Athlete's Heart vs. Cardiomyopathy

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Chair, Department of Cardiovascular Medicine
Medical Director, Cardiovascular Service Line
Former Team Cardiologist to the New York Jets

BEST HOSPITALS U.S.News & WORLD REPORT NATIONAL CARDIOLOGY & HEART SURGERY 2017-18

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No disclosures

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Questions asked of Echo

- Is increased wall thickness physiologic or pathologic?
- Are increased dimensions physiologic or pathologic?
- Is “reduced” function physiologic or pathologic?

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Is this normal or abnormal?

- Can this patient play sports (make a living, take a scholarship)?
- Are there genetic/family implications to my decision?
- What is the prognosis?
- Is this patient at risk for SCD
- Does this patient need a defibrillator?

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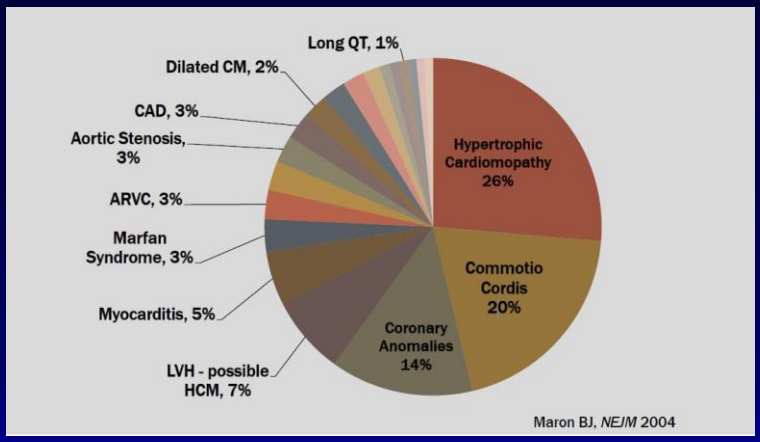
CAUSE OF SCA IN YOUNG ATHLETES
(N=387, BASED ON AUTOPSY REPORTS



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Causes of SCD

- Structural
- Electrical
- Other
  - Commotio cordis
  - Myocarditis, dcm

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The Changing Face of the American Athlete - Youth

Thanks to Mat Martinez, MD

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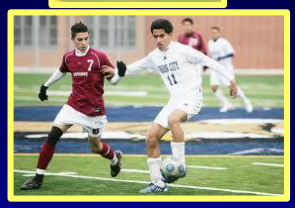
The Changing Face of the American Athlete – High School



Thanks to Mat Martinez, MD

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The Changing Face of the American Athlete - Collegiate




Thanks to Mat Martinez, MD

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The Changing Face of the American Athlete - Masters

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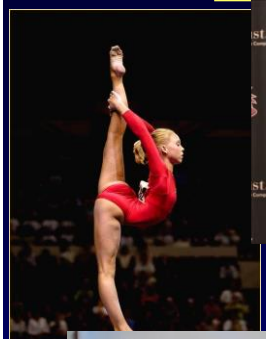
Atletes Come in All Shapes and Sizes



Pay attention to age,gender,race, body size and sport specific norms!

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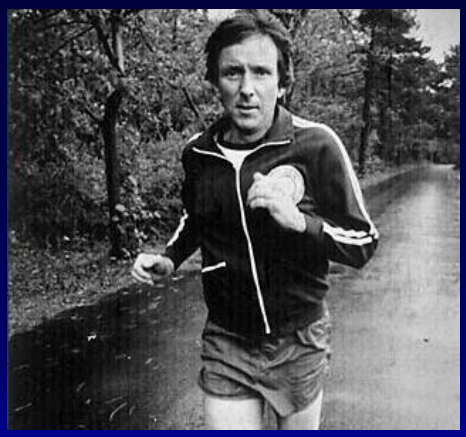
Reminder

Non-myopathic conditions affect athletes too

- CAD
- HTN
- BAV etc



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European Heart Journal – Cardiovascular Imaging (2015) **16**, 353
doi:10.1093/ehjci/jeu323

RECOMMENDATION PAPER

The multi-modality cardiac imaging approach to the Athlete's heart: an expert consensus of the European Association of Cardiovascular Imaging

Maurizio Galderisi[1]*, (Chair), Nuno Cardim[2], (Co-chair), Antonello D'Andrea[3], Oliver Bruder[4], Bernard Cosyns[5], Laurent Davin[6], Erwan Donal[7], Thor Edvardsen[8], Antonio Freitas[9], Gilbert Habib[10], Anastasia Kitsiou[11], Sven Plein[12], Steffen E. Petersen[13], Bogdan A. Popescu[14], Stephen Schroeder[15], Christof Burgstahler[16], and Patrizio Lancellotti[17]

Document Reviewers: Rosa Sicari, (Italy), Denisa Muraru, (Romania), Massimo Lombardi, (Italy), Raluca Dulgheru, (Romania), Andre La Gerche (Austraila)

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Table 4 *Average and upper limits of the main echocardiographic LV parameters in elite athletes (*sample sizes≥400)

Athlete's left heart morphologic and functional parameters						Upper limit
Authors	**Journal**	**Number of athletes**	**Type of sport**	**Parameter**	**Average value**	
Pelliccia et al.[7]	*Ann Intern Med* 1999;130:23–31	1309	Endurance/strength	LV end-diastolic diameter (adult male) (mm)	55	70
Whyte et al.[167]	*Eur J Appl Physiol* 2004;92:592–597	442	Endurance/strength	LV end-diastolic diameter (adult female) (mm)	49	66
Pelliccia et al.[168]	*JAMA* 1996;276:211–215	600	Endurance/strength			
Makan et al.[170]	*Heart* 2005;91:495–499	900	Endurance	LV end-diastolic diameter (adolescent) (mm)	51	60
Spirito et al.[31]	*Am J Cardiol* 1994;74:802–806	947	Endurance/strength	LV wall end-diastolic thickness (adult male) (mm)	10	16
Rawlins et al.[169]	*Circulation* 2010; 121:1078–1085	440	Endurance/strength	LV wall end-diastolic thickness (adult female) (mm)	9.5	13
Sharma et al.[6]	*J Am Coll Cardiol* 2002;40:1431–1436	720	Endurance/strength	LV wall end-diastolic thickness (adolescent) (mm)	9.5	12
Basavarajaiah et al.[166]	J Am Coll Cardiol 2008;51:2256–62	300	Endurance/strength	LV wall end-diastolic thickness (black athlete) (mm)	11.5	16
Pelliccia et al.[76]	*J Am Coll Cardiol* 2005;46:690-696	1777	Endurance/strength	LA diameter (male) (mm)	37	50
				LA diameter (female) (mm)	32	45
D'Andrea et al.[77]	*Am Heart J* 2010;159:1155–1161	650	Endurance/strength	LA volume index (male) (ml/m^2)	28	36
				LA volume index (female) (mL/m^2)	26.5	33
D'Andrea et al.[32]	*J Am Soc Echocardiogr* 2010;23:1281–1288	650	Endurance /strength	IVS Tissue Doppler s' (cm/s)	13	18
				IVS Tissue Doppler e' (cm/s)	24	21
				LV Tissue Doppler s' (cm/s)	15	20
				LV Tissue Doppler e' (cm/s)	16	22
				LV Tissue Doppler e'/a' (cm/s)	1.45	1.7

