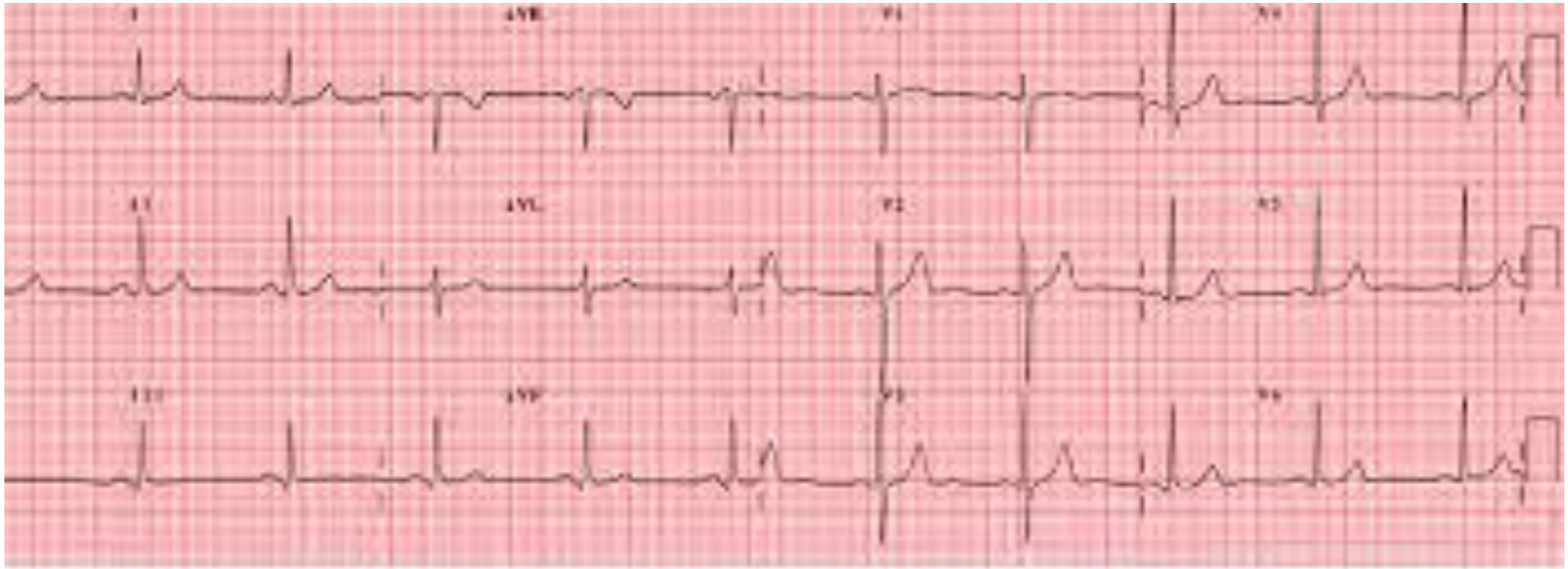
La telemedicina nella diagnostica e nella ricerca sul territorio: l'esempio dell' ECG

Dr. Bennicelli Riccardo

Fano 8 aprile 2017

Elettrocardiogramma

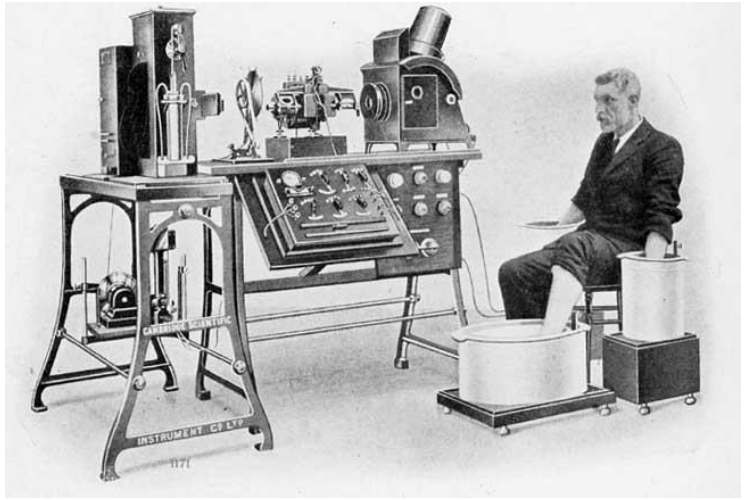


Elettrocardiogramma standard (ECG 12 derivazioni, eseguito con il paziente sdraiato e a riposo)

ECG

L’ECG rappresenta la metodica più utilizzata nella pratica medico-sportiva,

La finalità principale dell’ ECG nello screening medico-sportivo è la identificazione delle patologie cardiache che sono responsabili della morte improvvisa dell’atleta.



ECG di routine in tutti gli atleti?

Due posizioni contrapposte

AHA Scientific Statement

Recommendations and Considerations Related to Preparticipation Screening for Cardiovascular Abnormalities in Competitive Athletes: 2007 Update

A Scientific Statement From the American Heart Association Council on Nutrition, Physical Activity, and Metabolism

Endorsed by the American College of Cardiology Foundation

Barry J. Maron, MD, Chair; Paul D. Thompson, MD, FAHA, Co-Chair; Michael J. Ackerman, MD, PhD; Gary Balady, MD, FAHA; Stuart Berger, MD; David Cohen, MD; Robert Dimeff, MD; Pamela S. Douglas, MD, FAHA; David W. Glover, MD; Adolph M. Hutter, Jr, MD, FAHA; Michael D. Krauss, MD; Martin S. Maron, MD; Matthew J. Mitten, JD; William O. Roberts, MD; James C. Puffer, MD

NO

ESC Report

Cardiovascular pre-participation screening of young competitive athletes for prevention of sudden death: proposal for a common European protocol

Consensus Statement of the Study Group of Sport Cardiology of the Working Group of Cardiac Rehabilitation and Exercise Physiology and the Working Group of Myocardial and Pericardial Diseases of the European Society of Cardiology

Domenico Corrado[1]*, Antonio Pelliccia[2], Hans Halvor Bjørnstad[3], Luc Vanhees[4], Alessandro Biffi[2], Mats Borjesson[5], Nicole Panhuyzen-Goedkoop[6], Asterios Deligiannis[7], Erik Solberg[8], Dorian Dugmore[9], Klaus P. Mellwig[10], Deodato Assanelli[11], Pietro Delise[12], Frank van-Buuren[10], Aris Anastasakis[13], Hein Heidbuchel[4], Ellen Hoffmann[14], Robert Fagard[4], Silvia G. Priori[15], Cristina Basso[19], Eloisa Arbustini[16], Carina Blomstrom-Lundqvist[17], William J. McKenna[18], and Gaetano Thiene[19]

SI

TABLE. The 12-Element AHA Recommendations for Preparticipation Cardiovascular Screening of Competitive Athletes

Medical history*

Personal history

1. Exertional chest pain/discomfort
2. Unexplained *syncope/near-syncope*†
3. Excessive exertional and unexplained dyspnea/fatigue, associated with exercise
4. Prior recognition of a heart murmur
5. Elevated *systemic* blood pressure

Family history

6. Premature death (sudden and unexpected, or otherwise) before age 50 years due to heart disease, in ≥1 relative
7. Disability from heart disease in a close relative <50 years of age
8. Specific knowledge of certain cardiac conditions in family members: hypertrophic or dilated cardiomyopathy, long-QT syndrome or other ion channelopathies, Marfan syndrome, or clinically important arrhythmias

Physical examination

9. Heart murmur‡
10. Femoral pulses to exclude aortic coarctation
11. Physical stigmata of Marfan syndrome
12. Brachial artery blood pressure (sitting position)§

ECG is not cost-effective for screening a large population of young athletes due to

- its low specificity
- limited diagnostic value for detecting coronary artery disease in asymptomatic masters population

Table 1. Causes of Sudden Death in 387 Young Athletes*

Cause	No. of Athletes	Percent
Hypertrophic cardiomyopathy	102	26.4
Commotio cordis	77	19.9
Coronary artery anomalies	53	13.7
Left ventricular hypertrophy of indeterminate causation†	29	7.5
Myocarditis	20	5.2
Ruptured aortic aneurysm (Marfan syndrome)	12	3.1
Arrhythmogenic right ventricular cardiomyopathy	11	2.8
Tunneled (bridged) coronary artery‡	11	2.8
Aortic valve stenosis	10	2.6
Atherosclerotic coronary artery disease	10	2.6
Dilated cardiomyopathy	9	2.3
Myxomatous mitral valve degeneration	9	2.3
Asthma (or other pulmonary condition)	8	2.1
Heat stroke	6	1.6
Drug abuse	4	1.0
Other cardiovascular cause	4	1.0
Long QT syndrome§	3	0.8
Cardiac sarcoidosis	3	0.8
Trauma causing structural cardiac injury	3	0.8
Ruptured cerebral artery	3	0.8

Incidenza M.I. negli atleti

(Maron BJ, JACC 1998)

For example, if we assume 10 million high school and middle school athletes would be eligible for annual screening with costs (based on Center for Medicare Services–approved reimbursements) of $25 per each personal and family history and physical examination and $50 for each ECG, the expense for the primary evaluations would be $750 million. These basic costs are ≈2-fold those estimated for Italy.[58] In addi-

Maron BJ, Shirani J, Poliac LC, Mathenge R, Boberts WC, Mueller FO. Sudden death in young competitive athletes. Clinical, demographics, and pathological profiles. JAMA 1996;276:199–204.

One retrospective analysis on 134 high
school and collegiate athletes who died suddenly
showed that cardiovascular abnormalities were suspected
by standard history and physical examination
screening in only 3% of the examined athletes and, eventually, less than 1%
received an accurate diagnosis.

Trends in Sudden Cardiovascular Death in Young Competitive Athletes After Implementation of a Preparticipation Screening Program

Domenico Corrado, MD, PhD; Cristina Basso, MD, PhD; Andrea Pavei, MD; Pierantonio Michieli, MD, PhD; Maurizio Schiavon, MD; Gaetano Thiene, MD

JAMA. 2006;296:1593-1601.

