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ECG Interpretation in Athletes

Abnormal ECG Criteria in Athletes

Any abnormal finding is considered training-unrelated and suggests the possibility of underlying pathologic cardiac disease, requiring further diagnostic work-up.

Abnormal ECG Finding	Definition
T wave Inversion	> 1 mm in depth from baseline in two or more adjacent leads not including aVR or V1 ([1]note exception below – Figure 1)
ST Segment Depression	≥ 1 mm in depth in two or more adjacent leads
Pathologic Q waves	> 3 mm in depth or > 0.04 sec in duration in two or more leads
Complete Left Bundle Branch Block	QRS > 0.12 sec, predominantly negative QRS complex in lead V_1 (QS or rS), and upright monophasic R wave in leads I and V_6 (Figure 2)
Complete Right Bundle Branch Block	QRS > 0.12 sec, terminal R wave in lead V_1 (rsR'), and wide terminal S wave in leads I and V_6 (Figure 3)
Intra-Ventricular Conduction Delay	Non-specific, QRS > 0.12 sec
Left Atrial Enlargement	Prolonged P wave duration of > 0.12 sec in leads I or II with negative portion of the P wave ≥ 1 mm in depth and ≥ 0.04 sec in duration in lead V_1
Left Axis Deviation	-30˚ to -90˚
Right Atrial Enlargement	High/pointed P wave ≥ 2.5 mm in leads II and III or V_1
Right Ventricular Hypertrophy	Right axis deviation ≥ 120˚, tall R wave in V1 + persistent precordial S waves (R-V_1 + S-V_5 > 10.5 mm)
Mobitz Type II 2˚ AV Block	Intermittently non-conducted P waves not preceded by PR prolongation and not followed by PR shortening
3˚ AV Block	Complete heart block
Ventricular Pre-excitation	PR interval < 0.12 sec with a delta wave (slurred upstroke in the QRS complex – Figure 4)
Long QT interval	QTc ≥ 0.47 sec (99% males) QTc ≥ 0.48 sec (99% females) [QTc ≥ 0.50 sec (unequivocal LQTS) [Figure 5]
Short QT interval	QTc ≤ 0.34 sec
Brugada-like ECG Pattern	High take-off and downsloping ST segment elevation in V_1-V_3 (Figure 6)
Epsilon Wave	Small negative deflection just beyond the QRS in V_1 or V_2 (Figure 7)
Profound Sinus bradycardia	< 30 BPM or sinus pauses ≥ 3 sec
Atrial Tachyarrhythmias	Supraventricular tachycardia, atrioventricular nodal reentrant tachycardia, , atrial-fibrillation, atrial-flutter
Premature Ventricular Contractions	≥ 2 per tracing
Ventricular Arrhythmias	Couplets, triplets, non-sustained ventricular tachycardia

[1]Note: Exception to T wave inversion: elevated ST-segment with an upward ("domed") convexity, followed by a negative T-wave in V_2-V_4 is a common pattern of early repolarization seen in athletes of African-Caribbean descent and should be considered normal (Figure 1). This should not to be confused with the downsloping ST segment elevation in V_1-V_3 found in a Brugada-like ECG pattern which is abnormal (Figure 6).

Common ECG Findings in Athletes

Training-related ECG alterations are common, physiologic adaptations to regular exercise and are considered normal variants in athletes.

1) Sinus bradycardia
2) Sinus arrhythmia
3) First degree AV block
4) Incomplete RBBB
5) Early repolarization
6) Isolated QRS voltage criteria for left ventricular hypertrophy[2]

[2]Note: Isolated increases in QRS amplitude are common in trained athletes. However, QRS voltage criteria for LVH + any non-voltage criteria for LVH (such as atrial enlargement, left axis deviation, a 'strain' pattern of repolarization, ST-segment depression, T-wave inversion, or pathologic Q waves) is abnormal and requires further evaluation.
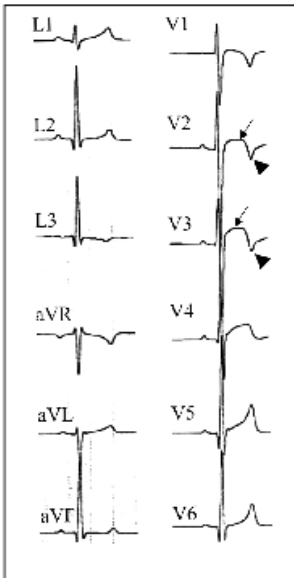
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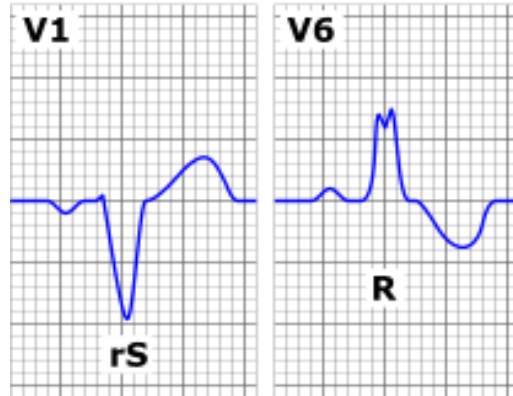**Figure 1-** Normal variant of T wave inversion in athletes of African-Caribbean descent