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F1000Research F1000Research 2015, 4:151 Last updated: 23 MAY 2017

Check for updates

REVIEW

Echocardiography in the evaluation of athletes [version 1; referees: 2 approved, 1 approved with reservations]

Gonzalo Grazioli*, Maria Sanz*, Silvia Montserrat, Bàrbara Vidal, Marta Sitges

Cardiology Department, Hospital Clínic, Universitat de Barcelona, IDIBAPS, Institut d'Investigacions Biomèdiques August Pi iSunyer, Barcelona, Catalonia, Spain

* Equal contributors

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Exercise Physiology Basics

- Exercise requires oxygen
- Increased pulmonary oxygen uptake
- Increased cardiac output
- Increased peripheral oxygen extraction

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Exercise Physiology Basics

- Exercise requires oxygen
- Increased pulmonary oxygen uptake
- Increased cardiac output
- Increased peripheral oxygen extraction

Cardiac Output = HR X Stroke Volume

Stroke volume = End-diastolic volume minus End-systolic volume*

* In the absence of valve regurgitation or intracardiac shunts

- Cardiac output may increase 5-6 X with HR responsible for the majority of the change
- Max HR does not increase with exercise training (age-related)
- Stroke volume does increase with exercise training (resting and peak exercise)
  - SV increases because EDV ↑ ± ↓ESV

2 Forms of Exercise Training (some overlap)

- Isotonic
  - Sustained increase in CO with normal or reduced SVR
- Isometric
  - Increased SVR and normal or slightly increased CO

Athlete's Heart

- Well recognized that repetitive physical exercise causes adaptive changes in cardiac structure and function

"Athlete's Heart"

- Although historically some dispute as to whether changes were harmful, consensus is that this is a favorable adaptive response rather than pre-clinical disease

Athlete's Heart

- Anatomic changes
- Functional changes

Left Ventricular Response

- Increased cavity size
- Increased wall thickness
  - Generally associated with increased cavity size
  - More pronounced in those who are large and Afro-Caribbean
- Morganroth hypothesis
  - Isotonic -> dilatation (eccentric LVH)
  - Isometric -> increased wall thickness (concentric LVH)

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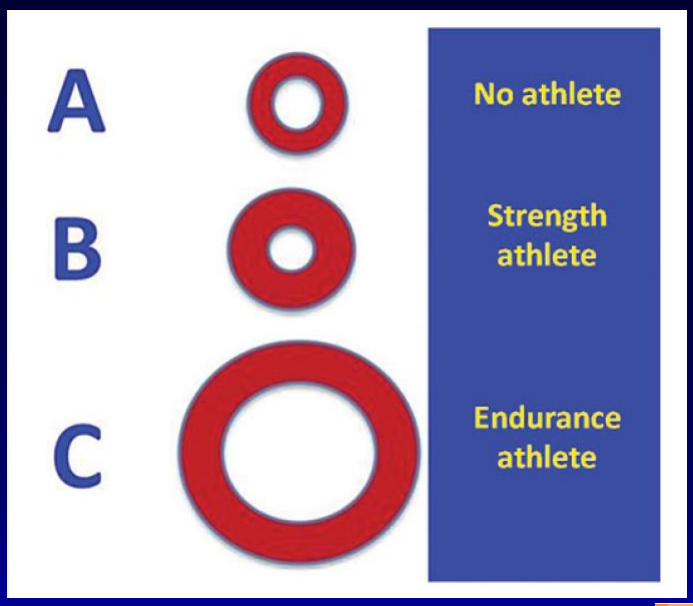

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Similar Changes with RV

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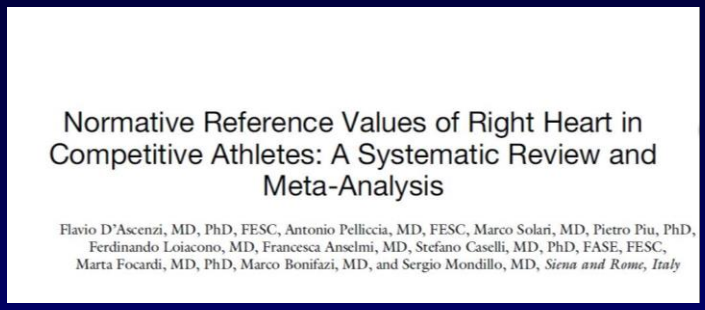

Normative Reference Values of Right Heart in Competitive Athletes: A Systematic Review and Meta-Analysis

Flavio D'Ascenzi, MD, PhD, FESC, Antonio Pelliccia, MD, FESC, Marco Solari, MD, Pietro Piu, PhD, Ferdinando Loiacono, MD, Francesca Anselmi, MD, Stefano Caselli, MD, PhD, FASE, FESC, Marta Focardi, MD, PhD, Marco Bonifazi, MD, and Sergio Mondillo, MD, *Siena and Rome, Italy*

