Cardiovascular Impacts of long-term endurance exercise: Implications of athlete’ s heart”

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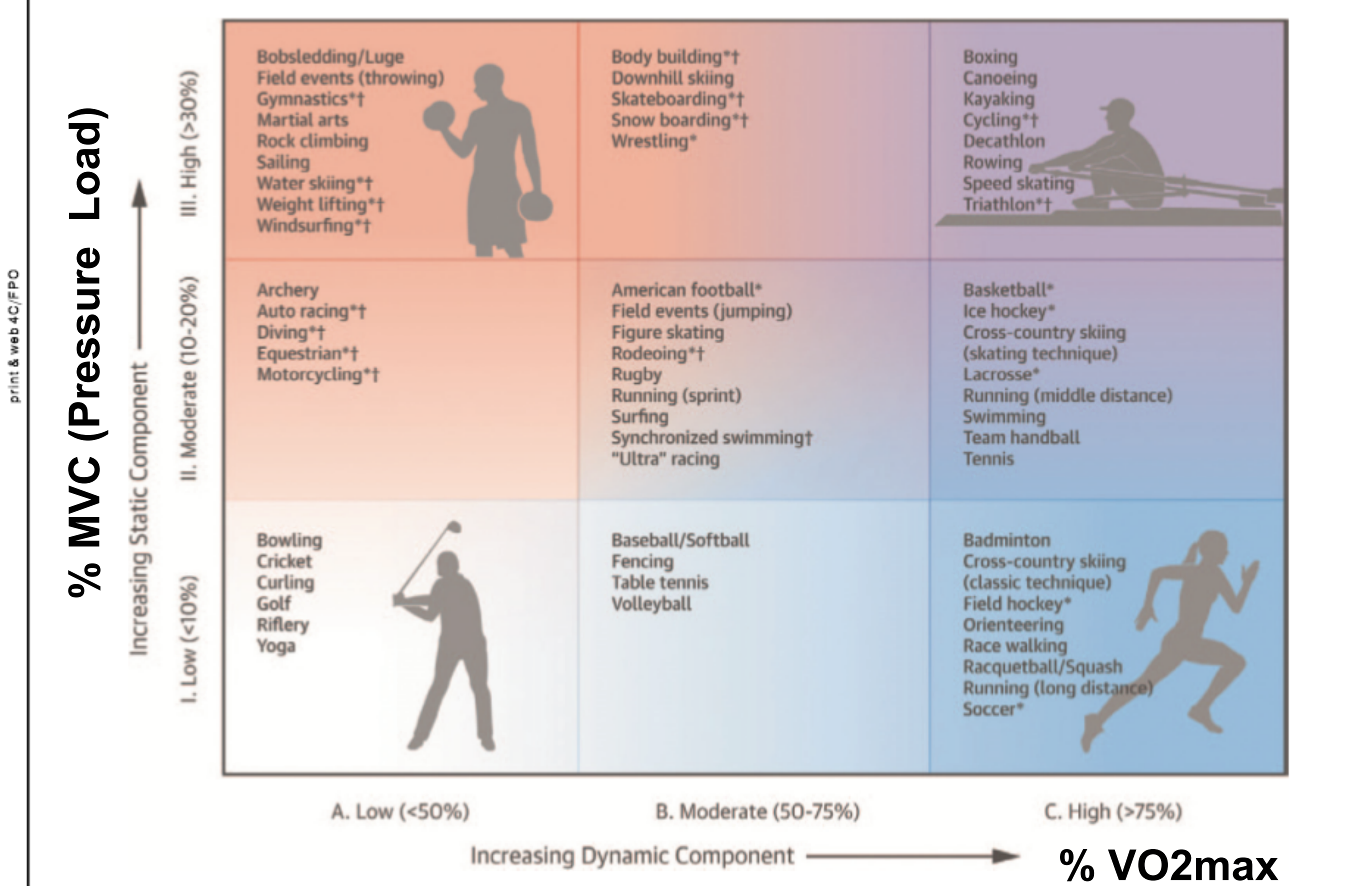
Static and Dynamic Exercise

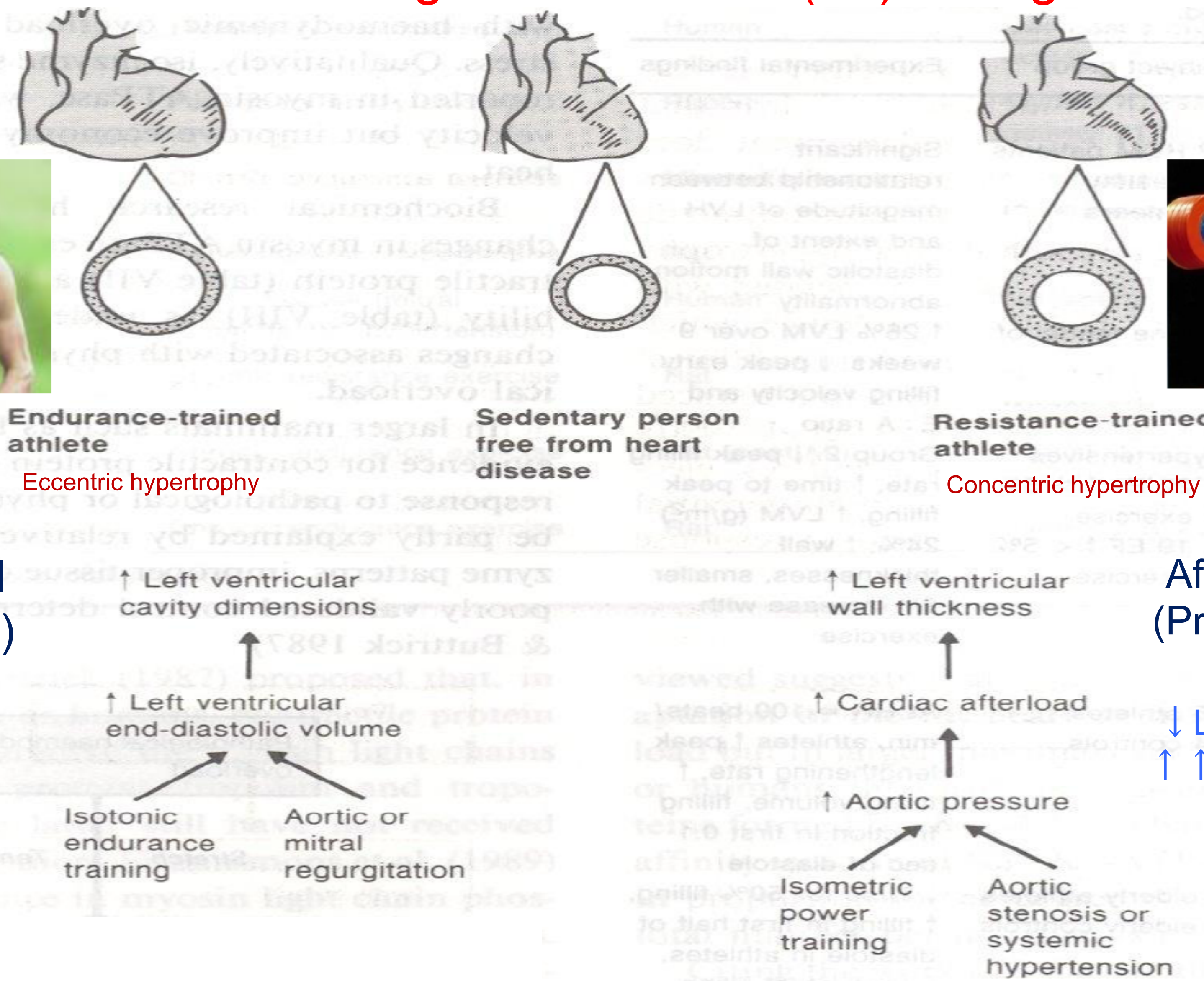
FIGURE Classification of Sports

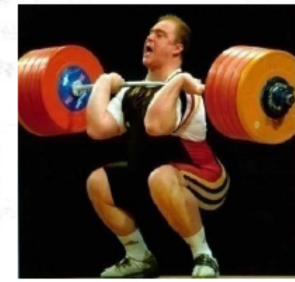


This classification is based on peak static and dynamic components achieved during competition; however, higher values may be reached during training. The increasing dynamic component is defined in terms of the estimated percentage of maximal oxygen uptake ($\dot{V}O_{2max}$) achieved and results in an increasing cardiac output. The increasing static component is related to the estimated percentage of maximal voluntary contraction reached and results in an increasing blood pressure load. The lowest total cardiovascular demands (cardiac output and blood pressure) are shown in the palest color, with increasing dynamic load depicted by increasing blue intensity and increasing static load by increasing red intensity. Note the graded transition between categories, which should be individualized on the basis of player position and style of play. *Danger of bodily collision (see Table for more detail on collision risk). †Increased risk if syncope occurs. Modified from Mitchell et al. (3) with permission. Copyright © 2005, *Journal of the American College of Cardiology*.

