Athlete’s Heart vs. Cardiomyopathy

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No disclosures
Questions asked of Echo

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

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?
CAUSE OF SCA IN YOUNG ATHLETES
(N=387, BASED ON AUTOPSY REPORTS)
Causes of SCD

• Structural
• Electrical
• Other
  – Commotio cordis
  – Myocarditis, dcm

The Changing Face of the American Athlete - Youth

Thanks to Mat Martinez, MD
The Changing Face of the American Athlete – High School

Thanks to Mat Martinez, MD

The Changing Face of the American Athlete - Collegiate

Thanks to Mat Martinez, MD
The Changing Face of the American Athlete - Masters

Atletes Come in All Shapes and Sizes
Pay attention to age, gender, race, body size and sport specific norms!

Reminder

Non-myopathic conditions affect athletes too

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

Maurizio Galderisi1*, (Chair), Nuno Cardim2, (Co-chair), Antonello D'Andrea3, Oliver Bruder4, Bernard Cosyns5, Laurent Davin6, Erwan Donal7, Thor Edwards8, Antonio Freitas9, Gilbert Habib10, Anastasia Kitsiou11, Sven Pkn12, Steffen E. Petersen13, Bogdan A. Popescu14, Stephen Schroeder15, Christof Burgstahler16, and Patrizio Lancellotti17

Document Reviewers: Rosa Sicari, (Italy), Denis Muraup, (Romania), Massimo Lombardi, (Italy), Raluca Dalgheru, (Romania), Andre La Gerche (Australia)

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Table 6: Average and upper limits of the main echocardiographic LV parameters in elite athletes (*sample sizes: 400)

<table>
<thead>
<tr>
<th>Authors</th>
<th>Journal</th>
<th>Number of athletes</th>
<th>Type of sport</th>
<th>Parameter</th>
<th>Average value</th>
<th>Upper limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pelliccione et al.</td>
<td>Am Heart J 2005;152(1):28–34</td>
<td>1328</td>
<td>Endurance</td>
<td>LV end-diastolic diameter (adult male) (mm)</td>
<td>55</td>
<td>70</td>
</tr>
<tr>
<td>Pelliccione et al.</td>
<td>J Anat Physiol 2004;292(3):357</td>
<td>492</td>
<td>Endurance</td>
<td>LV end-diastolic diameter (adult female) (mm)</td>
<td>49</td>
<td>66</td>
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<tr>
<td>Pelliccione et al.</td>
<td>J Anat Physiol 2004;292(3):357</td>
<td>492</td>
<td>Endurance</td>
<td>LV end-diastolic diameter (adolescent) (mm)</td>
<td>51</td>
<td>60</td>
</tr>
<tr>
<td>Spiriti et al.</td>
<td>Am J Cardiol 1994;74(9):802–806</td>
<td>947</td>
<td>Endurance</td>
<td>LV wall end-diastolic thickness (adult male) (mm)</td>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td>Reiner et al.</td>
<td>Am J Cardiol 1991;73(7):983–985</td>
<td>940</td>
<td>Endurance</td>
<td>LV wall end-diastolic thickness (adult female) (mm)</td>
<td>9.5</td>
<td>10.5</td>
</tr>
<tr>
<td>Sharma et al.</td>
<td>J Am Coll Cardiol 2003;41(1):141–146</td>
<td>730</td>
<td>Endurance</td>
<td>LV wall end-diastolic thickness (adolescent) (mm)</td>
<td>9.3</td>
<td>11.5</td>
</tr>
<tr>
<td>Basso et al.</td>
<td>J Am Coll Cardiol 2002;39(1):322–42</td>
<td>300</td>
<td>Endurance</td>
<td>LV wall end-diastolic thickness (female) (mm)</td>
<td>11.5</td>
<td>14</td>
</tr>
<tr>
<td>Pelliccione et al.</td>
<td>J Am Coll Cardiol 2002;40(4):406</td>
<td>1777</td>
<td>Endurance</td>
<td>LV anterior (male) (mm)</td>
<td>37</td>
<td>45</td>
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<td>Pelliccione et al.</td>
<td>J Am Coll Cardiol 2001;38(7):1433–1440</td>
<td>450</td>
<td>Endurance</td>
<td>LV anterior (female) (mm)</td>
<td>35</td>
<td>45</td>
</tr>
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<td>Pelliccione et al.</td>
<td>J Am Coll Cardiol 2001;38(7):1433–1440</td>
<td>450</td>
<td>Endurance</td>
<td>LV posterior (male) (mm)</td>
<td>36</td>
<td>44</td>
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<td>J Am Coll Cardiol 2001;38(7):1433–1440</td>
<td>450</td>
<td>Endurance</td>
<td>LV posterior (female) (mm)</td>
<td>26</td>
<td>33</td>
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<td>Pelliccione et al.</td>
<td>J Am Coll Cardiol 2001;38(7):1433–1440</td>
<td>450</td>
<td>Endurance</td>
<td>LV interventricular septum (male) (mm)</td>
<td>13</td>
<td>18</td>
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<td>J Am Coll Cardiol 2001;38(7):1433–1440</td>
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<td>Endurance</td>
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<td>31</td>
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<td>LV posterior (male) (cm²)</td>
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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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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)
Similar Changes with RV

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 Lotacono, MD, Francesca Arnelmi, 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
Wall thickness

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

Gender Matters


Race Matters
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

NFL 2011-2013

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

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
Chamber dimensions


![Graph showing LVEDD]
Pro Cyclists LV chamber size

From: Abergel, J Am Coll Cardiol. 2004;44:

LV chamber size in the NBA


All but 5 with normal EF > 50%
Effect of Sex and Sporting Discipline on LV Adaptation to Exercise

Gherardo Finocchiaro, MD, Harshil Dhokia, MBBS, Andrez D’Silva, MBBS, Anel Mallotra, MBBS, Cao,
Alexandros Steriotis, MD, PhD, Lynne Millar, MBBS, Keerthi Prakash, MBBS, Rajay Nain, MBBS, Michael Papadakis, MD, MBBS, Rajan Shama, MD, MBBS, Sanjay Shama, MD, MBBS
Women less likely to develop concentric vs. eccentric hypertrophy

Systolic Function
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

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.

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

Left atrium

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

LA AP diameter

From Galderisi et al EACVI Recommendations
Diastolic Function: Myopathy or Athlete’s Heart?

- 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

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.
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’
Wall thickness = 1.2 cm

Decel time = 187 ms
Athlete’s Heart

IVS = 1.4, PW = 1.2
Hypertrophic CM
When left atrial pressure is elevated

Aorta

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

MRI

- Assessment of LV/RV Mass, Dimensions
- Fibrosis
- Inflammation
- Pathognomonic findings in myopathies
Sometimes even the experts are not sure

Deconditioning
Impact of extreme endurance activity

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
CIRCULATIONAH/2008/811273 [R2]
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
• Multimodality approach is essential
  – Advanced EKG interpretive skills
  – MRI
• Meticulous echocardiography
  – Precise measurements
  – Strain
  – Stress echocardiography
• Specialized centers important
Sports Cardiology at Morristown

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