JASE 2017 Volume 30, Issue 9, Pages 845–858

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Wall thickness

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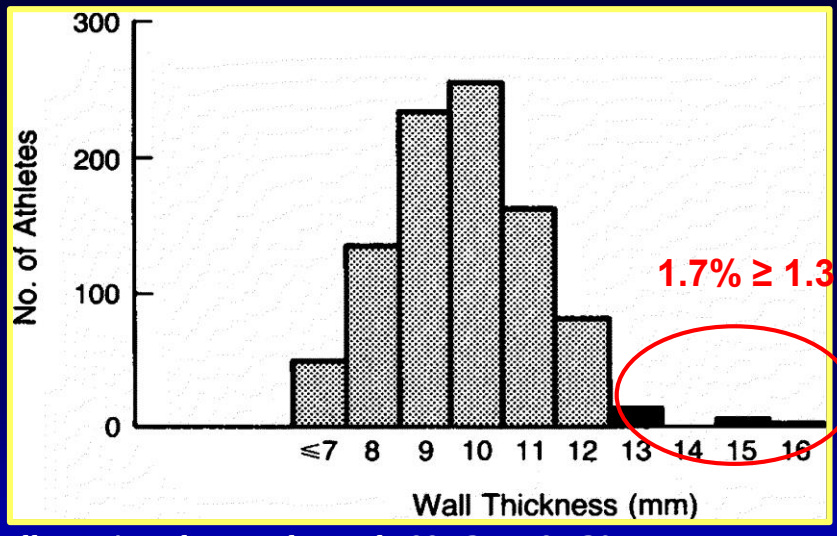
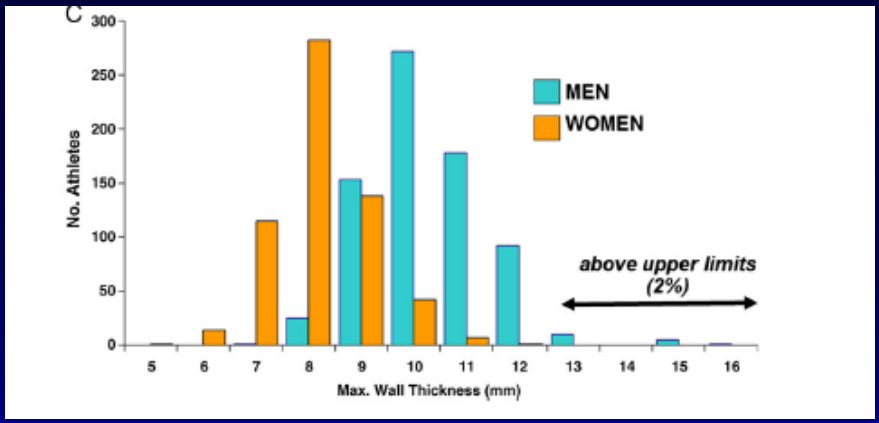
Distribution of Maximal Left-Ventricular-Wall Thicknesses in the 947 Elite Athletes.



Pelliccia A et al. N Engl J Med 1991;324:295-301

Pelliccia A et al. N Engl J Med 1991;324:295-301

Gender Matters



Maron Circulation 2006 citing Pelliccia et al Ann Intern Med. 1999;130(1):23-31.

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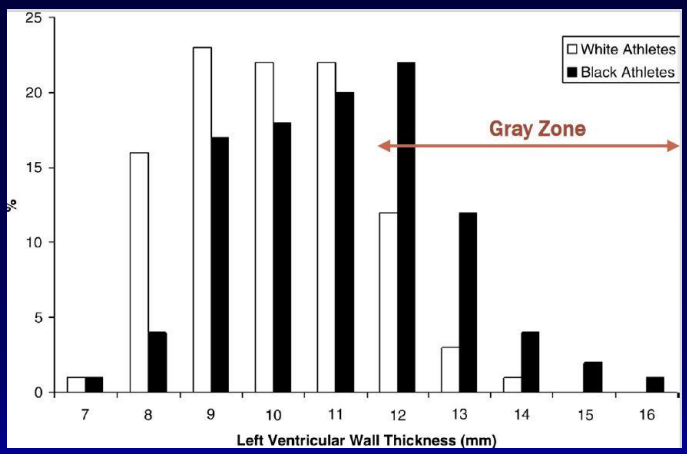
Race Matters



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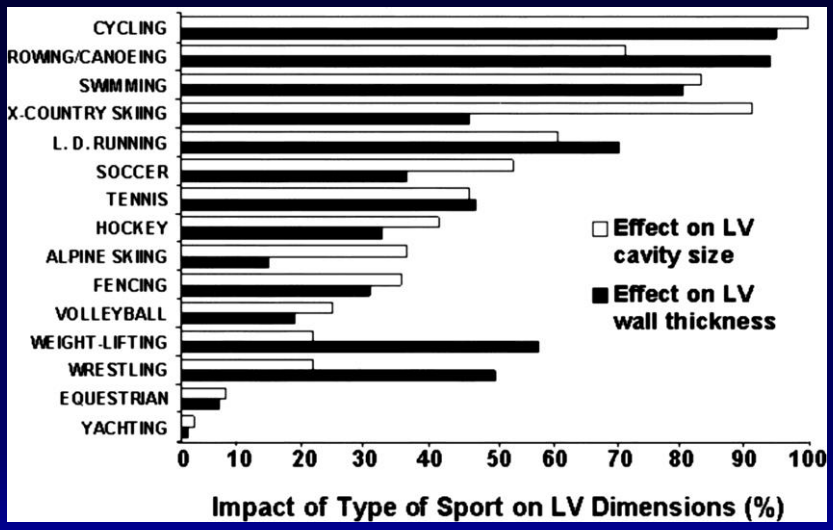
Effect of specific sports training on LV cavity dimension or wall thickness in elite athletes, representing 27 different sporting disciplines.



Barry J. Maron, and Antonio Pelliccia Circulation. 2006;114:1633-1644

American Heart Association

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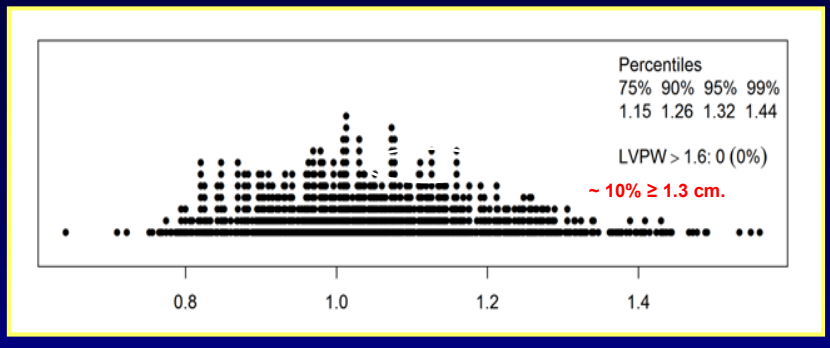
NFL 2011-2013



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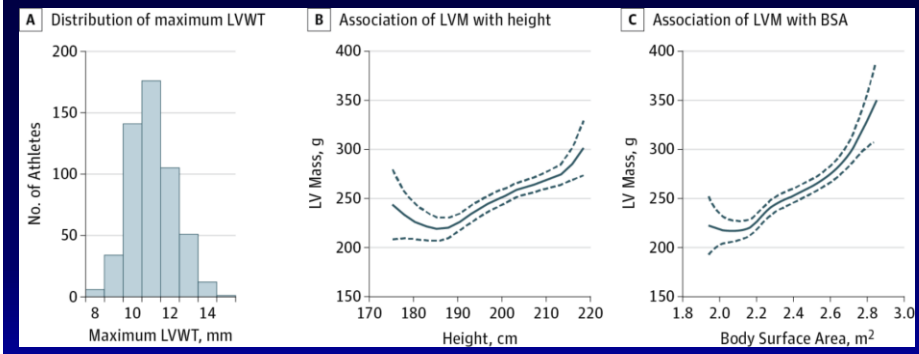
NFL data Courtesy of Dr Kovacs ACC 2013

From: **Athletic Cardiac Remodeling in US Professional Basketball Players: Engel et al**
N= 526, 77% black, average age 26 yrs
JAMA Cardiol. 2016;1(1):80-87.



