to enhance the sensitivity of the PPE, one must also accept that the test layers on additional risk of harm through a greater number of false-positives, costly secondary investigations, and the potential for unnecessary interventions including temporary sports restriction and prohibiting exercise when not indicated. This added layer of risk may be magnified as the incidence of SCA/D declines.

Identification of CV abnormalities also leads to opportunities for risk assessment and disease management. Published studies of ECG screening in relatively small U.S. athlete cohorts have not reported major adverse events/harm or death as a result of screening.^{34,39-41,53,70,72,83} Nonetheless, the potential risks and complications from invasive CV procedures and therapeutic interventions remain a valid concern.^{112,113} More outcomes data is needed to define the procedural risk in athletes with conditions detected through screening. Screening by history and physical examination alone also has potential risks, such as false-positive responses requiring unnecessary investigations, a higher false-negative rate, and perhaps false reassurance regarding cardiac safety.

Physician Autonomy

The lack of clear outcomes data at this time precludes an algorithmic or universal approach to the decision of adding an ECG to preparticipation screening. In addition, while this panel strongly supports the goals of both the PPE and cardiovascular screening, in the absence of clear outcomes-based evidence, legislative mandates requiring any particular cardiovascular screening strategy as obligatory, including history and physical examination with or without ECG, are unwarranted at this time. In the context of a developing evidence-base, this panel respects the autonomy of physicians to choose the best strategy for the athlete population under their care. Physicians should be guided by the previously discussed considerations and their assessment of relevant and emerging research.

Sports medicine physicians responsible for the CV care of athletes they deem high risk for SCA/D should thoughtfully consider more intensive screening strategies, such as ECG screening. Until more definitive outcomes data are available, maintaining the current standard of CV screening, without adding the ECG, is a reasonable choice for physicians caring for athletes. Some physicians, however, may favor the potential to prevent SCA/D in targeted risk groups and chose to add ECG screening in higher risk athlete populations. Some physicians interested in ECG screening may be limited by the lack of local cardiology resources and are unable to employ ECG screening programs with sufficient quality control. And finally, physicians with extensive experience in ECG screening and robust cardiology resources may choose to include ECG for all of their athletes. A standardized questionnaire should be considered during the PPE and during well child care visits that serve as the PPE to guide a comprehensive cardiac symptom and family history evaluation. Additional screening with an ECG should be considered if (and only if) accurate interpretation and proper cardiology resources can be developed or are currently available.

The Essential Role of AEDs and Emergency Action Plans

No screening program provides absolute protection against SCA/D. A proper emergency action plan (EAP) and access to an automated external defibrillator (AED) are essential to improving outcomes from SCA in athletes.^{6,13,114-116} Every school, club, and organization that sponsors athletic activities should be prepared to respond to a collapsed athlete with an acute cardiac emergency. An EAP for SCA with written policies and procedures is recommended to ensure an efficient and structured response to a cardiac emergency. An EAP for SCA including access to an AED increases the likelihood of bystander cardiopulmonary resuscitation (CPR), reduces the time to defibrillation, and improves survival from SCA. Successful programs require an organized and practiced response, an established communication method to activate the emergency medical services (EMS) system, and rescuers trained and equipped to provide CPR and defibrillation.

Prompt recognition of SCA is the first step to an efficient emergency response. Resuscitation can be delayed because SCA is mistaken for a seizure or the rescuer misinterprets agonal gasping for normal breathing.^{13,115} Coaches, sports medicine professionals, and other anticipated first responders to SCA in an athlete must maintain a high index of suspicion for SCA in any collapsed and unresponsive athlete. Treatment of SCA involves immediate recognition and activation of the local EMS system (call 9-1-1), early CPR (starting with chest compressions), and prompt retrieval of an AED for defibrillation. AEDs should be strategically placed within schools and sporting facilities to achieve a collapse to first shock time of < 3 minutes (although immediate availability of AEDs is ideal).^{116,117}

FUTURE RESEARCH DIRECTIONS

This panel has identified many knowledge gaps that would benefit from further investigation.

However, the following research priorities are suggested:

- 1) Higher quality data on the etiology of SCA/D in athletes to guide screening strategies. This requires standardized autopsies, wider application of post-mortem genetic testing, and review of the diagnosis in cases of SCA with survival.
- 2) The downstream impact of any screening program requires more research, a better understanding of the natural history of cardiac disorders, and more complete outcomes data. The outcomes and clinical course of athletes identified with CV disorders at risk for SCA/D should be monitored inclusive of adverse events from diagnostic or therapeutic procedures, continued participation in sports and exercise, and the occurrence of major CV events or other CV morbidity.
- 3) Potential avenues to refine the history and physical examination as a screening tool for cardiac disorders that place an athlete at elevated risk for SCA/D remain largely unexplored. Research efforts to improve the sensitivity, specificity, and reliability of the history and physical examination are needed.
- 4) A potential gap exists between the quality and results of ECG screening at expert centers compared to the results of screening at more novice sites with less experience. More data addressing implementation research is needed to address the potential risks and benefits of ECG screening more broadly, and the potential impact of technology advances to assist accurate ECG interpretation results.

CONCLUSIONS

The primary goal of CV screening in competitive athletes is to detect cardiac disorders early in their natural history to more effectively mitigate the risk of SCA/D through improved risk stratification, targeted management, and evidence-driven activity recommendations. Acknowledging the gaps and limitations of the history and physical examination, as well as those associated with the potential addition of ECG, to accomplish the goal of CV screening does not in itself endorse a particular strategy, but is fair to the current state of the science. ECG screening does offer enhanced detection of cardiac disorders at potential risk of SCA/D, but also increases the potential for false-positive results and the associated downstream consequences. In choosing a screening strategy, sports medicine physicians should consider and assess the differential risk of the athlete, the individual needs of their specific athlete population and community, their experience and available cardiology infrastructure, and their evaluation of the risks and benefits of early detection as a means of reducing CV morbidity and mortality in athletes. No screening strategy provides absolute protection from SCA/D, and, therefore, proper emergency planning and prompt availability of AEDs during training and competition are critical. Widely practiced and accepted screening standards are not perfect and should undergo continual revision as new data emerges. Accordingly, in the absence of a clear evidence-based strategy, AMSSM supports continued research in this area to validate the optimal strategies for reducing SCA/D in athletes. Finally, AMSSM respects and supports the autonomy of an individual sports medicine physician to assess the needs of their athlete population and the assets of their community to implement an appropriate screening strategy.

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Legends

Figure 1. Major considerations and strength of rationale for electrocardiogram screening.

Table 1. Incidence studies of Sudden Cardiac Arrest and Death in U.S. Competitive Athletes, Military Personnel, and the Young General Population

Table 2. Causes of Sudden Cardiac Death in Athletes, Military Personnel, and the Young General Population

Table 3. The Impact of Differential Risk: Number of Athletes with Detectable Cardiac Disorders Needed to Prevent One Death

Appendix I: Volunteer Positions, Board and Other Affiliations of the Writing Group

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