

18 highlights from the International Criteria for ECG interpretation in athletes

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ECG interpretation in athletes is a required skill for the sports medicine physician. Whether used for screening or diagnostic purposes, ECG facilitates the detection of conditions at risk for sudden cardiac death (SCD). ECG interpretation standards have evolved over the last decade as scientific studies improved the division of physiological from pathological ECG changes. The Seattle Criteria (2013) provided consensus recommendations by an international panel of experts in sports cardiology and emerged as a practical guideline to improve ECG interpretation accuracy.¹ In 2017, the International Criteria was released by the same expert panel and intended to supersede prior guidelines as the current standard for ECG interpretation in athletes.² Each revision of ECG standards has improved specificity without compromising sensitivity for ECG-detectable pathological conditions associated with SCD.³⁻⁵ In a cohort of 5258 college athletes from the USA, application of the International Criteria lowered the false-positive rate compared with the Seattle Criteria from 2.8% to just 1.3%.³ Likewise, in a cohort of 11 168 adolescent soccer players from the UK, the total number of athletes with an abnormal ECG was reduced 57% by moving from the Seattle Criteria (4.3%) to the International Criteria (1.8%).⁴

DIFFERENCES BETWEEN THE SEATTLE AND INTERNATIONAL CRITERIA

The most substantive change is the introduction of a ‘yellow’ box or list of borderline ECG findings in which two or more borderline findings warrant additional evaluation (figure 1). Recognition of juvenile T wave inversion (TWI) as a normal finding in athletes age <16 years, and a new definition for pathological Q waves are also key changes to improve specificity.^{3 6} New additions to the ‘red’ box or list of abnormal ECG findings include

epsilon waves, and TWI ≥ 1 mm in V5 or V6 alone. Findings that warrant evaluation for coronary artery disease in athletes ≥ 30 years are also discussed. Perhaps most importantly, the International Criteria guideline provides a clear link between specific ECG abnormalities and the recommended next steps for secondary testing.

Let’s review: 18 key points from the International Criteria

- ▶ The presence of high QRS voltages that fulfil voltage criteria for left or right ventricular hypertrophy in the absence of other ECG or clinical markers suggestive of pathology are considered normal ECG changes in athletes related to physiological increases in cardiac chamber size and/or wall thickness.
- ▶ Incomplete right bundle branch block (RBBB) results from cardiac adaptations to exercise and does not require further evaluation.

- ▶ Anterior TWI in V1-V3 is a normal variant in asymptomatic adolescent athletes age <16 years.
- ▶ TWI in leads V1-V4 when preceded by J-point elevation and convex ST segment elevation is a normal repolarisation variant in black athletes.
- ▶ Left and right axis deviation, left and right atrial enlargement, and complete RBBB are considered borderline variants in athletes. The presence of only one of these findings in isolation or with other recognised physiological patterns does not warrant further assessment in asymptomatic athletes without a family history of premature cardiac disease or SCD. Conversely, the presence of two or more of these borderline findings is considered abnormal and warrants additional investigation.
- ▶ TWI affecting the lateral leads (V5-V6, I and aVL) is abnormal irrespective of race/ethnicity and should prompt a comprehensive investigation to exclude cardiomyopathy.
- ▶ Cardiac MRI should be a standard assessment for apical hypertrophic cardiomyopathy (HCM) in athletes with a markedly abnormal ECG, specifically an ECG with deep (> -0.2 mV) TWI and ST segment depression in the lateral or inferolateral leads.
- ▶ Anterior TWI beyond V2 in the absence of J-point elevation or with