~10% ≥ 1.3 cm.

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Impact of Gender and Race

- Less remodeling in women (even with correcting smaller baseline heart sizes)
- More remodeling in blacks
  - LV wall thickness >12mm in 20% black men vs 4 % whites
- Black women have thicker walls than white women

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Chamber dimensions

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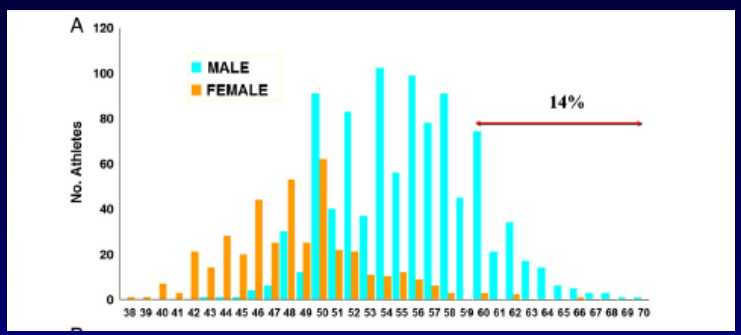
Pelliccia. Ann Intern Med. 1999;130(1):23-31.
1309 elite athletes, all with EF >50%



LVEDD

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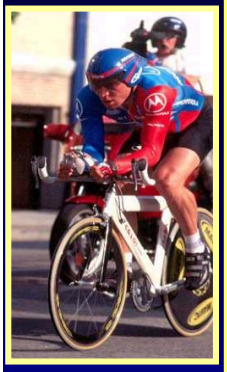
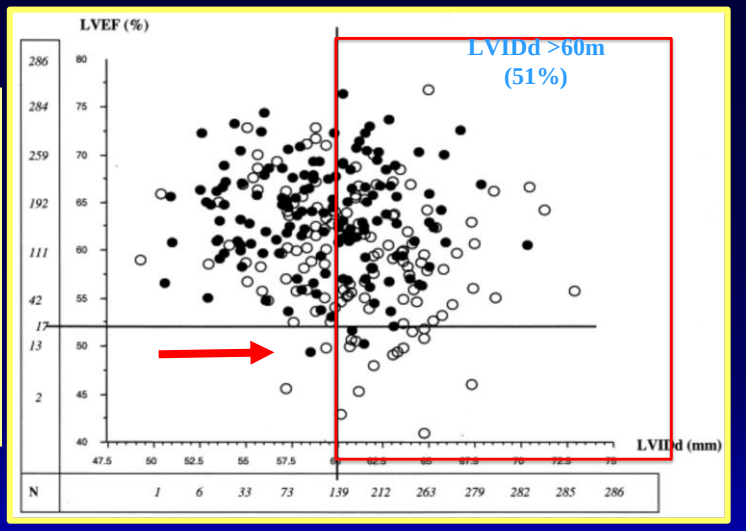
Pro Cyclists LV chamber size

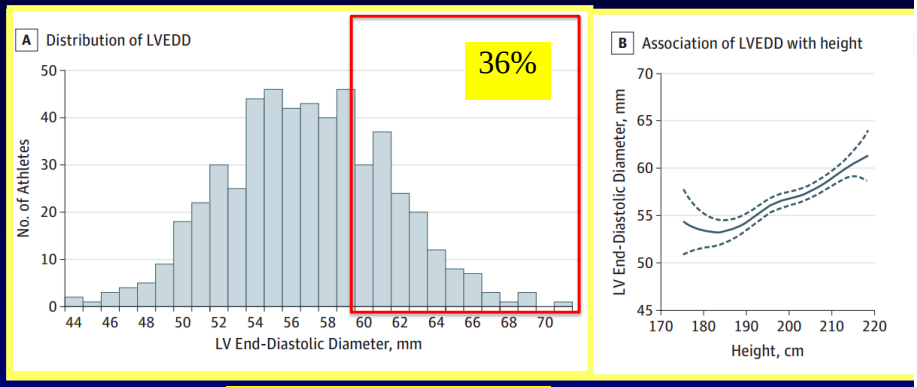




Abergel. J Am Coll Cardiol. 2004;44

LV chamber size in the NBA

From: **Athletic Cardiac Remodeling in US Professional Basketball Players: Engel et al** JAMA Cardiol. 2016;1(1):80-87.



All but 5 with normal EF > 50%

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JACC: CARDIOVASCULAR IMAGING
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http://dx.doi.org/10.1016/j.jcmg.2016.08.011

ORIGINAL RESEARCH

Effect of Sex and Sporting Discipline on LV Adaptation to Exercise

Gherardo Finocchiaro, MD, Harshil Dhutia, MBBS, Andrew D'Silva, MBBS, Aneil Malhotra, MBBChir, Alexandros Steriotis, MD, PhD, Lynne Millar, MBBS, Keerthi Prakash, MBBS, Rajay Narain, MBBS, Michael Papadakis, MD, MBBS, Rajan Sharma, MD, MBBS, Sanjay Sharma, MD, MBChB

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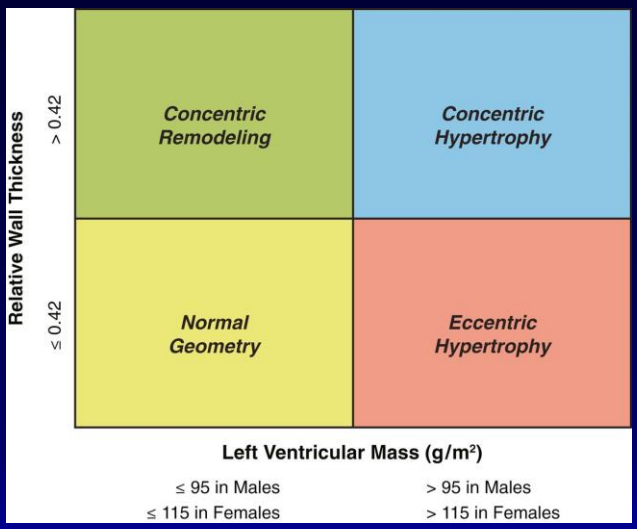
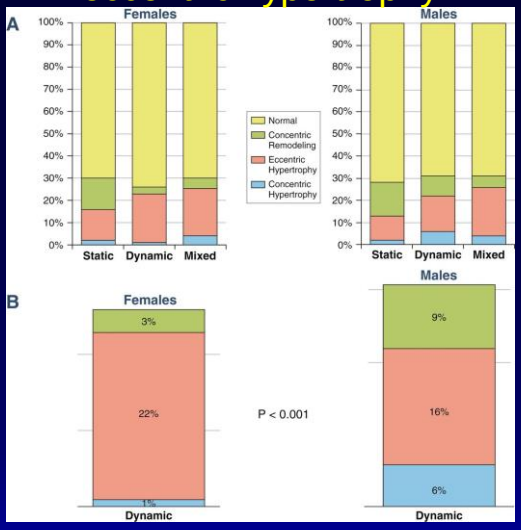


