

Pre-Participation Cardiac Screening in Athletes: What is the Evidence

Professor Sanjay Sharma

St George's Hospital University London

sasharma@sgul.ac.uk



@SSharmacardio



Objectives

To provide an overview of sudden cardiac death in athletes.

To compare the effectiveness of accepted screening models.

To provide a realistic view of some of the concerns with ECG screening.



Sudden Cardiac Death in Athletes



Incidence of Sudden Cardiac Death

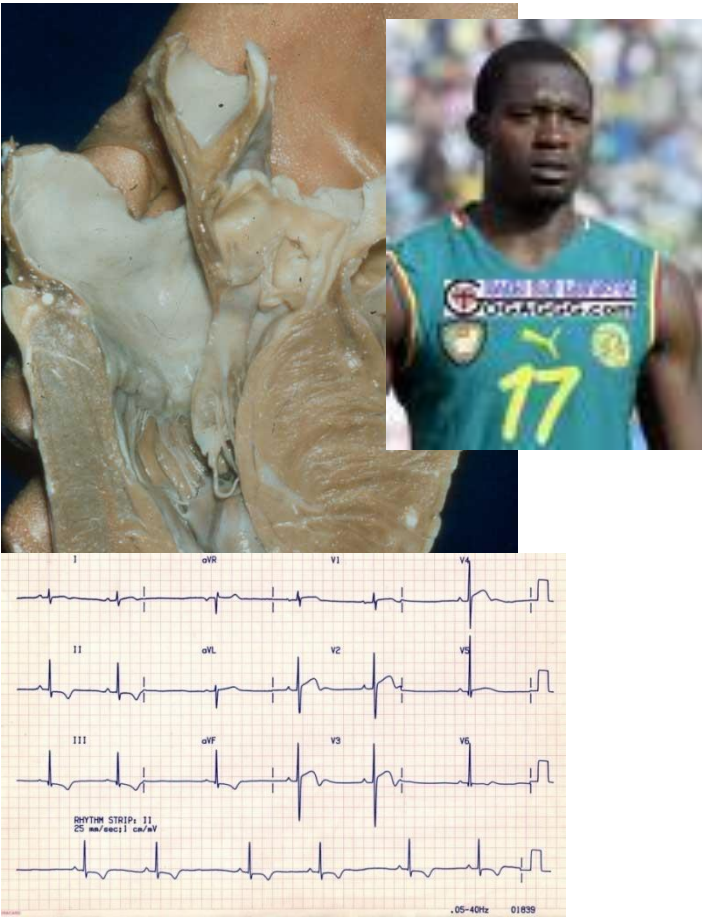
POPULATION	AGE	DURATION	INCIDENCE
Organised high school ¹ and college athletes	13-17	12 years	0.5/100,000
Competitive athletes ²	14-35	25 years	2/100,000/yr
Marathon (London) ³	Mean 42	26 years	2.2/100,000 runs
Rhode island jogger ⁴	30-65	7 years	13/100,000/yr

1. Roberts WO. JACC. 2013; 62: 1298
2. Corrado D. JAMA. 2006; 296: 1953
3. Tunstall-Pedoe D. Sports Med. 2007; 37: 448
4. Thompson P. JAMA. 1982; 12: 247

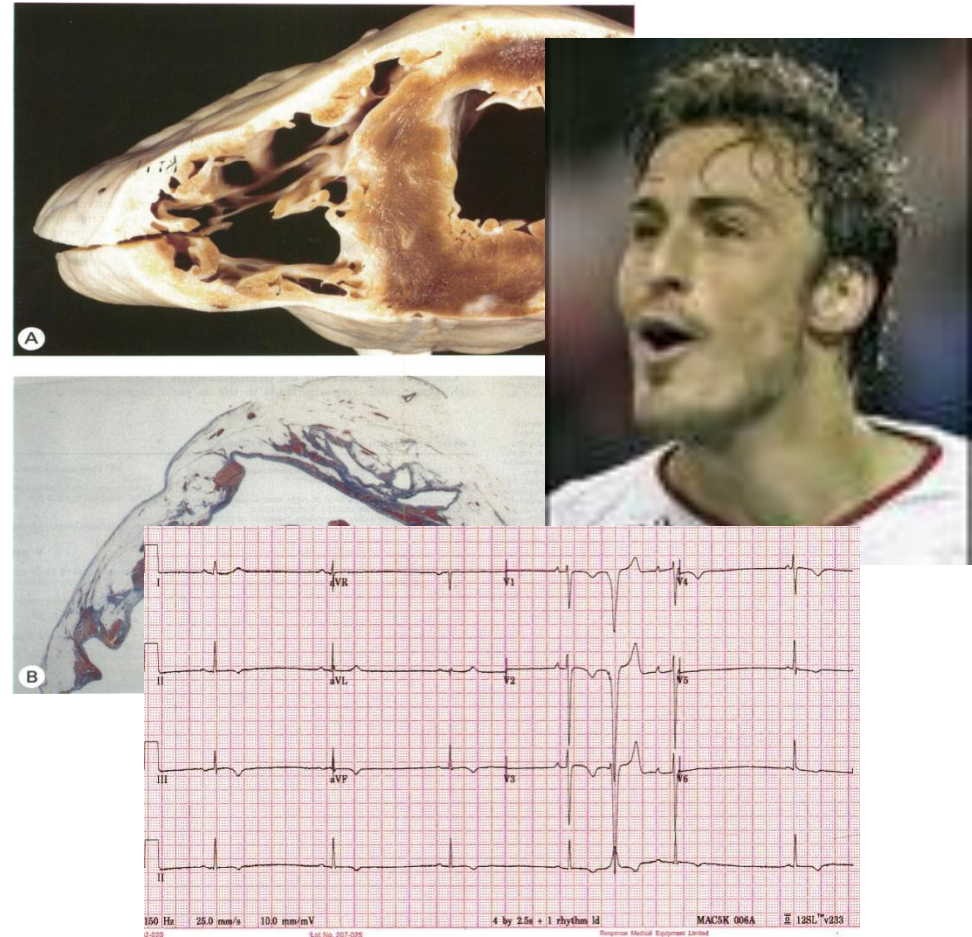
Sudden Death in Young Athletes



Sudden Cardiac Death in Sport

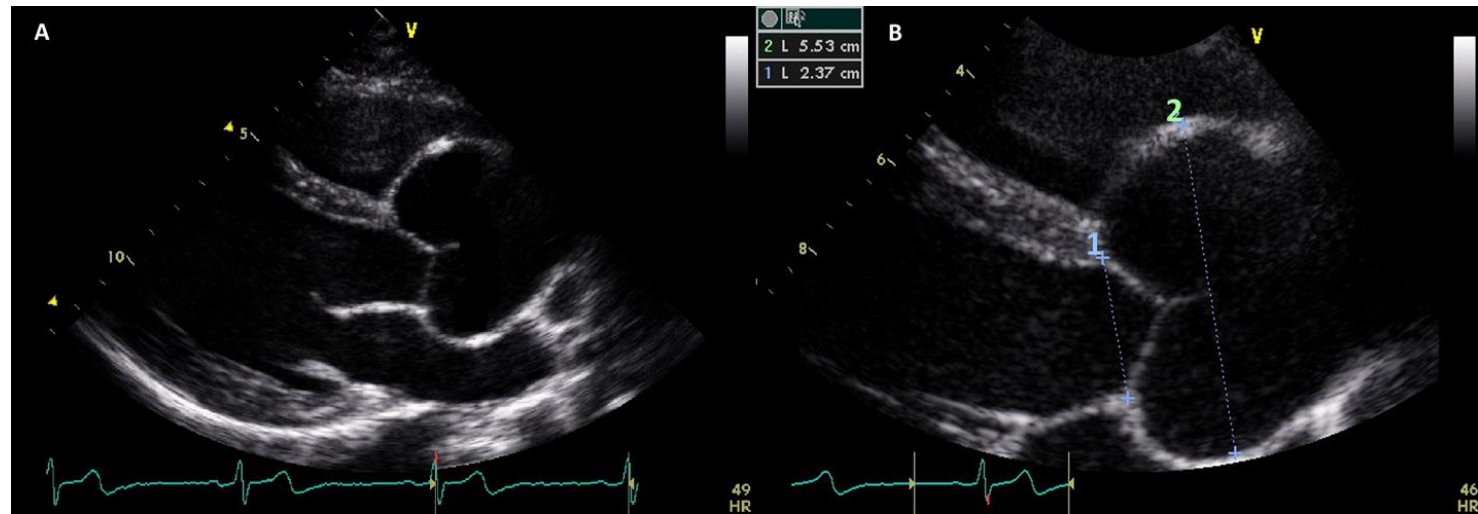
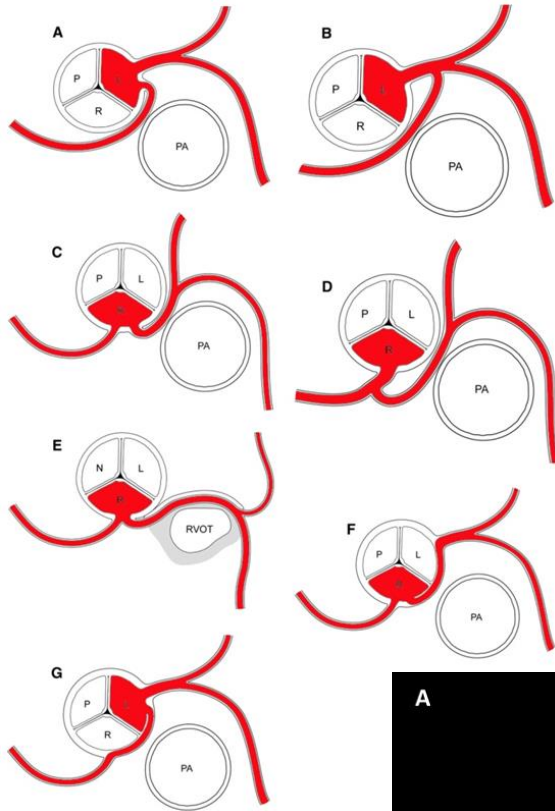