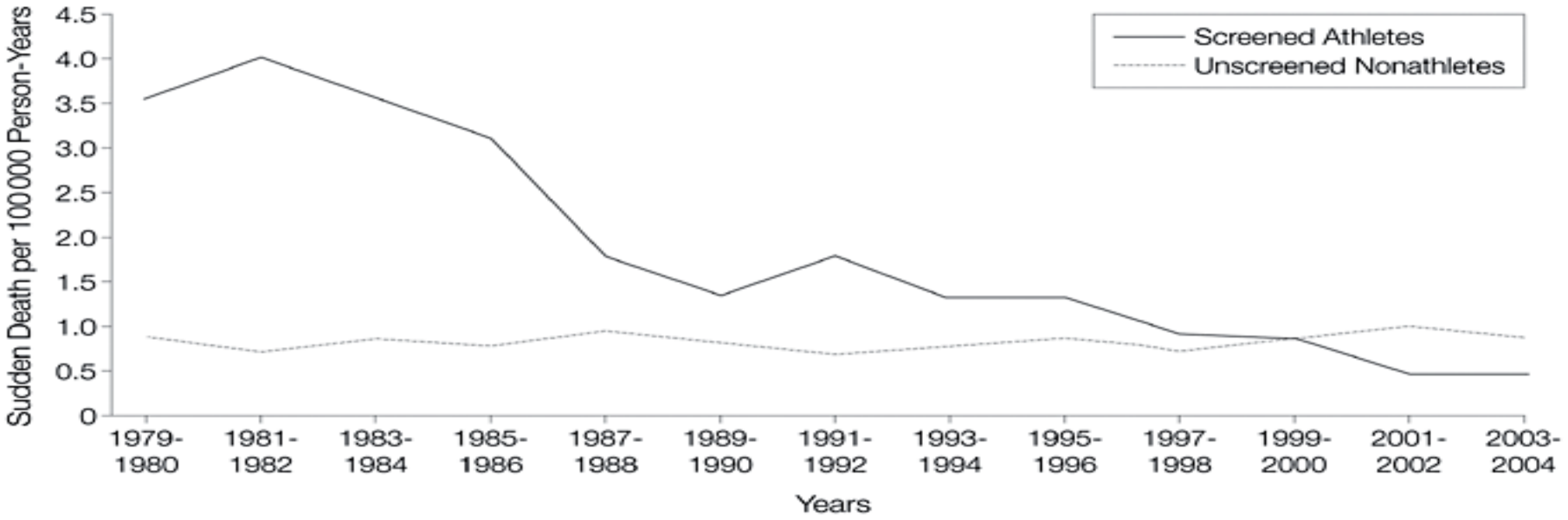


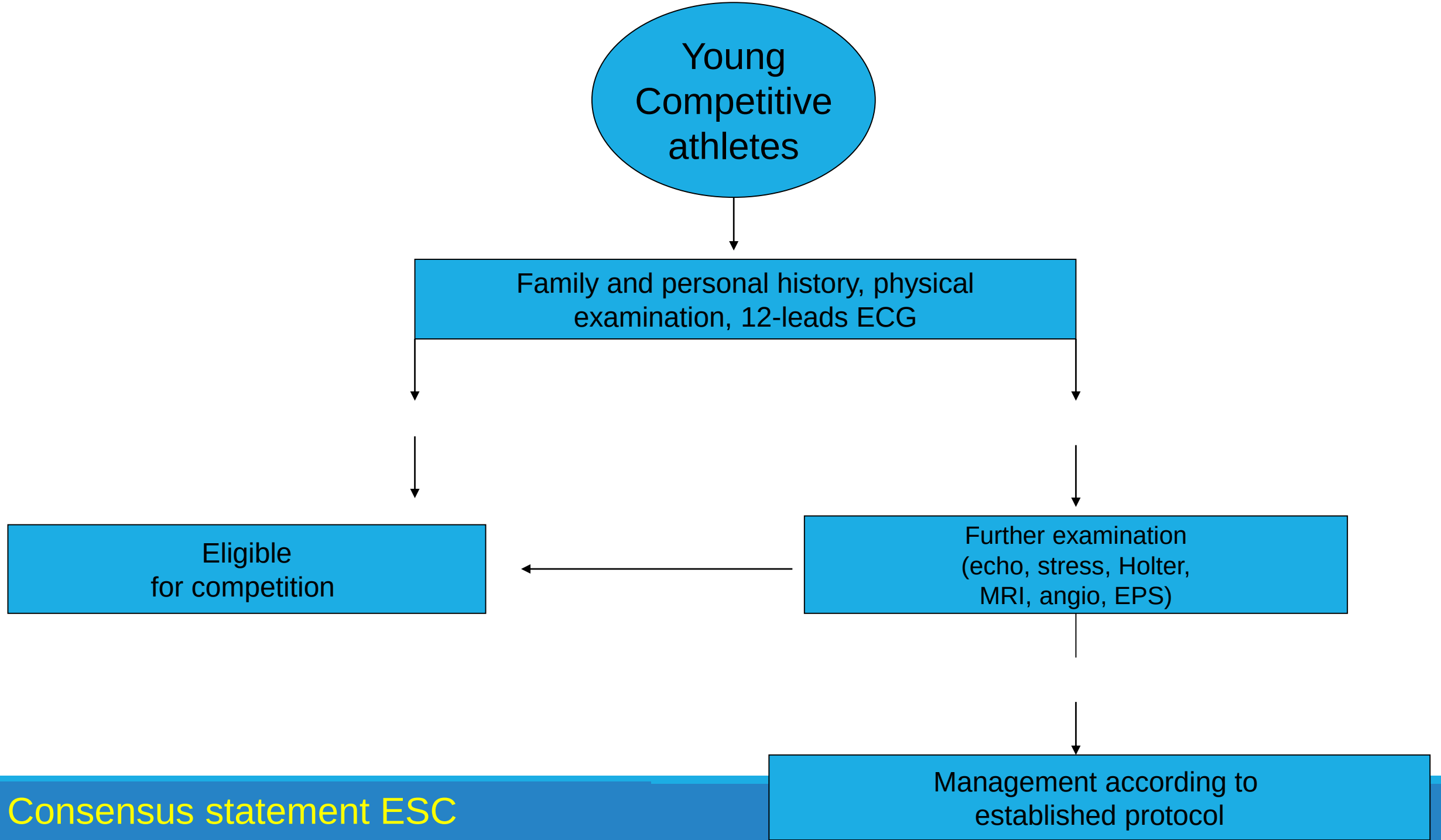
Figure. Annual Incidence Rates of Sudden Cardiovascular Death in Screened Competitive Athletes and Unscreened Nonathletes Aged 12 to 35 Years in the Veneto Region of Italy (1979-2004)

A large proportion of cardiovascular diseases underlying sudden death in young competitive athletes are detectable by ECG.[13] Silent but potentially lethal conditions, distinctively manifesting with ECG abnormalities, include cardiomyopathies, such as hypertrophic cardiomyopathy, arrhythmogenic right ventricular cardiomyopathy, and dilated cardiomyopathy; conduction system diseases, such as Lenègre disease and Wolff-Parkinson-White syndrome; and cardiac ion channel diseases, such as long and short QT syndromes and Brugada syndrome.

The Italian screening, essentially based on 12-lead ECG (in addition to history and physical examination) has been previously shown to be effective in detecting athletes with hypertrophic cardiomyopathy.[11, 23-24] Moreover, no deaths occurred during long-term follow-up among athletes with hypertrophic cardiomyopathy who were disqualified from competitive sports, suggesting that screening may prevent sudden death.[11]

Table 2 Causes of sudden deaths in athletes and non-athletes (aged ≤35 years) in the Veneto region of Italy from 1979 to 1996

	Athletes (*n*=49) *n* (%)	Non-athletes (*n*=220) *n* (%)	Total (*n*=269) *n*(%)
Arrhythmogenic RV cardiomyopathy	11 (22.4)	18 (8.2)*	29 (10.8)
Atherosclerotic coronary artery disease	9 (18.5)	36 (16.4)	45 (16.7)
Anomalous origin of coronary artery	6 (12.2)	1 (0.4)**	7 (2.6)
Conduction system pathology	4 (8.2)	20 (9)	24 (8.9)
Mitral valve prolapse	5 (10.2)	21 (9.5)	26 (9.7)
HCM	1 (2)	16 (7.3)	17 (6.3)
Myocarditis	3 (6.1)	19 (8.6)	22 (8.2)
Myocardial bridge	2 (4)	5 (2.3)	7 (2.6)
Pulmonary thrombo-embolism	1 (2)	3 (1.4)	4 (1.5)
Dissecting aortic aneurysm	1 (2)	11 (5)	12 (4.5)
Dilated cardiomyopathy	1 (2)	9 (4.1)	10 (3.7)
Other	5 (10.2)	61 (27.7)	66 (24.5)



Consensus statement ESC

Dati non comparabili

Differences in ethnic and genetic factors

Age

- US High-school and College Athletes (mean age 19 yrs)

  Vs

- Italian Athletes

  (< 35 yrs)

The standard 12-lead ECG is of limited diagnostic value for detecting coronary artery disease in an asymptomatic masters population.

Nevertheless, the ECG, when used as part of a preparticipation screening evaluation, may occasionally identify unexpected evidence of a healed myocardial infarction.

ECG can be particularly helpful in detecting certain diseases less common in the masters population, such as hypertrophic cardiomyopathy, long-QT, Brugada, and Wolff-Parkinson-White syndromes, and arrhythmogenic right ventricular cardiomyopathy.

ECG is abnormal in up to 95% of patients with HCM, which is the leading cause of sudden death in the athlete.

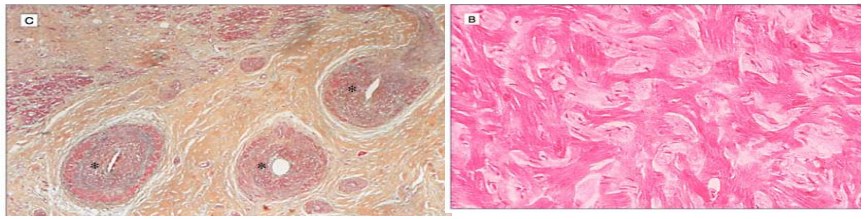
Likewise, ECG abnormalities have also been documented in the majority of athletes who died from ARVC/D (50-70%).