‘Morganroth Hypothesis’

Endurance training leads to heart (LV) enlargement





Preload (volume)

↑ ↑ LV volume
↑ LV mass

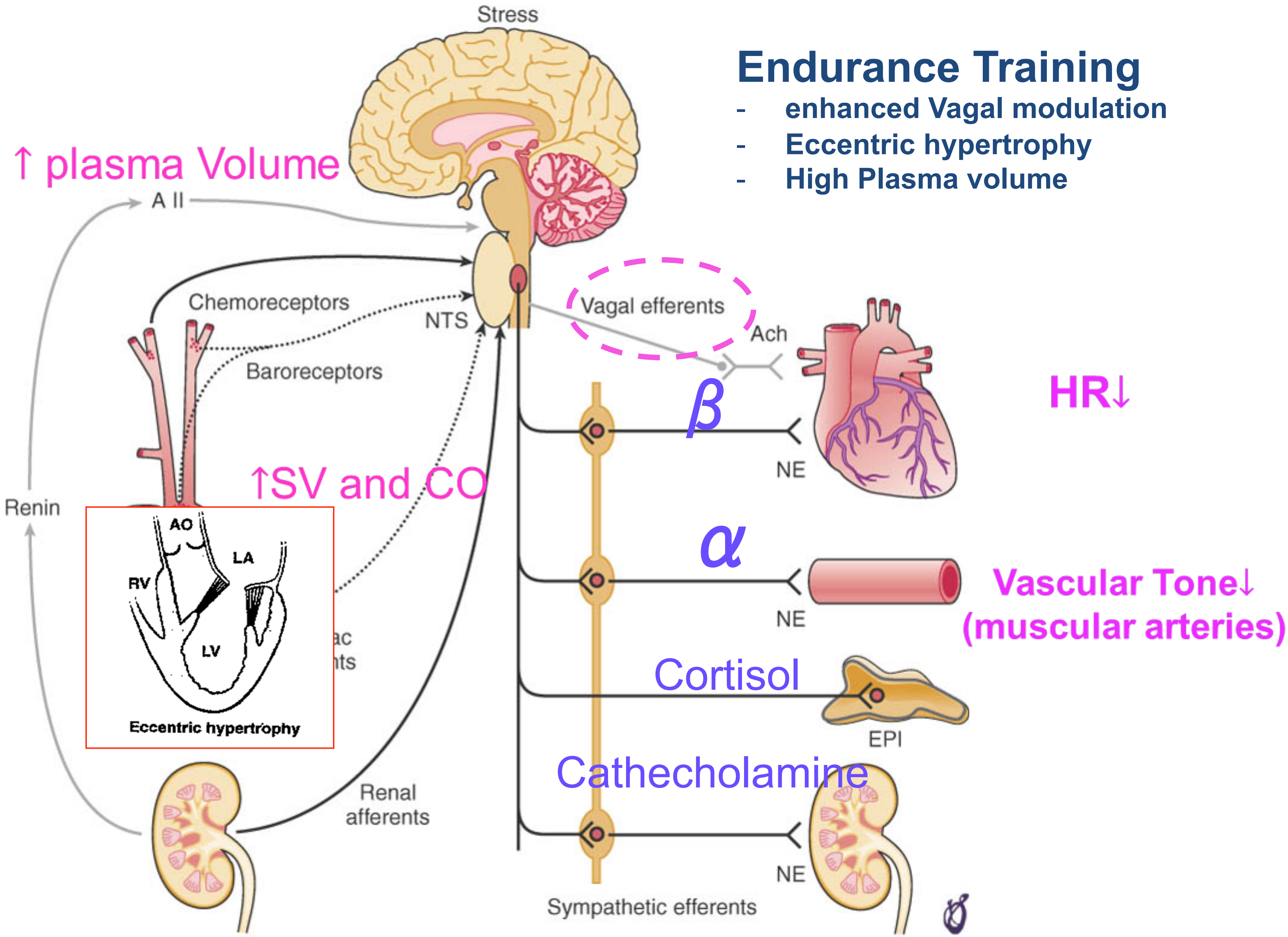
Afterload (Pressure)

↓ LV volume
↑ ↑ LV mass

Morganroth J, Maron BJ,. Comparative left ventricular dimensions in trained athletes. Ann Intern Med 1975;82:521–4.

Endurance Training

- enhanced Vagal modulation
- Eccentric hypertrophy
- High Plasma volume



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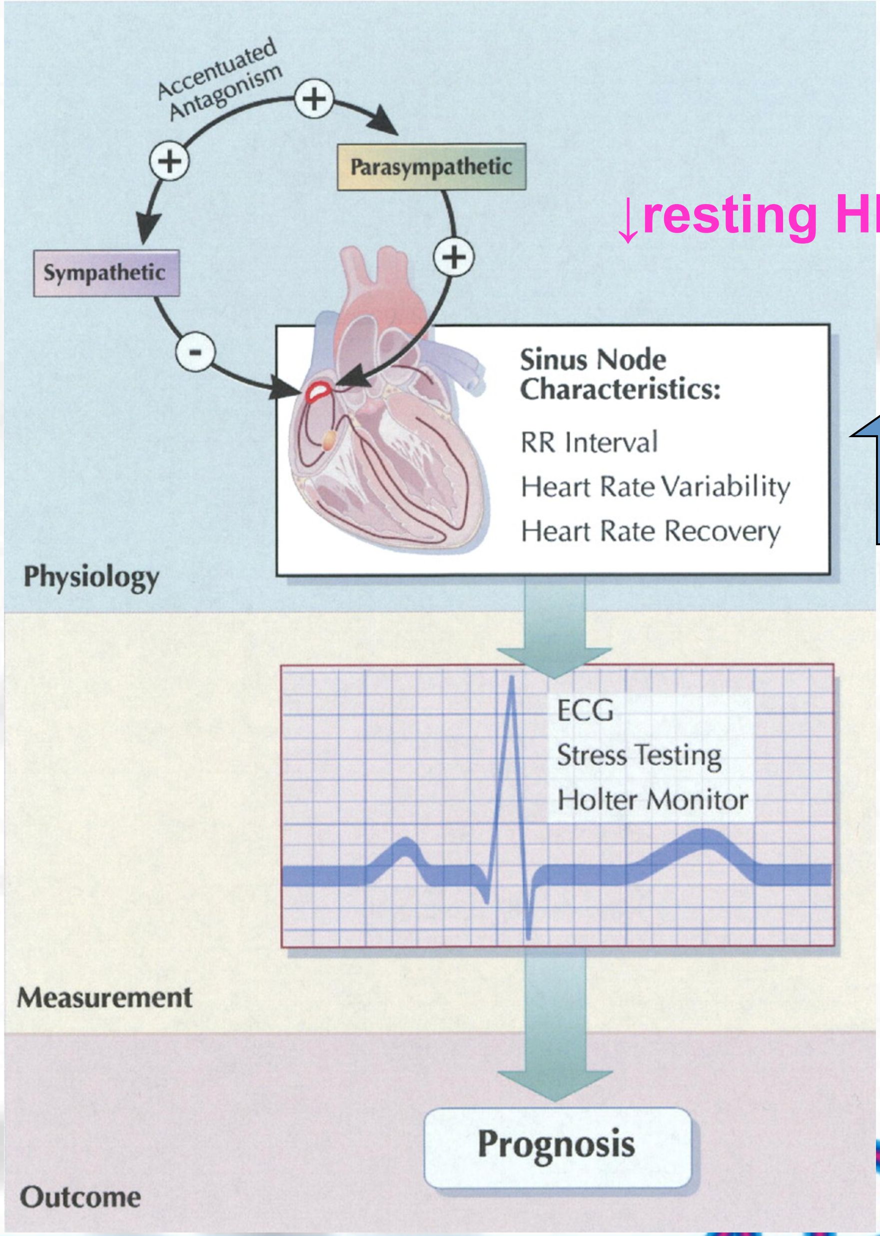
Regular Endurance training=>
Enhanced Vagal Modulation

