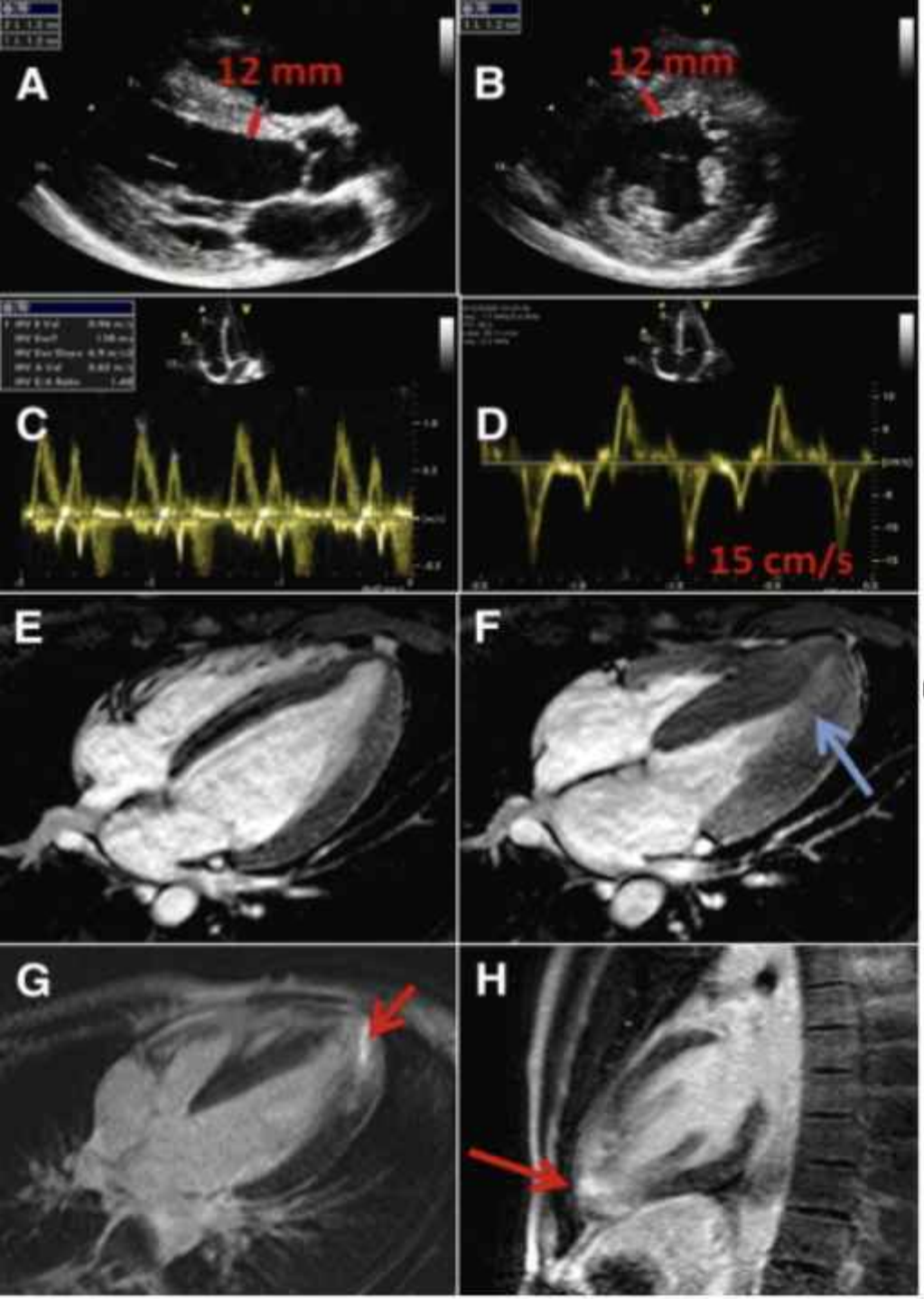


ΚΛΙΝΙΚΟ ΦΡΟΝΤΙΣΤΗΡΙΟ Ασκηση-Προαθλητικός έλεγχος

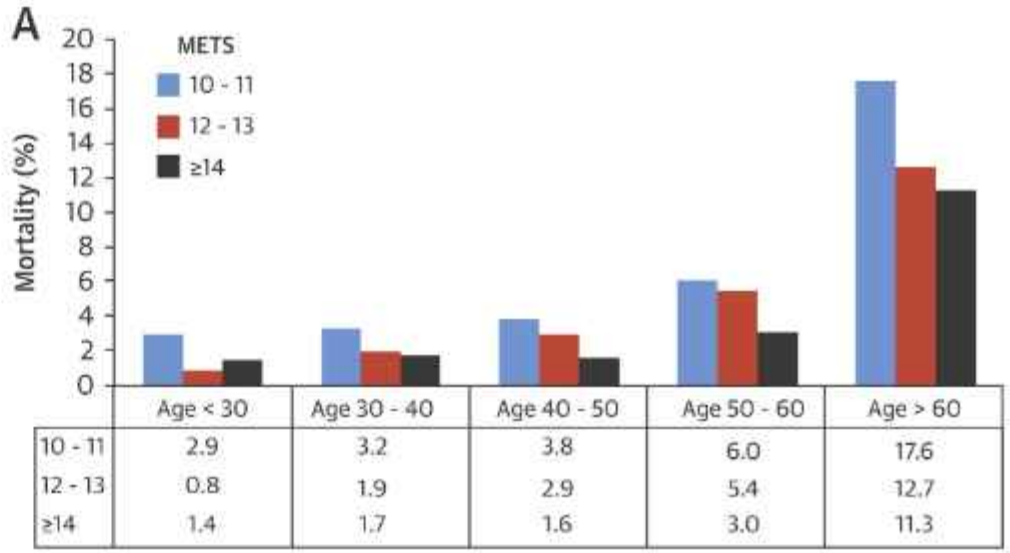
Ο απεικονιστικός έλεγχος είναι απαράιτητος σε όλους;

Ζαχαρένια Καλλινίκου
Επιμελήτρια Β΄Καρδιολογίας
Βενιζέλειο ΓΝΗ

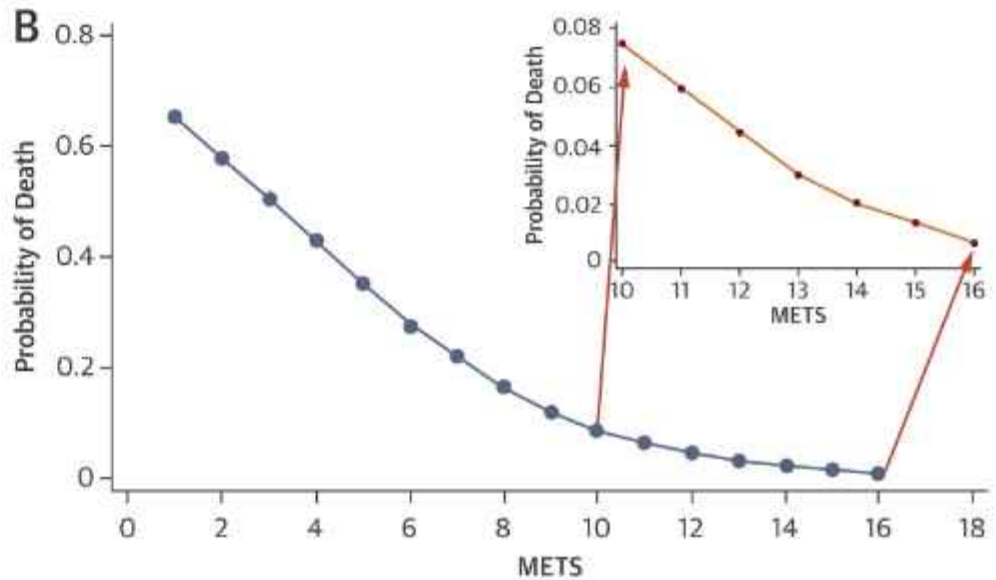
Positive Impact of Physical Activity

Higher exercise capacity in all age groups is associated with reduced mortality

↓ *BP, Chol, gluc, obesity, smoking, stress, depression*



	Age < 30	Age 30 - 40	Age 40 - 50	Age 50 - 60	Age > 60
10 - 11	2.9	3.2	3.8	6.0	17.6
12 - 13	0.8	1.9	2.9	5.4	12.7
≥14	1.4	1.7	1.6	3.0	11.3



D.I. Feldman et al., JACC 2015

Role of Pre-Athletic Control

SCD Prevention

Despite the substantial health benefits of regular exercise, intense exercise may paradoxically act as a trigger for life-threatening VA in the presence of underlying CVD.

- SCD is the leading cause of sports & exercise-related mortality in athletes:

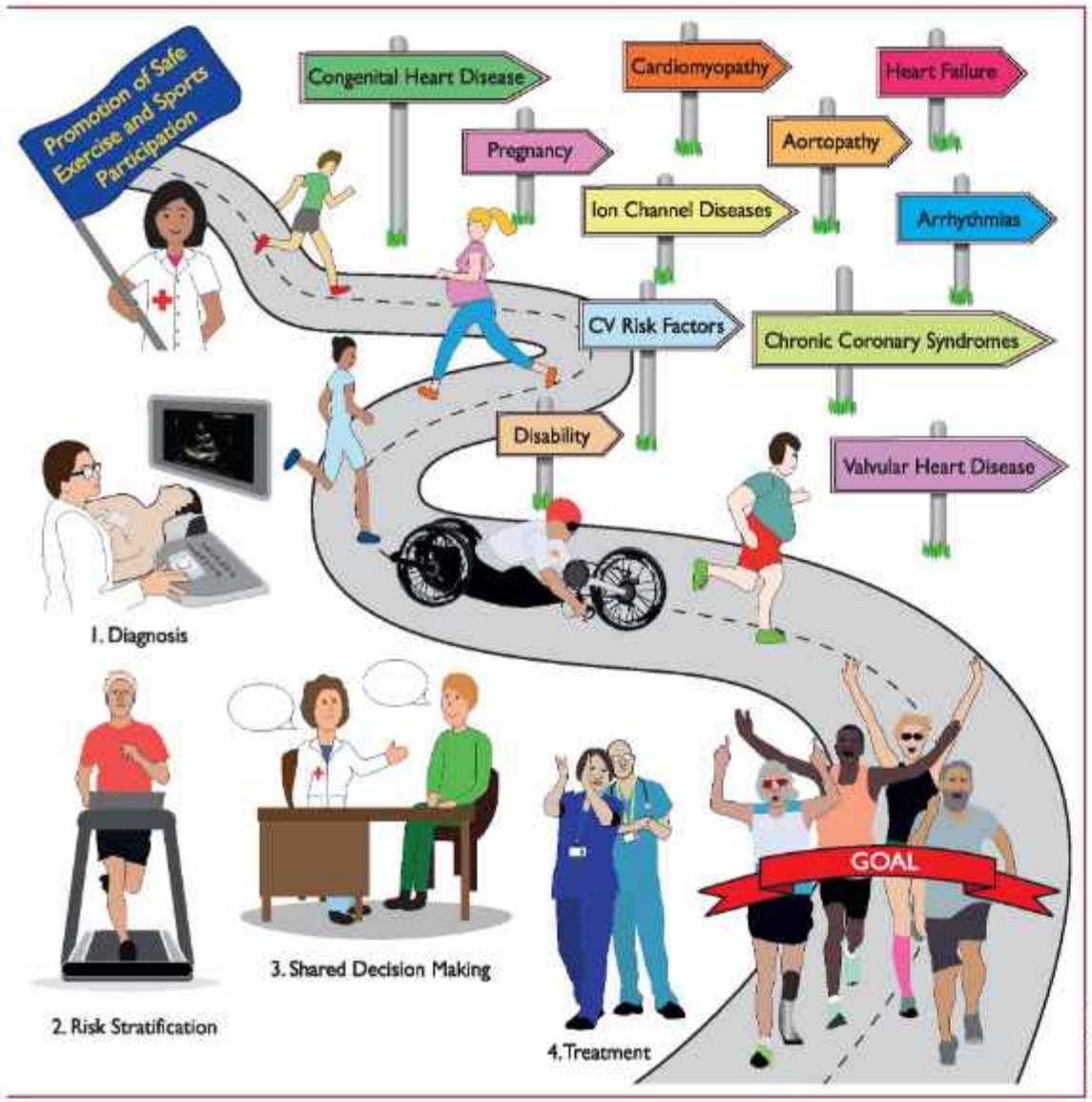
2.1/100’000 athletes vs. 0.7/100’000 non athletes/year

- 1/1’000’000 to 1/5’000 athletes/year

- Higher risk based on sex, race or sport:

Male, black athletes, basketball (US) and soccer (Europe) athletes

Role of Pre-Athletic Control
CVD and Physical Activity

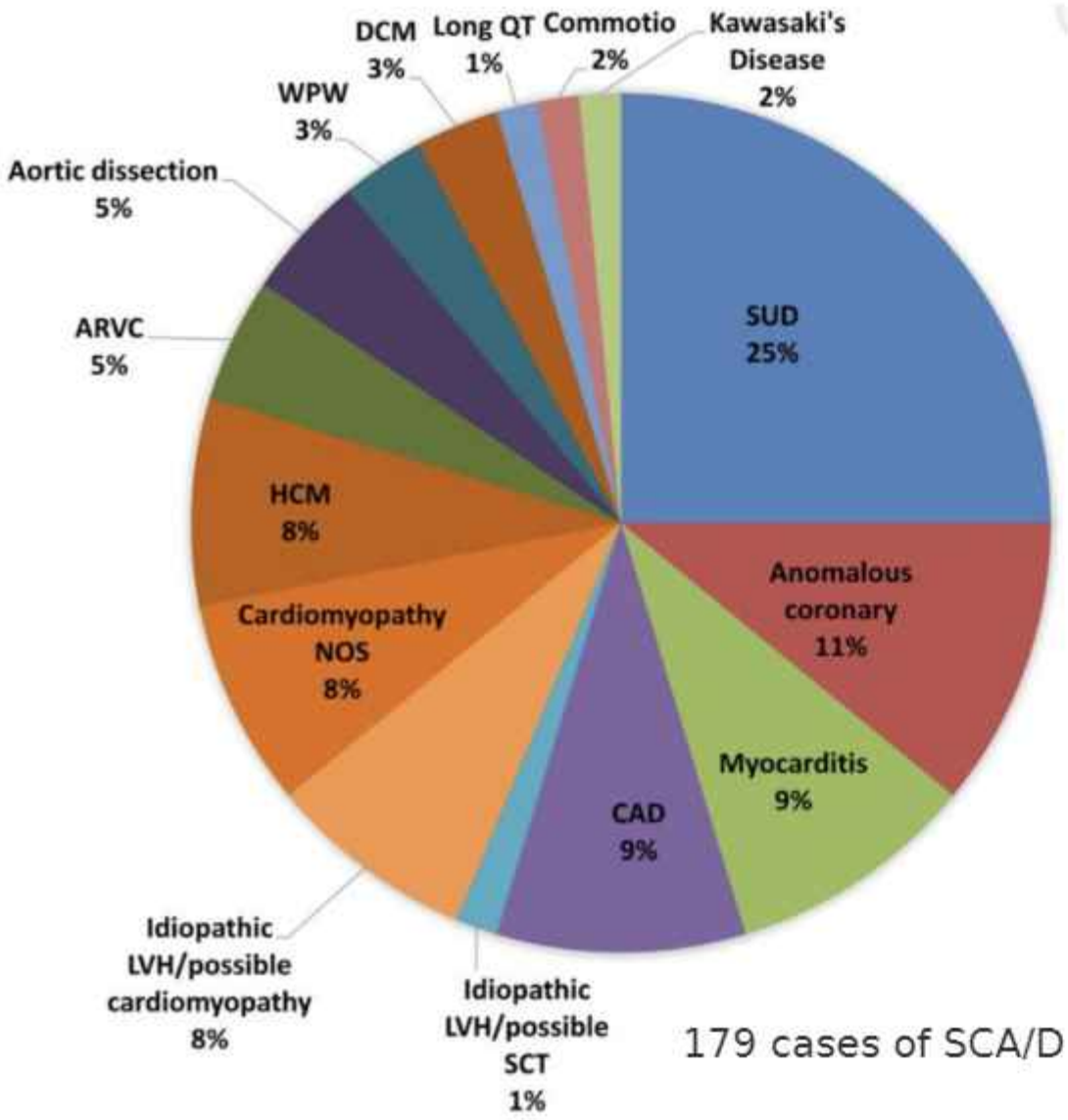


Moderate physical activity should be promoted in all individuals with CVD

More vigorous activity: appropriate risk stratification & optimal therapy are essential for providing exercise prescription.

Eur Heart J, Volume 42, Issue 1, 1 January 2021, Pages 17–96

Aetiology of SCD in competitive athlets



179 cases of SCA/D

K Harmon et al., Circulation 2015

SCD in young athletes:

- Usually caused by genetic or congenital structural & electrical cardiac disorder.

- 44%: autopsy-negative sudden unexplained death (AN-SUD) (sudden arrhythmic death syndrome) with structurally normal heart.

- 0.3% prevalence of SCD-associated cardiac disorders.

In athletes >35 years:

- 80% of all SCD due to atherosclerotic CAD.

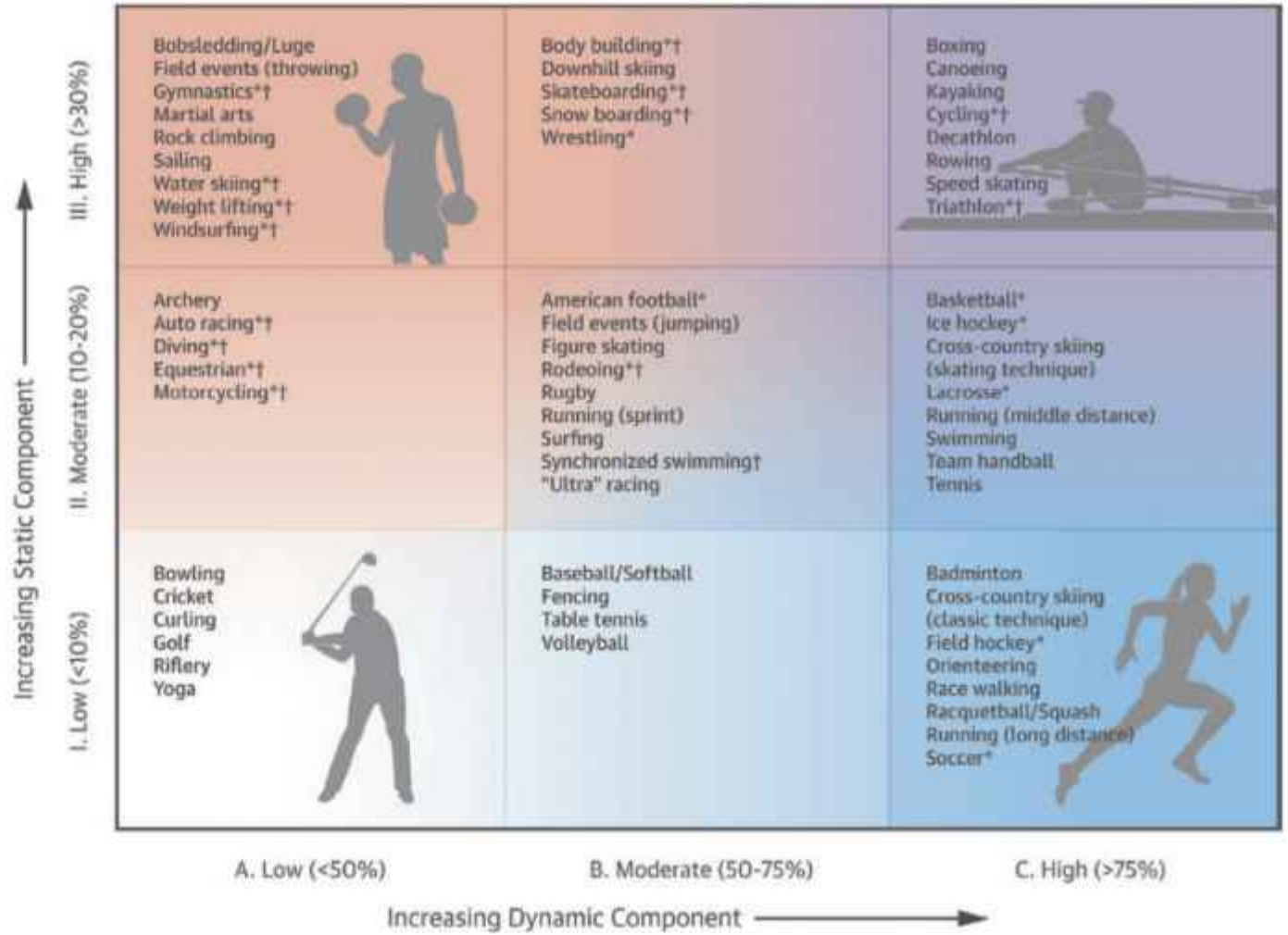
- Vigorous physical exertion ↑↑ risk of AMI & SCD.

- Little or no background in systematic training: at greatest risk.

Classification of Sports…

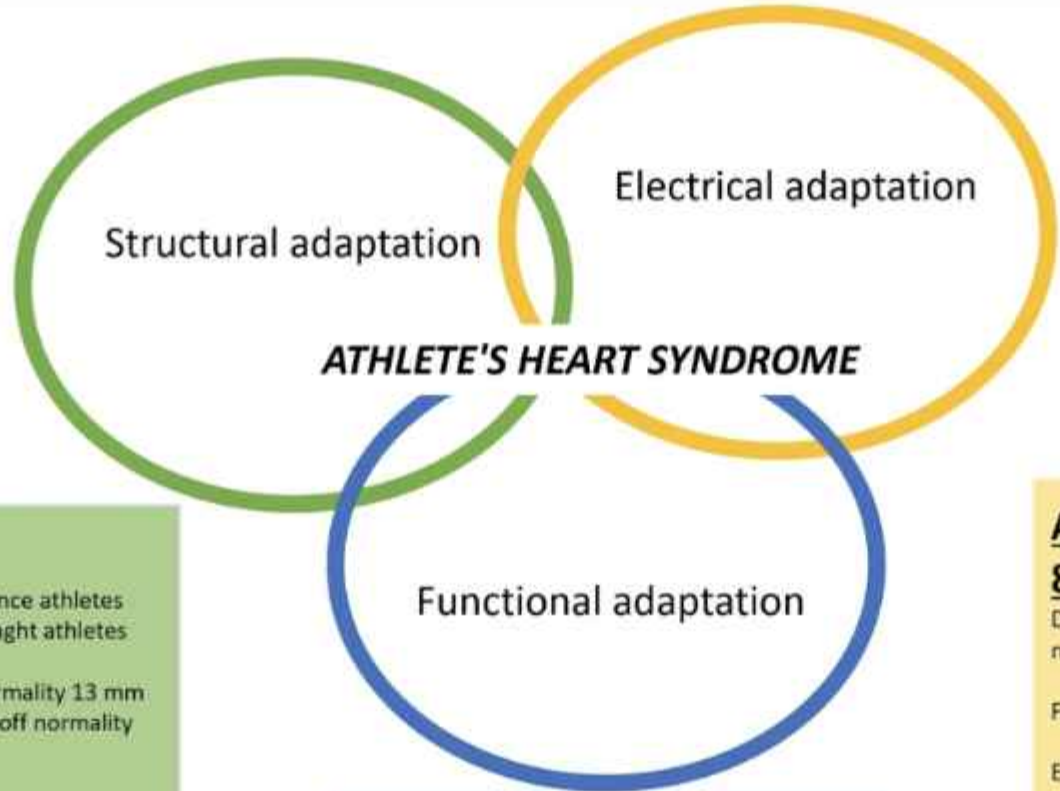
…based on peak static & dynamic components achieved during competition

FIGURE Classification of Sports



B. Maron, D. Zipes, R. Kovacs, JACC 2015

Structural, functional, & electrical myocardial remodeling induced by exercise training in competitive athletes



LV hypertrophy:

- eccetric hypertrophy in endurance athletes
- concentric hypertrophy in strenght athletes

LVWT (15-20% greater) cut-off normality 13 mm
LV Diameter (10-15% greater) cut-off normality 60 mm

Left atrium dilation:

cut-off value: 46 mm F; 50 mm M

RV dilation:

Overlapping ARVC, but involving mostly the inflow and with absent RV wall bulging

Greater diastolic compliance and reduced EF

Functional recovery during exercise and after detraining

Arrhythmias in more than 80% of athletes:

Due to conditioning of the cardiac autonomic nervous system and structural remodeling

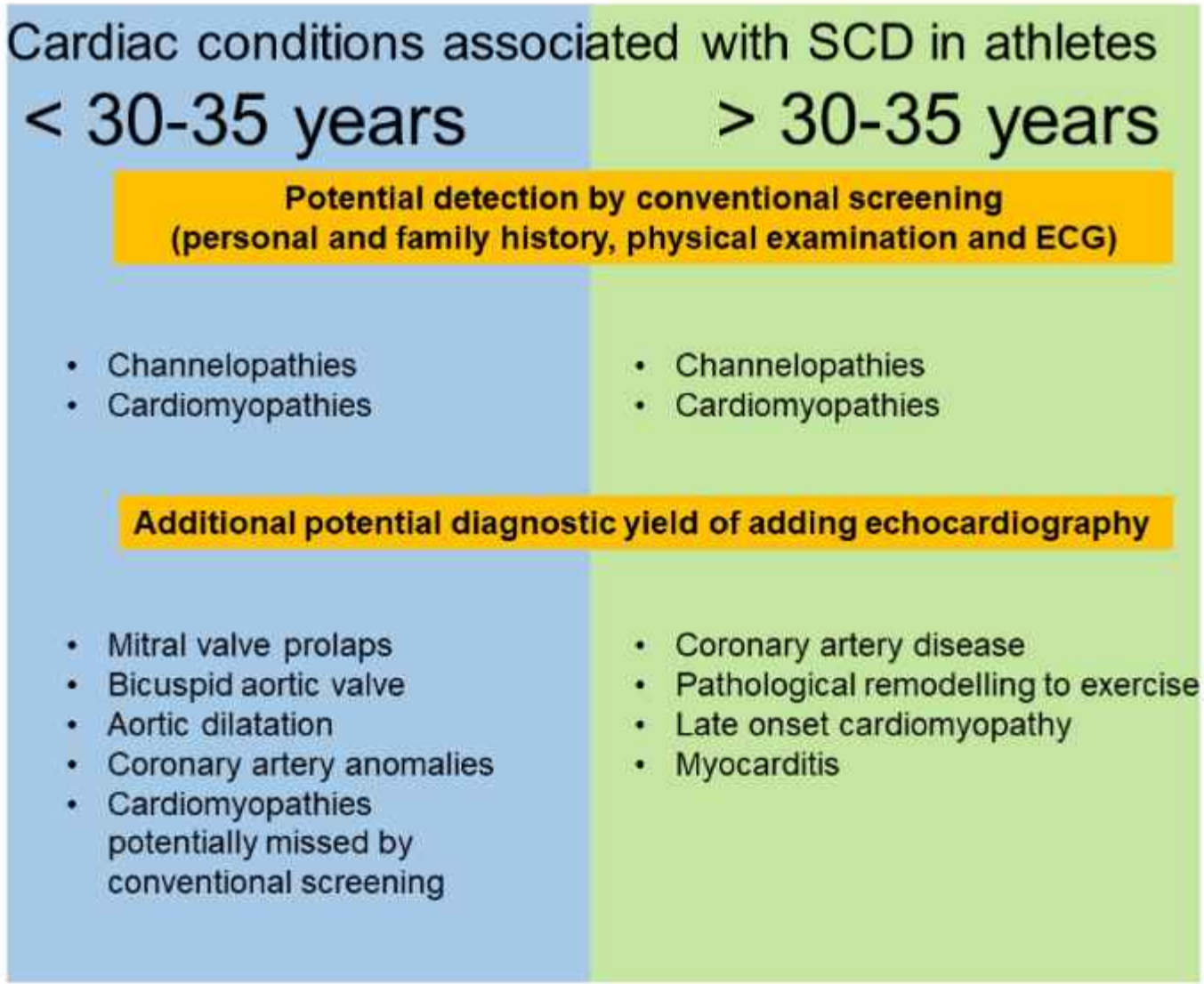
FA the most frequent in endurance athletes

ECG alteration can be classified as:

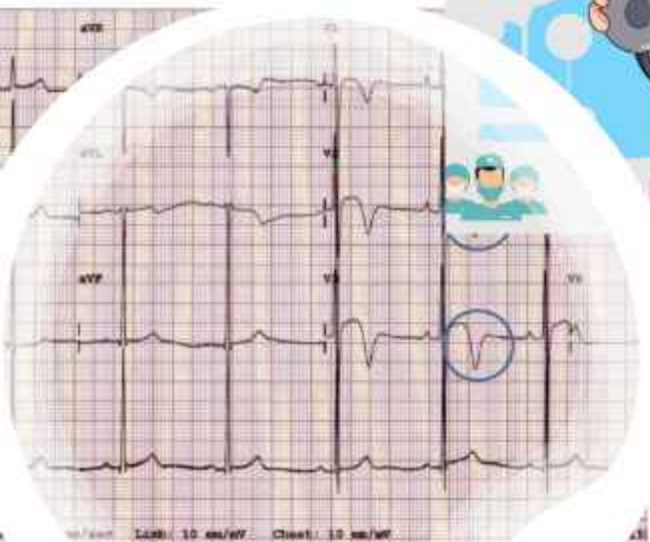
- ***training related changes*** (sinus bradycardia, first-degree atrioventricular block, incomplete right bundle branch block and isolated QRS voltage criteria for LV hypertrophy)

- ***uncommon and trained-unrelated changes*** (T wave inversion, ST depression, Pathological Q wave).