Hypertrophic
Cardiomyopathy

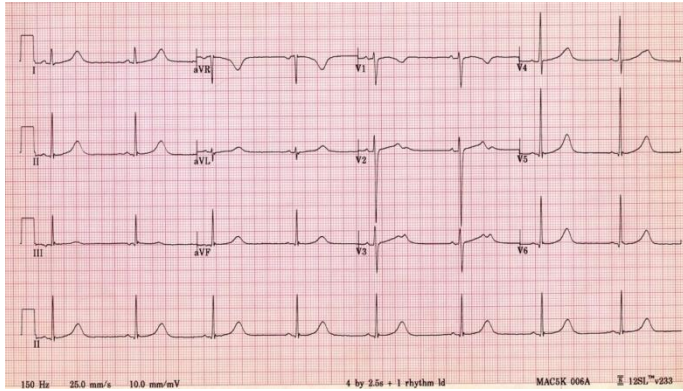


Arrhythmogenic right
ventricular cardiomyopathy

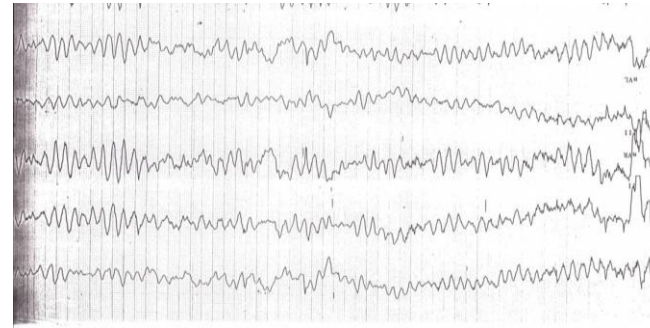
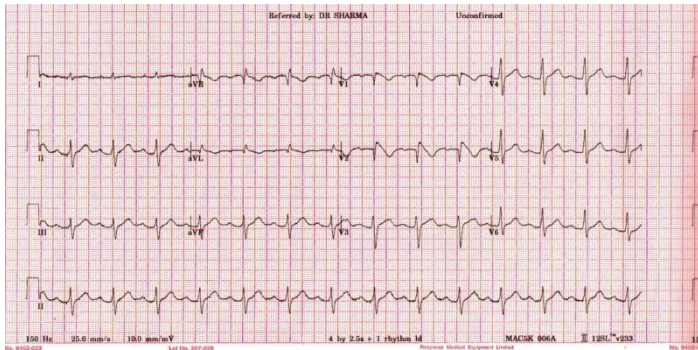
Coronary arteries and aorta



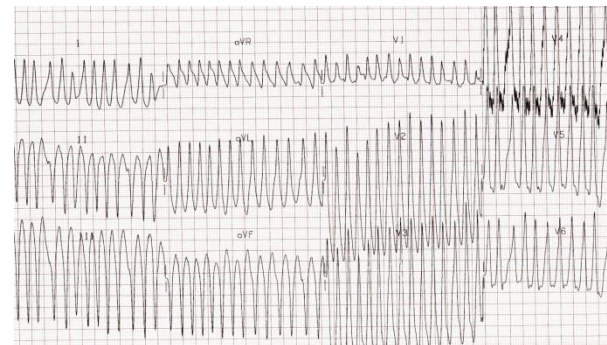
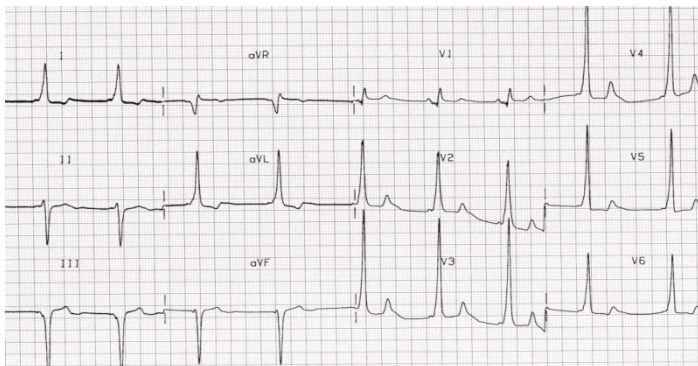
Sudden Cardiac Death with a Normal Heart