Autonomic Nervous System
&
Cardiovascular Response

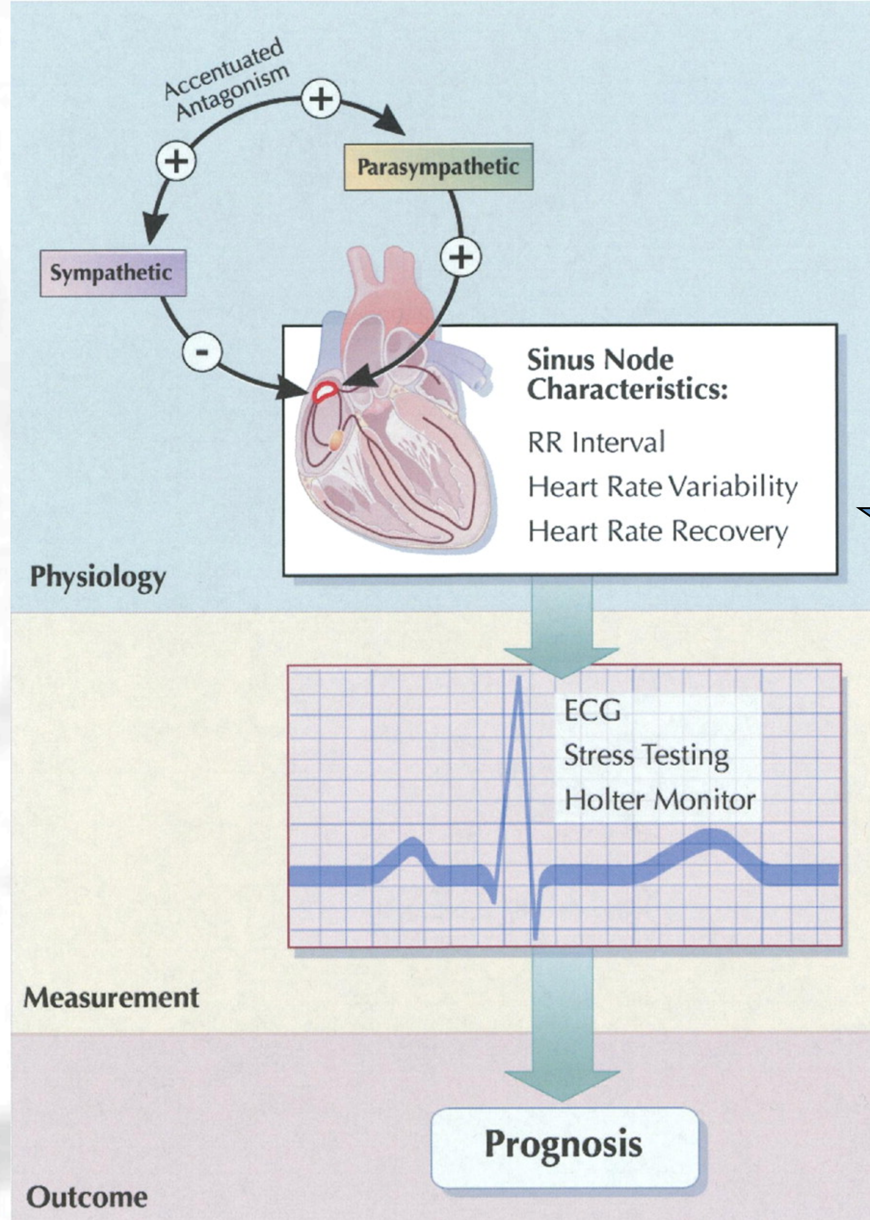


↓resting HR

Lahiri, M. K. et al. J Am Coll Cardiol 2008;51:1725-1733

Sub-optimal CP reserve / Excessive intensive exercise / overtraining => Sympathetic predominance

Autonomic Nervous System & Cardiovascular Response



PRO-CARDIO 心滙

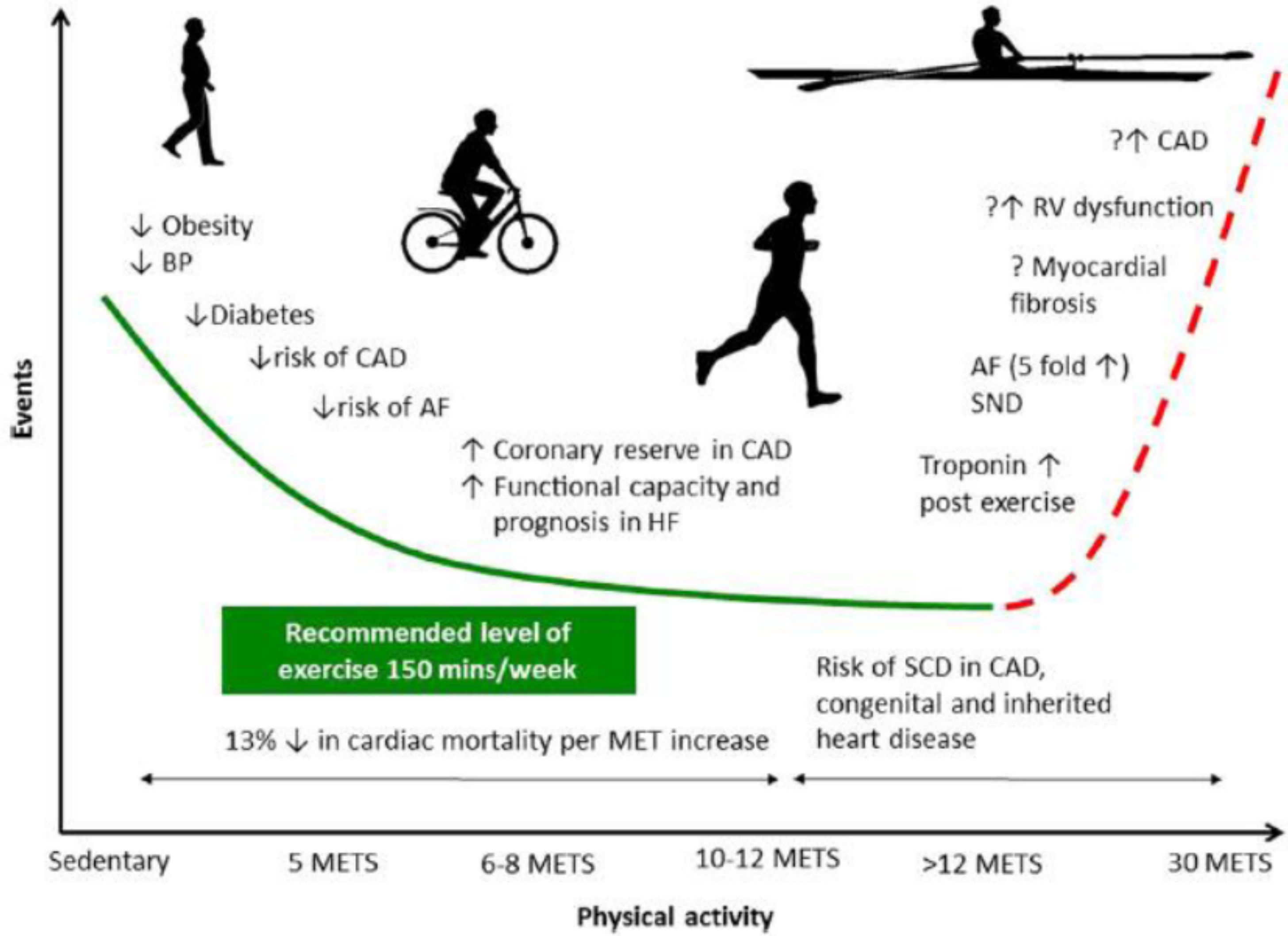
Lahiri, M. K. et al. J Am Coll Cardiol 2008;51:1725-1733