Gherardo Finocchiaro et al. JIMG 2017;10:965-972

JACC Cardiovascular Imaging

Women less likely to develop concentric vs. eccentric hypertrophy



Gherardo Finocchiaro et al. JIMG 2017;10:965-972

JACC Cardiovascular Imaging

Systolic Function

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LVEF/Systolic function

- Typically normal
- But may be borderline or mildly reduced (50-55%) leading to concern about dilated cardiomyopathy
- Role for stress echocardiography in establishing contractile reserve
- Strain also helpful

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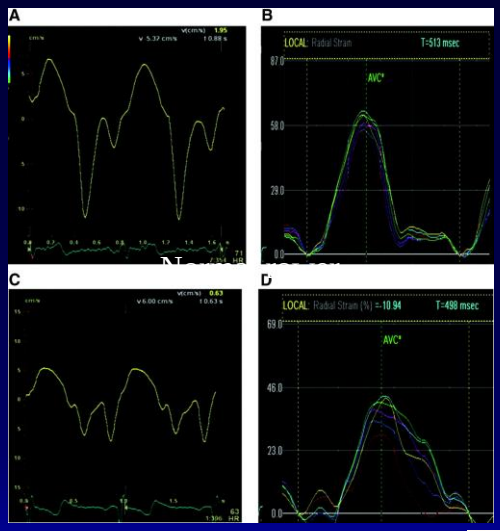
Echocardiographic tissue Doppler imaging (A and C) and speckle-tracking radial strain analysis (B and D) in 2 different athletic patients presenting with left ventricular hypertrophy.

Normal rower

HCM football player



Baggish A L , Wood M J Circulation 2011;123:2723-2735

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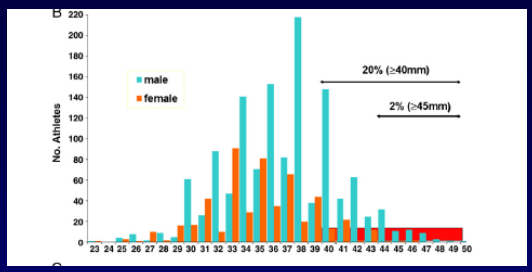
Atria

Left atrium

- In Italian series >20% had enlarged left atria (as measured by AP diameter)
  - No volume data
- Questionable association with supraventricular arrhythmias

Pelliccia. Ann Intern Med. 1999;130(1):23-31.



LA AP diameter

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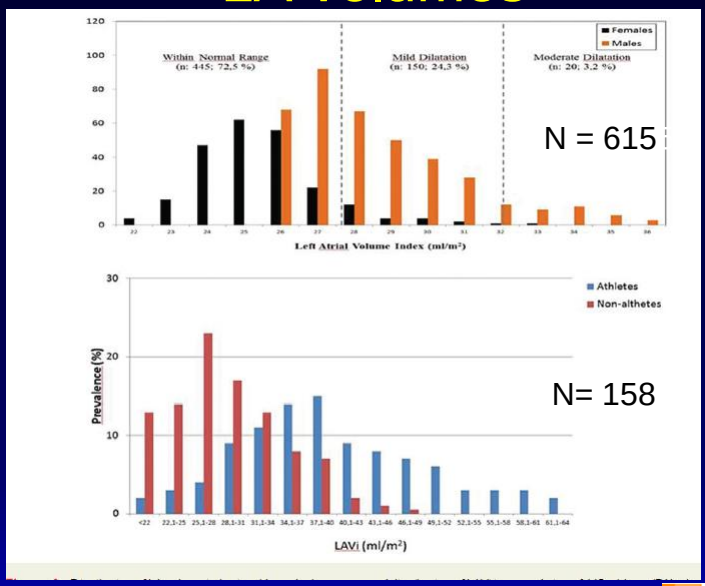
LA volumes



From Galderisi et al EACVI Recommendations

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Diastolic Function: Myopathy or Athlete's Heart?

Diastolic Function

- Isotonic training
  - Enhanced relaxation
- Isometric training
  - Impaired or unchanged relaxation (less well studied)

- In athlete's heart diastolic function is normal or super-normal
- In HCM, diastolic function is variably abnormal

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Diastolic Function in the Athlete

- Increased early diastolic filling
  - E/A ratio > 1
- normal deceleration time
  - 100 -200 ms
- normal isovolumetric relaxation time
  - <100 ms.

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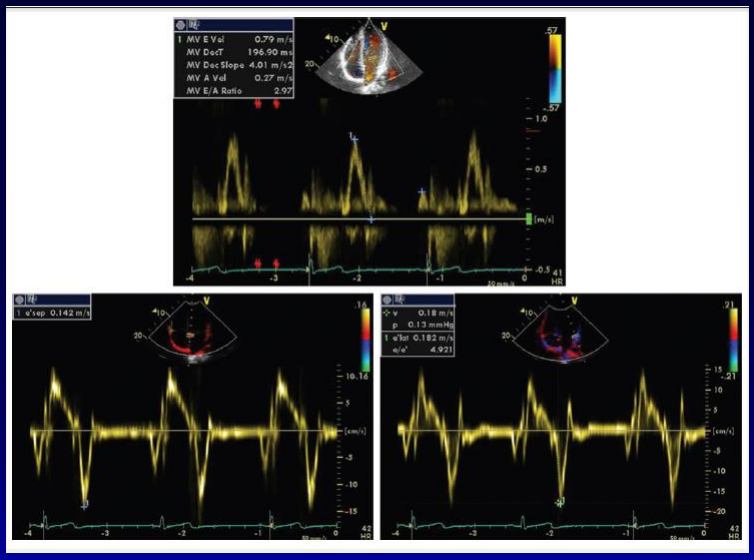

Galderisi et al European Heart Journal – Cardiovascular Imaging (2015) 16, 353

Diastolic Function in HCM

- Decreased early diastolic filling
  - E/A ratio <0.5
- Lengthened deceleration time
  - >280 ms
- Ar-Ad > 30 ms
- Decreased annular e'