LQTS



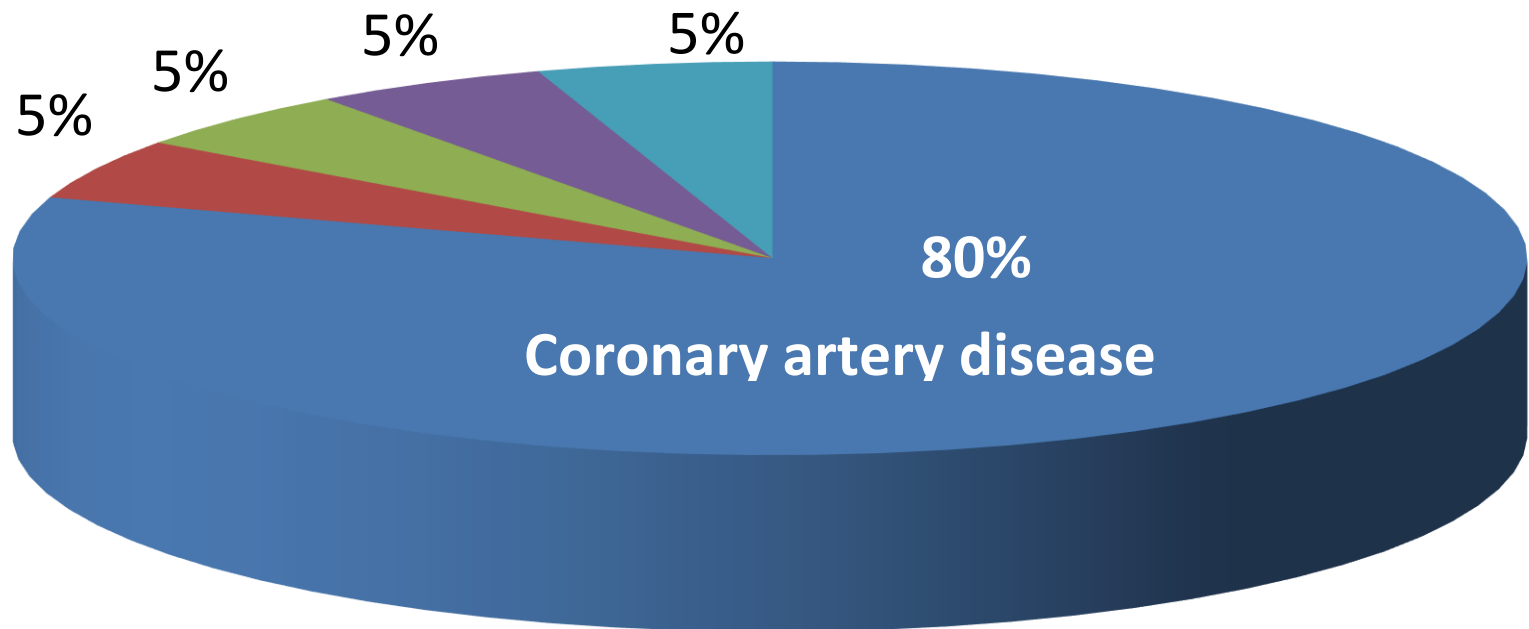
Brugada



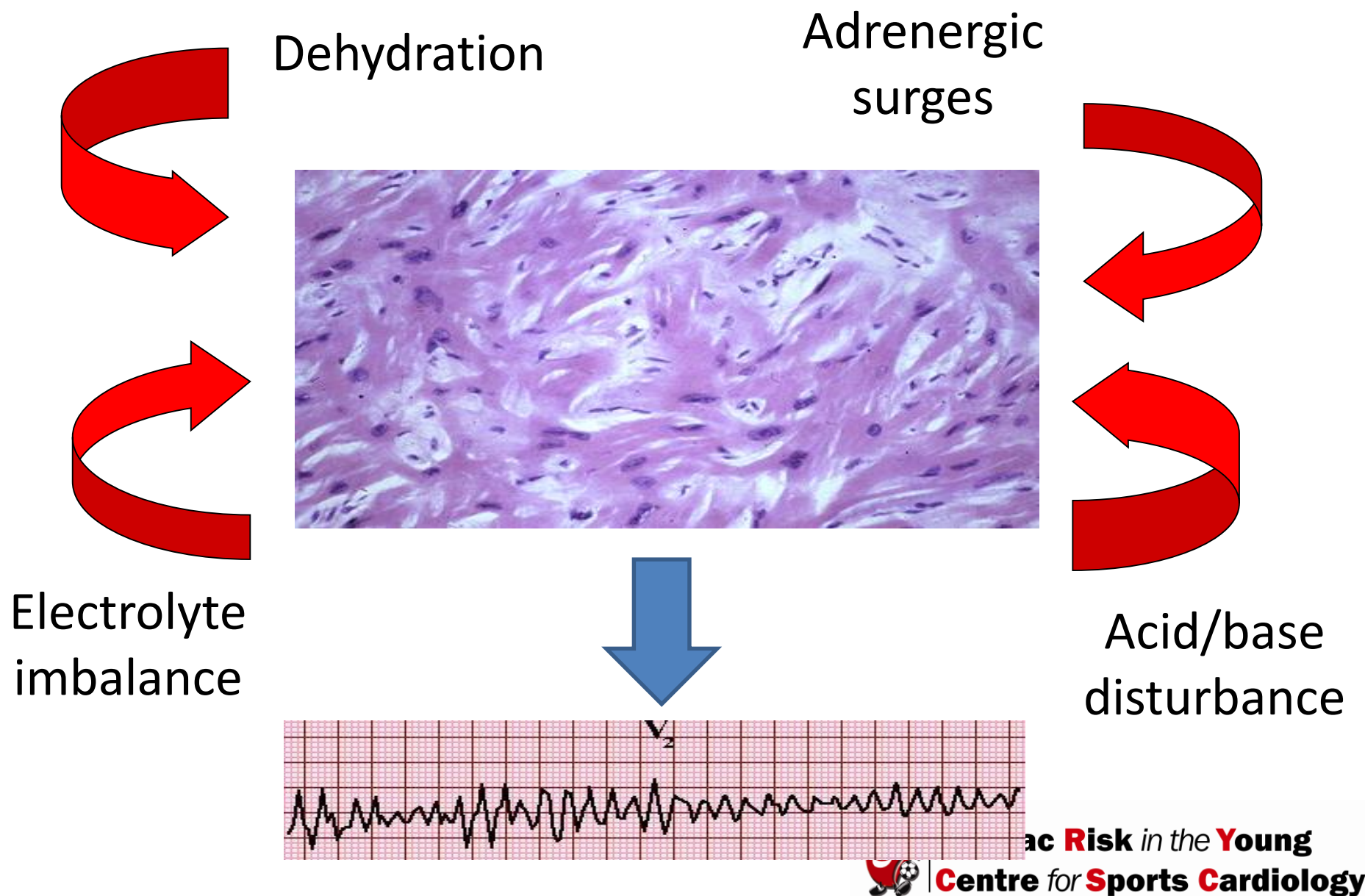
WPW



Cause of Death in Senior Athletes



Triggers for Sudden Cardiac Death



Sudden Cardiac Death in Athletes



Sudden Deaths in Triathlon

Harris K et al ACC 2016

USA Triathlon Experience 1985-2015

1 in 67,000.

80% non traumatic.

35% in first time participants

85% in males

Mean age 47 years old

70% of all deaths in swimming

Deaths During Swimming

- **Drowning**
 - Precipitated by water aspiration
 - Kicked and knocked unconscious
- **Lung Problem**
 - Swimming Induced Pulmonary Edema (SIPE)
 - Asthma attack
 - Anaphylaxis from jellyfish sting
- **Cardiac Problem**
 - Long QT Syndrome (1 subtype provoked by swimming)
 - Myocardial infarction (older athlete)
 - Hypertrophic or other cardiomyopathy (younger athlete)
- **Heat Stroke (rare)**

Sudden Death in USA Triathlons 1985-2015

106 deaths and 11 resuscitated events.

41 had autopsy.

22 (54%) showed cardiac pathology.

Predominantly coronary artery disease but also cases of cardiomyopathy, coronary artery anomalies and electrical disorders.

Screening Strategies for Detecting Athletes with Potentially Serious Cardiac Disease



Screening Athletes

Condition	History	Examn	ECG	Echo
HCM	Pos/Neg	Pos in 25%	Positive	Pos
ARVC	Pos/Neg	Negative	Positive	Neg/Pos
WPW	Pos/Neg	Negative	Positive	Neg
LQTS	Pos/Neg	Negative	Positive	Neg
Marfan	Pos/Neg	Positive	Negative	Pos
CAA	Pos/Neg	Negative	Negative	Neg
Myocarditis	Pos/Neg	Pos/Neg	Pos/Neg	Pos



INCREASING COST



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

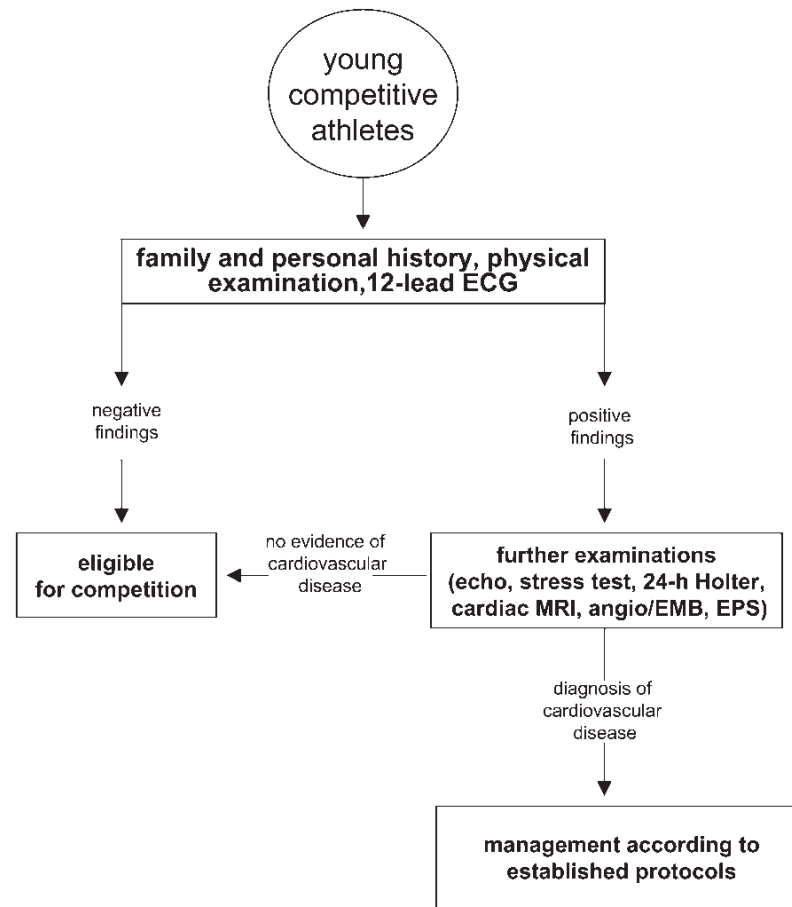
6. Premature death (sudden and unexpected, or otherwise) before age 50 years due to heart disease, in ≥ 1 relative
7. Disability from heart disease in a close relative <50 years of age
8. Specific knowledge of certain cardiac conditions in family members: hypertrophic or dilated cardiomyopathy, long-QT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