HCM

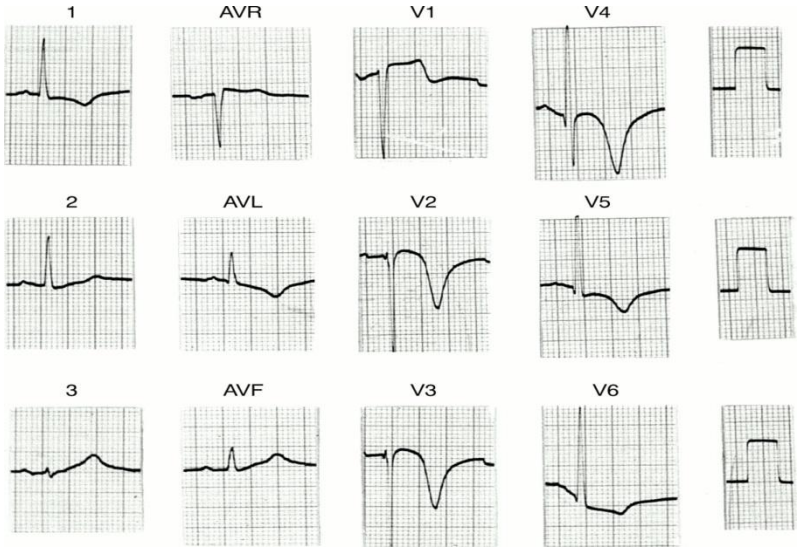
ipertrofia del ventricolo sinistro

VS non dilatato

aumento della frazione di eiezione (ridotto VTS)



- ipertrofia e disorganizzazione dei miociti
- aumento del collageno intestiziale



ECG

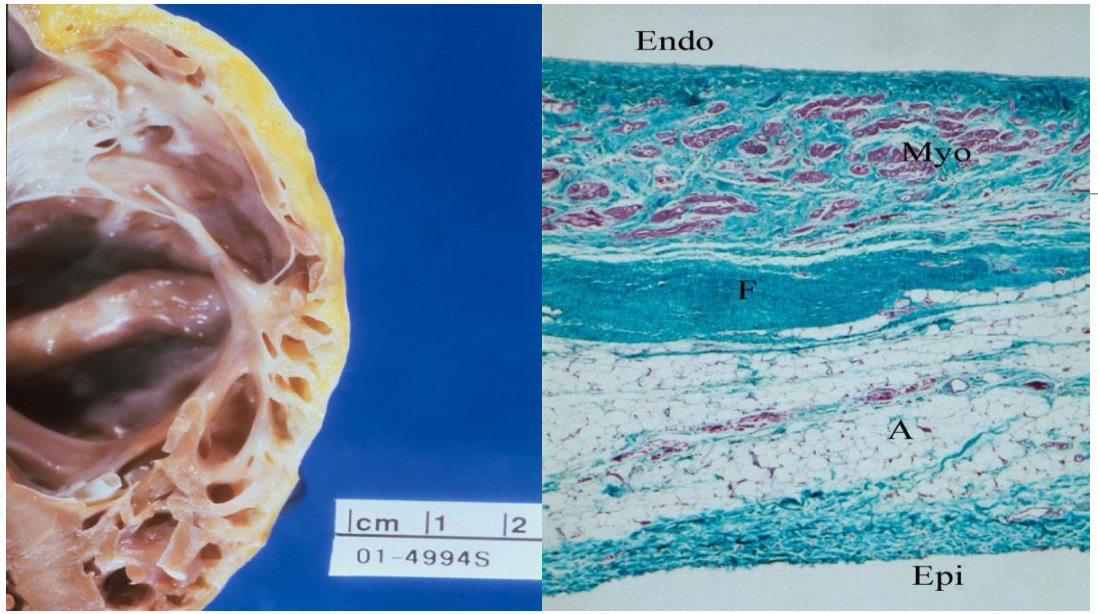
Alti voltaggi nelle precordiali sn

Onde Q in inf. o lat.

Sopra- /sotto-ST

Onde T invertite giganti

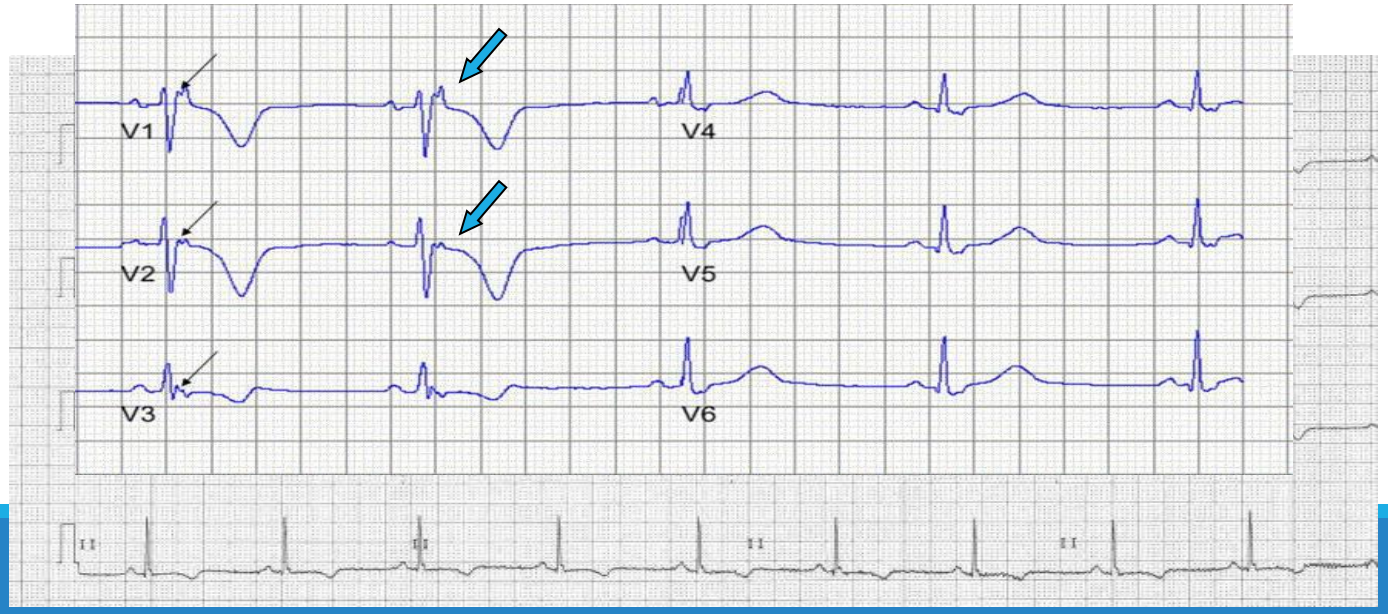
ARVC / D



Interessamento predominante del VD

Perdita progressiva di miociti e sostituzione con tessuto adiposo o fibroadiposo

Alterazioni globali o segmentarie della contrattilità VD



Alterazioni ECG nel 90% dei pazienti

QRS >110 ms in V1-V3

Onde ε inV1–V3 (30% pz)

Onde T invertite in V1-V3 (50-70% pz)

BBD completo o incompleto (15-20% pz)

TV con morfologia tipo BBS

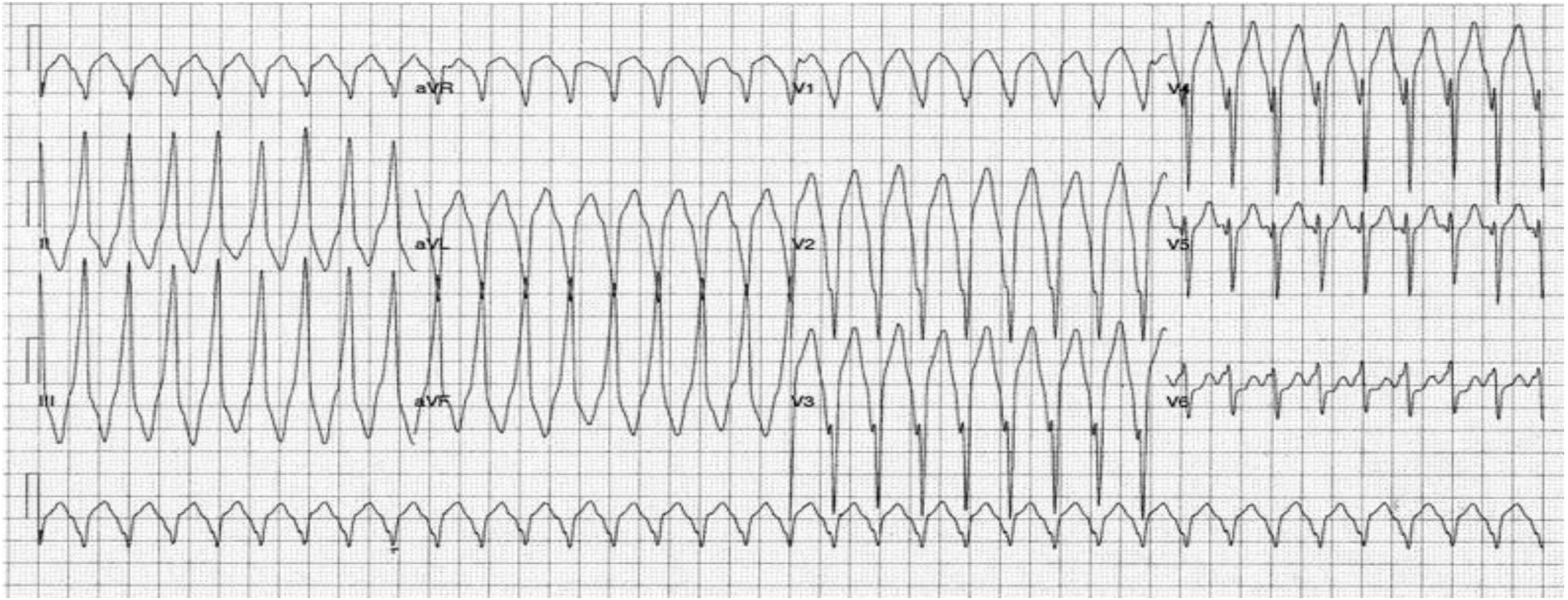
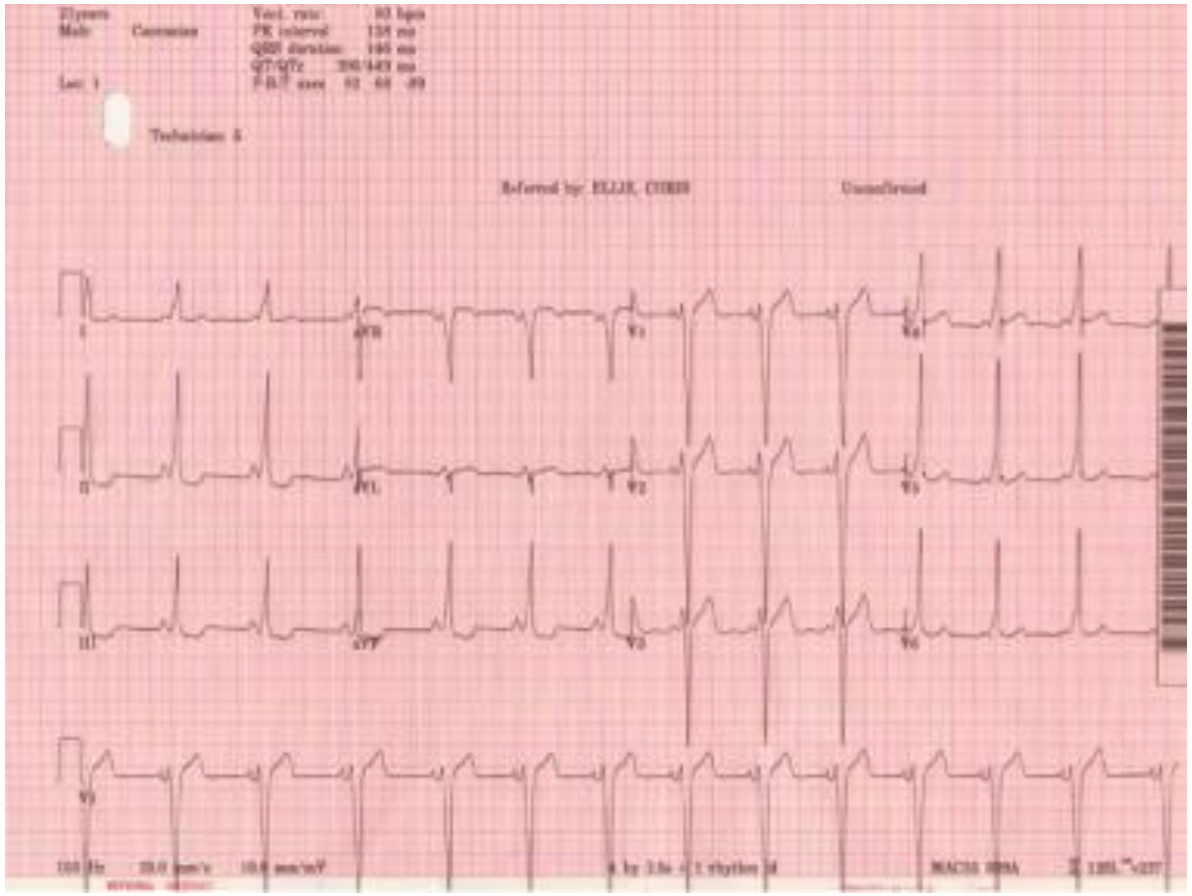


