

# Current Perspectives on Cardiovascular Screening for Athletes

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## **Introduction**

Sudden cardiac arrest (SCA) remains the leading cause of fatalities in athletes and young adults during sports and exercise.<sup>1,2</sup> In view of the devastating effects of premature SCA or death in a young athlete, cardiovascular screening for the early detection of potentially lethal disorders is compelling on both ethical and medical grounds.<sup>3</sup> The primary goal of cardiovascular screening is to identify cardiac disorders predisposing to SCA with the intent of mitigating risk through individualized, patient-centered and disease-specific management.<sup>4</sup> Indeed, most major medical organizations and sports governing bodies support cardiovascular screening prior to participation in competitive sports.<sup>3-6</sup> However, considerable controversy exists regarding the most effective and feasible method for cardiovascular screening, and specifically whether a resting 12-lead electrocardiogram (ECG) should be routinely added to a history and physical examination (H&P). In adopting a cardiovascular screening program, careful consideration should be given to the risk of SCA within the targeted athlete population, the potential benefits and limitations of the different screening tests, and the availability of sports cardiology expertise and infrastructure.<sup>4</sup> Our aim is to update this discussion with a review of recent developments in the cardiovascular screening of athletes.

## **Evolution of ECG Interpretation Criteria**

Over the past decade, our understanding of the physiological manifestations from athletic cardiac remodeling on an ECG and their distinction from pathological ECG findings has progressed substantially. Several renditions of ECG interpretation criteria have greatly improved specificity and lowered the false positive rate which in turn has fundamentally transformed the discussion regarding the feasibility, accuracy, and costs of an ECG screening program.<sup>7-9</sup>

The 2010 European Society of Cardiology criteria for ECG interpretation in athletes was the first to separate ECG findings into training-related or training-unrelated categories.<sup>7</sup> Through international sports medicine and sports cardiology collaboration, the 2013 Seattle Criteria provided a pragmatic listing of normal and abnormal ECG findings and increased use of the ECG as a screening tool within the sports

medicine community.<sup>8,10</sup> Further advanced by new and emerging scientific evidence for accurate ECG interpretation in athletes, the currently accepted ECG interpretation standards are the 2017 International Criteria.<sup>9</sup> Importantly, each iteration in interpretation guidelines has improved specificity without compromising sensitivity for conditions at risk of SCA. Utilization of modern interpretation criteria by centers with experience in athlete ECG screening has reduced the false positive rate from ~17% to as low as 1-2%.<sup>4,7,9-11</sup> The need for greater physician education for accurate ECG interpretation in athletes is recognized, and comprehensive E-learning training modules based on the International Criteria are freely available at: <https://uwsportscardiology.org/E-academy>

### **Performance of H&P versus ECG**

While the performance of ECG has progressively improved, the performance of the H&P for detecting cardiovascular disease in young athletes has remained sub-optimal. Multiple studies have demonstrated that the H&P is limited by high false positive response rates, low specificity, and poor sensitivity.<sup>12-14</sup> Recently, sports cardiology investigators compared the performance of the American Heart Association (AHA) 14-point evaluation to ECG in a large cohort of healthy adolescent athletes.<sup>15</sup> They found that inclusion of two additional history questions into the AHA 14-point evaluation did not improve the sensitivity or specificity in detecting cardiovascular disease in this population.<sup>15</sup> In the 3,620 high school athletes studied, the AHA 14-point H&P had a sensitivity of 19%, specificity of 68% (false-positive rate 32%), and positive predictive value of 0.3%, whereas ECG interpreted by the Seattle criteria had a sensitivity of 88%, specificity of 97.6% (false-positive rate 2.4%), and positive predictive value of 13.6%.<sup>15</sup> Importantly, the authors acknowledge that the limitations of pre-participation cardiovascular screening by H&P does not equate with a recommendation for universal ECG screening; however, understanding the shortcomings of H&P is an important step towards improving preventative strategies.

### **Risk of SCA in Athletes**

A precise understanding of risk is needed to fully assess the indications and required rigor of potential screening strategies. When sports cardiology resources are limited, many physicians may choose to first implement ECG screening in the athletes at highest risk of SCA<sup>4</sup>. Many estimates of SCA incidence are hampered by limited study methodology, major discrepancies in case ascertainment, and heterogeneous population comparisons. Based on a systematic review of available studies, a generally accepted annual incidence of SCA is ~1:80,000 in high school athletes and ~1:50,000 in college athletes.<sup>16</sup>

Data supports that some athletes are at higher risk for SCA or sudden cardiac death (SCD) based on sex, race, or sport.<sup>1,17</sup> Incidence rates are consistently higher in male athletes compared to female athletes and black athletes of Afro-Caribbean descent compared to white athletes.<sup>1,17</sup> In a study of U.S. college athletes, male basketball players had the highest annual risk of SCD (1:9,000), and male black basketball players had a risk of 1:5,300.<sup>1</sup> In a study of elite adolescent soccer players from the English Football Association, the incidence of SCD was 1:14,800 athletes per year with a higher incidence in black athletes (1:3,700).<sup>18</sup>

### **Does Early Detection Improve Outcomes?**

Central to the principle of pre-participation cardiovascular screening is the goal of improving long-term health and reducing potential cardiovascular morbidity and mortality. Outcome studies on cardiovascular screening programs are limited and fraught with methodological challenges.<sup>18-20</sup> These include geographic variation of disease prevalence; differences in screening, management, and sport restriction practices; low event rates that are difficult to monitor; and variable methods and accuracy to determine the population of athletes at risk.<sup>18-20</sup>

The premise of early detection of athletes with underlying cardiac disorders at risk for SCA relies in part on evidence from disease-specific data and individualized treatment strategies shown to lower risk.

Studies support that identification and utilization of current risk stratification and management strategies for cardiovascular conditions such as Wolf-Parkinson-White, hypertrophic cardiomyopathy, and long QT syndrome improve long-term survival.<sup>21-23</sup> While extrapolation of these results to athletes undergoing intense aerobic and/or static exercise is largely unknown, several reports suggest disease-specific management and prudent activity restrictions will improve outcomes and reduce sudden death in athletes.<sup>24-27</sup>

### **Conclusion & Future Directions**

While there is universal agreement on the potential utility of cardiovascular screening in athletes, the exact methodology remains a topic of debate. Given the recent evolution of ECG interpretation criteria with substantially lower false-positive rates and a growing sports cardiology infrastructure, cardiovascular screening strategies that extend beyond H&P deserve careful consideration. It is apparent that standardized history questionnaires are woefully inadequate and lack evidence, and cardiovascular screening in competitive athletes is unlikely to be effectively accomplished using H&P alone. ECG-inclusive programs will better meet the stated objective of cardiovascular screening but require physician expertise in modern ECG interpretation standards and a dedicated sports cardiology infrastructure. When limited sports cardiology resources are available, targeted ECG screening should be considered for higher risk athlete groups. Additional research and educational initiatives are needed to further refine cardiovascular screening strategies for the prevention of SCA/SCD in athletes.

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