**EUROPEAN
SOCIETY OF
CARDIOLOGY®**



Etiology of Sudden Death in Sports

Insights From a United Kingdom Regional Registry

JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY

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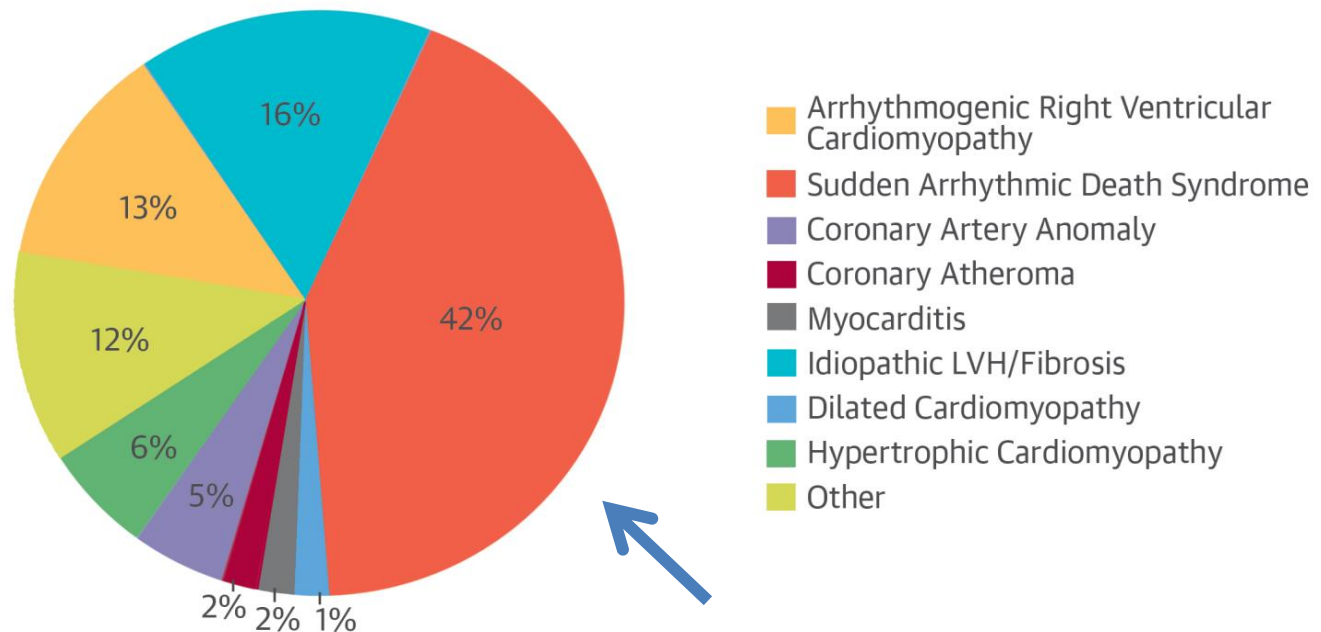
PUBLISHED BY ELSEVIER

Finnocchiaro G, Sharma JACC 2016

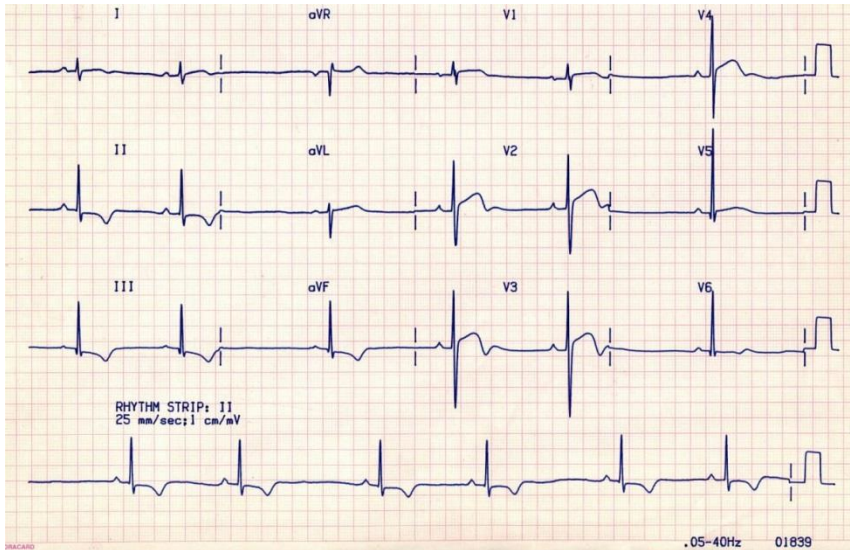
357 consecutive athletes. Mean age 29 ± 11 years old.

92% Male. 69% competitive.

A. Sudden Death in Overall Population

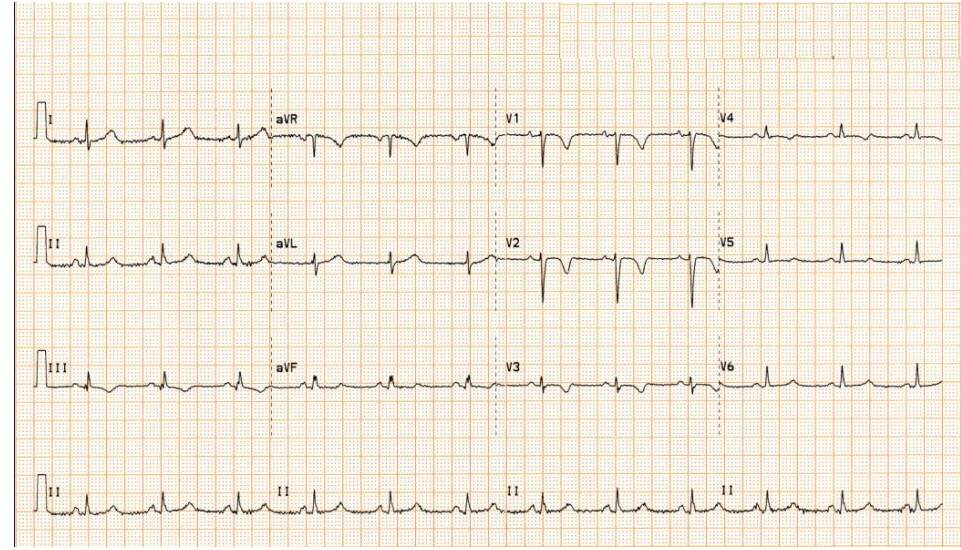


ECG in Patients with Cardiomyopathy



HCM
95%

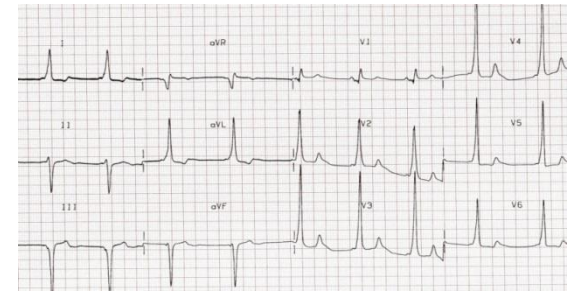
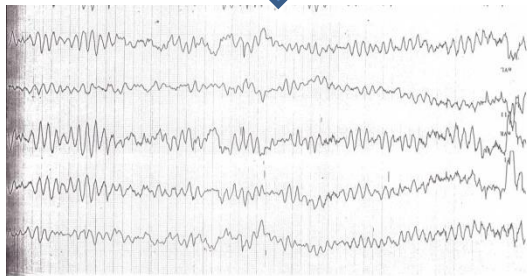
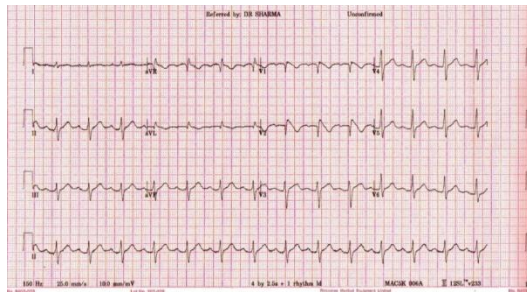
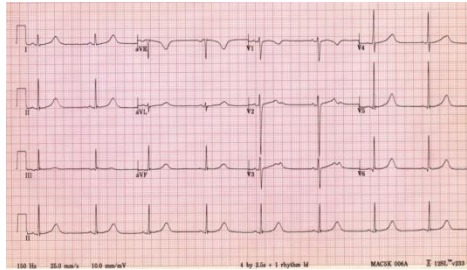
Inferior and/or lateral TWI
ST segment depression
Pathological q waves



