

PLACE 2026

"Le anomalie della ripolarizzazione ventricolare (RVA) nell'atleta giovane"



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ECG with ventricular repolarization abnormalities



What does it mean?

PHYSIOLOGICAL ADAPTATION

- Early repolarization
- Juvenile pattern
- Training effect

UNDERLYING HEART DISEASE

- Cardiomyopathies
- Myocarditis
- Channelopathies



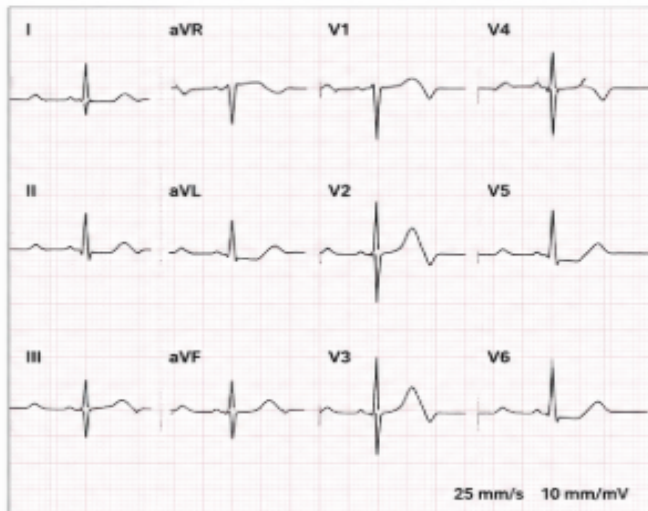
The challenge is not detecting the abnormality, but interpreting its clinical significance

A heterogeneous spectrum of ECG findings with different physiological and pathological implications





Repolarization pattern in a young athlete



Autonomic Adaptation

↑ Vagal Tone



Structural Remodeling

Athlete's Heart



Electrical Remodeling

Ion Channel Modulation



Growth & Maturation

Juvenile ECG Pattern



Exercise training reshapes ventricular repolarization through **autonomic**, **structural** and **electrical** adaptations.



How Common Are Ventricular Repolarization Abnormalities in Young Athletes?



PREVALENCE OF VENTRICULAR REPOLARIZATION ABNORMALITIES



EARLY REPOLARIZATION PATTERN

30–50%

Most common finding in trained athletes



JUVENILE PATTERN

5–15%

Age-dependent and usually benign



T-WAVE INVERSION

2–5%

Less common – requires careful evaluation

Values may vary depending on population, ethnicity and evaluation criteria. Sources: 1–4

FACTORS INFLUENCING PREVALENCE



Age

Younger athletes show higher prevalence



Ethnicity

Higher prevalence in Black athletes



Sex

Males > Females



Type of Sport

Endurance > Power



Training Load

Greater training volume increases prevalence



Most ventricular repolarization abnormalities are **physiological**, but **prevalence varies substantially** according to athlete characteristics.

WHAT THE LITERATURE TELLS US

1

Corrado D, et al.

JAMA. 2006;296:1593–1601

ERP is the most common ECG finding in elite athletes (up to 50%).

2

Papadakis M, et al.

Br J Sports Med. 2011;45:55–60

T-wave inversion prevalence 2–5%, more frequent in Black athletes.

3

Sharma S, et al.

Br J Sports Med. 2017;51:704–731

International Criteria improve interpretation and reduce false-positive rate.

4

D'Ascenzi F, et al.

Eur Heart J. 2019;40:1902–1910

Physiological cardiac adaptation explains most ECG changes in athletes.

ERP: Early Repolarization Pattern; ECG: Electrocardiogram; TWI: T-Wave Inversion.