Figure 2 – Left Bundle Branch Block: QRS > 0.12 sec, predominantly negative QRS complex in lead V_1 (QS or rS), and upright monophasic R wave in leads I and V_6
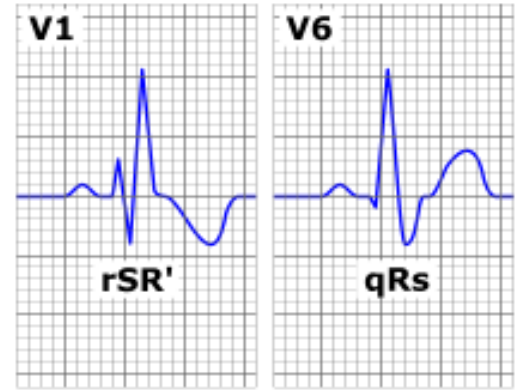

Figure 3 – Right Bundle Branch Block: QRS > 0.12 sec, terminal R wave in lead V_1 (rsR'), and wide terminal S wave in leads I and V_6
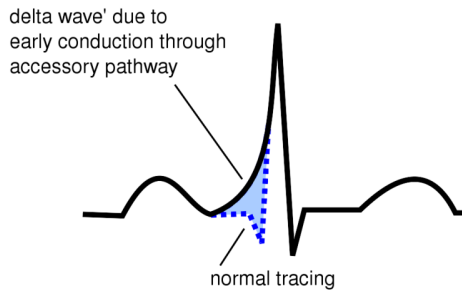

Figure 4 – Delta Wave: Suggestive of ventricular pre-excitation; PR interval < 0.12 sec with or without a delta wave (slurred upstroke in the QRS complex)

Note:
1. Use Preceding RR Interval
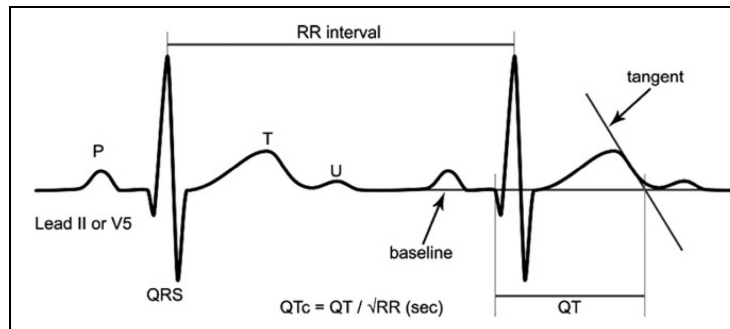2. RR in sec
3. QT in sec

Figure 5 – QTc Interval: LONG QT : QTc ≥ 0.47 sec (99% males) or QTc ≥ 0.48 sec (99% females) [QTc ≥ 0.50 sec (unequivocal LQTS)] SHORT QT: QTc ≤ 0.34 sec
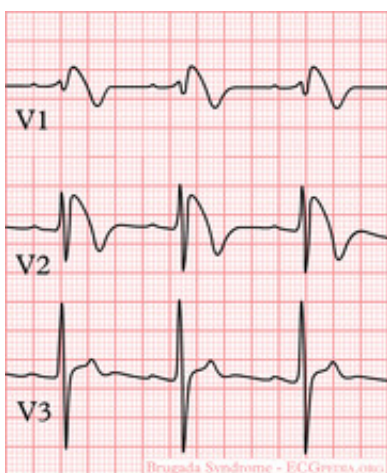

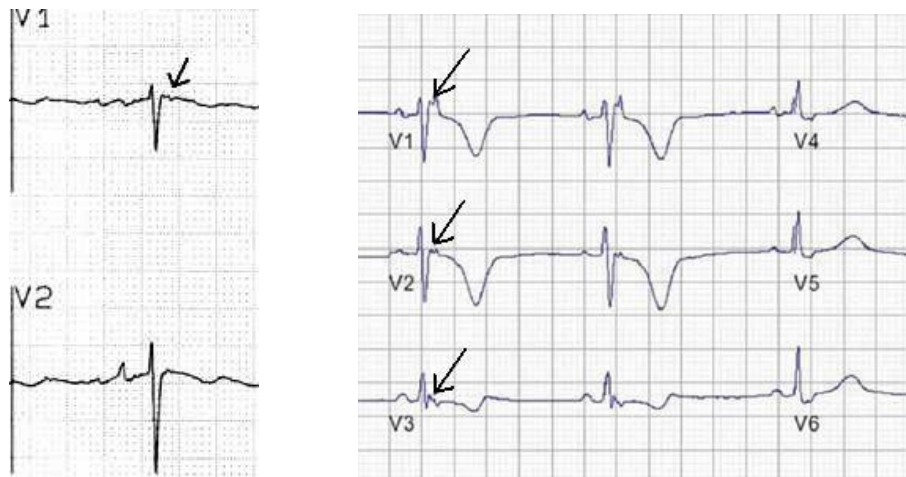**Figure 6-** Brugada ECG: High take-off and downsloping ST segment elevation in V_1-V_3

Figure 7 – Epsilon Wave: Small negative deflection just beyond the QRS in V_1 or V_2

[ECG criteria based on: Corrado D, Pelliccia A, Heidbuchel H, et al. Recommendations for interpretation of 12-lead electrocardiogram in the athlete. *Eur Heart J.* Jan 2010;31(2):243-259]