ARVC
40-50%

Anterior TWI (V2-V3/V4)
with isoelectric J point
Epsilon wave
Ventricular extra-systoles

Deaths in Triathlon



Medical history*

Personal history

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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)§

Cheap

Pragmatic

Poor sensitivity (<45%)

Most athletes asymptomatic

Most diseases are not
associated with abnormal
physical signs



Does Cardiac Screening Save Lives?



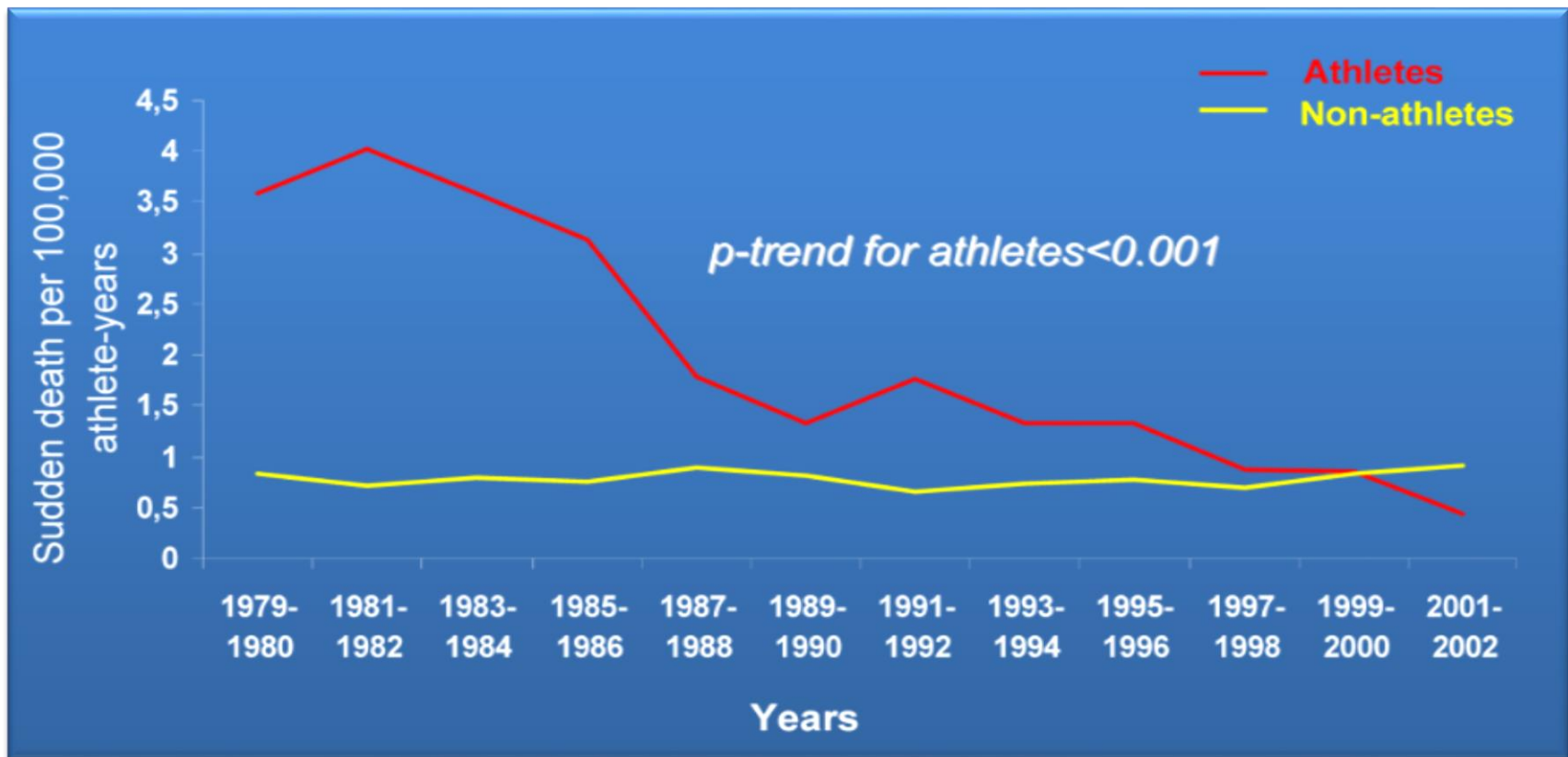
Screening Athletes: Impact on SCD

Corrado. JAMA 2006; 296:1593-1601

- 1979-2004
- 42,386 athletes (12-35 years)
- History, examination and 12-lead ECG
- 55 sudden cardiac deaths in screened athletes
- Death rates fell from 3.6/100,000/person years (pre-screening to 0.4/100,000/person years following screening.
- Reduction in deaths mainly from cardiomyopathies