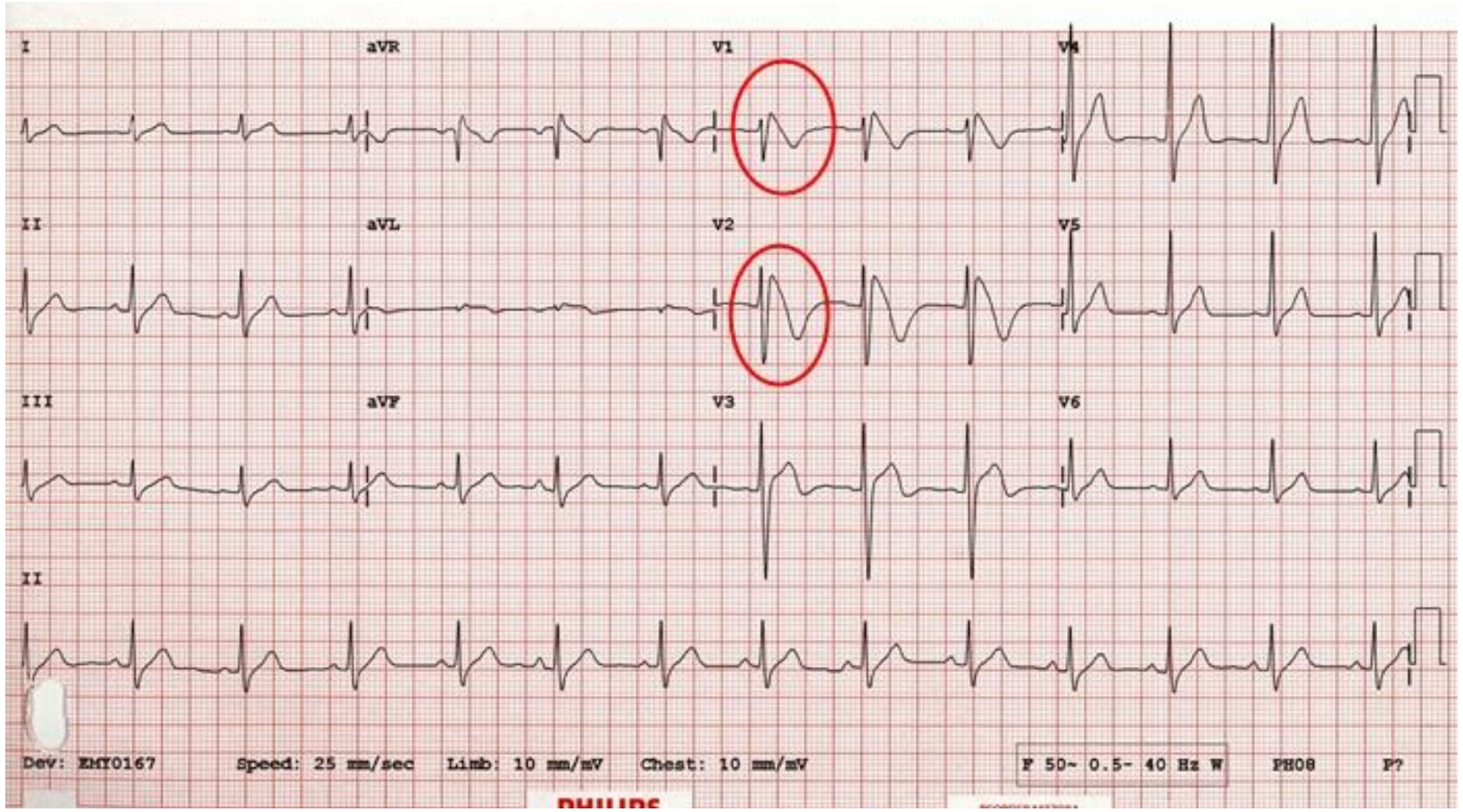
Table 4 ECG Features of cardiac diseases detectable at pre-participation screening in young competitive athletes

Disease	QTc interval	P wave	PR interval	QRS complex	ST interval	T wave	Arrhythmias
Dilated cardiomyopathy	Normal	(Left atrial enlargement)	(Prolonged ≥0.21 s)	LBBB	Down-sloping (up-sloping)	Inverted in inferior and/or lateral leads	PVB; (VT)
Long QT syndrome	Prolonged >440 ms in males >460 ms in females	Normal	Normal	Normal	Normal	Bifid or biphasic in all leads	(PVB); (torsade de pointes)
Brugada syndrome	Normal		Prolonged ≥0.21 s	S1S2S3 pattern; (RBBB/LAD)	Up-sloping coved-type in right precordial leads	Inverted in right precordial leads	(Polymorphic VT); (atrial fibrillation) (sinus bradycardia)
Lenègre disease	Normal	Normal	Prolonged ≥0.21 s	RBBB; RBBB/LAD; LBBB	Normal	Secondary changes	(2nd or 3rd degree AV block)
Short QT syndrome	Shortened <300 ms	Normal	Normal	Normal	Normal	Normal	Atrial fibrillation (polymorphic VT);
Pre-excitation syndrome (WPW)	Normal	Normal	Shortened <0.12 s	Delta wave	Secondary changes	Secondary changes	Supraventricular tachycardia; (atrial fibrillation)
Coronary artery diseases[a]	(Prolonged)	Normal	Normal	(Abnormal Q waves)[b]	(Down- or up-sloping)	Inverted in ≥2 leads	PVB; (VT);