Athletes' Heart

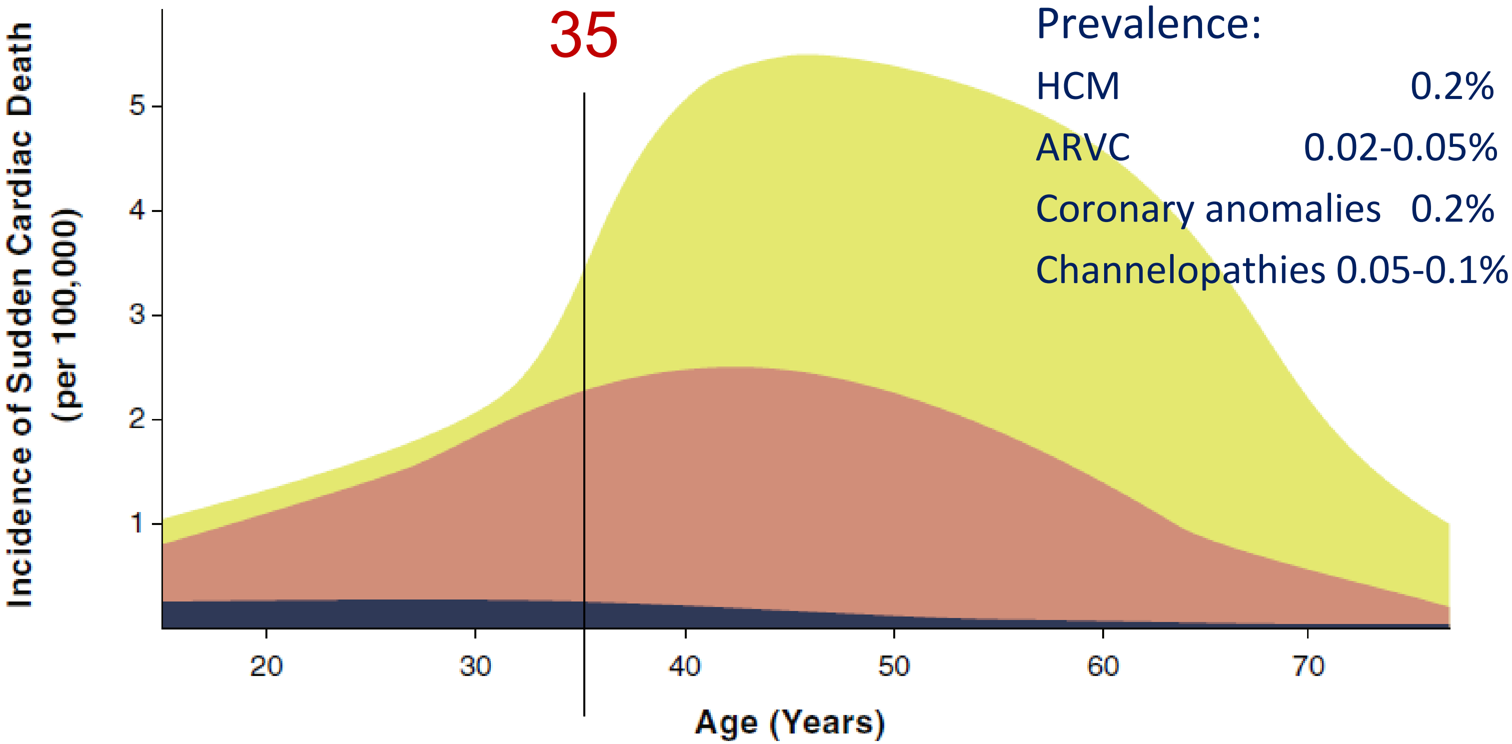
- Left Ventricular Hypertrophy (eccentric)
- Effect of high vagal tone
  - Slow HR: Sinus Bradycardia at rest ,rarely < 40 bpm
  - Early repolarization pattern
  - Extra Beats: predispose to increased atrial or ventricular ectopy,
  - Conduction defects: atrioventricular (AV) block

Arrhythmia, esp. Atrial Fibrillation

The U Shaped Hypothesis



Merghani A et al: The U-shaped relationship between exercise and cardiac morbidity. Trends Cardiovasc Med. 2015 Jun 18. pii: S1050-1738(15)00171-1.



La Gerche et al. JACC: CV IMAGING, 2 0 1 3

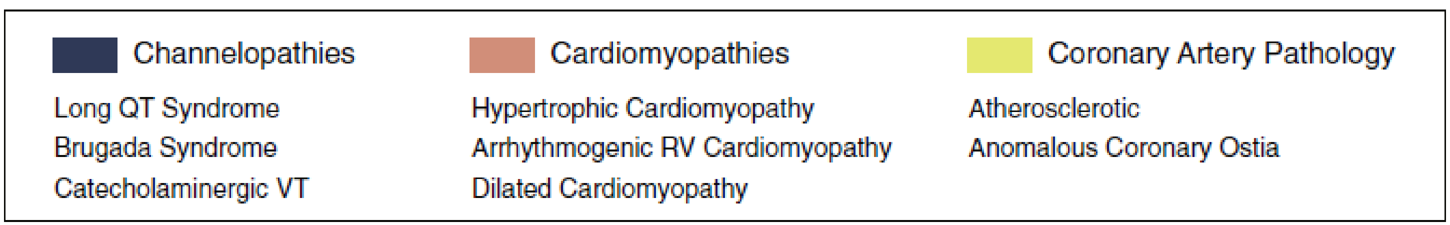
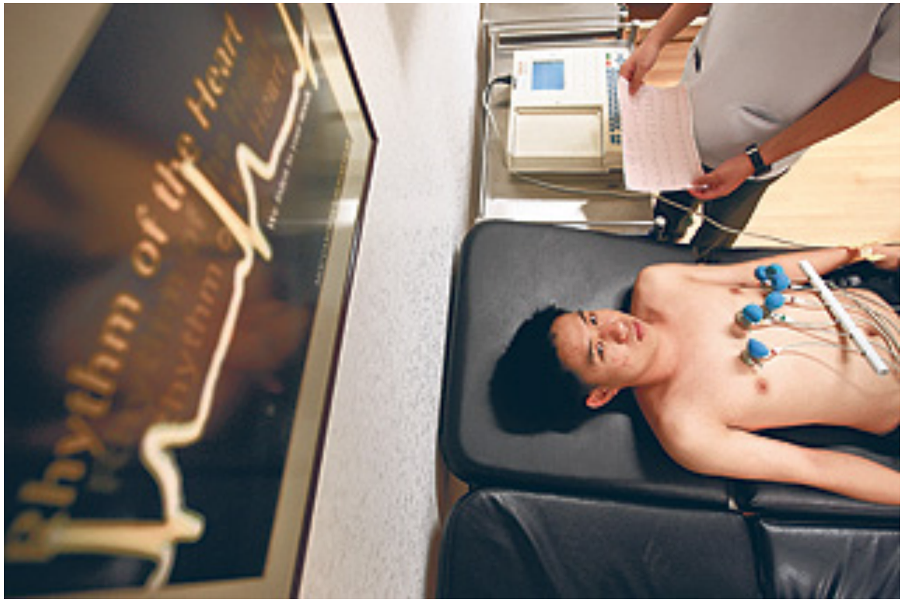


Figure 1. Age-Dependent Changes in Incidence and Etiology of Sudden Cardiac Death

This figure represents an interpretation of the combined experience from studies that have assessed the causes of sudden cardiac death in athletes (3,5,8,9,11–13). While the majority of deaths may be attributed to inherited cardiomyopathies and channelopathies in those younger than 30 years old, there is no absolute cutoff. Thus athletes in their thirties and forties (the median age in many competitive sports) are at greatest risk of sudden cardiac death caused by inherited and acquired causes. RV = right ventricular; VT = ventricular tachycardia.

