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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 ($R\text{-}V_1$ + $S\text{-}V_5$ > 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)<br>QTc ≥ 0.48 sec (99% females)<br>[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 $V_1$-$V_3$<br>(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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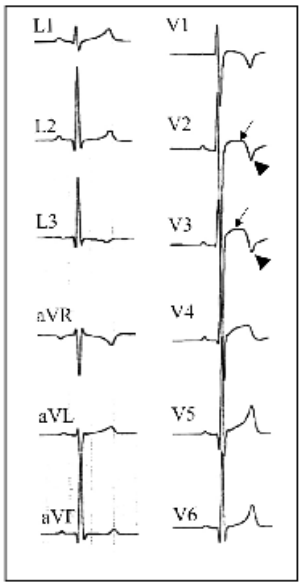



**Figure 1-** Normal variant of T wave inversion in athletes of African-Caribbean descent

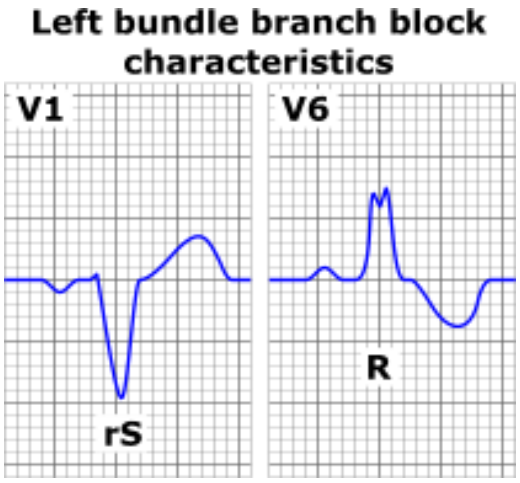



**Figure 2** – Left Bundle Branch Block: QRS > 0.12 sec, predominantly negative QRS complex in lead $V_1$ (QS or rS), and upright monophasic R wave in leads I and $V_6$

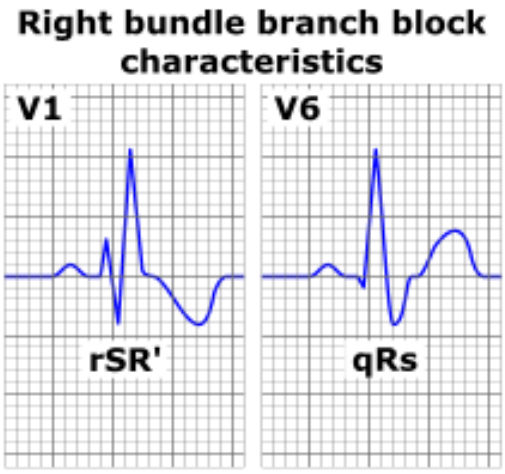



**Figure 3** – Right Bundle Branch Block: QRS > 0.12 sec, terminal R wave in lead $V_1$ (rsR'), and wide terminal S wave in leads I and $V_6$

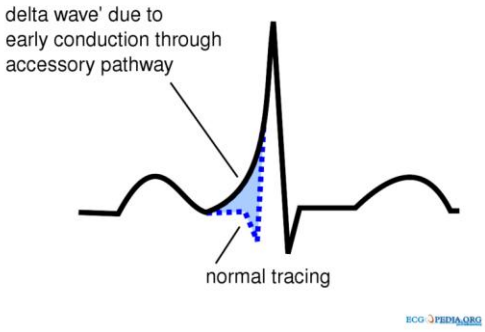
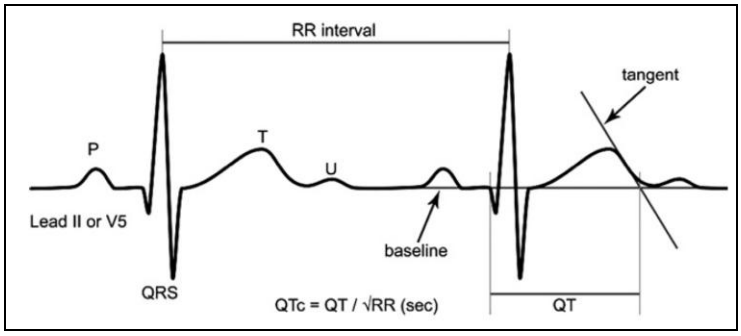



**Figure 4** – Delta Wave: Suggestive of ventricular pre-excitation; PR interval < 0.12 sec with or without a delta wave (slurred upstroke in the QRS complex)




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

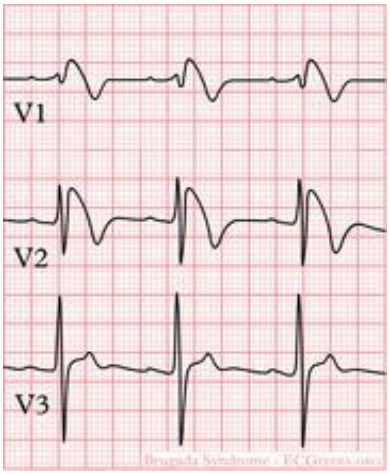
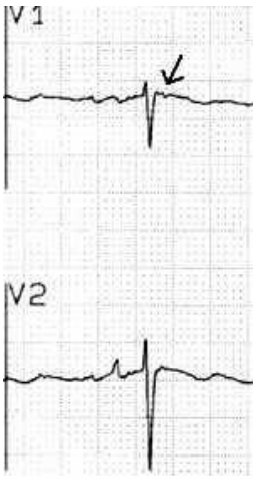



**Figure 6**- Brugada ECG: High take-off and downsloping ST segment elevation in $V_1$-$V_3$



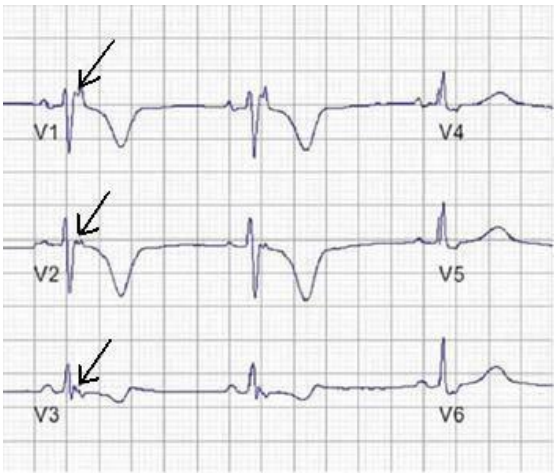




**Figure 7** – Epsilon Wave: Small negative deflection just beyond the QRS in $V_1$ or $V_2$

[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]