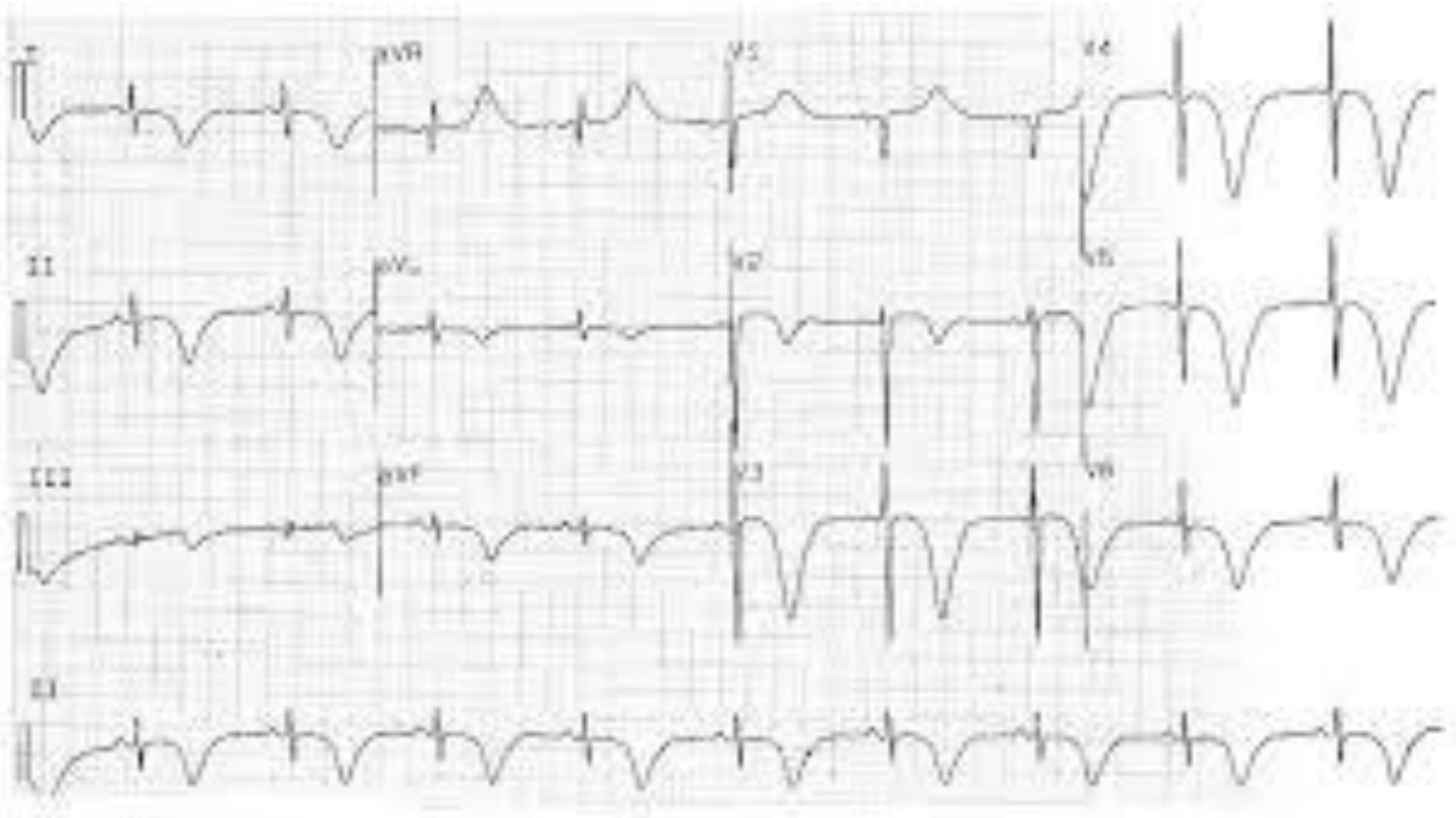
Wolff Parkinson White



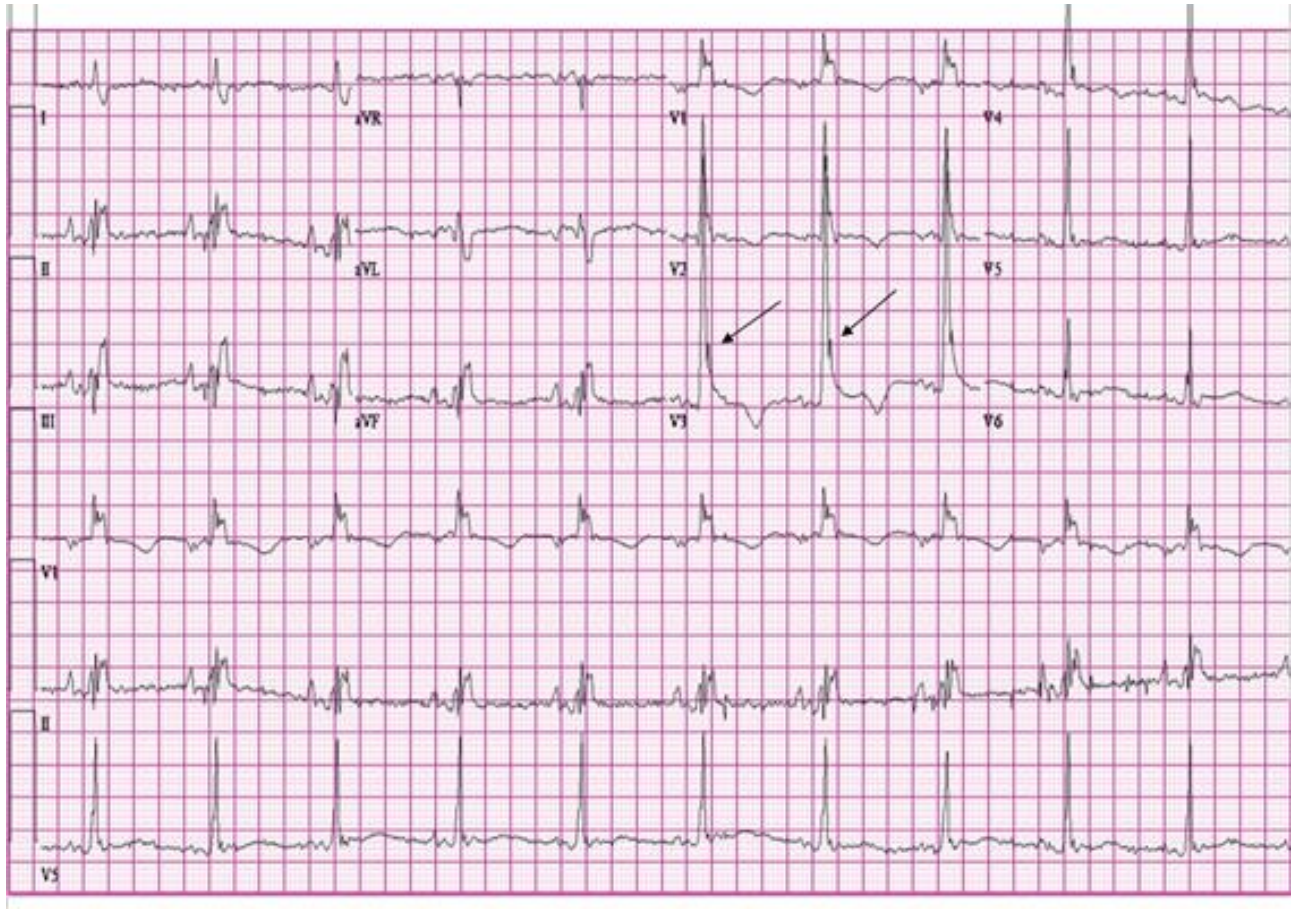
Brugada Pattern tipo 1



HCM



Displasia aritmogena del Vn destro



Valore predittivo dell'ECG nelle cardiopatie a elevato rischio di M.I.

Patologie cardiache	V.P.
ARVD; CMPI; Sindromi: WPW, QT-lungo, QT-corto, Brugada. Anomalie di conduzione	+++
CAD e anomalie coronariche; miocarditi; CMP dilatativa	++
Patologie valvolari	+

Per Telemedicina si intende una modalità di erogazione di servizi di assistenza sanitaria, tramite il ricorso a tecnologie innovative, in particolare alle Information and Communication Technologies (ICT), in situazioni in cui il professionista della salute e il paziente (o due professionisti) non si trovano nella stessa località.

La necessità di nuovi dati

Sports Med
DOI 10.1007/s40279-016-0609-7

ORIGINAL RESEARCH ARTICLE

Electrocardiograms of Children and Adolescents Practicing Non-competitive Sports: Normal Limits and Abnormal Findings in a Large European Cohort Evaluated by Telecardiology

Giuseppe Molinari[1] · Natale Daniele Brunetti[2] · Luigi Biasco[3] · Sandro Squarcia[4] · Yvonne Cristoforetti[3] · Riccardo Bennicelli[1] · Cecilia Del Vecchio[1] · Cecilia Viacava[1] · Carla Giustetto[3] · Fiorenzo Gaita[3]

Abstract

Objective The objective of this study was to derive normal electrocardiographic values and to report the abnormal findings in a large contemporary European cohort of physically active children and young adolescents.

Methods In a 3-month period, data derived from subjects aged between 3 and 14 years and referred to the Telecardiology Centre (Genoa, Italy) for electrocardiogram (ECG) evaluation as pre-participation screening for non-competitive sports were analyzed.

Results A total of 2060 ECGs were recorded. Of those, 1962 did not show any morphological abnormality and were used to derive normality ranges for heart rate, PR interval, QRS duration, corrected QT interval, and voltage of R wave as measured in V1 according to age and sex. Findings and clinical implications of the 98 ECGs with abnormal findings were also reported. Abnormal ECG findings were not as uncommon as expected in this population, being manifest in about 5 % of subjects. However, major ECG anomalies (diffuse negative T-waves, pre-excitation) were present in just ten subjects (0.5 %). Lower mean heart rate values (from 90–100 bpm at 3 years of age to 80–85 bpm at 14 years of age) and lower rates of the prevalence of negative T-waves in the V3 lead (from 55–60 % at 3 years of age to 8–10 % at 14 years of age) were observed with increasing age.

Conclusions This is the first work reporting derived normal limits and abnormal ECG findings in a large contemporary European cohort of children and adolescents aged 3–14 years practicing non-competitive sports. Clear pathological alterations are extremely uncommon, deserving, when encountered, additional examinations. Even in a physically active population, the common features of an adult athlete's ECG are absent.

Key Points

Electrocardiogram limits of normality in children or adolescents practicing sport activity are not well known.

Fig. 1 Location of centers participating in the study and sending children and adolescents' electrocardiograms to a telemedicine 'hub' center where electrocardiograms were interpreted and sent back [number per Italian district (province)]

Table 1 Baseline characteristics of subjects with normal ECGs

Characteristics	$n = 1962$
Age (years)	8 (6–10)
Male, *n* (%)	1075 (52)
Ethnicity, *n* (%)	
Caucasian	1889 (96.3)
Asian	22 (1.1)
African	26 (1.3)
Latin American	25 (1.2)
Practiced sports[a], *n* (%)	
A	188 (9.6)
B	163 (8.3)
C	322 (16.4)
D1	754 (38.4)
D2	535 (27.3)
ECG[b]	
Heart rate (bpm)	85 (75–96)
PR interval (ms)	140 (130–154)
QRS duration (ms)	92 (82–100)
Sokolow Lyon index (mV)	25 (22–30)
QT duration (ms)	358 (340–376)
QTc (Bazett) (ms)	426 (407–444)

ECGs electrocardiograms, *COCIS* Comitato Organizzativo Cardiologico per l'Idoneità allo Sport

[a] According to the COCIS classification [A: low cardiac involvement (e.g., golf), B: moderate cardiac involvement (horse riding), C: cardiac involvement with isometric strain (body building), D1: moderate to high cardiac involvement (e.g., football), D2: moderate to high cardiac involvement with persistent increase in heart rate (marathon)]

[b] Data are expressed as median (interquartile range)

