**Table 1: International Consensus Standards for Electrocardiographic Interpretation in Athletes: Definitions of ECG Criteria**

|  |  |
| --- | --- |
| **Abnormal ECG findings in athletes**  *These ECG findings are unrelated to regular training or expected physiologic adaptation to exercise, may suggest the presence of pathologic cardiovascular disease, and require further diagnostic investigation.* | |
| **ECG abnormality** | **Definition** |
| T wave inversion   * Anterior * Lateral * Inferolateral * Inferior | ≥ 1 mm in depth in two or more contiguous leads; excludes leads aVR, III, and V1   * V2-V4   + excludes: black athletes with J-point elevation and convex ST segment elevation followed by TWI in V2-V4; athletes < age 16 with TWI in V1-V3; and biphasic T waves in only V3 * I and AVL, V5 and/or V6 (only one lead of TWI required in V5 or V6) * II and aVF, V5-V6, I and AVL * II and aVF |
| ST segment depression | ≥ 0.5 mm in depth in two or more contiguous leads |
| Pathologic Q waves | Q/R ratio ≥ 0.25 or ≥ 40 ms in duration in two or more leads (excluding III and aVR) |
| Complete left bundle branch block | QRS ≥ 120 ms, predominantly negative QRS complex in lead V1 (QS or rS), and upright notched or slurred R wave in leads I and V6 |
| Profound nonspecific intra-ventricular conduction delay | Any QRS duration ≥ 140 ms |
| Epsilon wave | Distinct low amplitude signal (small positive deflection or notch) between the end of the QRS complex and onset of the T wave in leads V1-V3 |
| Ventricular pre-excitation | PR interval < 120 ms with a delta wave (slurred upstroke in the QRS complex) and wide QRS (≥ 120 ms) |
| Prolonged QT interval\* | QTc ≥ 470 ms (male)  QTc ≥ 480 ms (female)  QTc ≥ 500 ms (marked QT prolongation) |
| Brugada Type 1 pattern | Coved pattern: initial ST elevation ≥ 2 mm (high take-off) with downsloping ST segment elevation followed by a negative symmetric T wave in ≥ 1 leads in V1-V3 |
| Profound sinus bradycardia | < 30 BPM or sinus pauses ≥ 3 sec |
| Profound 1° AV block | ≥ 400 ms |
| Mobitz type II 2° AV block | Intermittently non-conducted P waves with a fixed PR interval |
| 3° AV block | Complete heart block |
| Atrial tachyarrhythmias | Supraventricular tachycardia, atrial fibrillation, atrial flutter |
| Premature ventricular contractions | ≥ 2 PVCs per 10 second tracing |
| Ventricular arrhythmias | Couplets, triplets, and non-sustained ventricular tachycardia |
| **Borderline ECG findings in athletes**  *These ECG findings in isolation likely do not represent pathologic cardiovascular disease in athletes, but the presence of two or more borderline findings may warrant additional investigation until further data become available.* | |
| **ECG abnormality** | **Definition** |
| Left axis deviation | -30° to -90° |
| Left atrial enlargement | Prolonged P wave duration of > 120 ms in leads I or II with negative portion of the P wave ≥ 1 mm in depth and ≥ 40 ms in duration in lead V1 |
| Right axis deviation | > 120° |
| Right atrial enlargement | P wave ≥ 2.5 mm in II, III, or aVF |
| Complete right bundle branch block | rSR′ pattern in lead V1 and a S wave wider than R wave in lead V6 with QRS duration ≥ 120 ms |
| **Normal ECG findings in athletes**  *These training-related ECG alterations are physiologic adaptations to regular exercise, considered normal variants in athletes, and do not require further evaluation in asymptomatic athletes with no significant family history.* | |
| **Normal ECG finding** | **Definition** |
| Increased QRS voltage | Isolated QRS voltage criteria for left (SV1 + RV5 or RV6 > 3.5 mV) or right ventricular hypertrophy (RV1 + SV5 or SV6 > 1.1 mV) |
| Incomplete RBBB | rSR′ pattern in lead V1 and a qRS pattern in lead V6 with QRS duration < 120 ms |
| Early repolarization | J point elevation, ST elevation, J waves, or terminal QRS slurring |
| Black athlete repolarization variant | J-point elevation and convex (“domed”) ST segment elevation followed by T wave inversion in leads V1-V4 in black athletes |
| Juvenile T wave pattern | T wave inversion V1-V3 in athletes < age 16 |
| Sinus bradycardia | ≥ 30 bpm |
| Sinus arrhythmia | Heart rate variation with respiration: rate increases during inspiration and decreases during expiration |
| Ectopic atrial rhythm | P waves are a different morphology compared to the sinus P wave, such as negative P waves in the inferior leads (“low atrial rhythm”) |
| Junctional escape rhythm | QRS rate is faster than the resting P wave or sinus rate and typically less than 100 beats/minute with narrow QRS complex unless the baseline QRS is conducted with aberrancy |
| 1° AV block | PR interval 200 ms to 400 ms |
| Mobitz Type I (Wenckebach) 2° AV block | PR interval progressively lengthens until there is a non-conducted P wave with no QRS complex; the first PR interval after the dropped beat is shorter than the last conducted PR interval |

\* The QT interval corrected for heart rate is ideally measured using Bazett’s formula with heart rates between 60-90 bpm; preferably performed manually in lead II or V5 using the teach-the-tangent method1 to avoid inclusion of a U wave (please see text for more details). Consider repeating the ECG after mild aerobic activity for a heart rate < 50 bpm, or repeating the ECG after a longer resting period for a heart rate > 100 bpm, if the QTc value is borderline or abnormal.