Age-related potential diagnostic yield of imaging



Niederseer D, et al. Heart 2020



Use of Downstream Testing following an ECG in young athletes

When to Avoid Downstream Testing

- Asymptomatic athlets
- No family history of inherrited cardiac disease or SCD
- Normal findings in physical examination
- Normal/training-related ECG findings according to international consensus standards

S. Sharma et al., Eur Heart J 2017, Volume 39, Issue 16

D. Engel, D. Phelan, Sports Cardiology, Care of the Athletic Heart from the Clinic to the Sidelines

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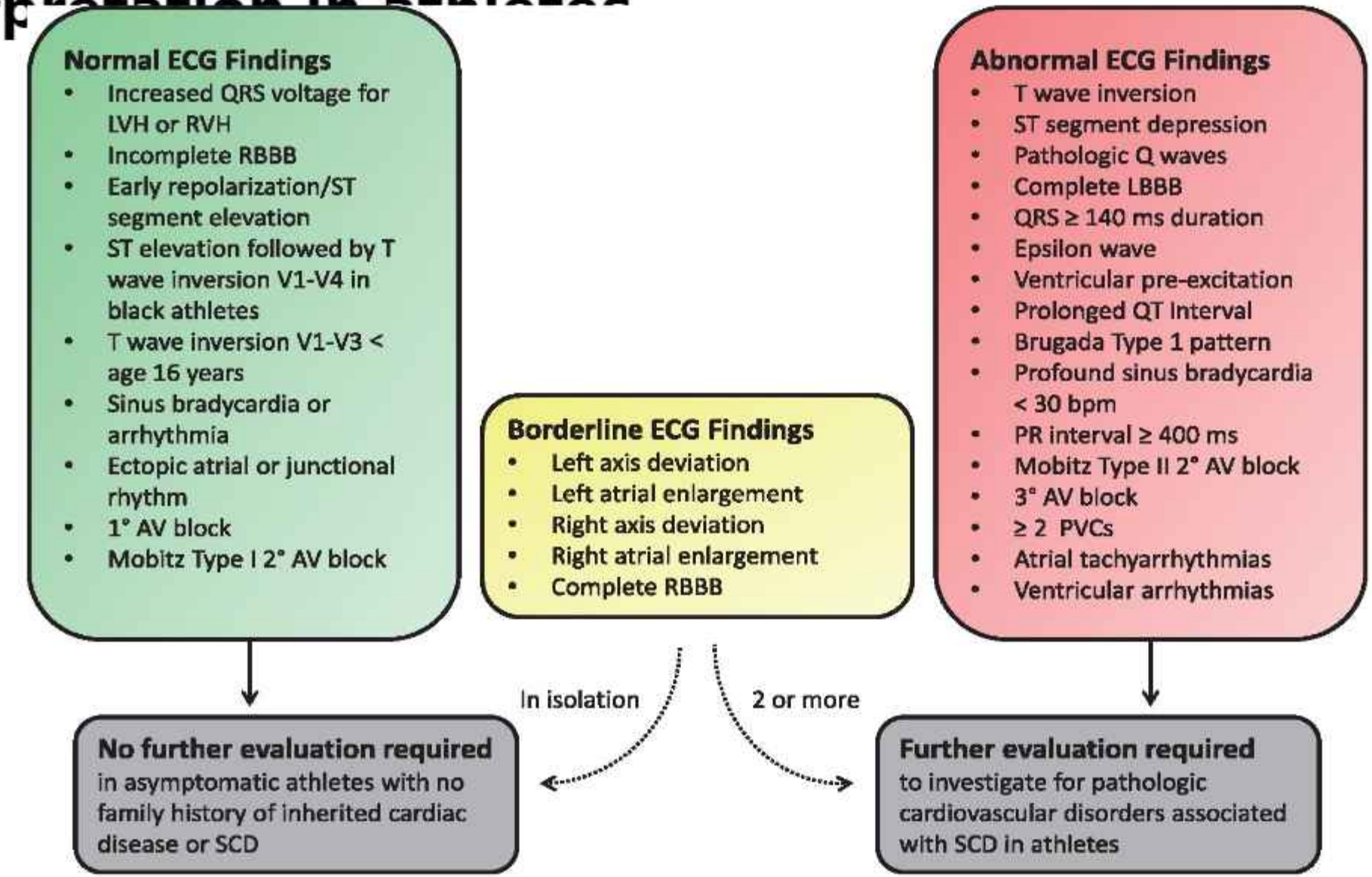
International consensus standards for ECG interpretation in athletes



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OXFORD UNIVERSITY PRESS

S. Sharma et al., Eur Heart J 2017, Volume 39, Issue 16

Use of Downstream Testing following an ECG in young athletes

When to proceed in Downstream Testing

- Symptoms during exercise (chest discomfort/tightness, pre-syncope, progressive inappropriately labored breathing, palpitations/arrythmias, loss of power…)
- Positive family history of inherrited cardiac disease or SCD
- Two or more borderline ECG findings on an ECG tracing
- Any abnormal ECG finding on an ECG tracing
- Abnormal findings on clinical examination, including HTN
- Physical features suggestive of genetic aortopathy

Πίνακας 1.Ύποπτα ευρήματα κατά την κλινική εξέταση αθλητών
Συστολικό ή διαστολικό φύσημα βαθμού >2/6
Αρτηριακή πίεση πάνω από 140/90mmHg σε ηρεμία
Διαφορά συστολικής πίεσης πάνω από 10mmHg μεταξύ των δύο άκρων
S1, S2 άρρυθμοι
Μεσο- ή τελοσυστολικό κλικ
Μονήρης S2 ή διχασμός του S2

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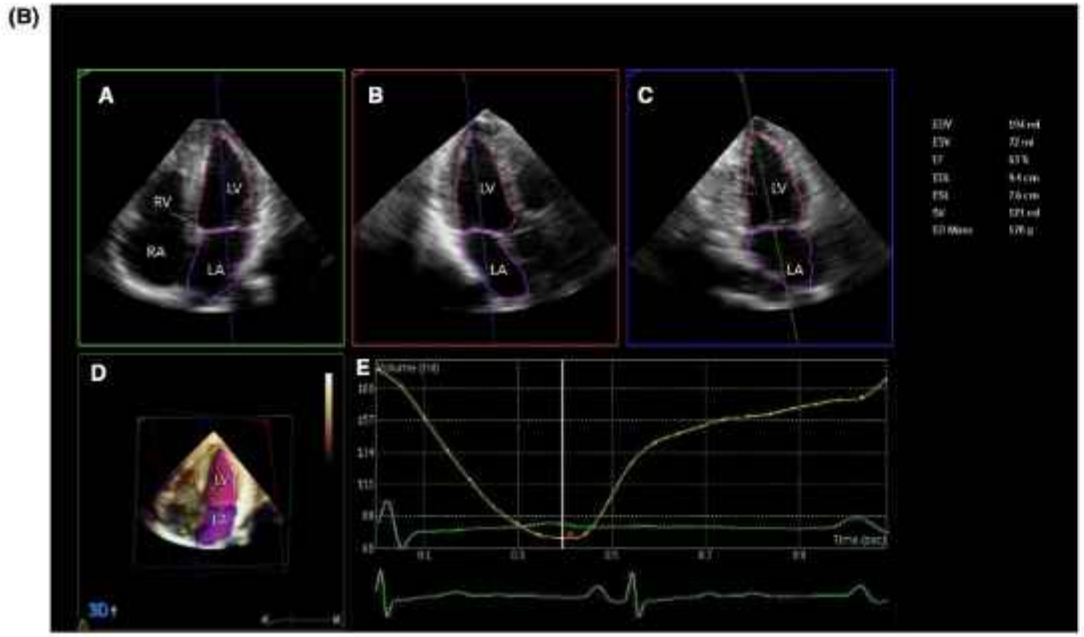
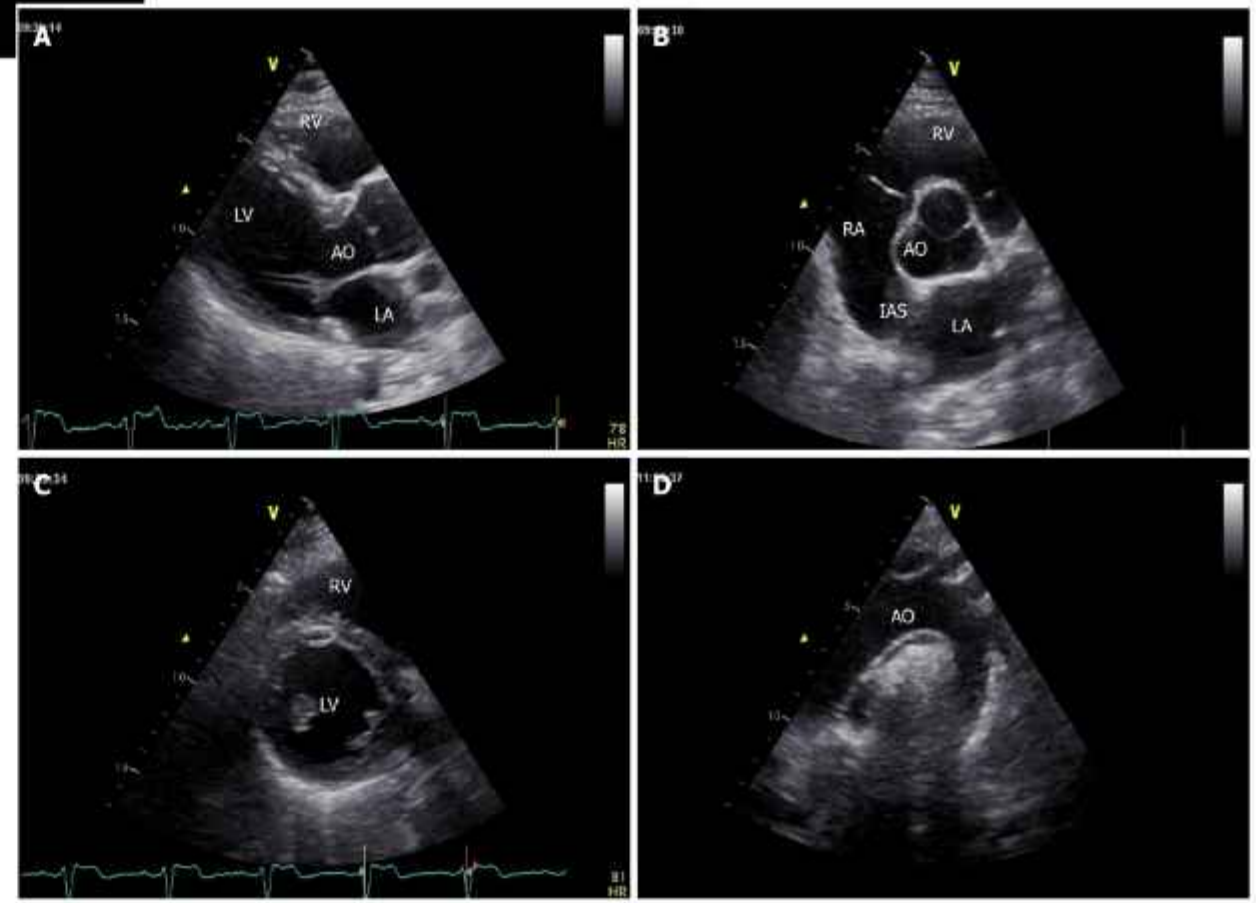
Fundamental downstream tests: TTE