TIME-TREND OF SUDDEN CARDIAC DEATH INCIDENCE IN ATHLETES VS NON-ATHLETES

Veneto Region of Italy 1979-2002



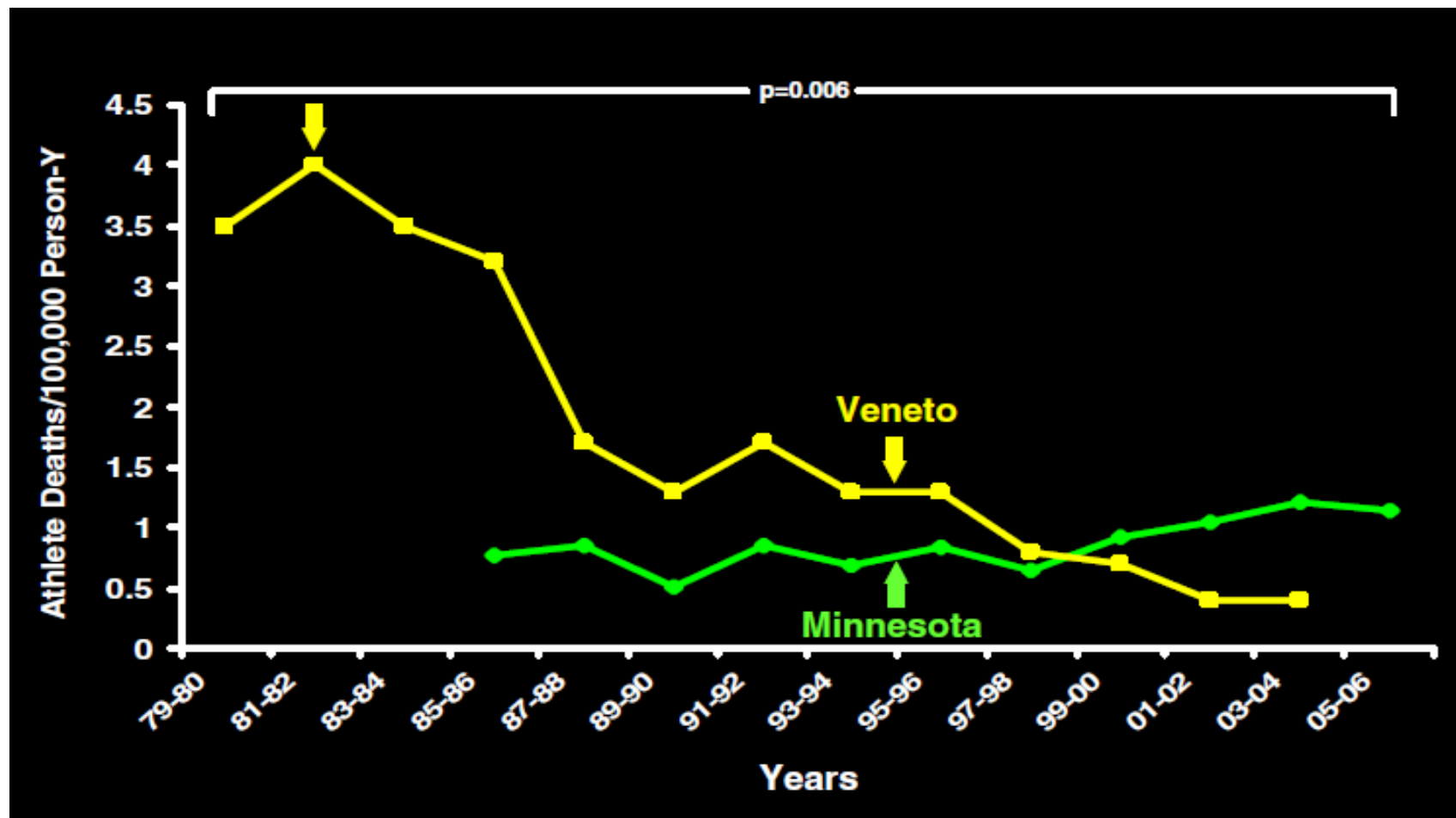
Corrado. JAMA 2006; 296:1593-1601



Cardiac Risk in the Young
Centre for Sports Cardiology

Comparison of U.S. and Italian Experiences With Sudden Cardiac Deaths in Young Competitive Athletes and Implications for Preparticipation Screening Strategies

Barry J. Maron, MD^{a,*}, Tammy S. Haas, RN^a, Joseph J. Doerer, BS^a, Paul D. Thompson, MD^b,
and James S. Hodges, PhD^c



Corrado et al. JAMA 2006; 296: 1593-601

Maron et al. Am J Cardiol 2009; 104: 276-280

Concerns Relating to ECG Screening

Low incidence of sudden cardiac death

High number of false positives

Concerns relating to false negatives

Cost

Other issues



Prevalence of Young Athletes with Conditions Predisposing to SCD

Reference	Population	Prevalence
AHA (2007)	Competitive athletes (U.S.)	0.3%
Fuller (1997)	5,617 high school athletes (U.S)	0.4%
Corrado (2006)	42,386 athletes age 12-35 (Italy)	0.2%
Wilson (2008)	2,720 athletes /children age 10-17	0.3%
Bessem (2009)	428 athletes age 12-35 (Netherlands)	0.7%
Baggish (2010)	510 collegiate athletes	0.6%
Sheikh (2015)	5000 British elite athletes	0.3%