Pre-participation Evaluation

For Young Competitive Athletes



The 12-Element AHA Recommendations for Preparticipation Cardiovascular Screening of Competitive Athletes, **2007 Update**

Family History

1. Premature sudden cardiac death
2. Heart disease in surviving relatives less than 50 years old

Personal History

3. Heart murmur
4. Systemic hypertension
5. Fatigue
6. Syncope/near-syncope
7. Excessive/unexplained exertional dyspnea
8. Exertional chest pain

Physical Examination

9. Heart murmur (supine/standing*)
10. Femoral arterial pulses (to exclude coarctation of aorta)
11. Stigmata of Marfan syndrome
12. Brachial blood pressure measurement (sitting)

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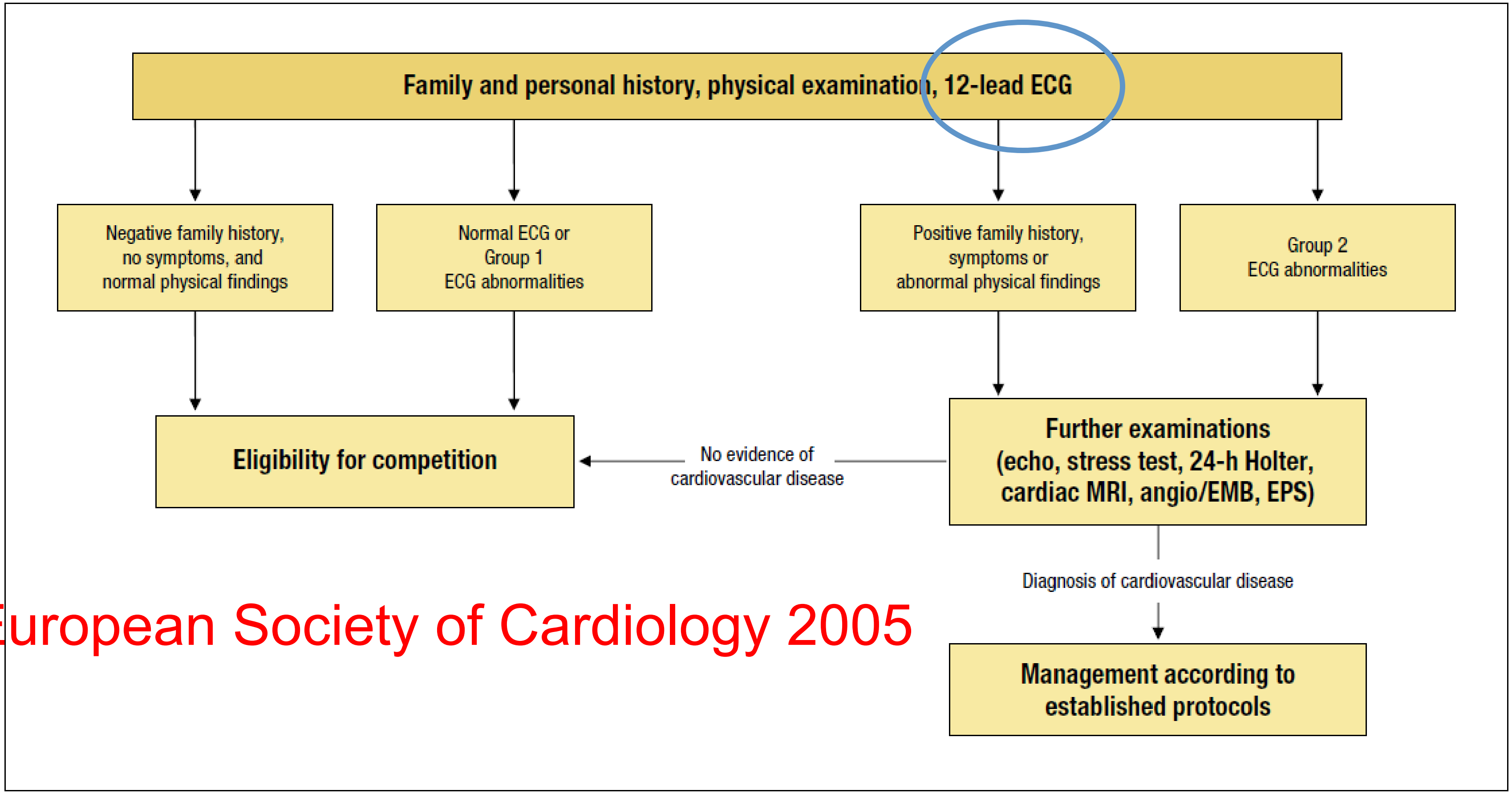
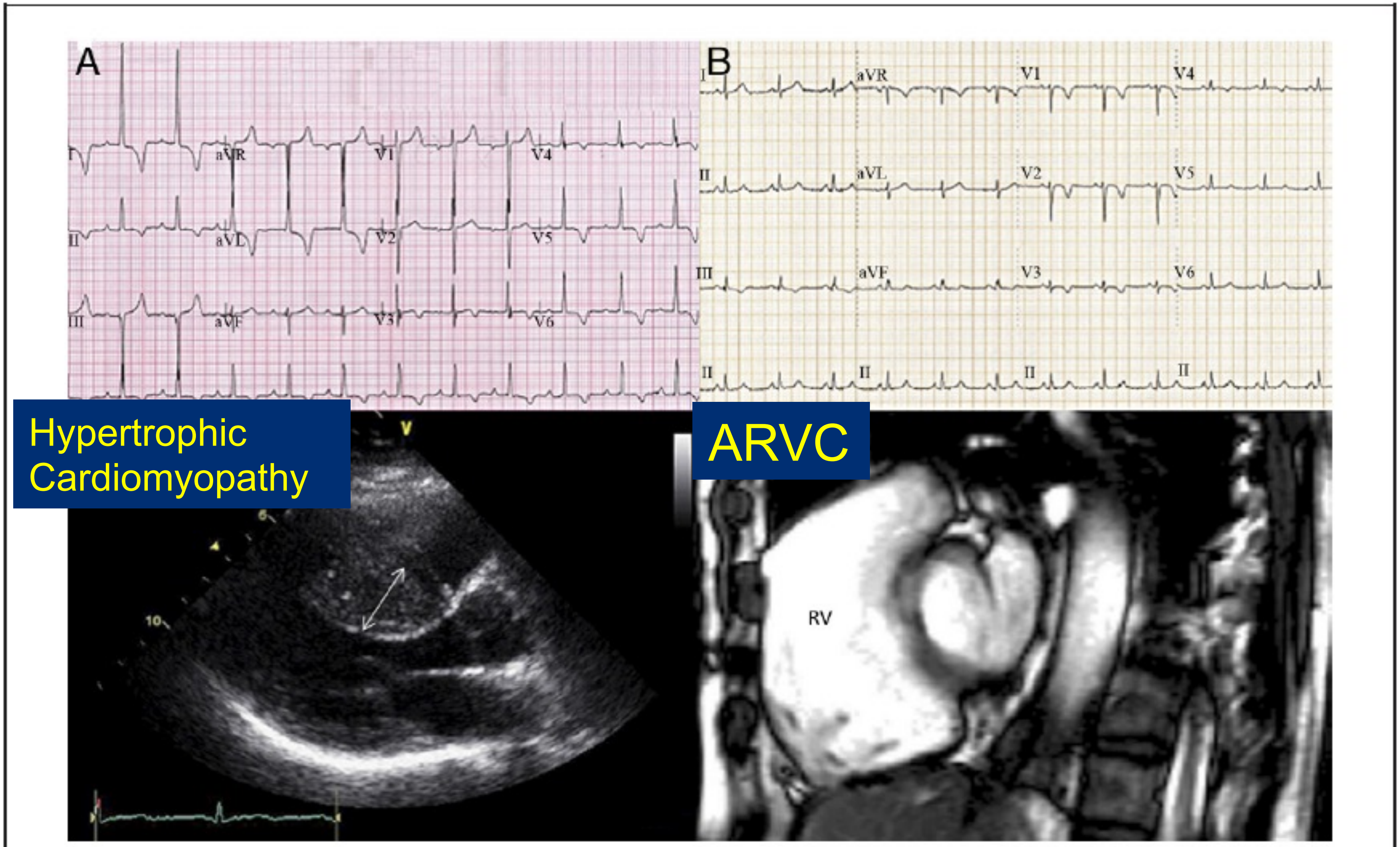
*In particular, to identify heart murmur consistent with dynamic obstruction to left ventricular outflow. From Maron BJ, et al. Circulation 1996;94:850−6, reprinted with permission of the American Heart Association.



European Society of Cardiology 2005

Figure 2: Flow diagram illustrating screening work-up according to the proposed criteria for ECG interpretation in trained athletes [15].