Landmark studies shaping the interpretation of repolarization abnormalities in athletes



INTERNATIONAL CRITERIA 2017 REPOLARIZATION ABNORMALITIES (ARV) IN ATHLETES

— Classifying ECG findings to distinguish physiological from pathological patterns —



NORMAL FINDINGS (PHYSIOLOGICAL VARIANTS)



EARLY REPOLARIZATION /
ST SEGMENT ELEVATION



T WAVE INVERSION
V1-V3 AGE <16 YEARS



BLACK ATHLETE PATTERN



ABNORMAL FINDINGS (PATHOLOGICAL)



T WAVE INVERSION



ST SEGMENT DEPRESSION



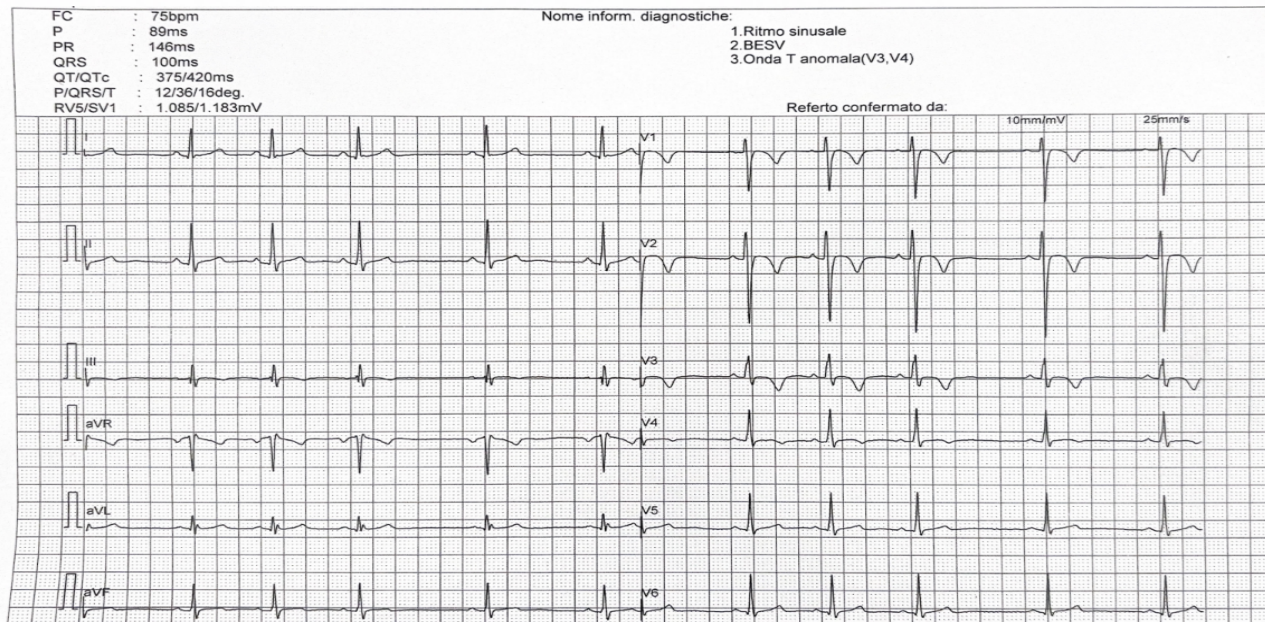
PROLONGED QT INTERVAL



BRUGADA PATTERN



13-year-old competitive athlete



Male



13 years



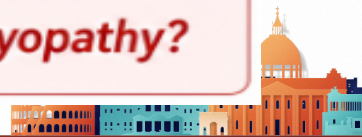
Asymptomatic



Competitive athlete

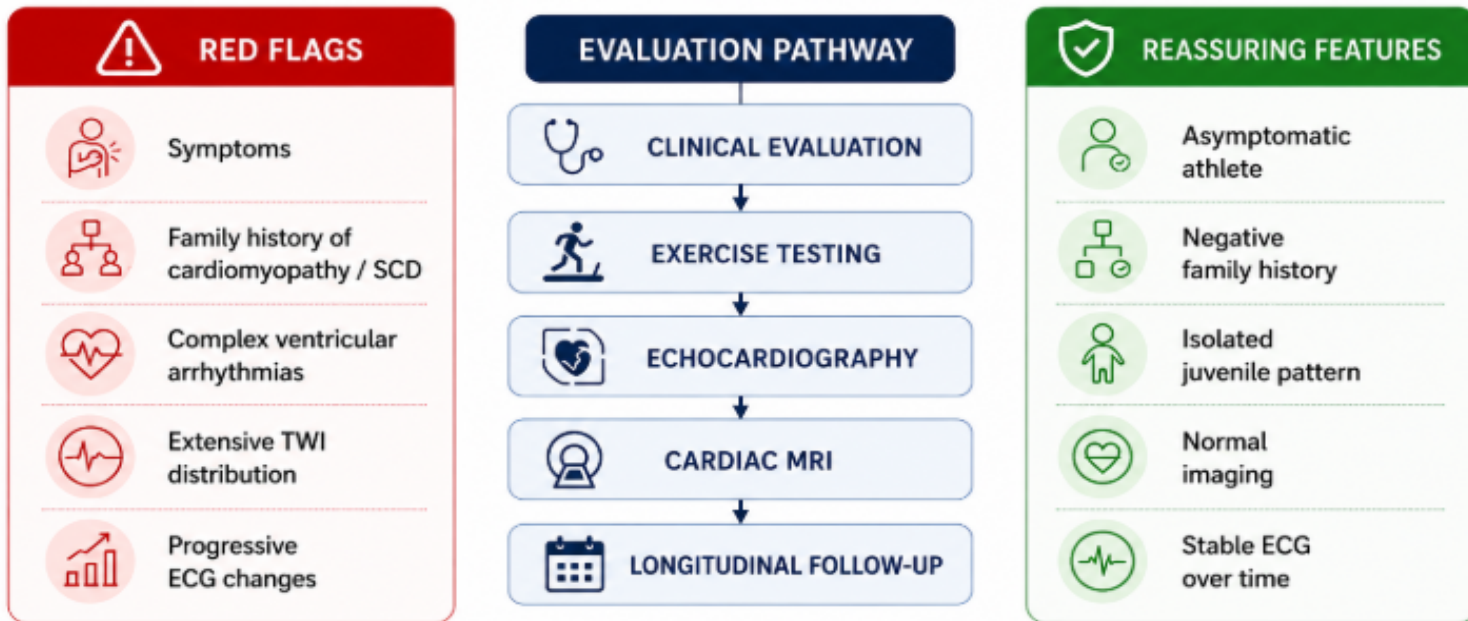


Physiological adaptation or marker of concealed cardiomyopathy?



T-WAVE INVERSION: beyond the ECG

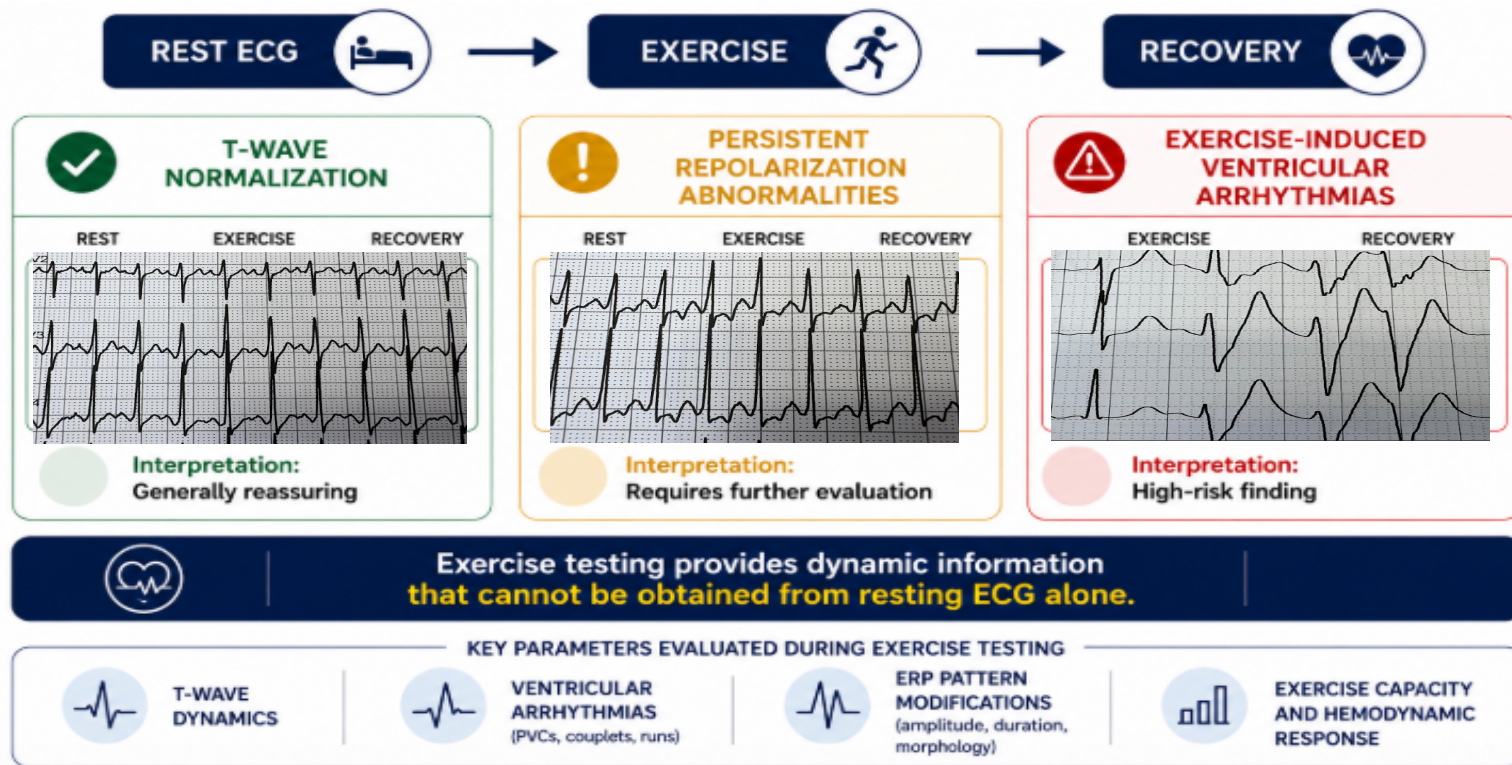
A multiparametric approach to risk stratification