Concerns Relating to ECG Screening

Low incidence of sudden cardiac death

High number of false positives

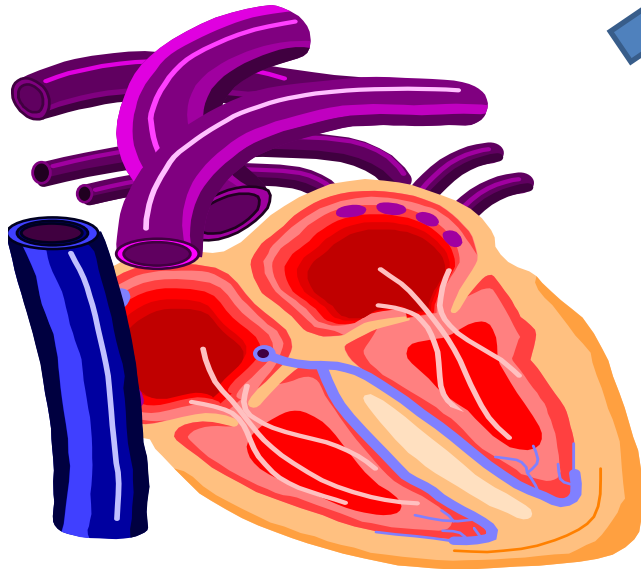
Concerns relating to false negatives

Cost

Other issues



ECG in Athletes



VAGOTONIA

Bradycardia

AV block

Repolarisation
anomalies

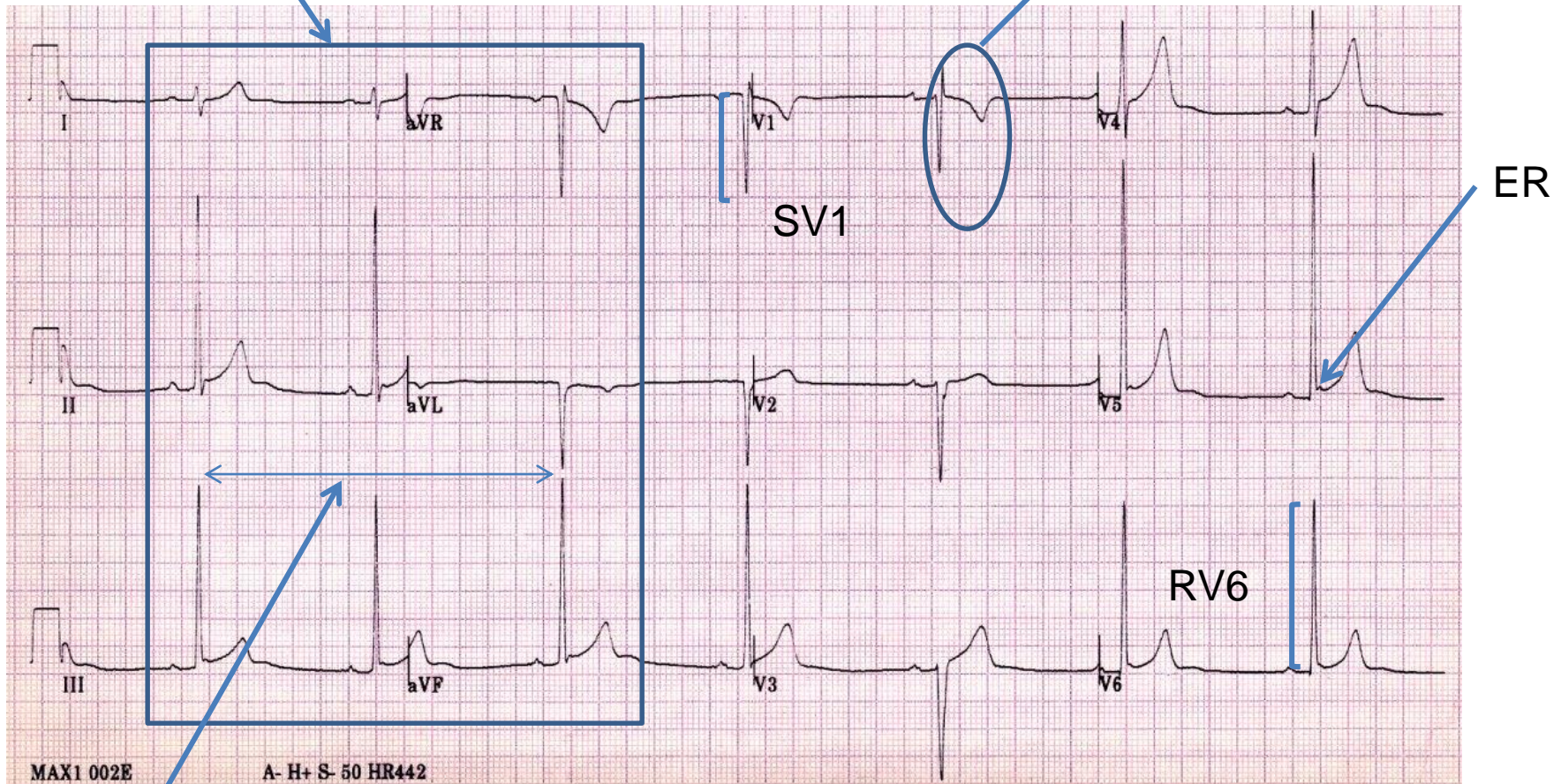
CHAMBER ENLARGEMENT

Sokolow-Lyon
Voltage criterion for
LVH

Incomplete RBBB

Right axis deviation

Incomplete RBBB



Sinus bradycardia 45 bpm

$SV1 + RV6 > 3.5 \text{ mV} = \text{LVH}$

ECG in Athletes

INFLUENCING FACTORS

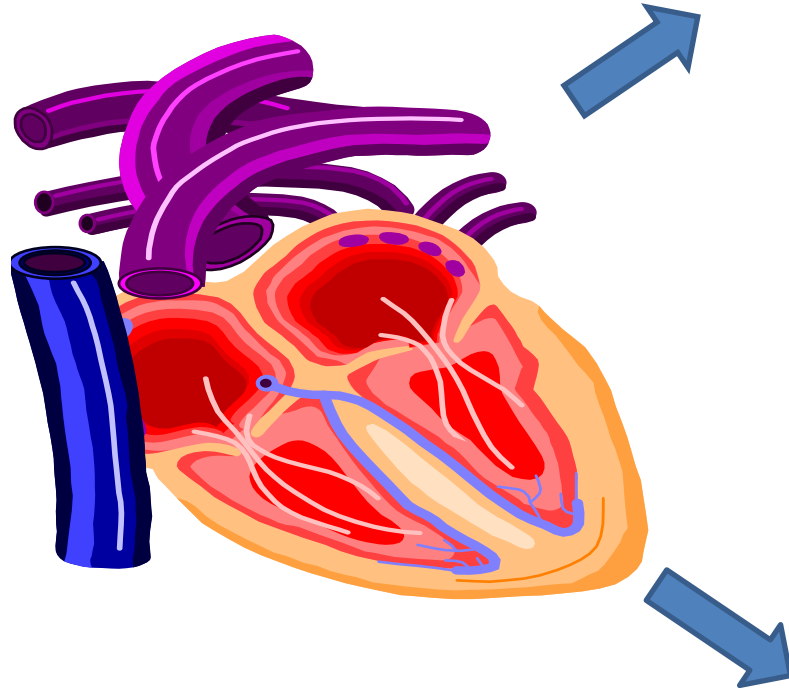
Age

Sex

Ethnicity

Type of sport

Intensity of sport



VAGOTONIA

Bradycardia

AV block

Repolarisation anomalies

CHAMBER ENLARGEMENT

Sokolow-Lyon
Voltage criterion for
LVH

Incomplete RBBB

ECG Interpretation in an Athlete

Table I Classification of abnormalities of the athlete's electrocardiogram

Group 1: common and training-related ECG changes

Sinus bradycardia
First-degree AV block
Incomplete RBBB
Early repolarization
Isolated QRS voltage criteria for left ventricular hypertrophy


Group 2: uncommon and training-unrelated ECG changes

T-wave inversion
ST-segment depression
Pathological Q-waves
Left atrial enlargement
Left-axis deviation/left anterior hemiblock
Right-axis deviation/left posterior hemiblock
Right ventricular hypertrophy
Ventricular pre-excitation
Complete LBBB or RBBB
Long- or short-QT interval
Brugada-like early repolarization

RBBB, right bundle branch block; LBBB, left bundle branch block.



Evidence Based ECG Interpretation: 2004-2014

 European Heart Journal
doi:10.1093/eurheartj/ehm404

Clinical research

Prevalence and significance of an isolated long QT interval in elite athletes

Sandeep Basavarajaiah¹, Matthew Wilson², Gregory Whyte³, Ajay Shah¹, Elijah Behr⁴, and Sanjay Sharma^{1*}

 European Heart Journal
doi:10.1093/eurheartj/ehr140


CLINICAL RESEARCH

The prevalence, distribution, and clinical outcomes of electrocardiographic repolarization patterns in male athletes of African/Afro-Caribbean origin

Michael Papadakis^{1,2}, Francois Carre³, Gaelle Kervio⁴, John Rawlins^{1,2}, Vasileios F. Panoulas², Navin Chandra^{1,2}, Sandeep Basavarajaiah², Lorna Carby², Tiago Fonseca², and Sanjay Sharma^{1,2*}

¹St George's University of London, Cranmer Terrace, SW17 0RE, London, UK; ²University Hospital Lewisham, London, UK; ³French Institute of Health and Medical Research (INSERM), U642, Rennes, F-35000, France; and ⁴French Institute of Health and Medical Research (INSERM), CIC-IT 804, Rennes, F-35000, France

Received 7 January 2011; revised 15 February 2011; accepted 25 March 2011

 European Heart Journal
doi:10.1093/eurheartj/ehs390


CLINICAL RESEARCH
Sports cardiology

Should axis deviation or atrial enlargement be categorised as abnormal in young athletes? The athlete's electrocardiogram: time for re-appraisal of markers of pathology

Sabiha Gati^{1,2}, Nabeel Sheikh¹, Saqib Ghani¹, Abbas Zaidi¹, Mathew Wilson³, Hariharan Raju¹, Andrew Cox¹, Matt Reed¹, Michael Papadakis¹, and Sanjay Sharma^{1,2*}

¹St George's University of London, Cranmer Terrace, SW17 0RE, London SE5 9RS, UK; ²University Hospital Lewisham, London, UK; and ³Aspetar, Department of Sports Medicine, Qatar Orthopaedic and Sports Medicine Hospital, Doha, Qatar

Received 19 February 2013; revised 20 August 2013; accepted 28 August 2013

 European Heart Journal
doi:10.1093/eurheartj/ehs391

CLINICAL RESEARCH
Sports cardiology

Clinical significance of electrocardiographic right ventricular hypertrophy in athletes: comparison with arrhythmogenic right ventricular cardiomyopathy and pulmonary hypertension

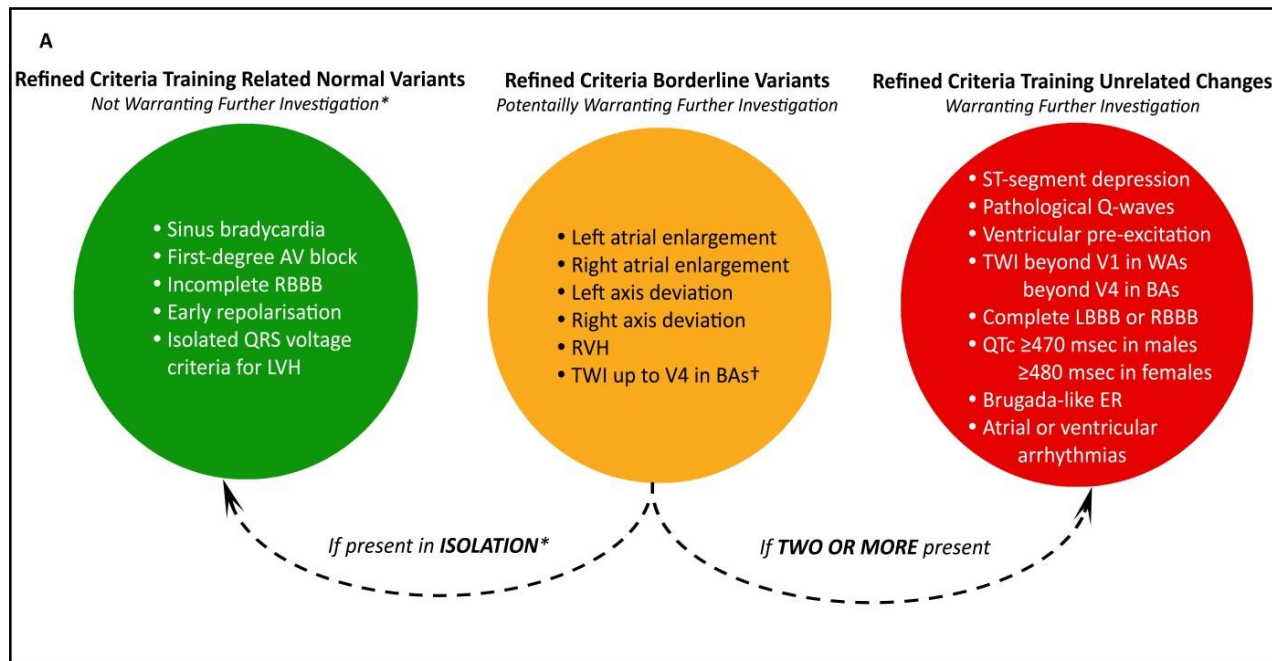
Abbas Zaidi[†], Saqib Ghani[†], Nabeel Sheikh[†], Sabiha Gati[†], Rachel Bastiaenen, Brendan Madden, Michael Papadakis[†], Hariharan Raju[†], Matthew Reed, Rajan Sharma, Elijah R. Behr, and Sanjay Sharma^{†*}

