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REVIEW ARTICLE

The hearts of competitive athletes: An up-to-date overview of exercise-induced cardiac adaptations

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Athlete's heart;
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Abstract Intense and regular physical exercise is responsible for various cardiac changes (electrical, structural and functional) that represent physiological adaptation to exercise training. This remodeling, commonly referred to as 'athlete's heart', can overlap with several pathological entities, in which sudden cardiac death may be the first clinical presentation. Although pre-competitive screening can identify athletes with life-threatening cardiovascular abnormalities, there are no widely used standardized pre-participation programs and those currently implemented are controversial. Data from personal and family history, features of physical examination and changes in the 12-lead electrocardiogram can raise the suspicion of cardiac disease and lead to early detection of entities such as hypertrophic cardiomyopathy. However, interpreting the electrocardiogram is often challenging, because some changes are considered physiological in athletes. Thus, clinical decision-making in such cases can prove difficult: missing a condition associated with an increased risk of life-threatening events, or conversely, mislabeling an athlete with a disease that leads to unnecessary disqualification, are both situations to avoid. This paper provides an up-to-date review of the physiological cardiac effects of exercise training and highlights key points that should be taken into consideration in the assessment of young competitive athletes.

PALAVRAS-CHAVE
Coração de atleta;
Adaptação fisiológica;

O coração dos atletas – revisão e atualização das adaptações cardíacas induzidas pelo exercício

Resumo A prática intensa e regular de exercício físico é responsável por diversas alterações cardíacas, desde eléctricas, estruturais ou funcionais, que representam adaptações

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Morte súbita;
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fisiológicas ao exercício. Esta remodelagem, frequentemente denominada por coração de atleta, pode mimetizar alterações típicas de diversas patologias, nas quais a morte súbita pode ser a primeira apresentação clínica. Apesar do rastreio pré-competição poder identificar atletas com alterações cardíacas potencialmente fatais, os programas de rastreio não estão estandardizados e aqueles já implementados permanecem controversos. Dados da história clínica pessoal e familiar, achados do exame físico e alterações no eletrocardiograma de 12 derivações, podem aumentar a suspeita de doença cardíaca e levar à deteção precoce de entidades como a miocardiopatia hipertrófica. Contudo, a interpretação do eletrocardiograma é frequentemente desafiante porque várias alterações são consideradas fisiológicas em atletas. Assim, as decisões clínicas são por vezes difíceis: não diagnóstico de condições associadas a um risco aumentado de eventos fatais, ou por outro lado, o diagnóstico errado de patologia cardíaca em atletas saudáveis pode originar a realização de exames de diagnóstico desnecessários ou a desqualificação inapropriada do atleta. Este artigo fornece uma revisão atualizada dos efeitos cardíacos fisiológicos do exercício físico e realça pontos-chave que deverão ser tidos em consideração na avaliação de atletas jovens de competição.

Introduction

A sedentary lifestyle is associated with the development of cardiovascular (CV) risk factors, progression of coronary disease and occurrence of adverse clinical events.[1,2] Health promotion efforts aimed at CV disease prevention, emphasizing physical activity, have led to increased participation in recreational and competitive sport.[3] However, cases of sudden cardiac death (SCD) among athletes continue to raise concerns regarding the safety of exercise. A higher risk of coronary events and malignant arrhythmias during vigorous exercise has been described (the so-called exercise paradox), but the incidence of exercise-related cardiac arrest in individuals aged under 35 years has recently been shown to be low.[4,5] Nonetheless, some doubts persist regarding the impact of prolonged and intense exercise training. In a study of 102 marathon runners, 12% had myocardial scarring on cardiac magnetic resonance imaging (MRI) with variable patterns (ischemic and non-ischemic), a finding three times more common than in age-matched controls.[6] The role of exercise-induced fibrosis as arrhythmogenic substrate is as yet poorly understood. Some authors argue that a high volume of endurance exercise is responsible for adverse CV effects and that there may be a upper limit beyond which the adverse effects outweigh the benefits.[7]

Exercise training induces a constellation of physiological CV adaptations. The first descriptions of heart enlargement in athletes date to the 1890s, when increased cardiac size was demonstrated with chest auscultation and percussion in Nordic skiers and university runners.[8,9] In the 1940s, a higher prevalence of resting sinus bradycardia was reported among Boston marathon runners.[10] Nearly four decades later, in 1975, with the development of M-mode echocardiography, Morganroth described different left ventricular (LV) remodeling according to the type of exercise: concentric hypertrophy for strength and eccentric for endurance exercise,[11] an observation that came to be known as the 'Morganroth hypothesis'. However, with the increasing numbers of athletes being assessed, along with the development of cardiac imaging and the growth of published data in sports cardiology, it has been ascertained that other factors influence cardiac remodeling.

Early identification of athletes at higher risk of SCD is a cornerstone of screening. A wrong diagnosis could have serious adverse consequences: under-diagnosis of pathology may lead to life-threatening events being missed, and over-diagnosis may result in unnecessary disqualification. The ideal balance has not been struck, and the cost-effectiveness of current screening programs remains controversial. While a clinical history and physical examination are consensual, the same is not true for the electrocardiogram (ECG). Electrical and structural cardiac remodeling can induce ECG changes considered normal in athletes but pathological in non-athletes. Standardization of ECG interpretation in athletes could reduce the rate of false positives and the need for further investigations.

This paper provides an up-to-date review of exercise-induced physiological cardiac effects and an overview of the key points that should be highlighted in the assessment of athletes.

Molecular mechanisms and physiology of exercise

Several complex mechanisms have been postulated to account for the beneficial effects of physical activity. Continuous exercise training decreases myocardial oxygen demand, improves myocardial perfusion, promotes an antithrombotic environment, balances the autonomic system and prevents the development of CV risk factors such as hypertension, dyslipidemia, obesity and diabetes.[3,12–15] At the molecular level, exercise enhances antioxidant capacity,