Using the 12-Lead Electrocardiogram in the Care of Athletic Patients

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KEYWORDS

• Sports cardiology • Preparticipation screening • Sudden cardiac death
• Electrocardiogram interpretation • Inherited cardiac disease

KEY POINTS

- The 12-lead electrocardiogram (ECG) in athletes differs significantly from that in nonathletes.
- Physiologic ECG abnormalities in athletes can overlap with potentially serious cardiac diseases, and efforts to differentiate between the two entities are continually being improved through contemporary ECG interpretation criteria.
- The benefits of detecting abnormalities and possibly preventing sudden cardiac death with ECG screening need to be balanced with variability in interpretation and the presence of cardiac diseases undetectable by ECG.

INTRODUCTION

More than 100 years after Einthoven's string galvanometer produced the first electrocardiogram (ECG) in a human, the 12-lead ECG (used interchangeably with ECG in this article) remains the cornerstone of diagnostic investigations in cardiology. Despite the advent of more technologically advanced imaging modalities, the ECG has maintained its status as an obligatory investigation in cardiology-related scenarios. The ECG's indispensable role is clearly shown in the care of athletes, in whom its use spans a myriad of possibilities from screening through to diagnosis, prognosis, risk stratification, and even possibly the prevention of sudden cardiac death (SCD).

DEFINITION OF AN ATHLETE

The American College of Cardiology and European Society of Cardiology (ESC) have similar qualitative definitions for a competitive athlete, namely a person who participates in regular competition, in which emphasis is placed on excellence and achievement, and systematic training is usually intense with a tendency for exertion to physical limits.[1,2] Although these definitions do not apply to noncompetitive, recreational, or leisure sports, the distinction between competitive and recreational athletes has been blurred with increasing participation rates and intensities of physical activity within the general population. Quantitative definitions have also been suggested in which an athlete is deemed to be a person who partakes in weekly intensive physical activity exceeding 4 to 10 hours.[3–5] The European Association for Cardiovascular Prevention and Rehabilitation acknowledges the need for inclusiveness by proposing that the definition of an athlete be based on the type, frequency, duration, and intensity of sport participation, as well as being categorized as competitive or recreational.[5]

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ORIGINS OF THE ATHLETE'S HEART

As early as 1899, Henschen described cardiac enlargement in long distance skiers using basic percussion techniques, followed by Linzbach coining the term physiologic left ventricular hypertrophy (LVH) in 1947.[6] Since then, the constellation of physiologic, electrical, structural, and functional adaptations related to regular intensive physical activity have been termed the athlete's heart, and the ECG is ubiquitous in this definition. Electrocardiographic changes of rhythm disturbances and voltage criteria for ventricular hypertrophy were more frequently identified in athletes compared with the general population in small cohort studies between 1960 and 1990.[7] This trend continued into the twenty-first century as abnormal ECG patterns compatible with the presence of cardiovascular disease were observed in up to 40% of substantially large cohorts of athletes.[8] Expectedly, the spectrum of some ECG patterns in athletes includes overlap with those described in individuals with potentially serious cardiac diseases, thus creating a gray area in ECG interpretation. With such marked differences between the ECGs of athletes and those of nonathletes, the ability to differentiate physiology from disorder is critical, considering the young age of most athletes and the societal impact of SCD in sport.

THE ATHLETE'S ELECTROCARDIOGRAM

Bradyarrhythmias, such as sinus bradycardia greater than 30 beats/min (bpm), sinus arrhythmia, first-degree and second-degree (Mobitz type 1) atrioventricular block, wandering atrial pacemaker, and ectopic atrial rhythm, have been attributed to increased vagal tone following regular physical activity and are common in athletes (**Figs. 1** and **2**).[3] Increased vagal tone also manifests as ethnic-specific early repolarization changes. White athletes typically show concave ST segment elevation, whereas Afro-Caribbean/black athletes show convex ST segment elevation often associated with either biphasic or deep T-wave inversions (TWIs) in V1 to V4.[3] Isolated Sokolow-Lyon voltage criteria (combined amplitude of S wave in V1 [SV1] + largest R wave in V5 or 6 [RV5/6] $\geq$3.5 mV, or R wave in aVL $\geq$1.1 mV) for LVH and incomplete right bundle branch block (RBBB) are recognized manifestations of increased cardiac chamber size and wall thickness and regarded as normal physiologic adaptations in athletes.[3]

DETERMINANTS OF ELECTROCARDIOGRAM PATTERNS IN ATHLETES

The manifestations of athletes' ECGs are governed by several demographic factors, including sporting discipline (see **Fig. 2**).

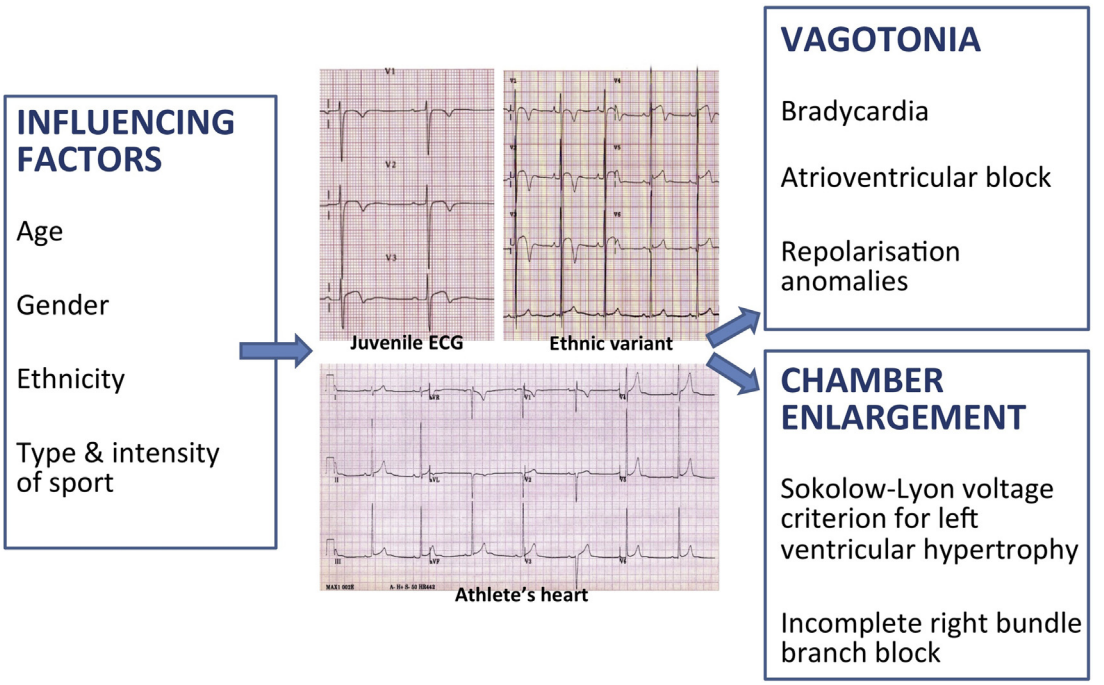

Fig. 1. Factors influencing athletes' ECGs and electrocardiographic manifestations of physiologic cardiac remodeling.