Valve morphology & function
Proximal coronary anatomy
Aorta evaluation

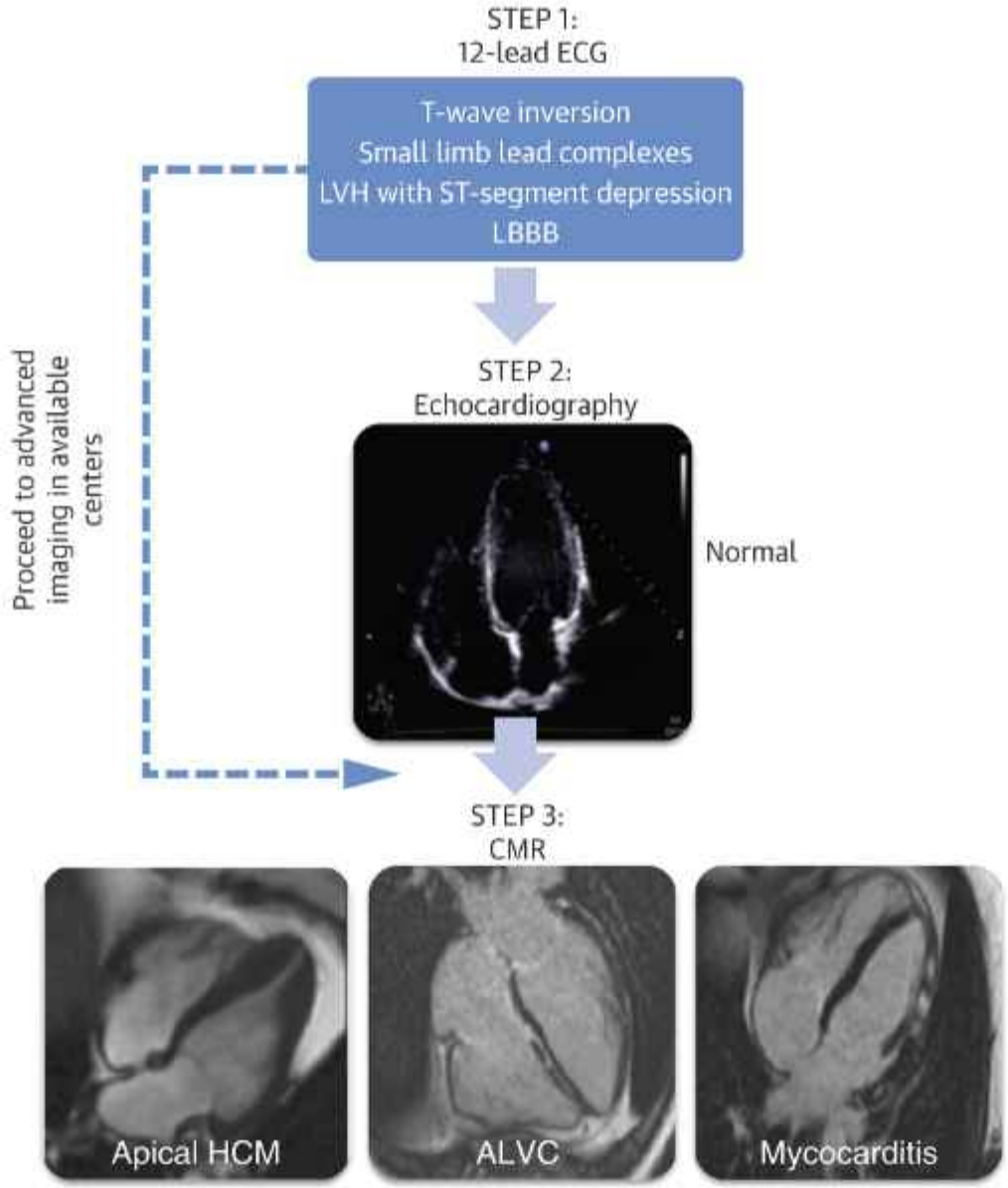


Myocardial structure
Systolic & diastolic function



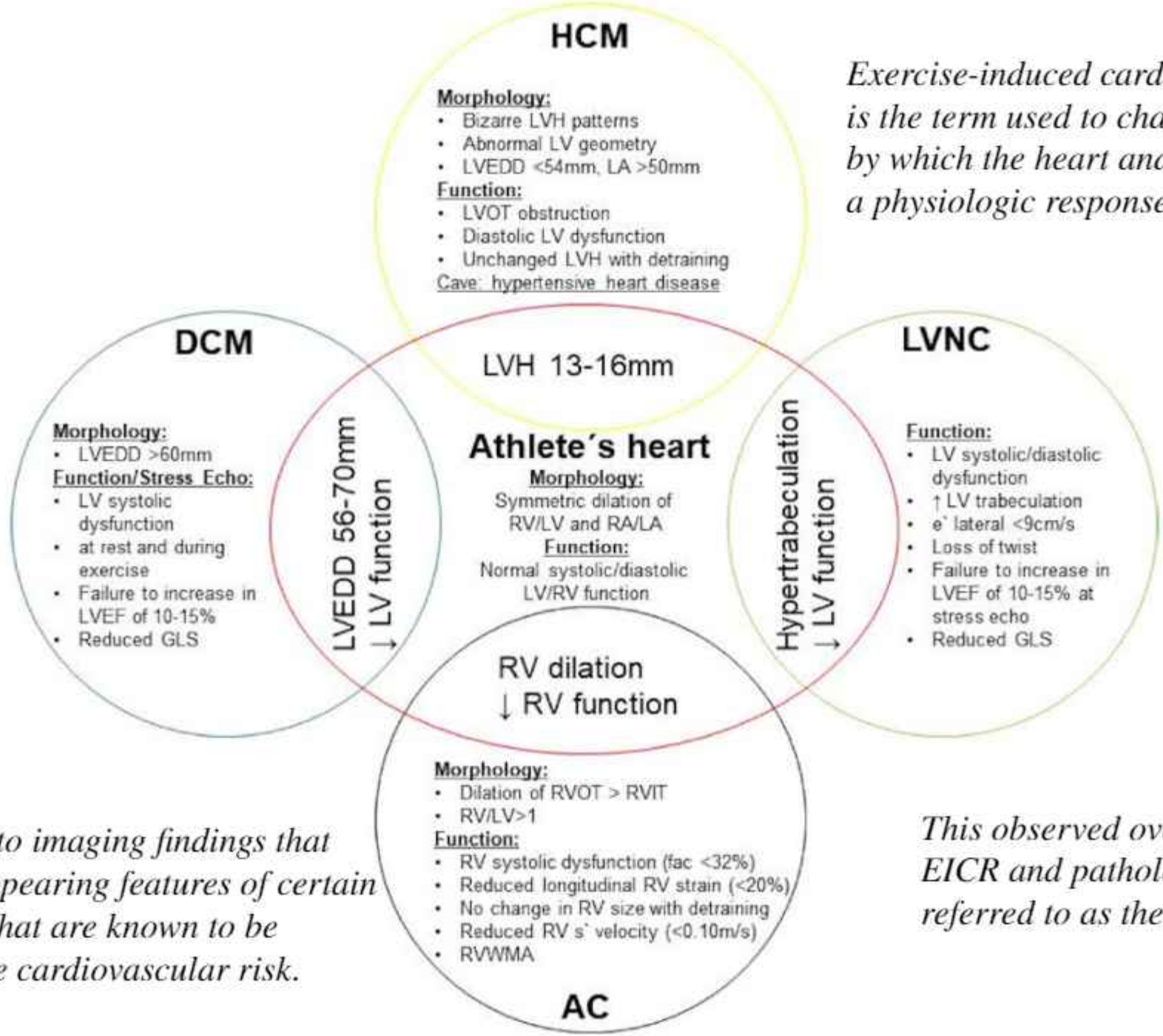
Albaeni et al., Echocardiophraphy 2021

Multimodality Imaging in Cardiovascular Assessment of Athlete



S Gati et al., JACC Card. Imag. 2018

Exercise-induced cardiac remodeling (EICR) is the term used to characterize the process by which the heart and vasculature change as a physiologic response to repetitive exercise



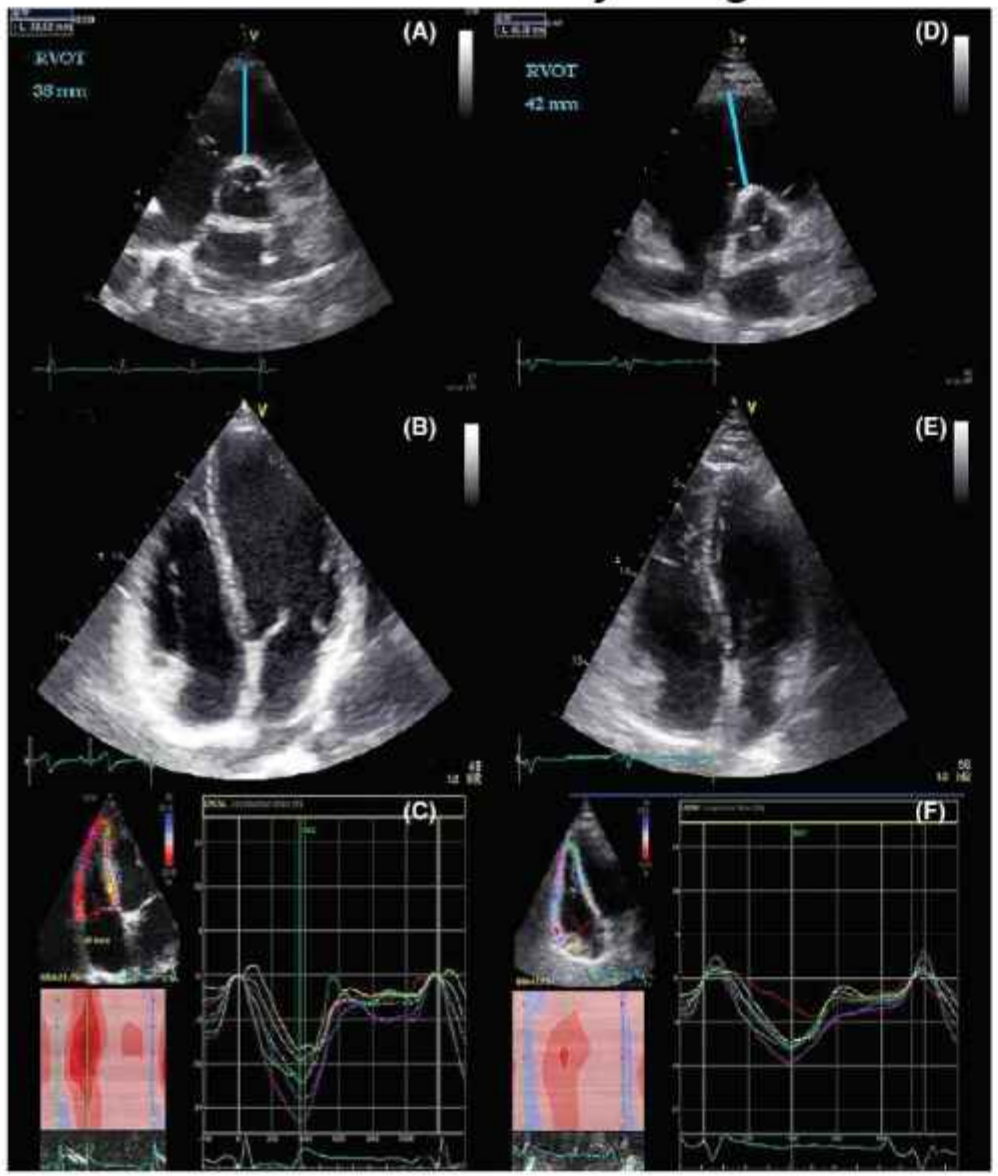
EICR commonly leads to imaging findings that overlap with similar appearing features of certain heart muscle diseases that are known to be associated with adverse cardiovascular risk.

This observed overlap between EICR and pathology is referred to as the "gray zone."

TTE Athlet vs. early stage ARVC

Athlet

Early stage ARVC

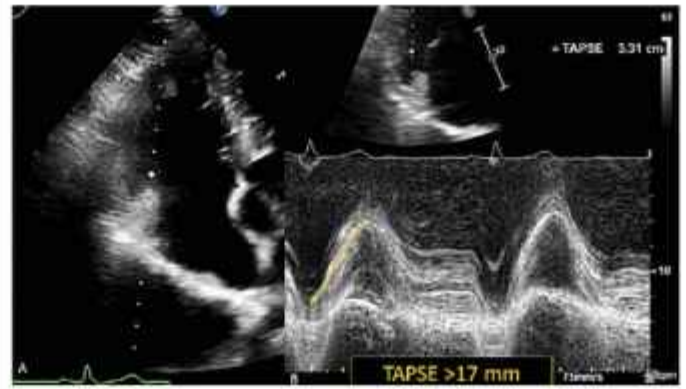


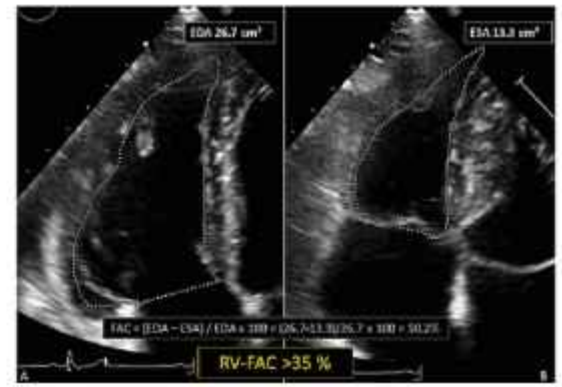
RVOT at least mildly dilated

RV/LV ratio ≥ 1

RV function/GLS

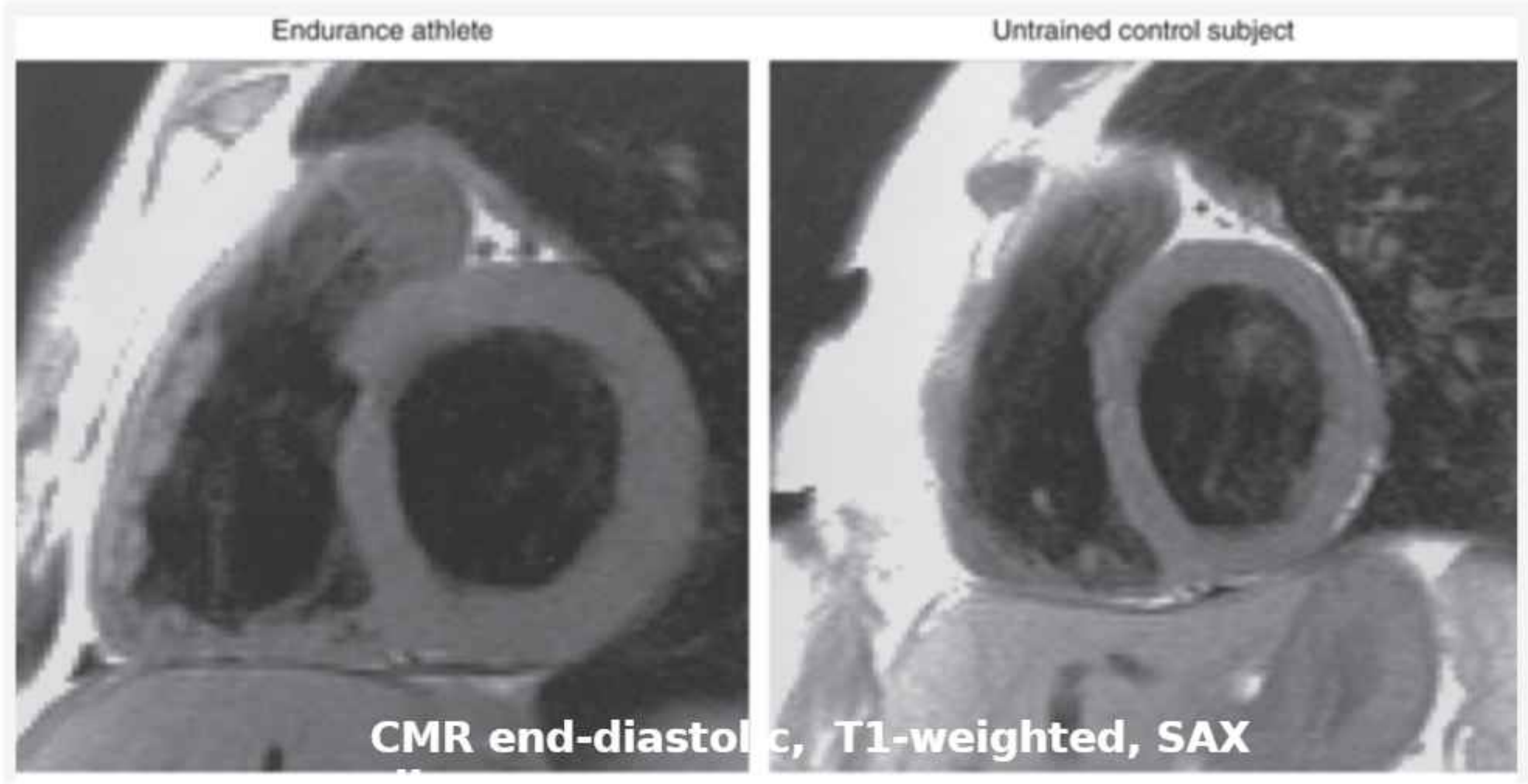
PARAMETER	UNIT	ABNORMAL IF
PLAx RVOT index	mm/m2	>19
PSAX RVOT index	mm/m2	>21
RVD1/LVEDD ratio		>0.9
RV FAC	%	<33
TAPSE	mm	<17
RV-GLS (3 segment model)	%	> -23
RV-GLS (6 segment model)		> -20
RV-MD (3 and 6 segment model)	ms	>25-30
3D-RVEF	%	≤40
LV-GLS	%	>
RV function		Wall motion abnormalities (akinesia or dyskinesia) or abnormal function on exercise echocardiography





