



REVIEW ARTICLE

Benign and pathological electrocardiographic changes in athletes[☆]



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Abstract Sudden cardiac death is the leading cause of death in athletes during sport. It is a tragic event that generates significant media attention and discussion throughout society as to whether everything possible had been done to prevent it. Regular physical exercise causes cardiac remodeling at both the mechanical and electrical level, known as athlete's heart, resulting in an electrocardiogram (ECG) considered abnormal compared with the ECGs of the general population. Some of these electrocardiographic changes are considered normal or physiological in athletes, while others suggest underlying cardiac disease with the potential to cause sudden cardiac death. There is thus an urgent need to define the electrocardiographic patterns that allow or prohibit participation in sports, and to differentiate them in terms of gender, ethnicity and age. The purpose of this review is to present the latest data on the electrocardiographic changes considered benign or pathological that are typically found in athletes and to critically analyze the most recent criteria for classifying ECGs in this population (the Seattle criteria), comparing them with previous guidelines and with the latest studies on the subject. This article also examines the question of including ECGs in preparticipation screening programs, the US and European approaches to the subject, and the most up-to-date data on the sensitivity, specificity and cost-effectiveness of the ECG in athletes.

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PALAVRAS-CHAVE

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Alterações eletrocardiográficas benignas e patológicas em atletas

Resumo A morte súbita cardíaca é a principal causa de morte em atletas durante a prática desportiva. É um evento trágico, com grande impacto nos média, gerando discussão dentro da comunidade no intuito de perceber se tudo foi feito para o evitar. A prática regular de exercício físico causa uma remodelagem cardíaca, tanto a nível mecânico como elétrico, conhecida como «coração de atleta», que se repercute num eletrocardiograma considerado «anormal» quando comparado com o da população geral. Algumas destas alterações do eletrocardiograma são consideradas normais/fisiológicas em atletas, enquanto outras traduzem, efetivamente, doença cardíaca de base, com potencial de causar morte súbita cardíaca. Assim, urge definir quais os padrões eletrocardiográficos que «permitem» ou, por outro lado, «proíbem» a prática desportiva, diferenciando-os em função do género, etnia e idade. Esta revisão pretende reunir a informação mais atual sobre as alterações eletrocardiográficas consideradas benignas ou patológicas encontradas tipicamente em atletas e analisar, de forma crítica, os critérios mais recentes para a classificação do eletrocardiograma nesta população (os Critérios de Seattle), comparando-os com as *guidelines* anteriores e com os estudos mais recentes sobre o tema. É também objetivo desta revisão dar a conhecer a problemática da inclusão do eletrocardiograma no programa de rastreio pré-desportivo, as perspetivas americana e europeia, e os dados mais recentes sobre a sensibilidade, especificidade e custo-efetividade do uso do eletrocardiograma em atletas.

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List of abbreviations

AHA	American Heart Association
AP	accessory pathway
ARVD	arrhythmogenic right ventricular dysplasia
AV	atrioventricular
BrS	Brugada syndrome
DCM	dilated cardiomyopathy
ECG	electrocardiogram, electrocardiographic
ESC	European Society of Cardiology
HCM	hypertrophic cardiomyopathy
ICD	implantable cardioverter-defibrillator
LQTS	long QT syndrome
LV	left ventricular
LVH	left ventricular hypertrophy
SCD	sudden cardiac death
SQTS	short QT syndrome
SUD	sudden unexplained death
VF	ventricular fibrillation
VT	ventricular tachycardia
WPW	Wolff-Parkinson-White

Introduction

Sudden cardiac death (SCD) in an athlete is a tragic event that generates significant media attention and discussion throughout society as to whether everything possible had been done to prevent it.

An athlete has been defined as an individual engaged in regular physical training and participating in official

sports competition with an emphasis on excellence and achievement.¹ Physical exercise is a very important component of primary and secondary cardiovascular prevention, and the 2012 European Society of Cardiology (ESC) guidelines on cardiovascular disease prevention recommend 2.5–5 hours/week of moderate-intensity physical activity or 1–1.5 hours/week of vigorous-intensity exercise, the benefits being greater with more hours of exercise.²

SCD is the leading cause of death (75–85%)^{3,4} in athletes during sports.⁵ The risk of cardiovascular death or isolated coronary artery disease is significantly lower in physically active and fit individuals, but the risk of sudden death increases 2–4.5 fold during high-intensity exercise.^{1,6–8}

The purpose of this review is to present the latest data on the electrocardiographic changes found in athletes related to cardiac remodeling that is considered physiological or related to underlying heart disease, the latter being associated with SCD.

Sudden cardiac death and electrocardiographic screening

SCD is defined as unexpected, non-traumatic cardiac death within one hour of symptom onset in an individual with no known potentially lethal cardiovascular condition. It may be due to various causes, which are conventionally divided into congenital abnormalities (structural or electrical), which are more common in individuals aged under 35, and acquired abnormalities, which are more frequent after the age of 35^{1,3,6,9,10} (Figure 1). The main causes of SCD

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