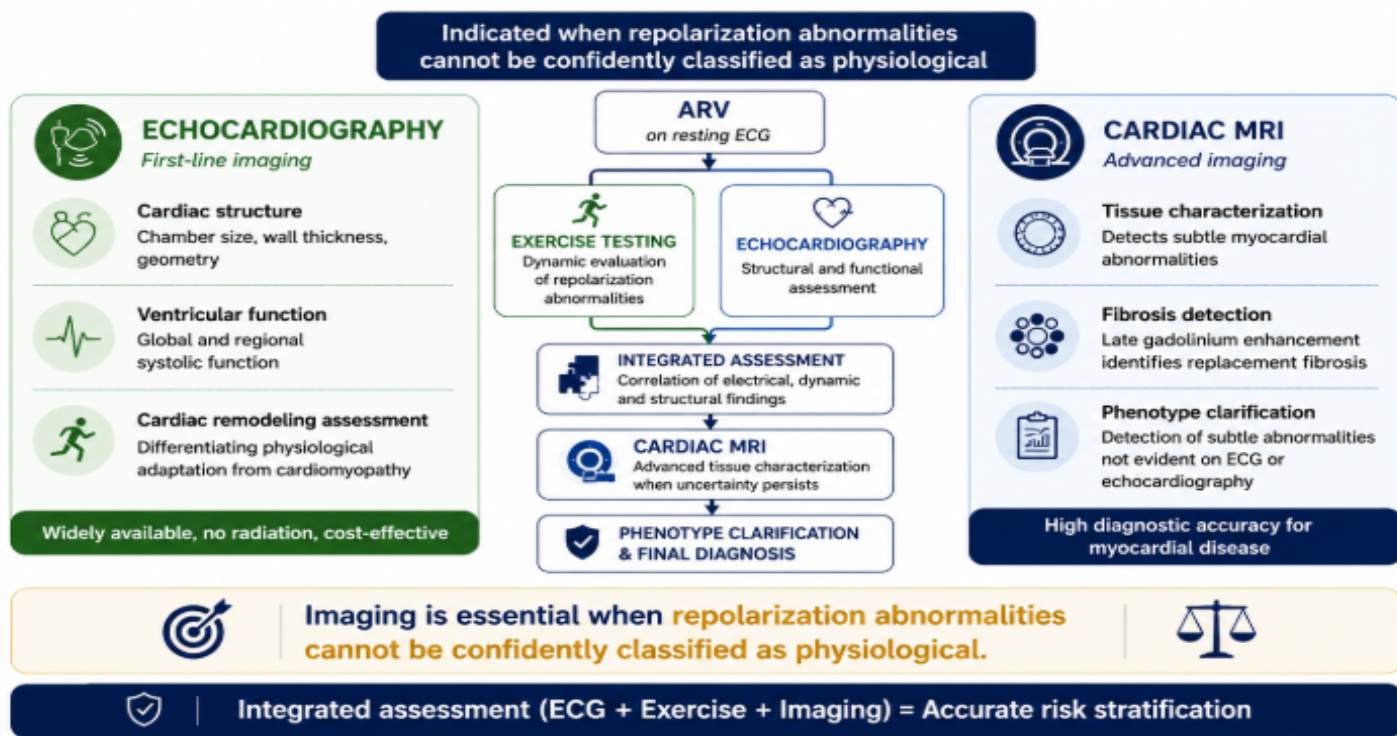
The clinical significance of T-wave inversion cannot be determined from the ECG alone.