Albaeni et al., Echocardiophraphy 202

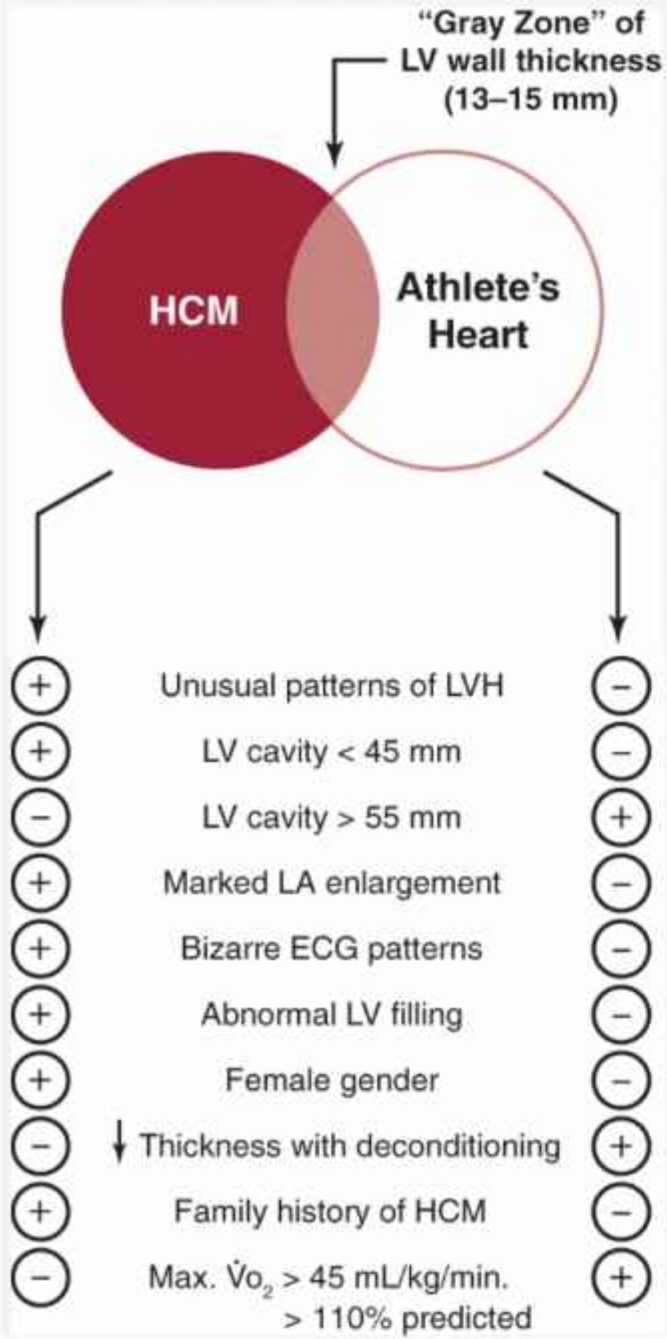
Endurance athlete's heart with symmetric dilation of LV/RV

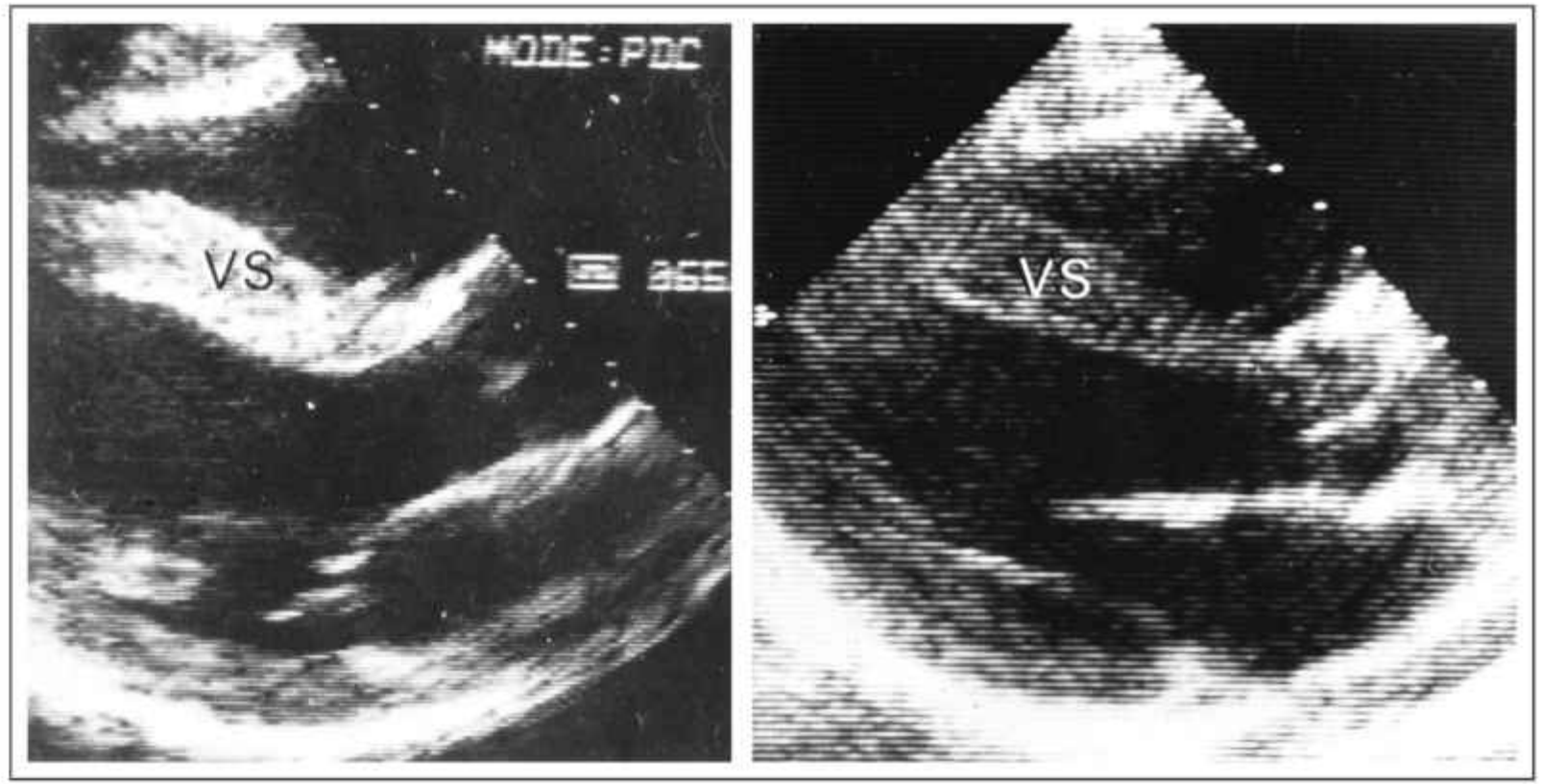


Enlarged volume & greater myocardial mass of both ventricles
Same proportions of LV/RV as in the untrained control subject

J. Scharhag et al. J Am Coll Cardiol 2002

Athlete's Heart vs. early HCM

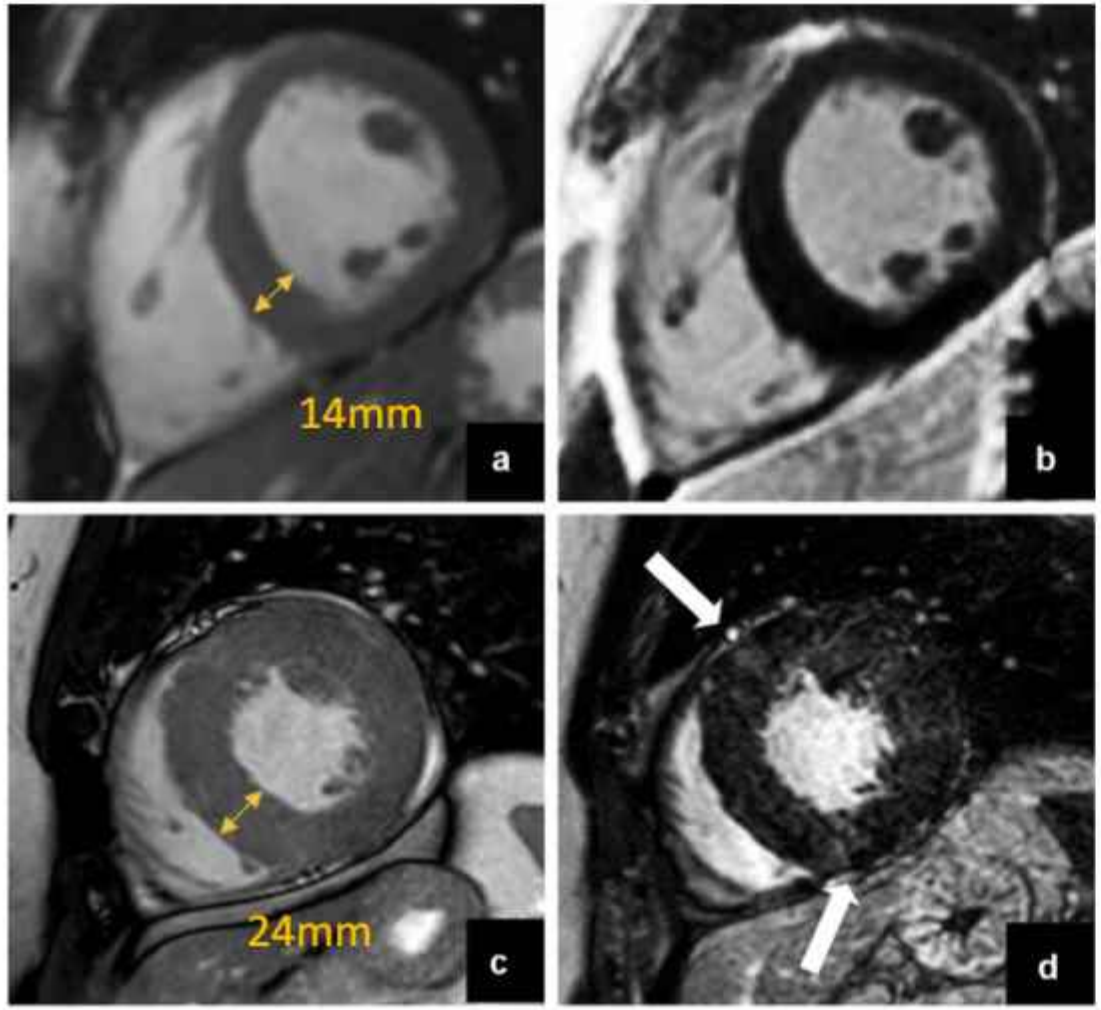




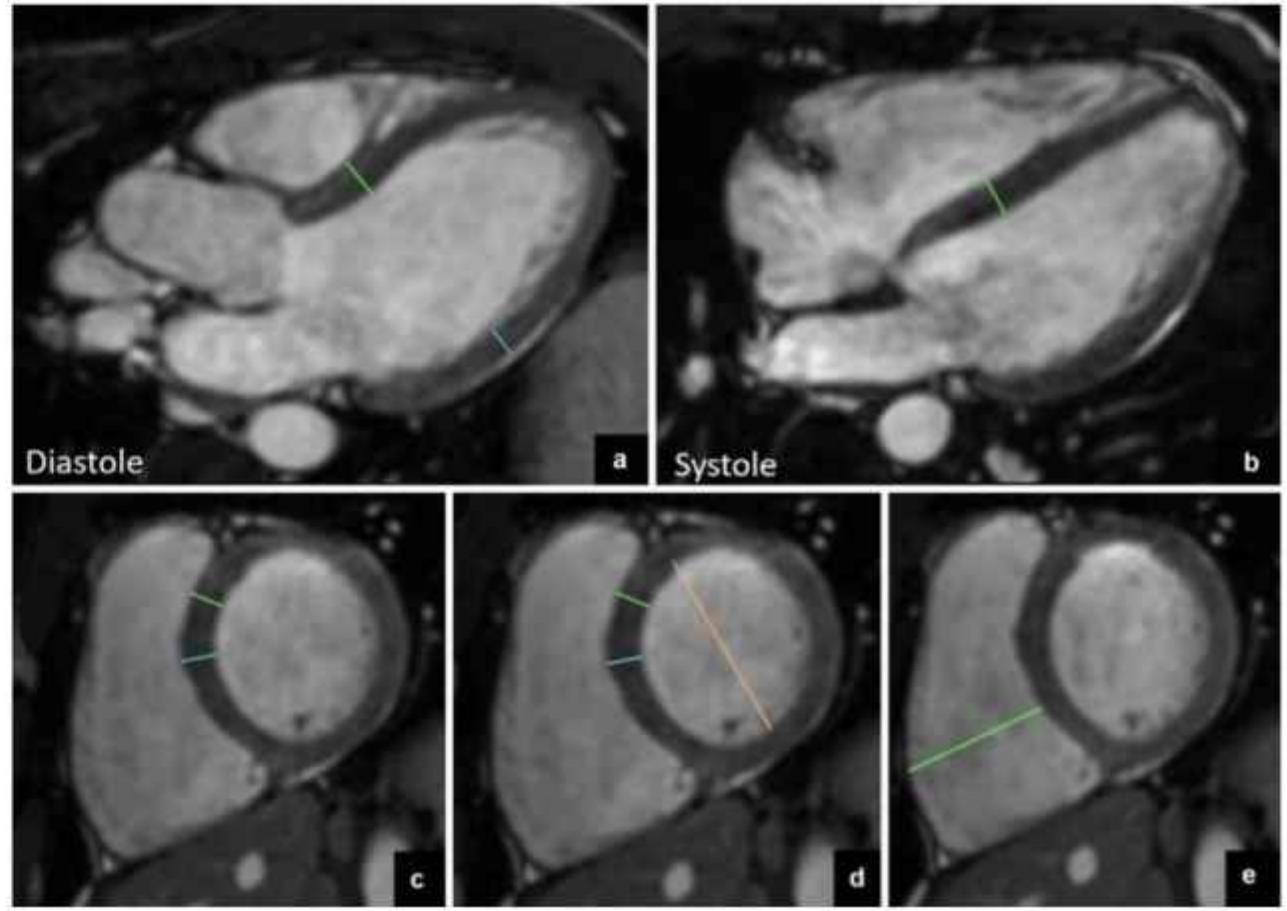
elite athlete (Olympic rower)

young asymptomatic patient with HCM

Fundamental downstream tests: CMR
Athlet's heart



Hypertrophic phenotype (a, b)
Symmetric HCM (c, d)