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Wall thickness = 1.2 cm

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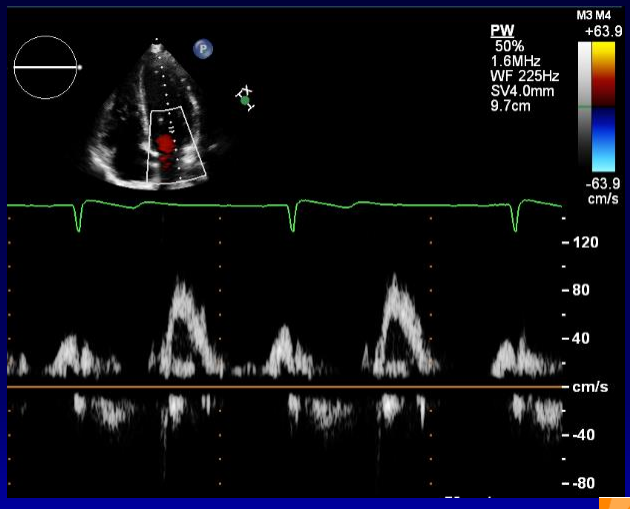
Decel time = 187 ms



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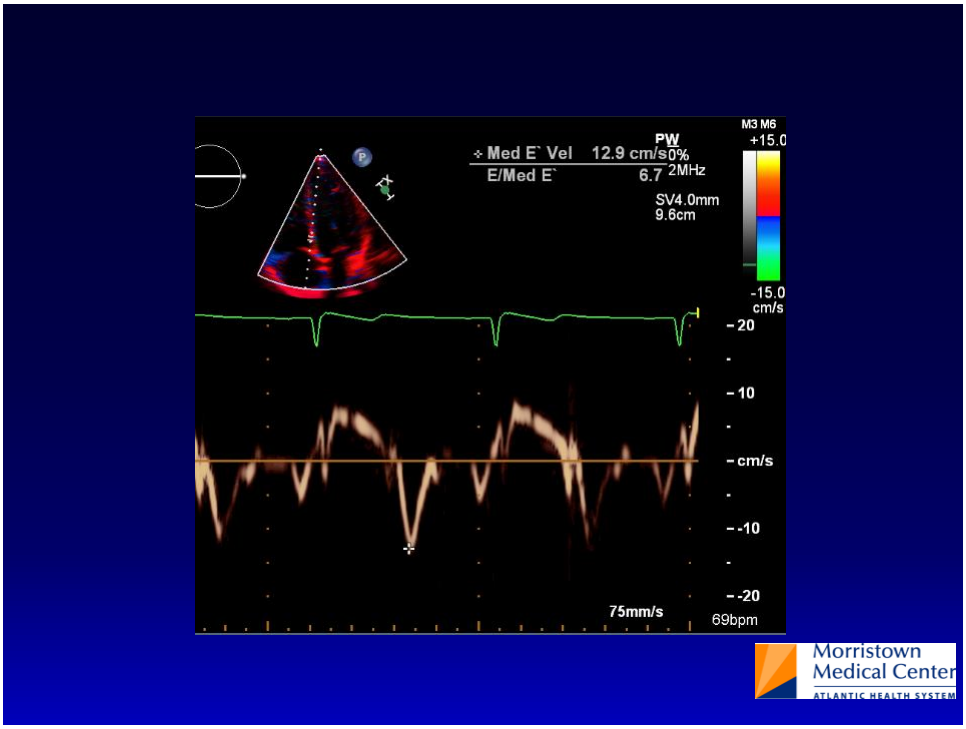
÷ Med E` Vel 12.9 cm/s
E/Med E` 6.7
PW
0%
2MHz
SV4.0mm
9.6cm
M3 M6
+15.0
-15.0
cm/s
20
10
cm/s
-10
-20
75mm/s
69bpm
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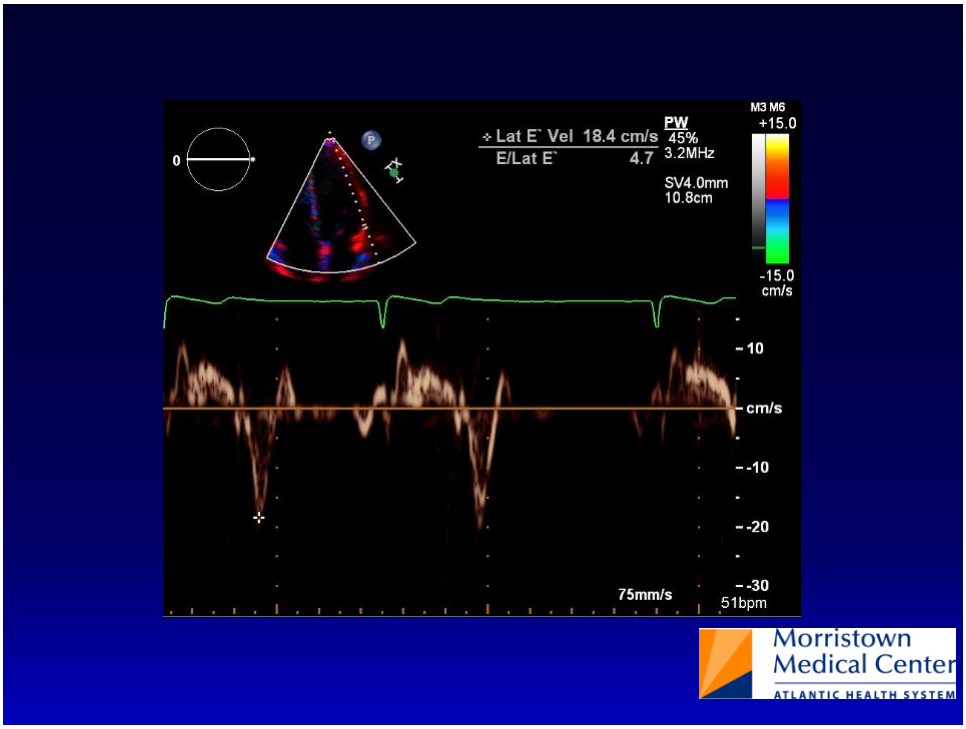
÷ Lat E` Vel 18.4 cm/s
E/Lat E` 4.7
PW
45%
3.2MHz
SV4.0mm
10.8cm
M3 M6
+15.0
-15.0
cm/s
10
cm/s
-10
-20
-30
75mm/s
51bpm
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Athlete's Heart