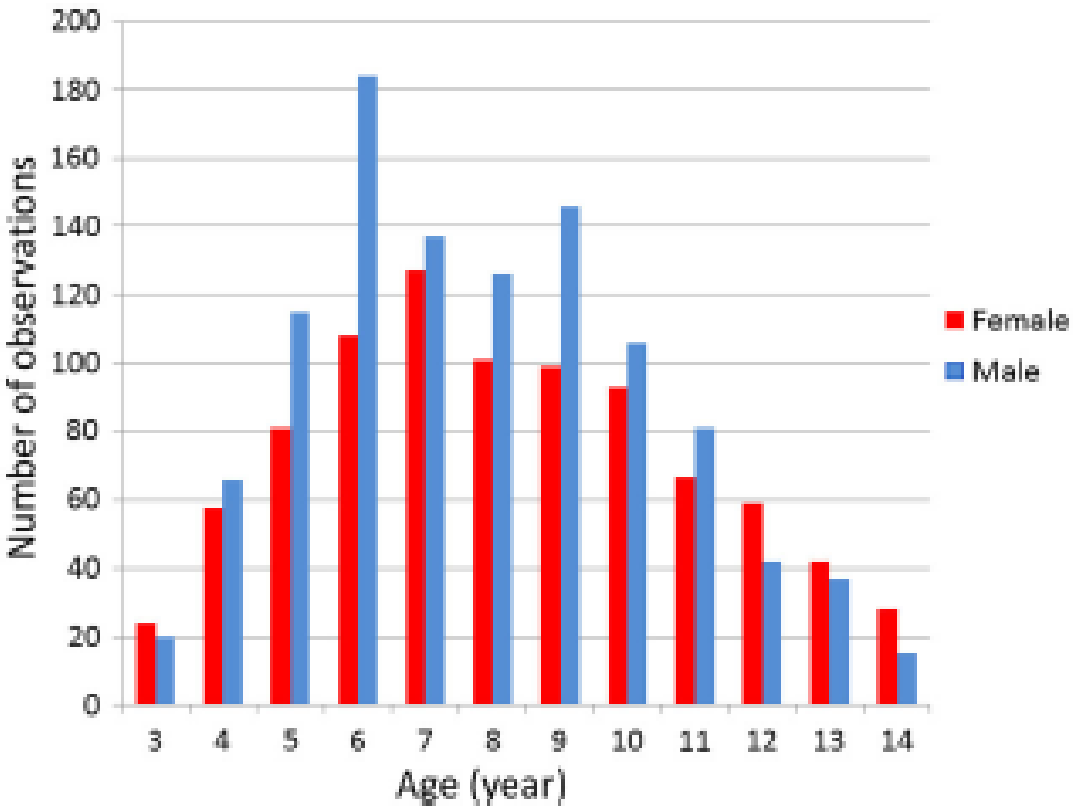
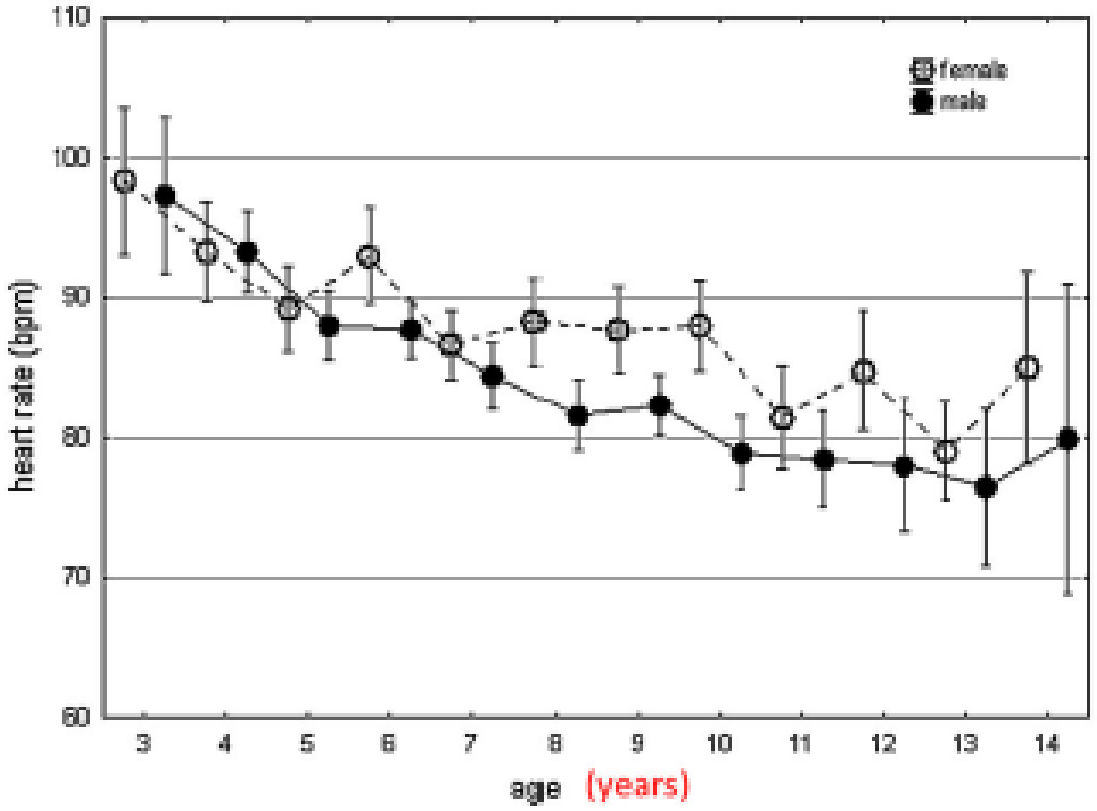
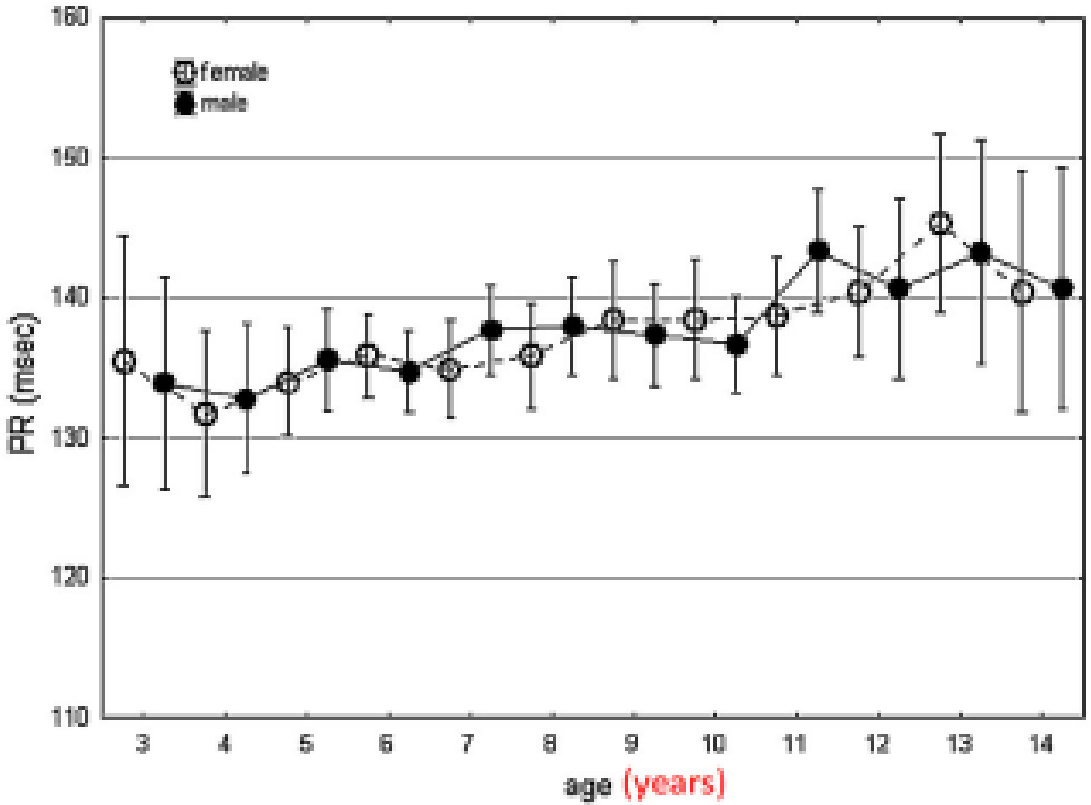
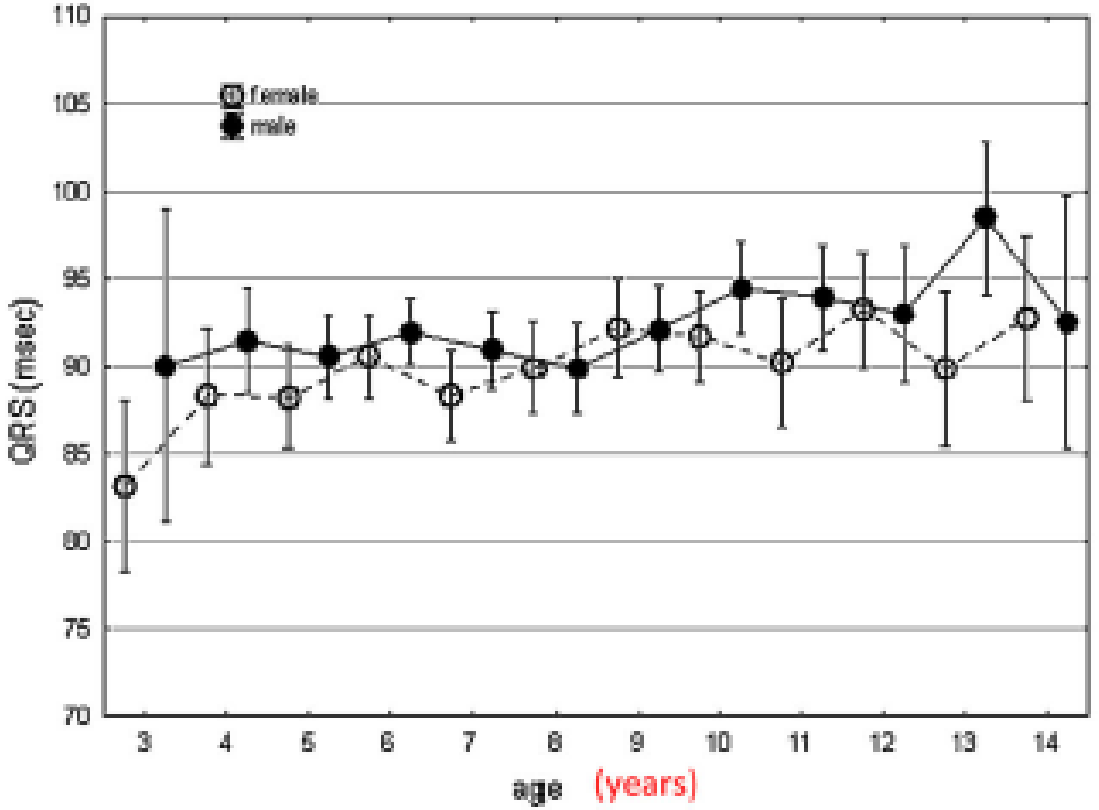