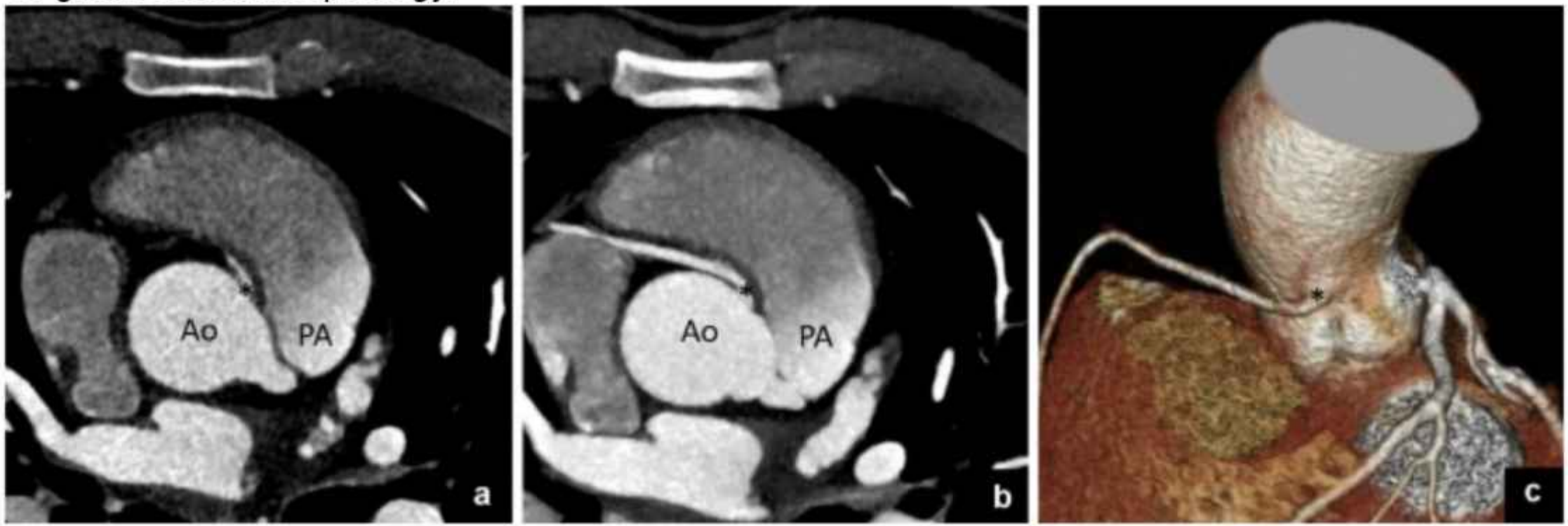


Dilated phenotype (LVEDD >58mm, EF 50%)

Palmisano A. et al. La Radiologia medica 126, 22 August 2021

Fundamental downstream tests:
Coronary Computed Tomography Angiography (CCTA)

Assessment of coronary artery anatomy and vessel course, aortic origins of the coronary ostia, the presence of coronary artery atherosclerosis & degree of stenosis, along with characterization of great vessel morphology.

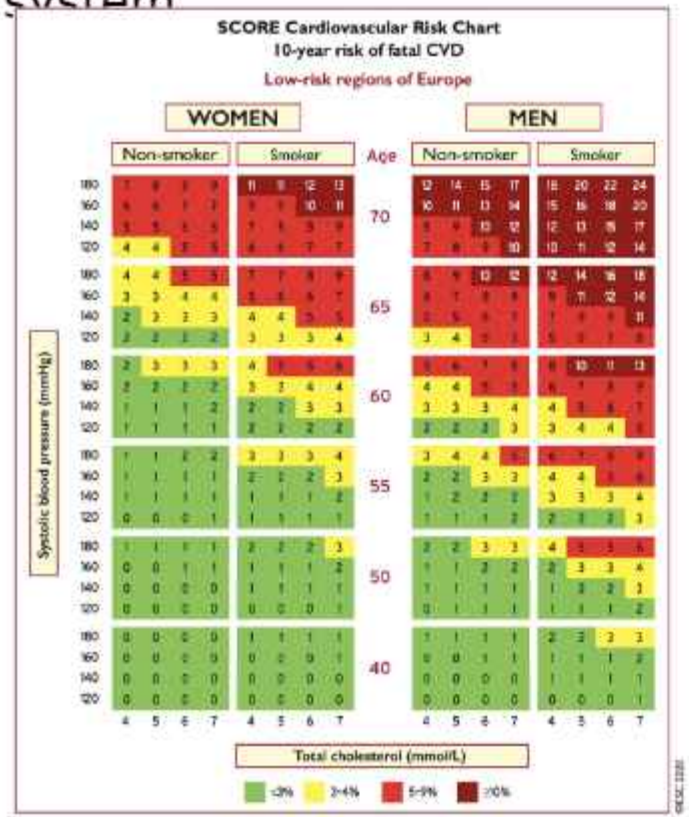


RCA arising from left coronary sinus with malignant inter-arterial course between PA - Ao

Palmisano A. et al. La Radiologia medica 126, 22 August 2021

Asymptomatic individuals > 35 according to CVD Risk-assessme

- CV screening in adult and senior athletes must target the higher prevalence of atherosclerotic CAD.
- Atrial tachyarrhythmias particularly AF, degenerative aortic & mitral VD & HTN heart disease
- Risk-assessment of CAD based on the ESC Systematic Coronary Risk Evaluation (SCORE) system



Very high-risk	People with any of the following: • Documented ASCVD, either clinical or unequivocal on imaging. Documented ASCVD includes previous ACS (MI or unstable angina), stable angina, coronary revascularization (PCI, CABG, and other arterial revascularization procedures), stroke and TIA, and peripheral arterial disease. Unequivocally documented ASCVD on imaging includes those findings that are known to be predictive of clinical events, such as significant plaque on coronary angiography or CT scan (multivessel coronary disease with two major epicardial arteries having >50% stenosis), or on carotid ultrasound. • DM with target organ damage,[a] or at least three major risk factors, or early onset of T1DM of long duration (>20 years). • Severe CKD (eGFR <30 mL/min/1.73 m^2). • A calculated SCORE ≥10% for 10-year risk of fatal CVD. • FH with ASCVD or with another major risk factor.

High-risk	People with: • Markedly elevated single risk factors, in particular TC >8 mmol/L (>310 mg/dL), LDL-C >4.9 mmol/L (>190 mg/dL) , or BP ≥180/110 mmHg. • Patients with FH without other major risk factors. • Patients with DM without target organ damage,[a] with DM duration ≥10 years or another additional risk factor. • Moderate CKD (eGFR 30–59 mL/min/1.73m^2). • A calculated SCORE ≥5% and <10% for 10-year risk of fatal CVD.
Moderate-risk	Young patients (T1DM <35 years; T2DM <50 years) with DM duration <10 years, without other risk factors. Calculated SCORE ≥1% and <5% for 10-year risk of fatal CVD.
Low-risk	Calculated SCORE <1% for 10-year risk of fatal CVD.

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A Pelliccia et al. Eur Heart J, Jan. 2021

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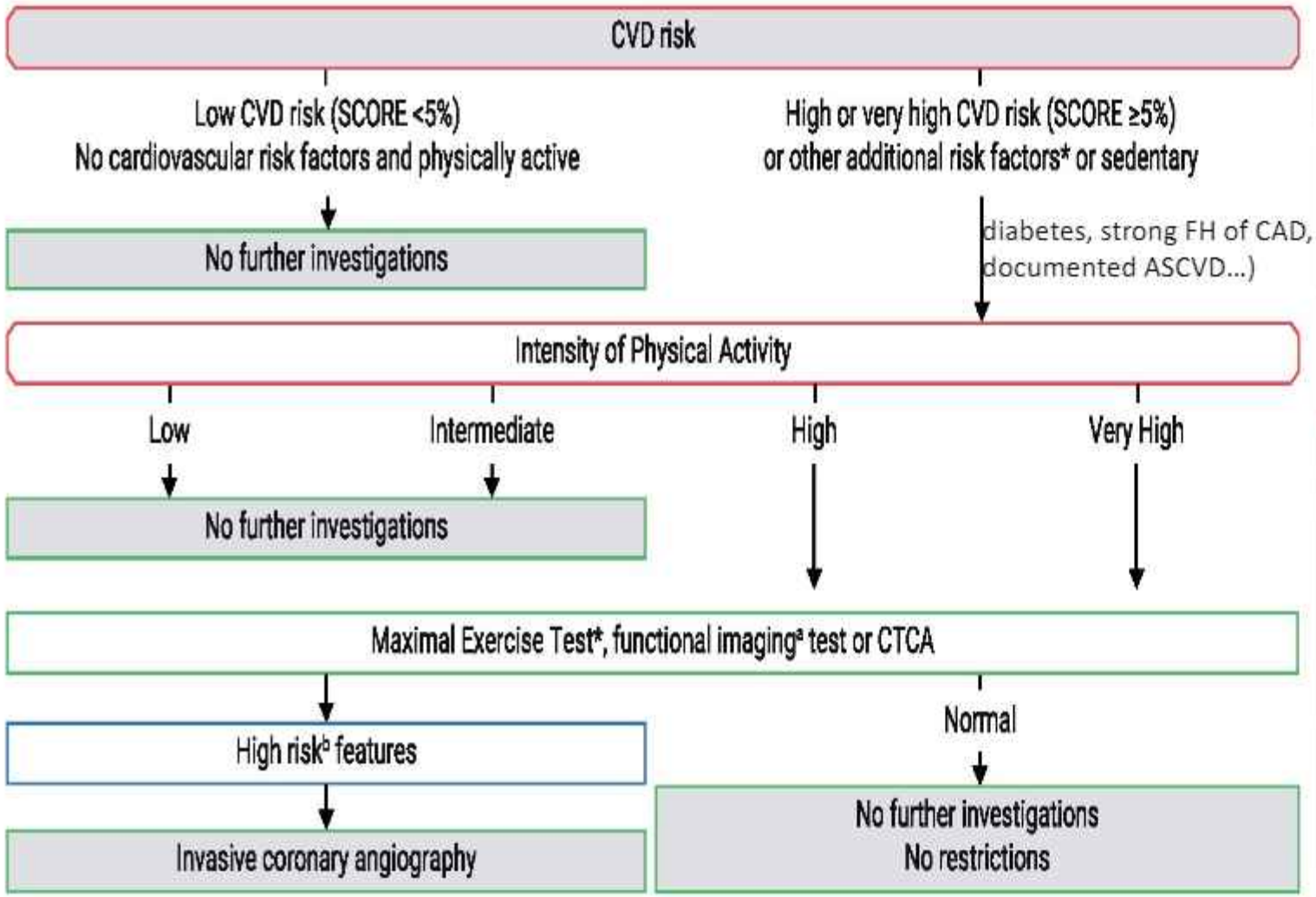
Asymptomatic individuals > 35 according to CVD Risk-assessme



Recommendations for cardiovascular evaluation and regular exercise in healthy individuals aged >35 years

Recommendations	Class[a]	Level[b]
Among individuals with low to moderate CVD risk, the participation in all recreational sports should be considered without further CV evaluation.	IIa	C
Cardiac screening with family history, symptoms, physical examination, and 12-lead resting ECG should be considered for competitive athletes.	IIa	C
Clinical evaluation, including maximal exercise testing, should be considered for prognostic purposes in sedentary people and individuals with high or very high CV risk who intend to engage in intensive exercise programmes or competitive sports.	IIa	C
In selected individuals without known CAD who have very high CVD risk (e.g. SCORE>10%, strong family history, or familial hypercholesterolaemia) and want to engage in high- or very high-intensity exercise, risk assessment with a functional imaging test, coronary CCTA, or carotid or femoral artery ultrasound imaging may be considered.	IIb	B

No evidence for routine screening cardiac imaging in asymptomatic >35yo with a normal exercise stress test

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Downstream imaging testing in pre-participation in individuals with CV risk factors

Dyslipidaemia

A maximal exercise stress test, functional imaging test, or CCTA may be considered in the risk assessment, particularly in individuals with familial hypercholesterolaemia

Diabetes mellitus

Individuals with diabetes have a priori a higher likelihood of subclinical CAD; therefore, all individuals with diabetes should undergo CV assessment before taking up an exercise programme of high intensity.

Obesety

A pre-participation CV assessment is warranted in obese individuals who intend to engage in high-intensity exercise due to associated comorbidities such as type 2 diabetes, hypertension, dyslipidaemia, and CV and respiratory diseases.