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IVS = 1.4, PW = 1.2

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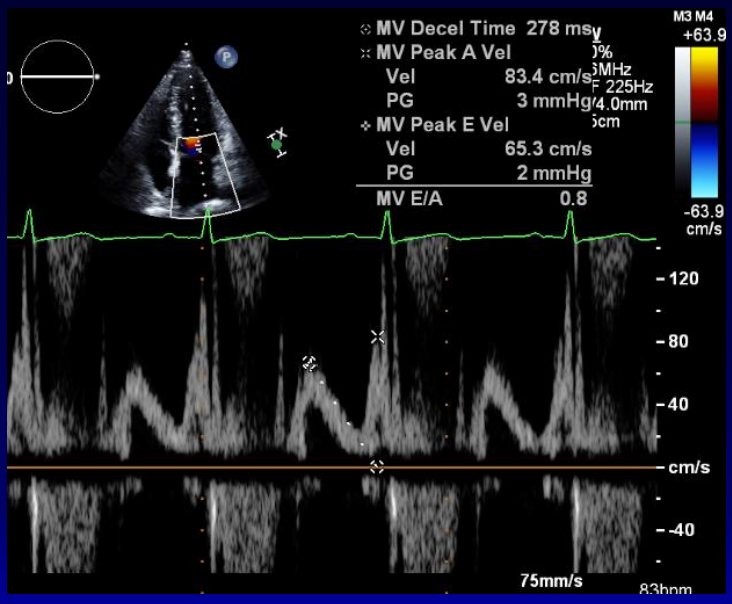

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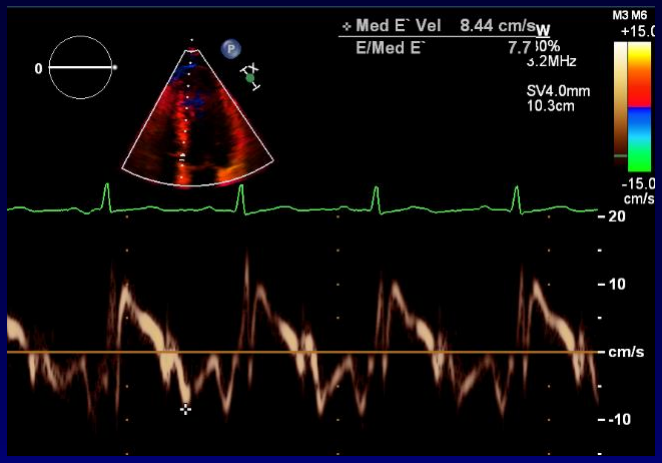

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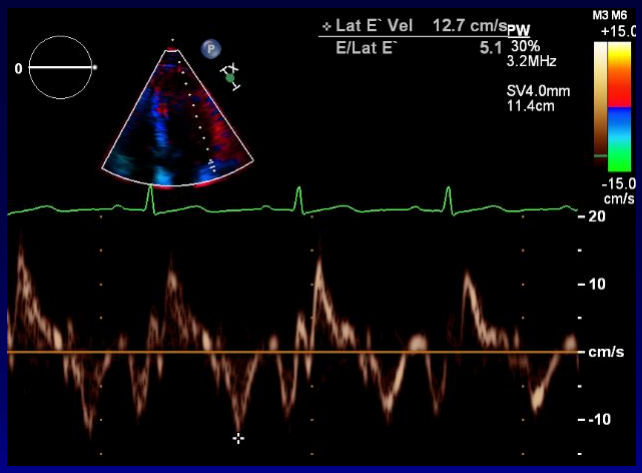

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Hypertrophic CM

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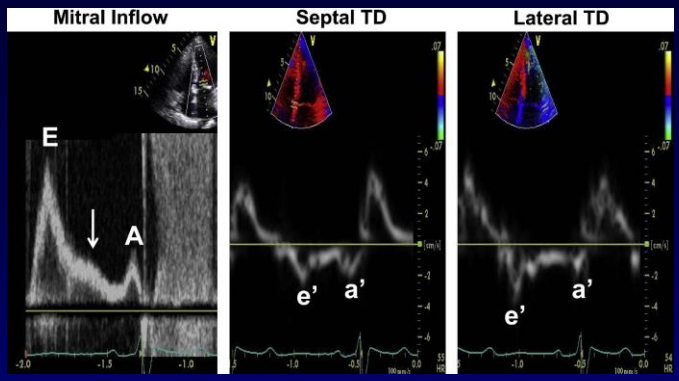
When left atrial pressure is elevated



Journal of the American Society of Echocardiography 2011 24, 473-498DOI:

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Aorta

- Pathologic enlargement typically not encountered (>4 cm)
- Inconsistent data on impact of training on aortic root size
- BUT in basketball players……

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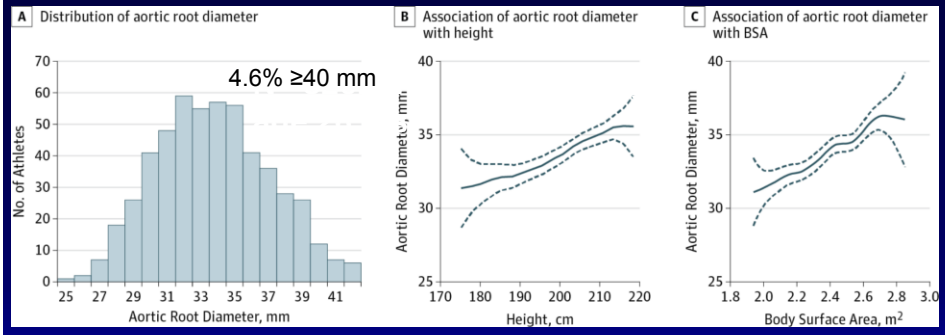
From: **Athletic Cardiac Remodeling in US Professional Basketball Players**
Engel et al.
JAMA Cardiol. 2016;1(1):80-87. doi:10.1001/jamacardio.2015.0252



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A word about complementary modalities

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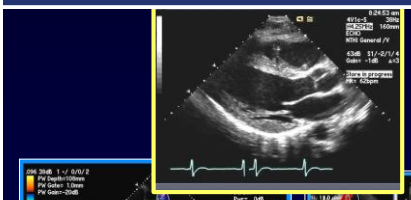

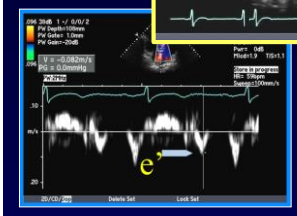

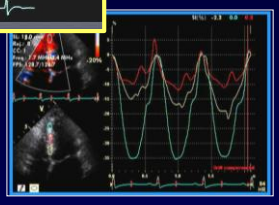

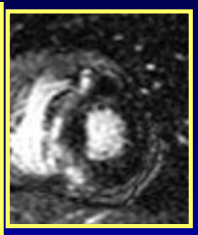

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EKG

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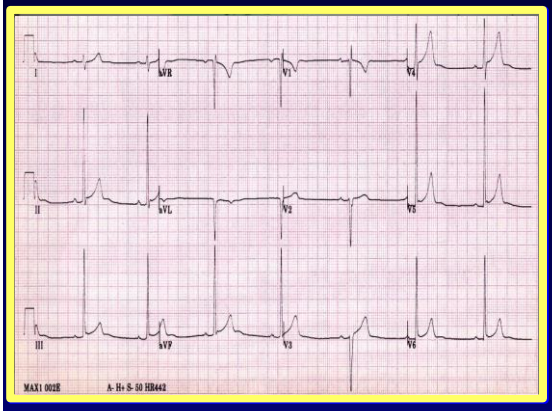
Athlete's EKG