Fig. 2 Age distribution of subjects with normal electrocardiograms


female
male
heart rate (bpm)
110
100
90
80
70
60
3
4
5
6
7
8
9
10
11
12
13
14
age (years)


female
male
PR (msec)
160
150
140
130
120
110
3
4
5
6
7
8
9
10
11
12
13
14
age (years)


female
male
QRS (msec)
110
105
100
95
90
85
80
75
70
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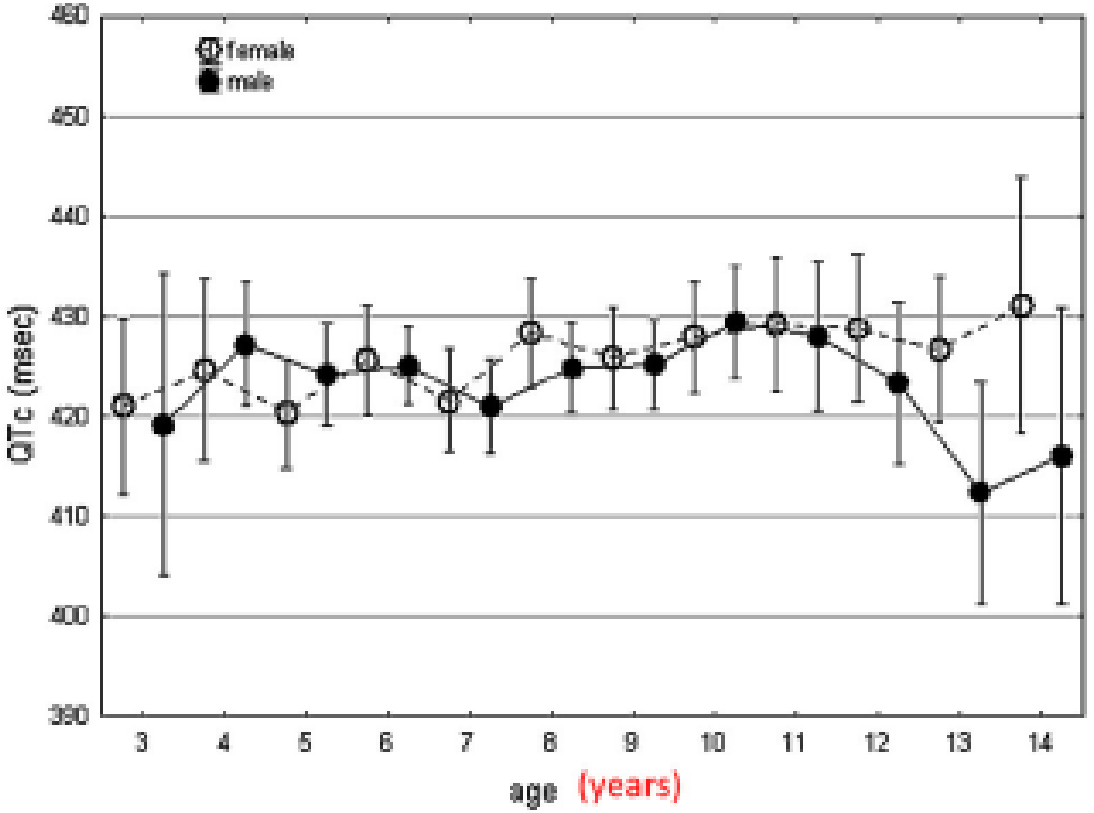
4
5
6
7
8
9
10
11
12
13
14
age (years)


female
male
QTc (msec)
460
450
440
430
420
410
400
390
3
4
5
6
7
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10
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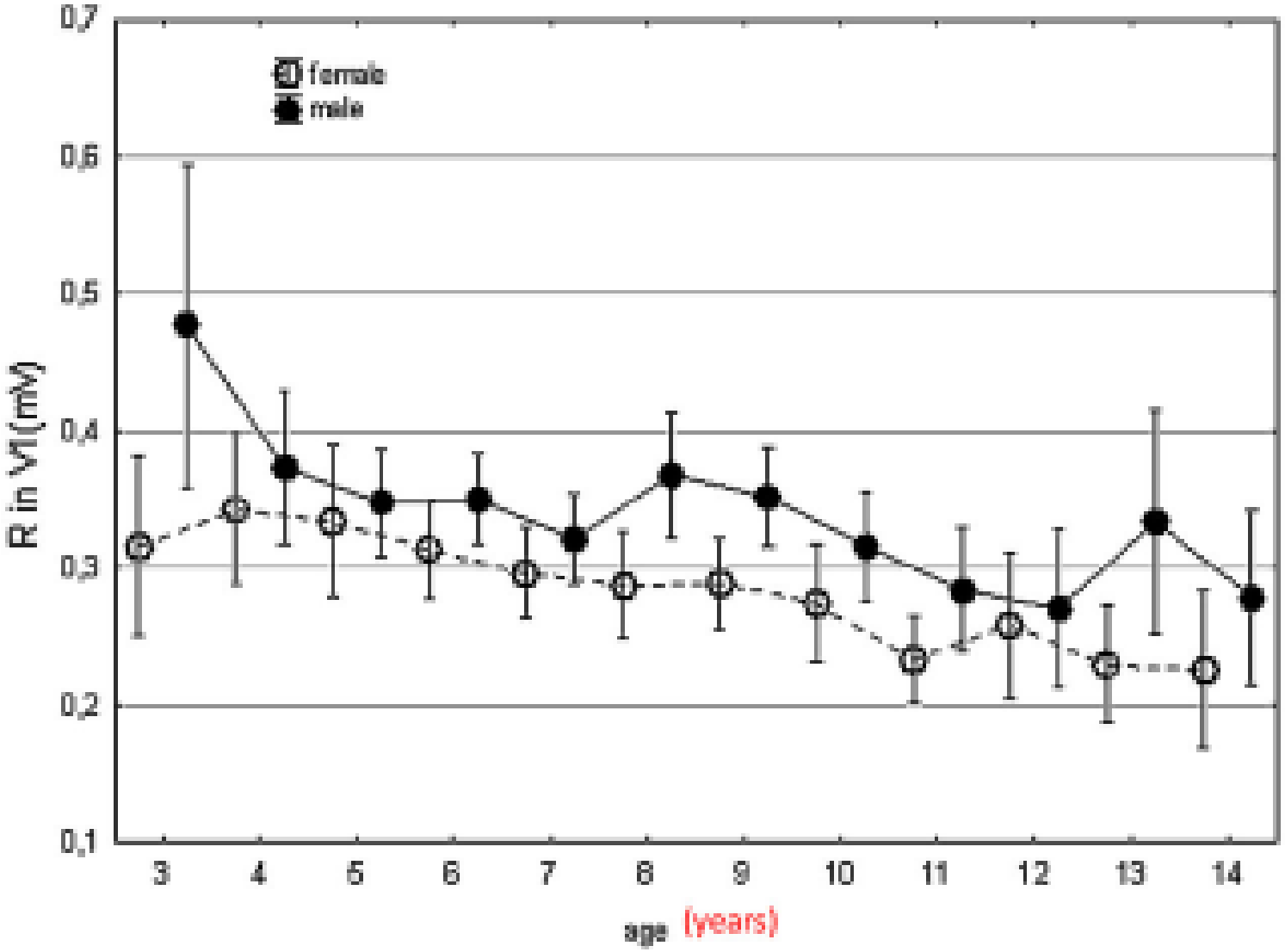
12
13
14
age (years)


0,7
0,6
0,5
0,4
0,3
0,2
0,1
R in V1(mV)
female
male
3
4
5
6
7
8
9
10
11
12
13
14
age (years)

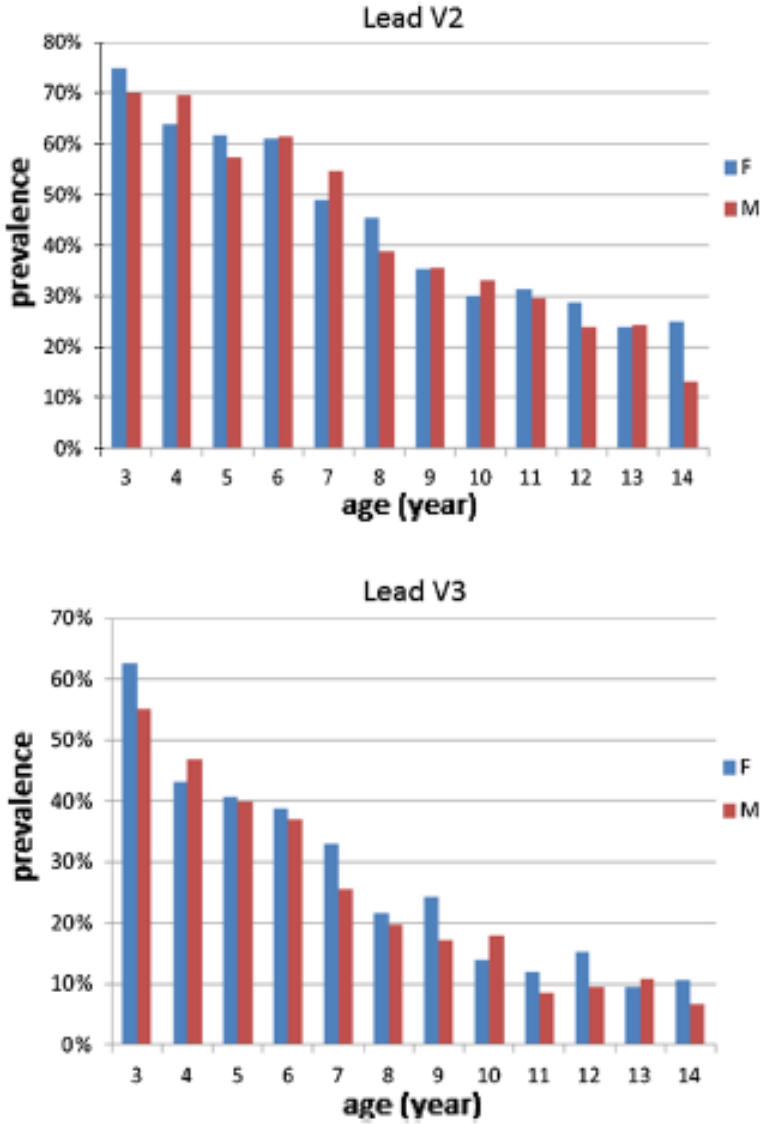


Fig. 5 Prevalence of negative T-waves in leads V2 and V3 according to age and sex