A Pelliccia et al. Eur Heart J, Jan. 2021

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Senior athletes & ageing individuals ≥65 y.o.

Annual clinical assessment including a maximal exercise test is recommended in master athletes performing a high level of sports and exercise programmes.

Recommendations for exercise in ageing individuals

Recommendations	Class[a]	Level[b]
Among adults aged 65 years or older who are fit and have no health conditions that limit their mobility, moderate-intensity aerobic exercise for at least 150 min/week is recommended.[212,214,215]	I	A
In older adults at risk of falls, strength training exercises to improve balance and coordination on at least 2 days a week are recommended.[201,212,214,215]	I	B
A full clinical assessment including a maximal exercise test should be considered in sedentary adults aged 65 years or older who wish to participate in high-intensity activity.	IIa	C
Continuation of high- and very high-intensity activity, including competitive sports, may be considered in asymptomatic elderly athletes (master athletes) at low or moderate CV risk.	IIb	C

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Stress echocardiography in athlete

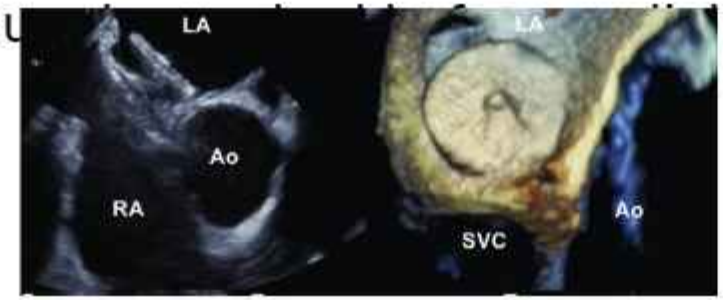
- To distinguish athlete’s dilated adaptation to training in the grey zone (LVEDD > 58 mm or LVEDV > 150 mL, EF< 55%) from mild DCM in absence of LGE.

- Coronary artery disease detection in symptomatic or asymptomatic individuals> 35 y.o. with high or very high CVD risk or sedentary.

Special Populations

Sport in deep sea:
Decompression illness & intracardiac shunts:

- Demonstration of a right to left shunt is essential and requires bubble contrast ultrasound (TTE/TEE contrast ECHO).
- Confirmation of shunt closu[illegible]ng



ercise in individuals with cancer

Recommendations for exercise in individuals with cancer		
Regular exercise during and after cancer therapy is recommended to reduce cancer-related fatigue, and improve quality of life, physical fitness, and prognosis.	I	A
Among individuals treated with cardiotoxic medications, echocardiography before participation in high-intensity exercise is recommended.	I	A

T Datta et al. Interventional Echocardiography 2022

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A Pelliccia et al. Eur Heart J, Jan. 2021

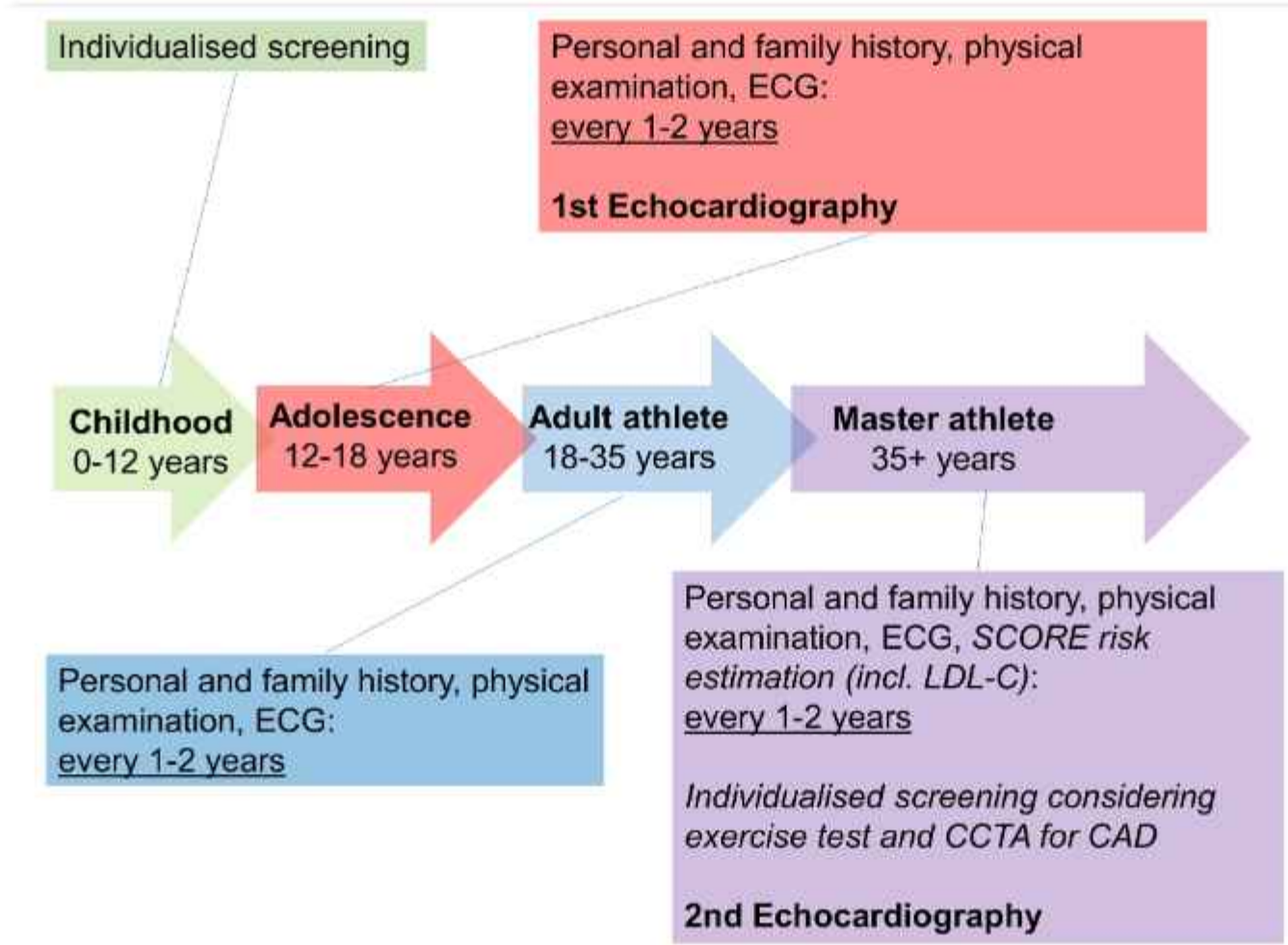
Multimodality Imaging in Cardiovascular Assessment of young Ath

Table 3.1 Important cardiac conditions and presenting signs/symptoms in athletes with recommended downstream testing approach

Suspected disease or clinical finding	First-line imaging	Additional imaging as needed
Hypertrophic cardiomyopathy	TTE and CMR	Ambulatory ECG, stress imaging
Arrhythmogenic ventricular cardiomyopathy	TTE and CMR	Ambulatory ECG
Familial/idiopathic dilated cardiomyopathy	TTE and CMR	
Left ventricular non-compaction cardiomyopathy	TTE and CMR	Stress imaging
Toxic cardiomyopathy (alcohol, illicit anabolic steroids, etc.)	TTE and CMR	
Myocarditis	TTE and CMR	Stress imaging, Ambulatory ECG
Complex congenital heart disease	TTE	CMR and CT, Stress imaging
Disorders of cardiac conduction		
Ventricular pre-excitation/Wolff-Parkinson-White syndrome	TTE and stress imaging	Ambulatory ECG, CMR or CTA
Congenital long-QT syndrome	Stress imaging	Ambulatory ECG
Catecholaminergic polymorphic ventricular tachycardia	Stress imaging	Ambulatory ECG
Idiopathic ventricular tachycardia	Stress imaging	Ambulatory ECG
Disorders of coronary circulation		
Congenital anomalies of coronary arterial origin and course	CTA or CMR or TTE	Exercise stress testing
Acquired atherosclerotic disease	TTE	Stress imaging or CMR
Disorders of the heart valves		
Bicuspid aortic valve (with stenosis +/− aortopathy)	TTE	CMR or CTA
Pulmonic stenosis (with ≥ moderate stenosis)	TTE	
Mitral valve prolapse (with corollary arrhythmogenicity)	TTE	Ambulatory ECG
Disorders of the aorta		
Bicuspid aortic valve aortopathy	CTA or CMR or TTE	
Familial aortopathy/TAA/Idiopathic aortopathy	CTA or CMR or TTE	
Marfan syndrome/Loeys-Dietz syndrome/ Ehlers-Danlos vascular type (IV)	CTA or CMR or TTE	
Symptoms or signs		
Murmur	TTE	CMR
Exertional chest pain/pressure or breathlessness	TTE and stress imaging	
Syncope	TTE	CMR
Loss of power	TTE and stress imaging	
Bradycardia	ECG	TTE

D. Engel, D. Phelan, Sports Cardiology, Care of the Athletic Heart from the Clinic to the Sidelines

A proposed screening algorithm for recreational and competitive athletes including echocardiography



Niederseer D, et al. Heart 2020

Take-Home messages
Downstream Imaging Testing when…

- Symptoms during exercise (chest discomfort/tightness, pre-syncope, progressive inappropriately labored breathing, palpitations/arrythmias, loss of power…).
- Positive family history of inherrited cardiac disease or SCD.
- 2 or more borderline ECG findings, or any abnormal ECG finding on an ECG tracing according to international consensus standards.
- Abnormal findings on clinical examination, including HTN.
- When myocarditis is suspected

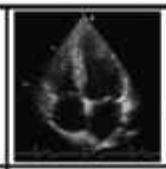
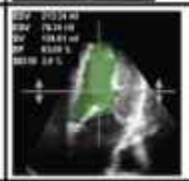
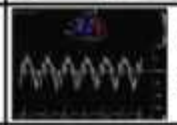
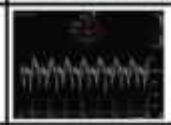
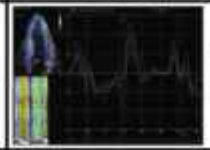
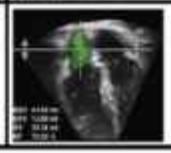
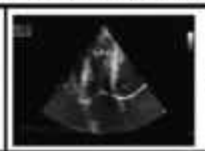
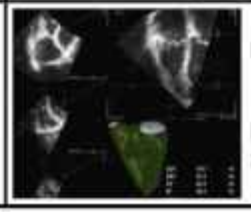
When US findings within the gray zone of overlapping Cardiomyopathies in highly competitive athletes.

Atrial tachyarrhythmias particularly AF, degenerative aortic & mitral VD & HTN heart disease (>35y.o.)

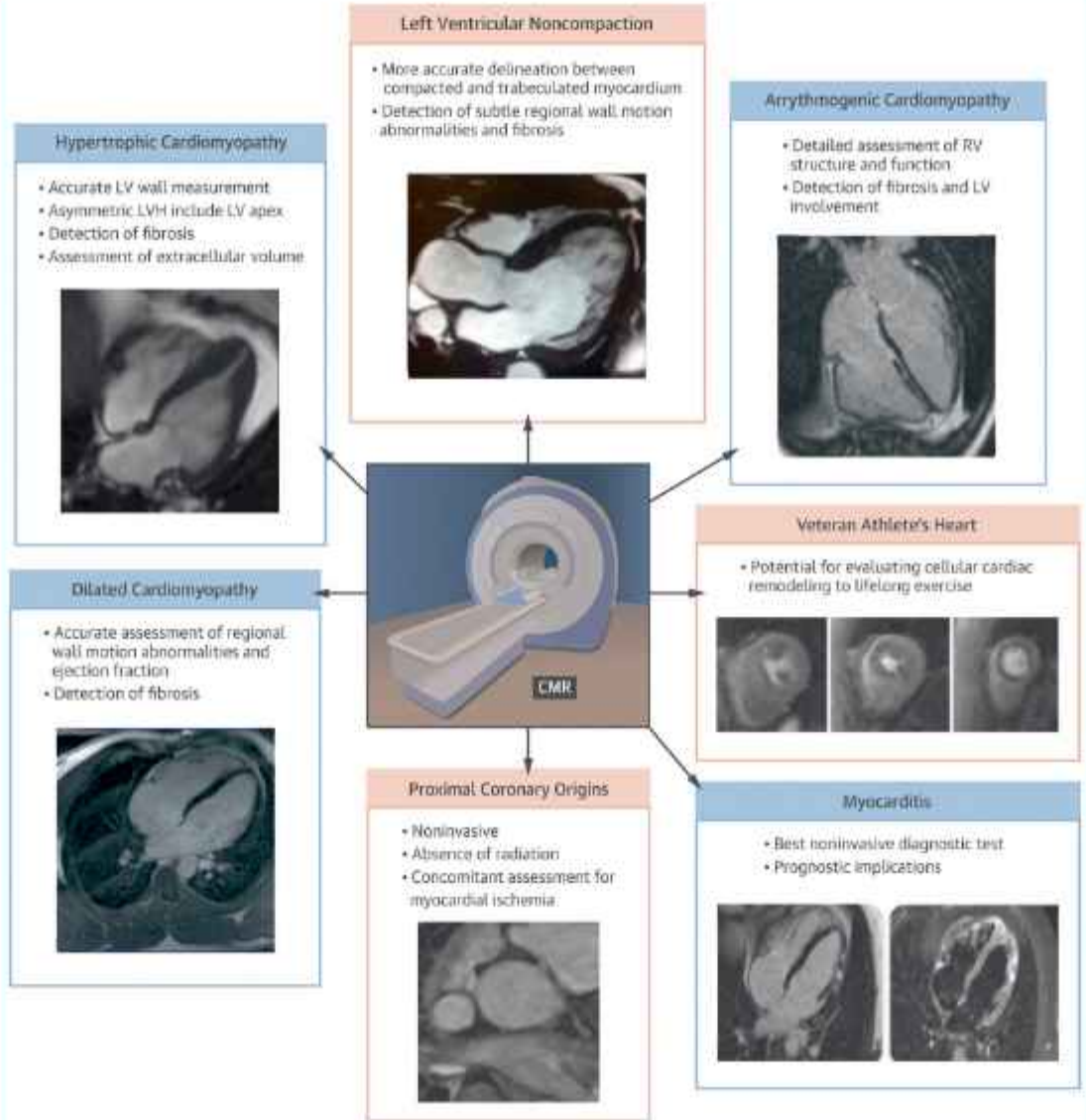
- In asymptomatic patients >35 y.o. at high and very high CAD, based on ESC SCORE system
- Annual assessment is recommended in master athletes > 65 y.o. performing high level exercise.
- For risk stratification and therapy guidance in known CVD
- In special populations /extreme special environments (e.g. diving, alpiing)

- Consider a baseline 1st TTE in recreational and competitive adolescents 12-18 y.o and a 2nd at 35 y.o.