Vagotonia

Sinus bradycardia
Sinus arrhythmia
First degree AVB
ST-elevation
Tall T waves

Increased chamber size

Left ventricular hypertrophy
Incomplete RBBB
Left atrial enlargement
Right atrial enlargement

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MRI

- Assessment of LV/RV Mass, Dimensions
- Fibrosis
- Inflammation
- Pathognomonic findings in myopathies

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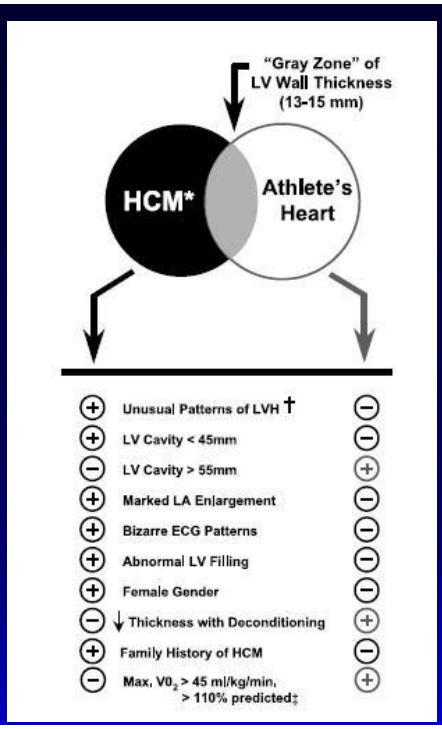

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Sometimes even the experts are not sure

Deconditioning

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Impact of extreme endurance activity

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Circulation

Circulation: Cardiovascular Imaging

Alteration in left ventricular strains and torsional mechanics after ultra-long duration exercise in athletes

Stéphane Nottin, Grégory Doucende, Iris Schuster-beck, Michel Dauzat, and Philippe Obert
CIRCULATIONAHA/2008/811273 [R2]

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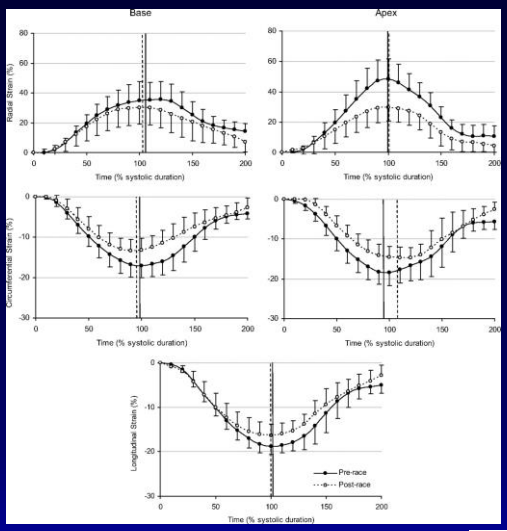
Figure 1. LV basal and apical circumferential and radial strains and LV longitudinal strains before (•) and after (○) the race.



Stéphane Nottin et al. Circ Cardiovasc Imaging. 2009;2:323-330

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Take home messages

- Athlete's heart may have altered anatomy and, to a lesser degree, function
- Published norms provide guidance but additional interventions (stress, deconditioning) may be essential

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- Multimodality approach is essential
  - Advanced EKG interpretive skills
  - MRI
- Meticulous echocardiography
  - Precise measurements
  - Strain
  - Stress echocardiography
- Specialized centers important

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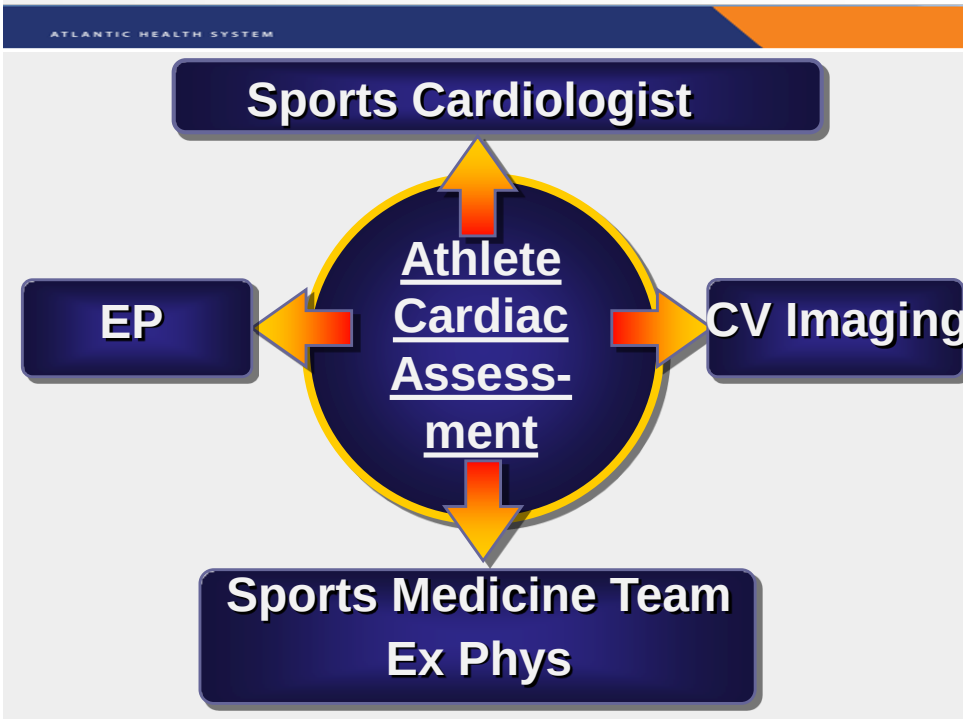
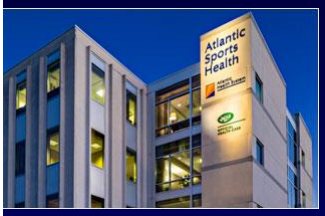


Sports Cardiology at Morristown



Mat Martinez, MD, FACC
Director of Sports Cardiology
Official Cardiologist to the New York Jets

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