ECG Abnormalities are present in up to 95% of Hypertrophic Cardiomyopathy and 80% of ARVC



physiological adaptive ECG changes (Athlete's Heart)

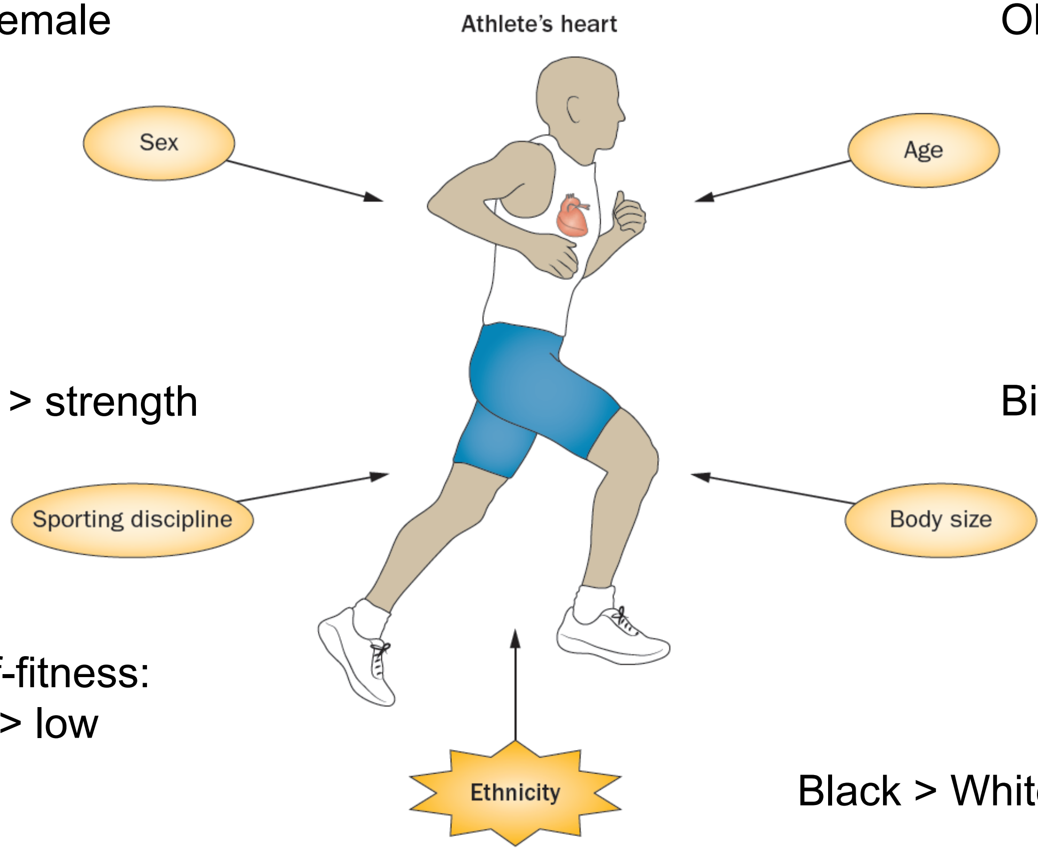
vs

pathological ECG abnormalities

Athlete's Heart

Male > Female

Old > Young



Endurance > strength

Big > small

Level-of-fitness:
high > low

Black > White

Black Athletes

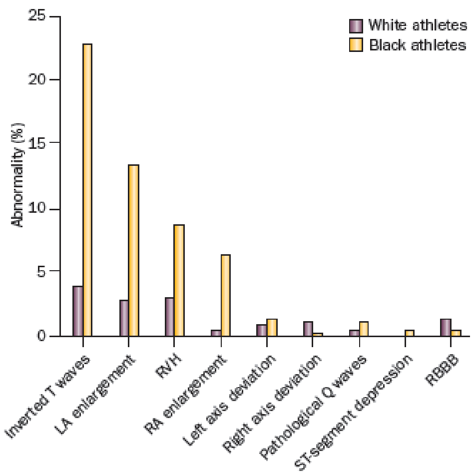
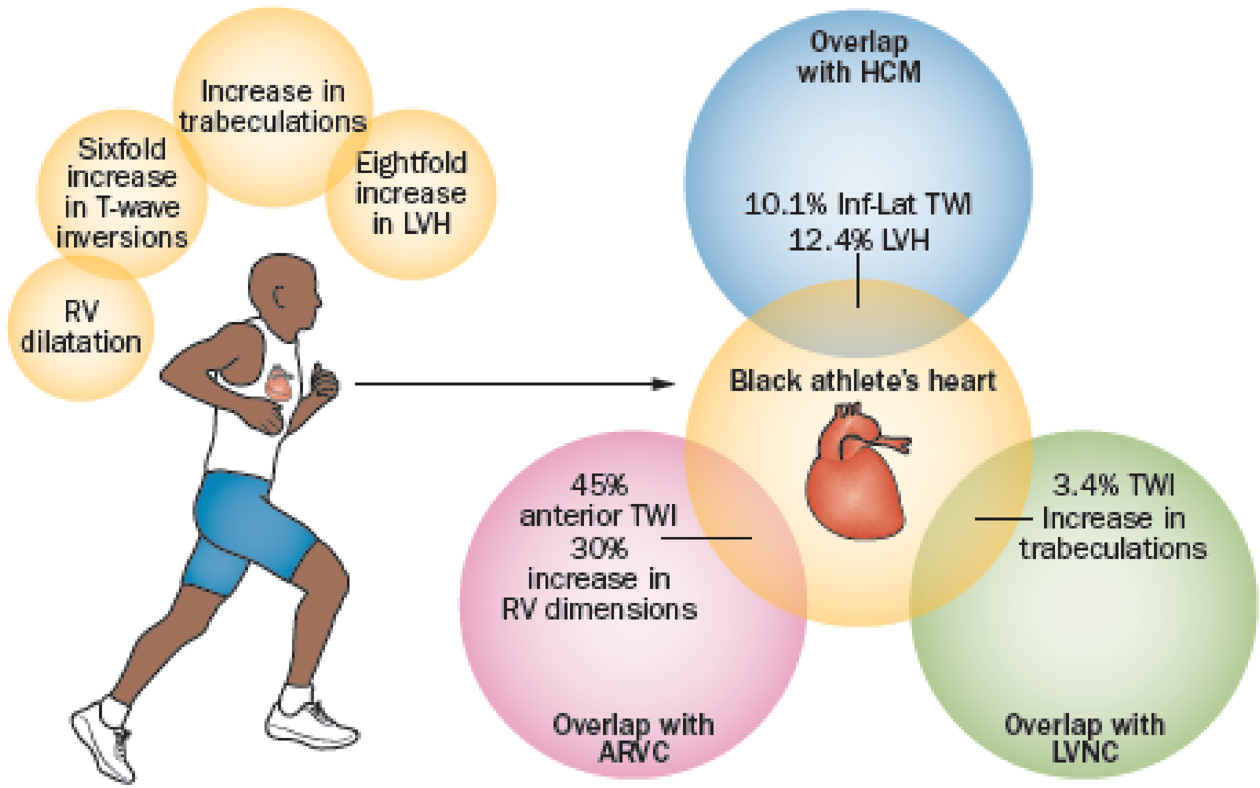


Figure 7 | Prevalence of abnormal electrocardiographic patterns other than T-wave inversions in a large cohort of adult black ($n = 904$) or white ($n = 1{,}819$) elite athletes undergoing preparticipation evaluation.[122] Abbreviations: LA, left atrial; RA, right atrial; RBBB, right bundle branch block; RVH, right ventricular hypertrophy.



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

ESC 2005

"physiological expressions" should be consistent with the gender, age, and race ,the level of training and type of sports.

'Seattle Criteria' 2012

1. Sinus bradycardia (≥ 30 bpm)
2. Sinus arrhythmia
3. Ectopic atrial rhythm
4. Junctional escape rhythm
5. 1° AV block (PR interval > 200 ms)
6. Mobitz Type I (Wenckebach) 2° AV block
7. Incomplete RBBB
8. Isolated QRS voltage criteria for LVH
   - *Except*: QRS voltage criteria for LVH occurring any non-voltage criteria for LVH such as lef enlargement, left axis deviation, ST segmer depression, T-wave inversion or pathologica Q waves
9. Early repolarisation (ST elevation, J-point elevation, J- or terminal QRS slurring)
10. Convex ('domed') ST segment elevation combined wi T-wave inversion in leads V1–V4 in black/African athl

These common training-related ECG alterations are physiological adaptations to regular exercise, conside normal variants in athletes and do not require furthe evaluation in asymptomatic athletes.

AV, atrioventricular; bpm, beats per minute; LVH, left ventricular hypertrophy; ms, milliseconds; RBBB, right bun branch block.