MERCI!
THANK YOU!

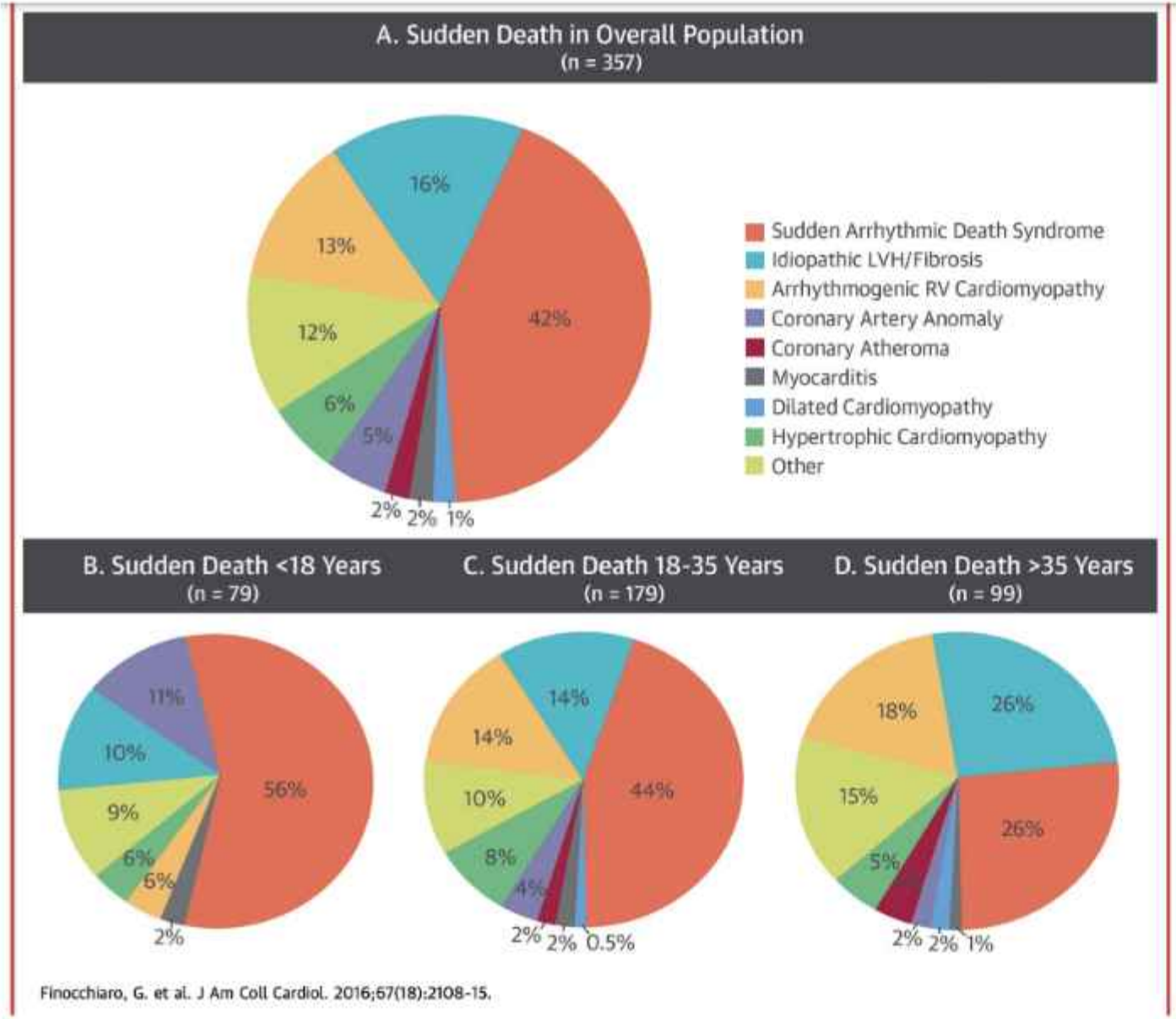
	Athlete	Non-Athlete
Left Ventricular Function		
Morphology	 IVSd 8 - 16* mm **< 13 mm** LVIDd 49 - 73 mm **< 65 mm** LVM 113 - 618* g **< 400 g**	 IVSd 6 - 10 mm LVIDd 42 - 59 mm LVM 88 - 224 g
Volumes/ EF(%)	 LVEDV 130 - 260 ml **< 240 ml** EF 41 - 77% **> 48%**	 LVEDV 67 - 155 ml EF >55%
Tissue Doppler	 S_m 6.5 - 14 cm/s E_m 7.5 - 16 cm/s	 S_m > 6 cm/s† E_m > 8 cm/s
Strain/ Strain rate	 Not clearly different from non-athletes	 Normal values not established
LA size	 22 - 55 mm (diameter)	 30 - 40 mm (diameter)
Right Ventricular Function		
RVFAC	 26 - 60%	 32 - 60%
Volumes/ EF (%)	 RVEDV 130 - 260 ml RVEF >45%	 RVEDV 60 - 150 ml RVEF >50%†

CENTRAL ILLUSTRATION: The Role of CMR in the Assessment of Cardiovascular Diseases in Athletes

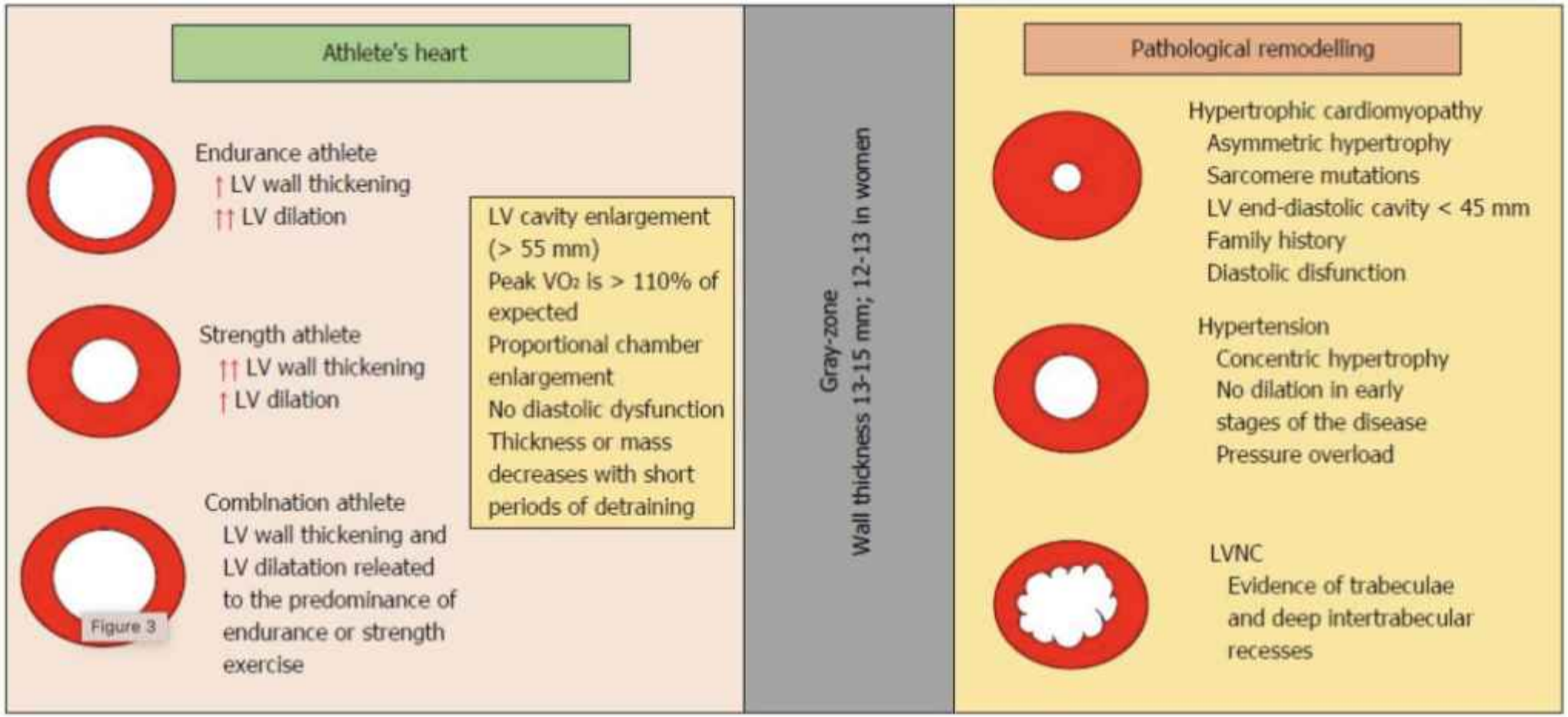


Gati, S. et al. J Am Coll Cardiol Img. 2018;11(2P1):247-59.

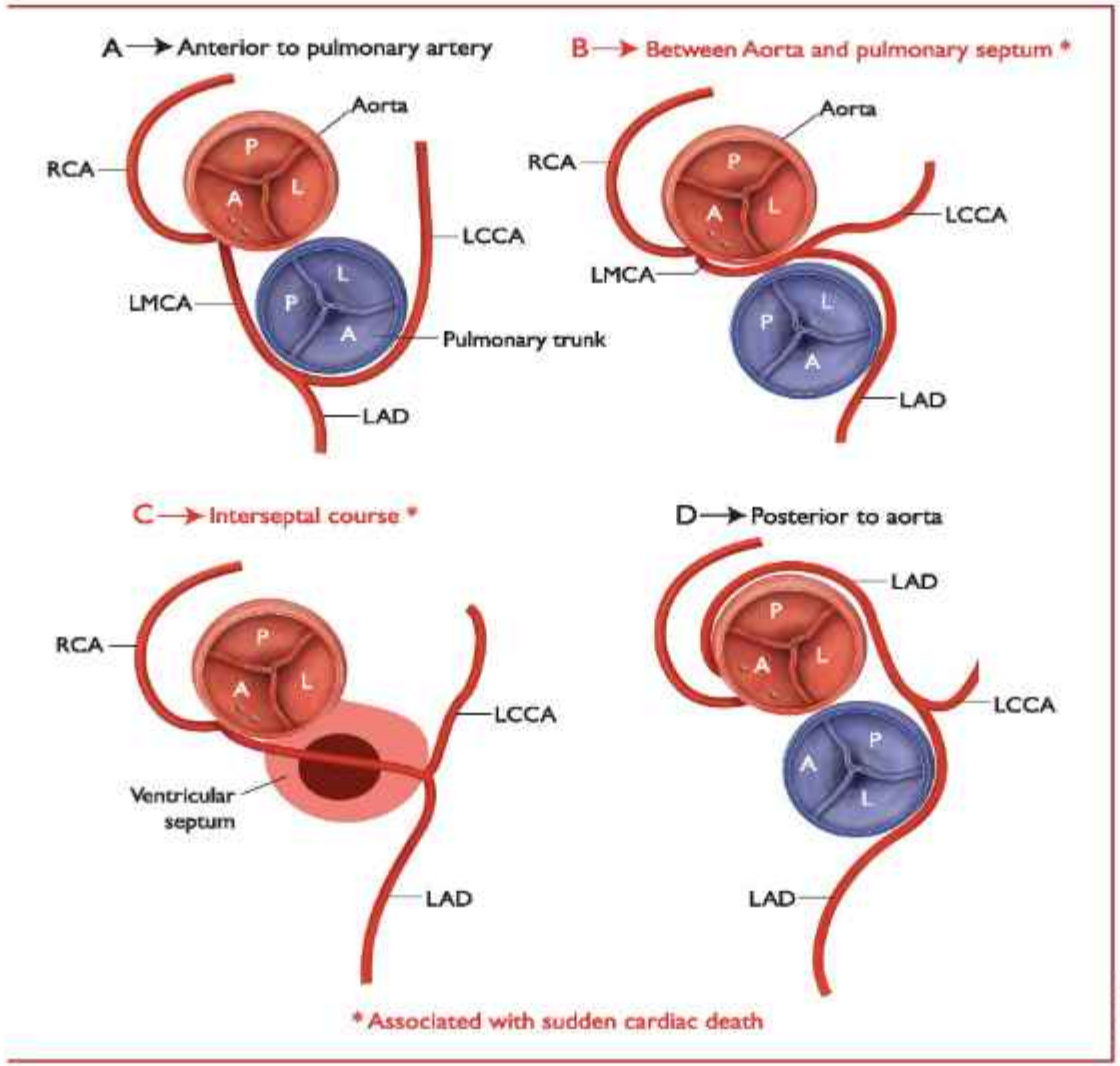
Aetiology of SCD in competitive athlets



UK registry
357 consecutive cases of athletes physical activity >3 h/week


Athlete's heart
Endurance athlete
↑ LV wall thickening
↑↑ LV dilation
Strength athlete
↑↑ LV wall thickening
↑ LV dilation
Combination athlete
LV wall thickening and
LV dilatation releated
to the predominance of
endurance or strength
exercise
LV cavity enlargement
(> 55 mm)
Peak VO2 is > 110% of
expected
Proportional chamber
enlargement
No diastolic dysfunction
Thickness or mass
decreases with short
periods of detraining
Gray-zone
Wall thickness 13-15 mm; 12-13 in women
Pathological remodelling
Hypertrophic cardiomyopathy
Asymmetric hypertrophy
Sarcomere mutations
LV end-diastolic cavity < 45 mm
Family history
Diastolic disfunction
Hypertension
Concentric hypertrophy
No dilation in early
stages of the disease
Pressure overload
LVNC
Evidence of trabeculae
and deep intertrabecular
recesses
Figure 3

Schematic representation of the most frequent anomalous origin of coronary arteries and associated risk of …



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Atrial fibrillation is the most common arrhythmia encountered in elite athletes, particularly in middle-aged men [66]. The prevalence has been reported to be as high as 9% depending on the population studied [67, 68]. The pathophysiology remains unclear but is clearly multifactorial in origin and associated with sustained endurance training and increased vagal tone. Atrial ectopy and shortened atrial effective refractory period from enhanced parasympathetic activity serve as triggers