Division of Cardiovascular Sciences, St George's University of London (SGUL), Cranmer Terrace, SW17 0RE London, UK

Received 9 May 2013; revised 7 August 2013; accepted 28 August 2013

Comparison of Electrocardiographic Criteria for the Detection of Cardiac Abnormalities in Elite Black and White Athletes

Nabeel Sheikh, MRCP; Michael Papadakis, MRCP; Saqib Ghani, MRCP; Abbas Zaidi, MRCP; Sabiha Gati, MRCP; Paolo Adami, MD; François Carré, PhD; Frédéric Schnell, PhD; Mathew Wilson, PhD; Paloma Avila, MD; William McKenna, MD, DSc, FESC; Sanjay Sharma, MD, FRCP, FESC (UK)



Sensitivity for all conditions

60%

Sensitivity for serious conditions

100%

Specificity

94% in Caucasians

84% in Black athletes



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 Myocardial and Pericardial Diseases of the European Society of Cardiology



European Heart Journal (2010) 31, 243–259
doi:10.1093/eurheartj/ehp473

ESC REPORT

Recommendations for interpretation of 12-lead electrocardiogram in the athlete



Normal electrocardiographic findings: recognising physiological adaptations in athletes

Jonathan A Drezner, Peter Fischbach, Victor Froelicher, et al.

Br J Sports Med 2013 47: 125-136
doi: 10.1136/bjsports-2013-092763

April 29, 2014

Original Article

Comparison of Electrocardiographic Criteria for the Detection of Cardiac Abnormalities in Elite Black and White Athletes

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Cardiac Risk in the Young
Centre for Sports Cardiology

The Journey so far

2005

False positives

2010

2013

2014

Normal ECG findings

- Voltage QRS criteria for LVH or RVH
- Incomplete RBBB
- Early repolarization/ ST segment elevation
- ST elevation followed by T wave inversion in V1-V4 in black athletes
- T wave inversion in V1-V3 < age 16
- Sinus bradycardia or arrhythmia
- Ectopic atrial or junctional rhythm
- 1st degree AV block
- Mobitz type 1- 2nd degree AV block

Borderline ECG findings

- Left or right atrial enlargement
- Left axis deviation
- Right axis deviation
- Complete RBBB

Abnormal ECG findings

- T wave inversion beyond V2 in Caucasian adult athletes/ beyond V4 in black athletes
- ST segment depression
- Pathological Q waves
- Complete LBBB
- IVCD ≥ 140 ms
- Ventricular pre-excitation
- Long QT interval
- Profound sinus bradycardia <30bpm
- Profound 1st degree AV block ≥ 400 ms
- Mobitz Type II 2nd degree AV block
- 3rd degree A V block
- ≥ 2 PVCs per 10 secs
- Atrial tacharrhythmias
- Ventricular tachyarrhythmias

In isolation

2 or more

No further evaluation required
In asymptomatic athletes with no family history of inherited cardiac disease/ SCD

Further evaluation required
to investigate for CV disorders associated with SCD in athletes



Concerns

Low incidence of sudden cardiac death

High number of false positives

Concerns relating to false negatives

Cost

Other issues



Deaths Despite Screening with ECG

False Negatives

Anomalous coronary arteries

Premature atherosclerotic coronary disease

Adrenergically driven ion channel disorders

Incomplete expressions of cardiomyopathy

Acquired conditions

Commotio cordis

Myocarditis

Electrolyte disorders



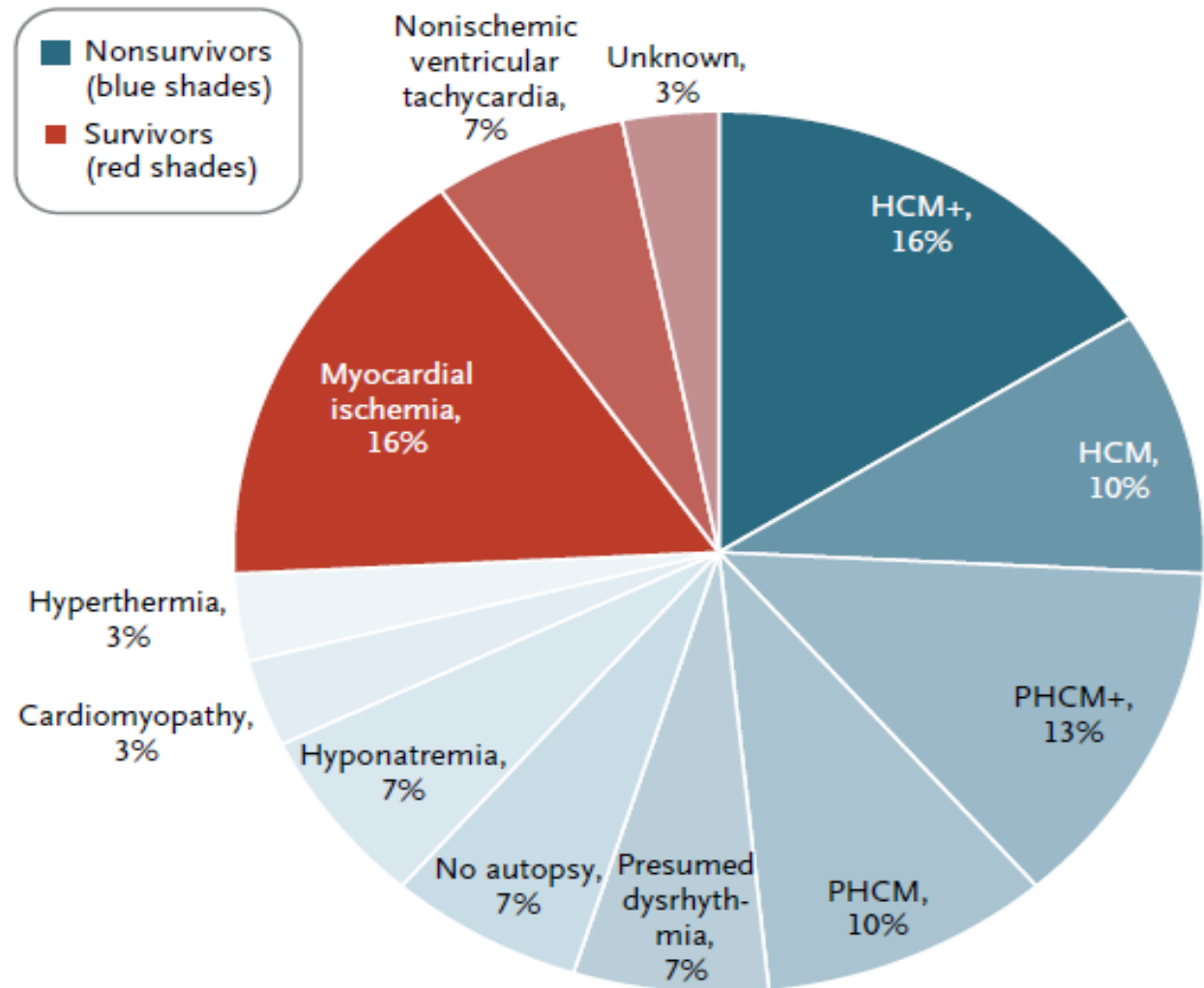
Cause of Cardiac Arrest in Marathons in the US

Kim J NEJM 2012

59 events

Information on 31
(23 dead and 8 survivors)

Athletes with
HCM did not
survive.



Concerns

Low incidence of sudden cardiac death

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Concerns relating to false negatives

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Conclusion

1. Sudden cardiac death in triathlon is rare.
2. Most triathlon deaths occur during swimming.
3. Screening with ECG will detect electrical faults and cardiomyopathies but will fail to identify most coronary artery abnormalities/disease.
4. Screening of athletes SHOULD take place in an EXPERT setting.



Pre-Participation Cardiac Screening in Athletes: What is the Evidence

Professor Sanjay Sharma

St George's Hospital University London

sasharma@sgul.ac.uk



@SSharmacardio