International Criteria for Electrocardiographic Interpretation in Athletes 2017

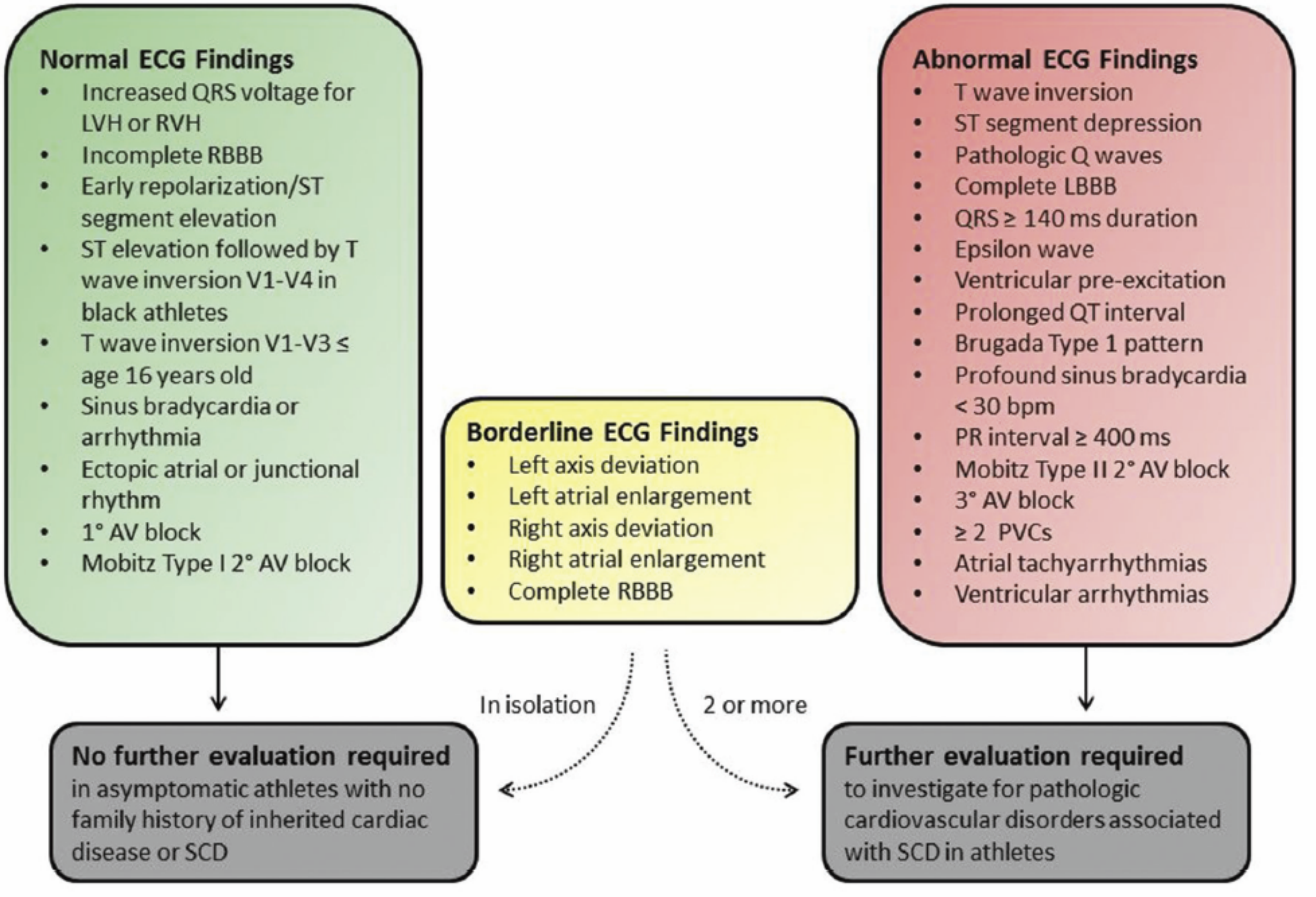


Figure 1 International consensus standards for ECG interpretation in athletes. AV, atrioventricular; LBBB, left bundle branch block; LVH, left ventricular hypertrophy; PVC, premature ventricular contraction; RBBB, right bundle branch block; RVH, right ventricular hypertrophy; SCD, sudden cardiac death.

Drezner JA, et al. Br J Sports Med 2017;1:1–28

Prevalence of an abnormal ECG was significantly reduced to 5.3% when using the 2014 Refined Criteria (International Criteria 2017) compared with the 2013 Seattle Criteria (11.6%) and the 2010 ESC recommendations (22.3%), respectively,

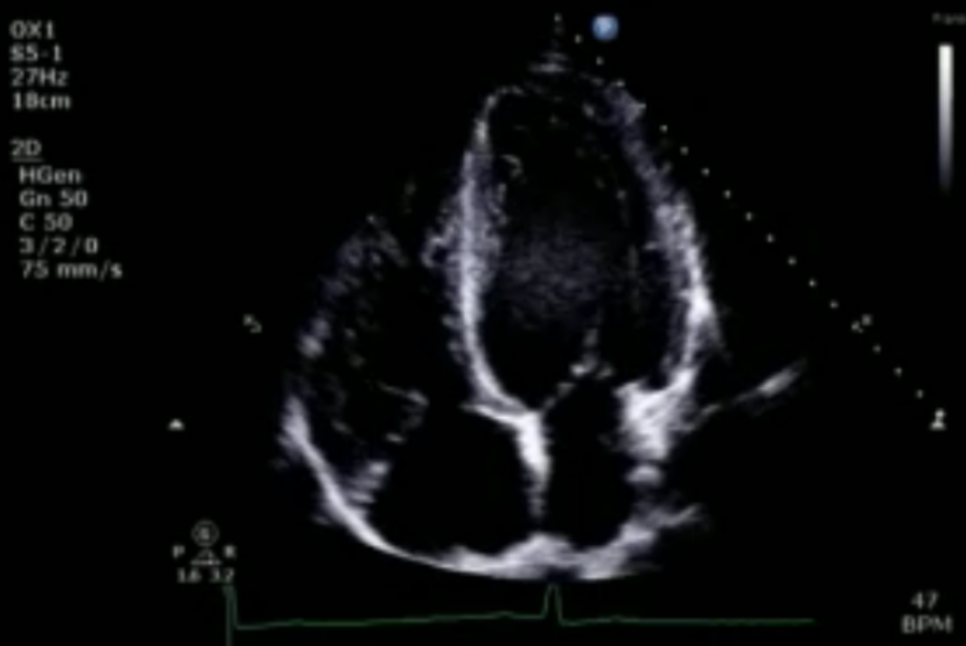
proved 100% sensitive, identifying all cases of serious cardiac pathology

Table 2 Performance comparison of three ECG interpretation criteria (ESC recommendations vs Seattle Criteria vs Refined Criteria)

	Combined (n=2491)	Arabic (n=1367)	Black (n=748)	Caucasian (n=376)
Prevalence of an abnormal ECG using ESC recommendations	555 (22.3%)	261 (19.1%)	224 (29.9%)	70 (18.6%)
Prevalence of an abnormal ECG using Seattle Criteria	289 (11.6%)	133 (9.7%)	124 (16.6%)	32 (8.5%)
Prevalence of an abnormal ECG using Refined Criteria	132 (5.3%)	49 (3.6%)	75 (10%)	8 (2.1%)
Number of identified conditions associated with SCD	10 (7 HCM; 3 WPW)	4 (2 HCM; 2 WPW)	6 (5 HCM; 1 WPW)	0
FPR when using ESC recommendations	21.9%	18.8%	29.1%	18.6%
FPR when using Seattle Criteria	11.2%	9.4%	15.8%	8.5%
FPR when using Refined Criteria	4.9%	3.3%	9.2%	2.1%

ESC, European Society of Cardiology; FPR, false-positive rate; HCM, hypertrophic cardiomyopathy; SCD, sudden cardiac death; WPW, Wolff–Parkinson–White syndrome.

The Young Athlete's Heart



10-20% increase in left ventricular wall thickness.

10% increase in LV and RV cavity.