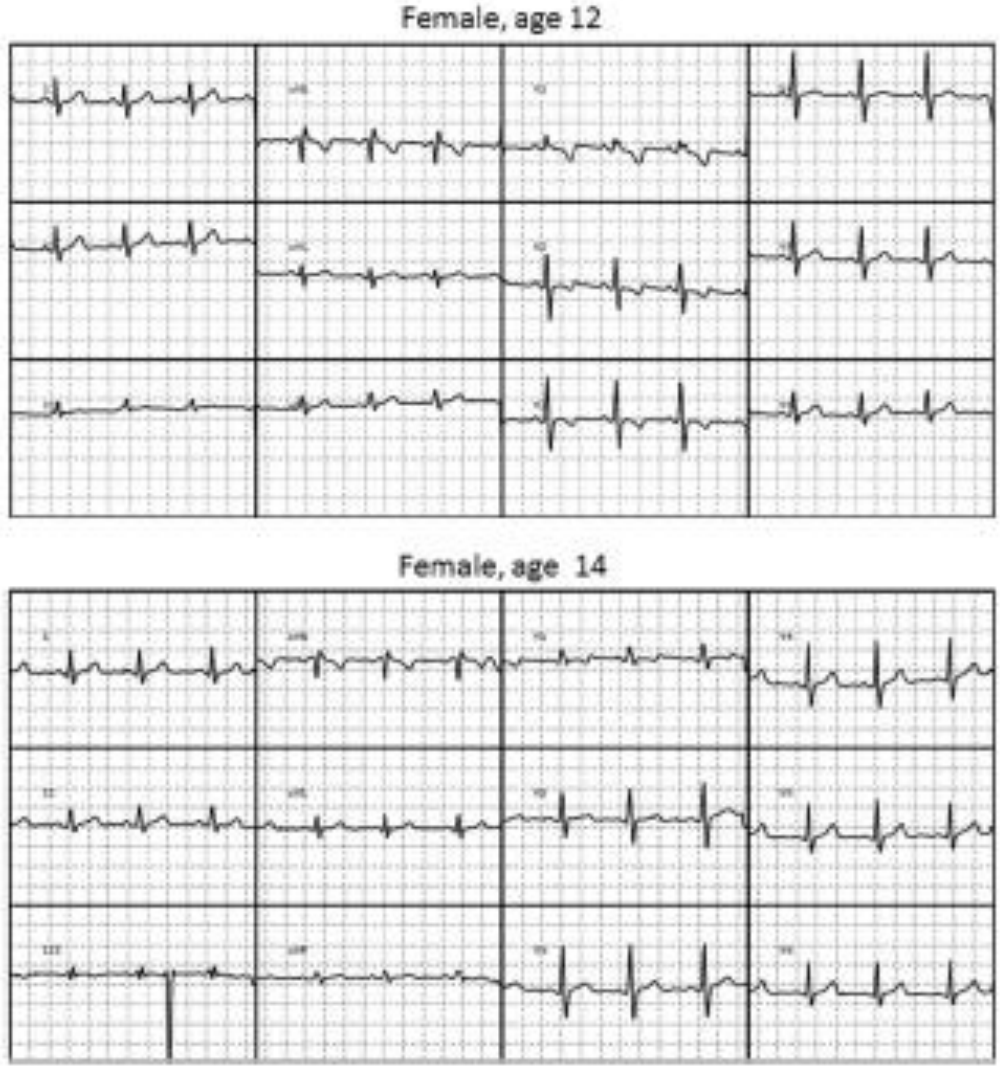
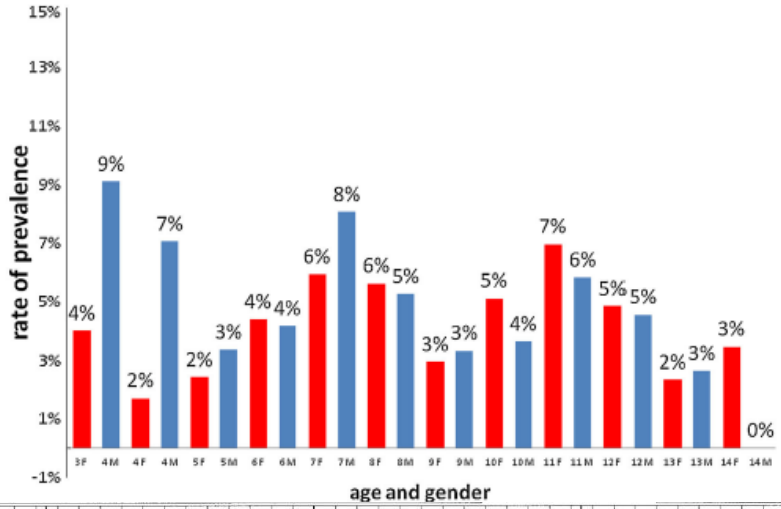


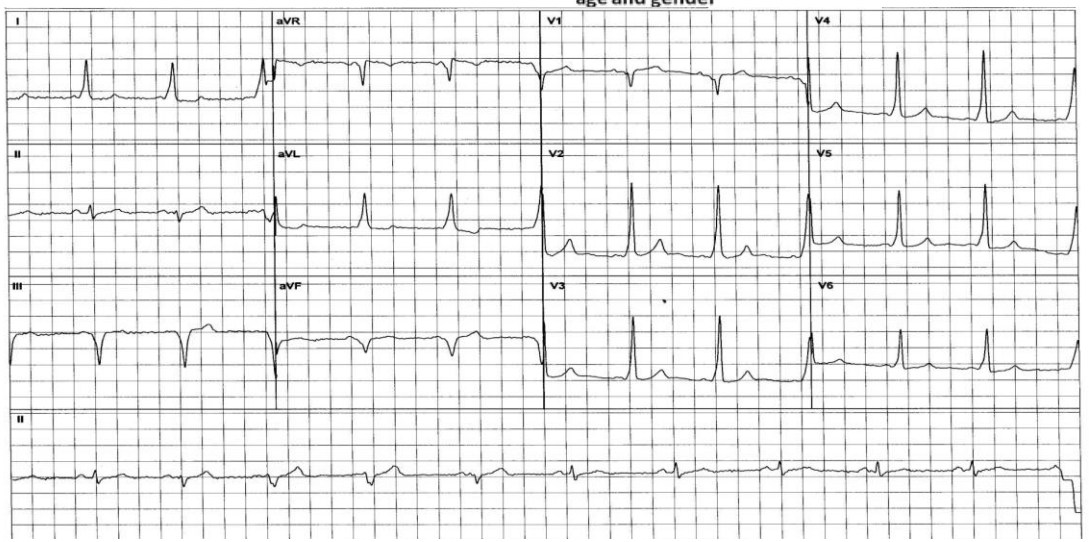
Fig. 6 Two electrocardiogram tracings of a girl recorded at the age of 12 and 14 years, showing transition from negative to positive T-waves in leads V2 and V3

Table 2 Characteristics of subjects with clearly abnormal ECG tracings

ECG parameters	$n = 98$
Rhythm	
Sinus rhythm, *n* (%)	93 (94.8)
Atrial/junctional rhythm, *n* (%)	5 (6.2)
HR (bpm)	85 (75–96)
Sinus tachycardia (HR >100 bpm), *n* (%)	7 (7.1)
Sinus bradycardia (HR <50 bpm), *n* (%)	2 (2.0)
AV conduction[a]	
PR interval (ms)	140 (130–154)
Normal, *n* (%)	98 (100)
Any degree of AV block, *n* (%)	0 (0)
Ventricular conduction	
QRS duration (ms)	92 (82–100)
Left axis deviation, *n* (%)	2 (2.0)
Right axis deviation, *n* (%)	1 (1.0)
Complete RBB, *n* (%)	3 (3.0)
Incomplete RBB, *n* (%)	43 (40.8)
Complete LBB, *n* (%)	0 (0)
Repolarization	
QT interval (ms)	358 (340–376)
Corrected QT interval (ms)	426 (407–444)
Sokolow Lyon index (mm)	24 (23–29)
QT interval exceeding age corrected normal limits *n* (%)	1 (1.0)
QT interval shorter than age corrected normal limits, *n* (%)	2 (2.0)
Type I or II Brugada pattern	0 (0)
Suspicious Brugada pattern	1 (1.0)
Negative T-waves[a], *n* (%)	3 (1.8)
Early repolarization pattern, *n* (%)	6 (6.1)
Wolf Parkinson White pattern	6 (6.1)
Other non-specific alterations, *n* (%)	12 (12.2)

Fig. 3 Age distribution of subjects with abnormal electrocardiograms





Costi screening ECG:
€ 668.53 per identificare una situazione a rischio medio-elevato di morte improvvisa.

Grazie per l'attenzione

Progetto

Tutti i Cuori di Rossana

Hai mai avuto malattie di cuore?	**Hai mai avuto altre malattie ? (esclusi esantemi infantili)**
• No • Si (specificare)……	• No • Si (specificare)……
In famiglia vi sono state Morti Improvvise?	**I tuoi genitori hanno malattie di cuore?**
• No • Si (specificare grado di parentela e causa, se conosciuta)…… ……	• No • Si (specificare chi dei due e quale malattia)…… ……

Hai mai avuto sensazione di battito cardiaco accelerato (veloce ma regolare) o irregolare (come se saltassero dei battiti)? 1) No mai 2) Si (specificare se accelerato o irregolare)……
Se si specificare con quale frequenza • Tutti i giorni • Alcune volte al mese • Alcune volte all'anno
Se si specificare con quale durata • Meno di 1 minuto • Tra 2 e 30 minuti • Più di 30 minuti

Sei mai svenuto?

3) No mai
4) Si (specificare se una o più volte).....

Se si specificare in che occasione

- Mentre facevo uno sforzo (camminando a passo svelto, correndo, durante sport, ecc.)
- Mentre ero a riposo

Prima di svenire hai avvertito un battito cardiaco veloce?

- No
- Si

Prendi abitualmente dei farmaci?

- No
- Si (specificare quale farmaci).....