



REVIEW ARTICLE

## Electrocardiographic evaluation in athletes: ‘Normal’ changes in the athlete’s heart and benefits and disadvantages of screening



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**Abstract** Young athletes are considered the healthiest group in society. Although rare, there are still reports of sudden death or cardiac arrest on the playing fields. Clinical evaluation is of paramount importance for the identification of possible pathological states that confer increased risk of these events. Interpretation of the electrocardiogram of young athletes can help identify changes associated with heart disease that might preclude the participation in sports. In this context, it is essential to recognize the electrocardiographic patterns that represent the structural and electrical remodeling resulting from continued adaptation to exercise, and which thus do not increase the risk of adverse events during exercise. The European Society of Cardiology (ESC) and the American Heart Association (AHA) have issued consensus documents summarizing which electrocardiographic abnormalities should be considered ‘physiological’, resulting from adaptation to exercise (‘athlete’s heart’), and which should be considered pathological and thus require further study. However, the two societies have different approaches with respect to the electrocardiographic screening of athletes. This paper provides a brief review of current evidence regarding the electrocardiographic findings considered normal and abnormal in athletes, and presents the arguments of the ESC and AHA for electrocardiographic screening in this population.

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### PALAVRAS-CHAVE

Coração de atleta;  
Rastreio de ECG;  
Morte súbita

**Avaliação eletrocardiográfica em atletas: alterações «normais» do coração de atleta, benefícios e desvantagens do seu rastreio**

**Resumo** Os jovens atletas são considerados como o grupo mais saudável da sociedade. Apesar de raros, surgem ainda relatos de morte súbita ou paragem cardiorrespiratória nos campos de

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jogo. A avaliação clínica reveste-se de primordial importância para a identificação de eventuais estados patológicos que confirmam risco acrescido destes eventos. A interpretação do eletrocardiograma destes jovens atletas pode permitir identificar alterações associadas a patologia cardíaca que condicione ou não a prática do exercício físico. Neste contexto, torna-se essencial reconhecer os padrões eletrocardiográficos que representam a remodelagem estrutural e elétrica resultantes da adaptação ao exercício continuado, e que por sua vez não acarretam risco acrescido de eventos adversos durante a prática de exercício. As Sociedades Europeia e Americana de Cardiologia emitiram documentos de consenso que procuram resumir quais as alterações eletrocardiográficas consideradas como «fisiológicas» e resultantes da adaptação ao exercício (coração de atleta) e quais as alterações consideradas como patológicas e que portanto implicam o estudo subsequente dos casos em que são identificadas. Estas sociedades apresentam, no entanto uma abordagem diferente no que se refere ao rastreio eletrocardiográfico de atletas. Este artigo fornece uma breve revisão da evidência atual referente aos achados eletrocardiográficos considerados como normais e anormais em atletas, assim como apresenta as argumentações das Sociedades Europeia e Americana de Cardiologia referentes ao rastreio eletrocardiográfico nesta população.

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## Introduction

“Mens sana in corpore sano” (“a sound mind in a healthy body”) is an aphorism known by millions worldwide. Sudden death is a tragic event on any occasion. However, if it occurs in an otherwise healthy, highly trained athlete, the impact is greater, because athletes are regarded as the healthiest group in society. Sudden death during sports is an extremely rare event, but has been described since ancient Greece: Pheidippides (490 BC) ran from Marathon to Athens to announce the Greek victory over the Persians, and after delivering the message he collapsed and died.

Interpretation of the athlete’s electrocardiogram (ECG) can reveal changes associated with cardiac disease. However, ECG changes in athletes are common and usually reflect structural and electrical remodeling of the heart as an adaptation to regular physical training (known as athlete’s heart). On the other hand, abnormalities on a young athlete’s ECG can also be an expression of an underlying disease that may carry a risk of sudden cardiac death (SCD) during sports. Lack of knowledge of the ‘normal’ ECG changes in athletes may lead to a diagnostic odyssey with an unfavorable cost–benefit ratio, and often limits participation in sports to athletes whose ECG patterns are within the normal pattern. Many of the ECG changes seen in athletes may overlap with patterns considered pathological in other subgroups of individuals, and this is one of the main limitations of ECG screening in this population – the high number of false positives. Alternatively, signs of potentially lethal cardiovascular disorders may be misinterpreted as normal variants of an athlete’s ECG.<sup>1</sup>

Current European Society of Cardiology (ESC) guidelines include an ECG, besides physical examination, as a pre-screening test for athletes. However, concern has focused in particular on the availability of practitioners qualified to interpret ECGs and the burden of false-positive results.

The American Heart Association (AHA) and the ESC have both published recommendations for the interpretation of the ECG in athletes.<sup>2,3</sup> The present review presents a summary of the most frequent ECG changes considered ‘normal’ in athletes, as well as a brief discussion regarding the advantages and disadvantages of ECG screening in this population.

## Cardiac remodeling in athletes

Athlete’s heart is currently defined as a non-pathological condition in which the heart undergoes morphological and functional changes that result from a process of adaptation to intensive exercise. The heart is usually enlarged and the resting heart rate is lower than normal. Henschen first described the athlete’s heart in 1899; using only careful thoracic percussion, he recognized an enlargement of the heart caused by athletic activity in cross-country skiers.<sup>4</sup> He concluded that both dilation and hypertrophy were present, involving both sides of the heart, and that these changes were adaptive and improved performance. Since then, numerous descriptions and characterization of the athlete’s heart have been performed with the improvements in cardiac imaging such as chest X-ray, echocardiography and cardiac magnetic resonance imaging (CMRI).

The cardiovascular adaptation to exercise differs with the type of conditioning: endurance (dynamic/aerobic) and strength training (isometric/anaerobic). Some sports, such as cycling and rowing, combine both types of conditioning. The adaptation to exercise has two distinct phases: an acute and a chronic phase. The acute response varies according to the type of exercise. In endurance training there is a substantial increase in maximum oxygen uptake, cardiac output, stroke volume and systolic blood pressure, associated with decreased peripheral vascular resistance.

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