45% increase in LV mass

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Exercise, Diet, and the Heart

Serial Left Ventricular Adaptations in World-Class Professional Cyclists

Implications for Disease Screening and Follow-Up

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Ales Linhart, MD,* Alain Ducardonnet, MD,‡ Joël Menard, MD, PhD§
Paris, France

- 286 Tour de France cyclists
- 146 (51.4%) had a LVED > 60 mm
- Of these 11.7% had a LVEF < 52%

LV Dilatation with borderline low LVEF

Are these Dilated Cardiomyopathy?

Athlete's Heart vs Dilated Cardiomyopathy

Symptoms

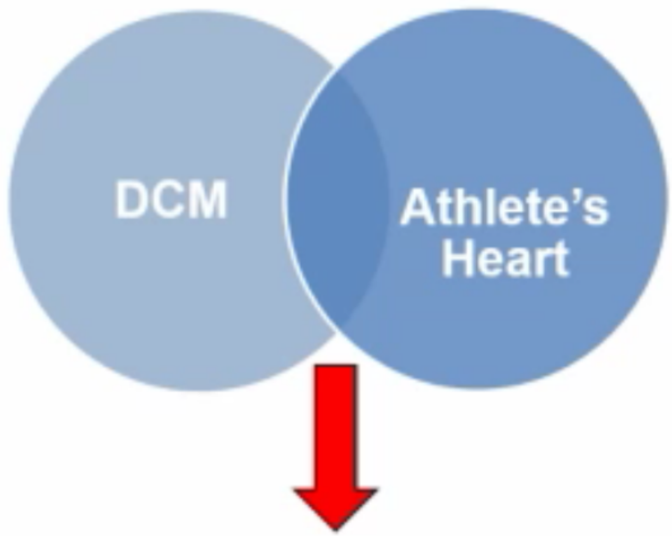
Family history

Raised BNP

T wave inversion lateral leads, q waves, ST depression or LBBB

Low peak VO2

Mid wall LV fibrosis



Enlarged LV Cavity

Low Ejection Fraction

Exercise echo or CMR shows Δ LVEF > 11% from baseline to peak exercise

Increase in peak EF > 65%

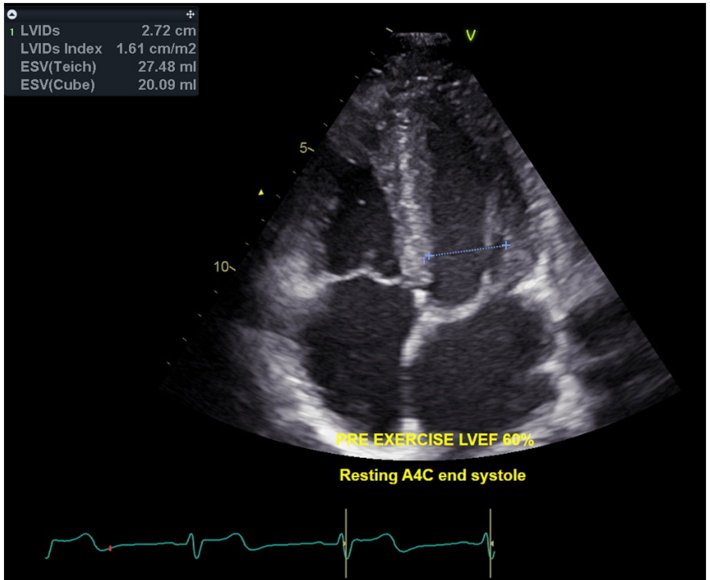
(High peak VO2)

Discriminating Variables Favouring DCM During Exercise Echocardiography

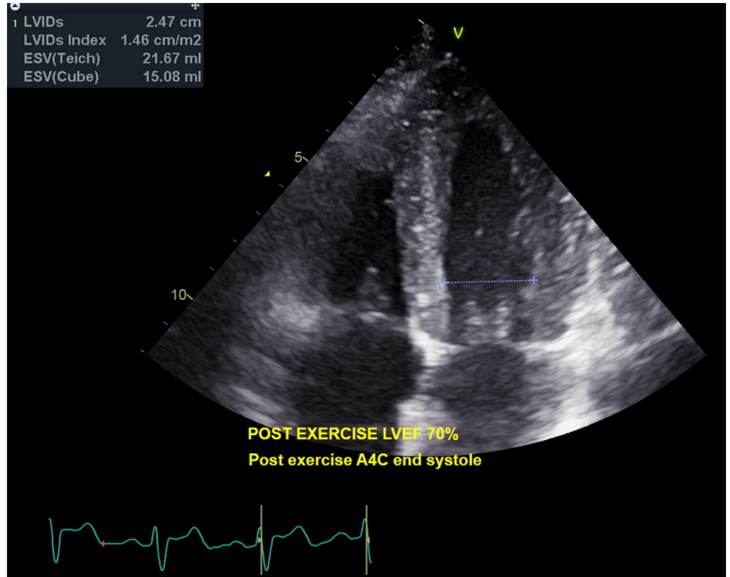
Millar L (unpublished)

Variable	AUC	Sensitivity	Specificity	p
E' Lateral Peak (<25cm/s)	0.578	71%	50%	p=0.401
S' Lateral Peak (≤23cm/s)	0.748	91%	53%	p<0.002
Stroke Volume Peak (≤94ml)	0.754	61%	100%	p<0.0004
LV Ejection Fraction (≤63%)	0.898	85%	91%	p<0.0001
Δ LV Ejection Fraction (≤ 11%)	0.891	83%	95%	P<0.0001

Stress Echo

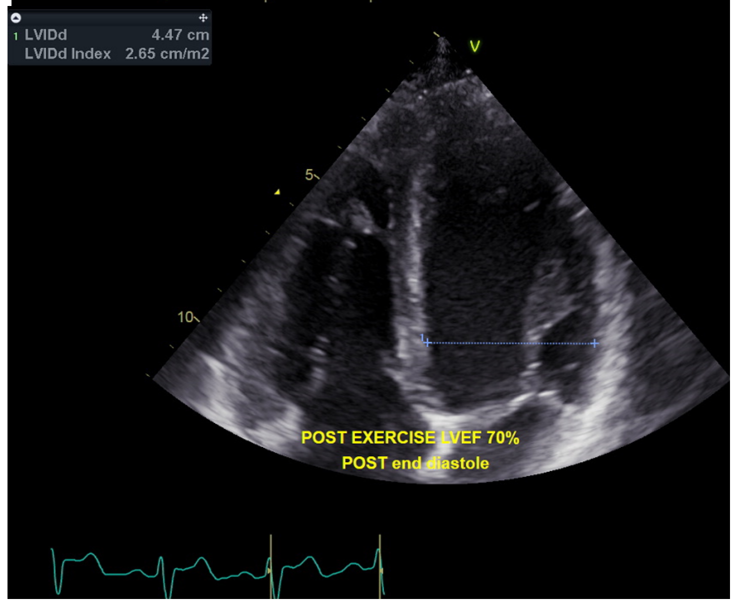


LVIDs 2.72 cm
LVIDs Index 1.61 cm/m2
ESV(Teich) 27.48 ml
ESV(Cube) 20.09 ml
PRE EXERCISE LVEF 60%
Resting A4C end systole



LVIDs 2.47 cm
LVIDs Index 1.46 cm/m2
ESV(Teich) 21.67 ml
ESV(Cube) 15.08 ml
POST EXERCISE LVEF 70%
Post exercise A4C end systole

LVIDd 4.81 cm
LVIDd Index 2.85 cm/m2
PRE EXERCISE LVEF 60%
Resting A4C end diastole



LVIDd 4.47 cm
LVIDd Index 2.65 cm/m2
POST EXERCISE LVEF 70%
POST end diastole

Conclusion I

- Regular endurance exercise induces significant cardiovascular adaptations including high parasympathetic tone, heart chambers enlargement with eccentric hypertrophy as well as increase of overall plasma volume resulting in a high cardiac output on exercise.
- The degree of adaptive changes varies with gender, age, body size, ethnicity, sports discipline, intensity and duration of exercise as well as the level of fitness.
- These adaptive changes would result in physiological and structural cardiovascular changes that might create confusions and mis-interpretations when one performs Pre-participation Physical Evaluation.

Conclusion II

- Major progress in the recognition of physiological changes in resting ECG were identified and has significantly reduced the positive rate with high degree of specificity.
- LV dilatation with borderline low LVEF is common in high endurance athletes and often confused with dilatated cardiomyopathy.
- Exercise Echo is currently one of the more reliable methods for the differentiation.