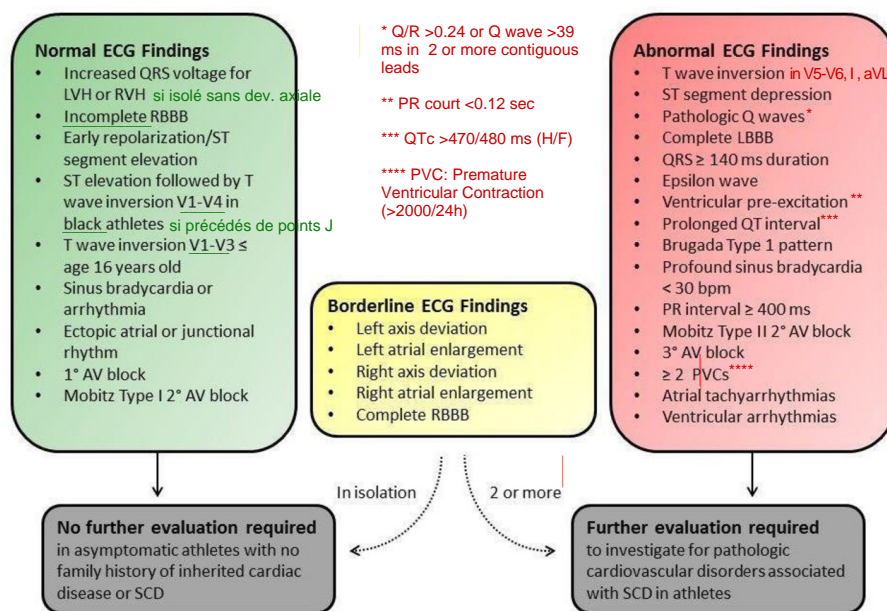


Figure 1 International criteria for ECG interpretation in athletes. Reproduced from Drezner et al.² AV, atrioventricular; LBBB, left bundle branch block; LVH, left ventricular hypertrophy; PVC, premature ventricular contraction; RBBB, right bundle branch block; RVH, right ventricular hypertrophy; SCD, sudden cardiac death.

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a coexistent depressed ST segment in athletes age ≥ 16 years should prompt an investigation to rule out arrhythmogenic right ventricular cardiomyopathy (ARVC). Other ECG findings suggestive of ARVC in the presence of anterior TWI include low limb lead voltages, prolonged S wave upstroke, ventricular ectopy and epsilon waves.

- ▶ ST segment depression in excess of 0.05 mV (0.5 mm) in two or more leads is an abnormal finding requiring additional evaluation.
- ▶ The new definition of pathological Q waves in athletes is a Q/R ratio ≥ 0.25 or a Q wave ≥ 40 ms in duration in two or more contiguous leads (except III and aVR).
- ▶ Profound non-specific intraventricular conduction delay (QRS duration ≥ 140 ms) warrants more evaluation with an echocardiogram.
- ▶ Athletes with complete left bundle branch block require a thorough investigation to exclude myocardial disease including echocardiography and a cardiac MRI with perfusion study.
- ▶ Asymptomatic athletes with Wolff-Parkinson-White pattern should be investigated for the presence of a low-risk or high-risk accessory pathway. Non-invasive risk stratification begins with an exercise stress test in which abrupt, complete loss of pre-excitation at higher heart rates suggests a low risk accessory pathway. If non-invasive testing cannot confirm a low risk pathway, electrophysiology testing should be considered.
- ▶ Corrected QT (QTc) intervals of ≥ 470 ms in males and ≥ 480 ms in females define thresholds of QT prolongation that warrant further assessment in asymptomatic athletes.
- ▶ Mobitz type II second degree and complete third degree atrioventricular (AV) block are pathological disruptions in AV conduction and require

additional evaluation to exclude myocardial disease.

- ▶ The threshold and extent of evaluation for premature ventricular contractions (PVCs) is controversial. In athletes with ≥ 2000 PVCs per 24 hours or with episodes of non-sustained ventricular tachycardia on ambulatory monitoring, or with an increasing burden of ectopy during an exercise test, additional evaluation should include contrast-enhanced cardiac MRI and possibly electrophysiology testing.
- ▶ Additional evaluation for underlying coronary artery disease should be considered in asymptomatic athletes age ≥ 30 years with TWI, pathological Q waves, ST segment depression, left or RBBB, abnormal R wave progression, left anterior fascicular block and atrial fibrillation.
- ▶ Several common heritable cardiomyopathies including HCM, ARVC and familial dilated cardiomyopathy may present with ECG abnormalities prior to the onset of overt heart muscle pathology. Athletes with an abnormal ECG suggestive of cardiomyopathy and initially normal clinical evaluations should be followed with serial evaluation during and after their competitive athletic careers.

Award winning free ECG training modules: don't miss out!

New ECG training modules based on the International Criteria can be found at: <https://uwsportscardiology.org/E-Academy>. These state-of-the-art modules are open access and recently received the Silver Global LearnX Award for 'Best Free E-Learning Resource'. Sports medicine physicians are strongly encouraged to fine tune their ECG interpretation skills, as future improvements are already on the horizon.⁷

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