Dynamic evaluation of repolarization abnormalities



Complementary tools in the evaluation of athletes with RVA



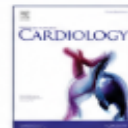


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**SICSport
EXPERT OPINION
STATEMENT**

SIC SPORT 2025

A PRACTICAL APPROACH TO T-WAVE INVERSION IN ATHLETES

— Key messages from the SICSport Expert Opinion Statement —



ANTERIOR TWI

Potentially Physiological

- Juvenile pattern
- Pre-pubertal athletes
- Negative family history
- Absence of symptoms

Typically V1–V3

May extend to V4 in pre-pubertal children



Clinical evaluation
and follow-up



INFERIOR TWI

Grey Zone

- Isolated finding
- Low positive predictive value
- Interpretation depends on clinical context
- Imaging often required



Individualized
assessment



LATERAL TWI

(I, aVL, V5–V6)

- Strong association with cardiomyopathy
- Echocardiography
- Exercise testing
- Cardiac MRI
- Serial follow-up



Mandatory
investigation



KEY MESSAGE

The clinical significance of T-wave inversion is determined by **its localization, phenotype and evolution over time** — not by the ECG finding alone.



Palermi S, Tardini L, Graziano F, et al. Interpretation and management of T wave inversion in athletes: An expert opinion statement of the Italian Society of Sports Cardiology (SICSport).

Int J Cardiol. 2025;422:132968.





THE FORO ITALICO LONGITUDINAL RESEARCH PROJECT

UNIVERSITÀ DEGLI STUDI DI ROMA
"FORO ITALICO"

Sports Cardiology
Research Unit

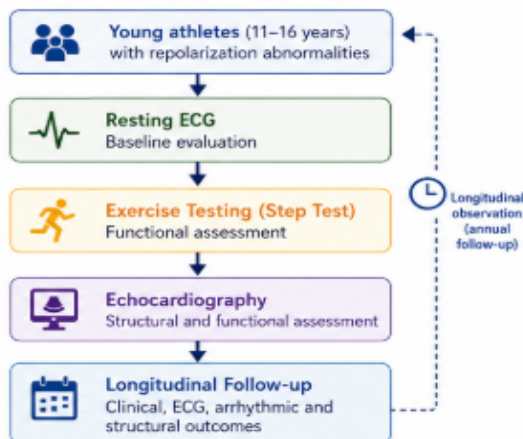
Moving from static interpretation to dynamic risk stratification



WHY IS IT NEEDED?

- Limited prospective longitudinal data in young athletes with ARV
- Uncertain prognostic significance of repolarization abnormalities
- Lack of pediatric and adolescent longitudinal studies
- Need for improved risk stratification beyond ECG and imaging

STUDY DESIGN



STUDY OBJECTIVES



Evolution of repolarization abnormalities over time



Development of ventricular arrhythmias



Structural and functional cardiac changes



Clinical outcomes and risk stratification



BIOCHEMICAL ASSESSMENT

Oxidative stress biomarkers

Assessment of the biological substrate underlying electrical and structural changes



Not all repolarization abnormalities are pathological — only **longitudinal observation and biological profiling** can distinguish benign adaptation from early cardiomyopathy.



A multidisciplinary approach for safer sports participation



Thank You for Your Attention

Lorenzo Morra, MD

University of Rome "Foro Italico"

