Athlete’s Heart vs. Cardiomyopathy

Linda D. Gillam, MD, MPH, FASE
Chair, Department of Cardiovascular Medicine
Medical Director, Cardiovascular Service Line
Former Team Cardiologist to the New York Jets

No disclosures
Sports Cardiology at Morristown

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

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)?
• Does this patient need a defibrillator?
• Are there genetic/family implications to my decision?
• What is the prognosis?
CAUSE OF SCA IN YOUNG ATHLETES
(N=387, BASED ON AUTOPSY REPORTS)

Causes of SCD

- Structural
- Electrical
- Other
  - Commotio cordis
  - Myocarditis, dcm
Corrado: J Am CollCard 2003

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 Galderisi*, (Chair), Nunzio Cardin*, (Co-chair), Antonello D’Andrea1, Oliver Bruder2, Bernard Cosyns3, Laurent Davin4, Erwan Donal5, Thor Edvardsen6, Antonio Freitas7, Gilbert Habib8, Anastasia Kitrou9,10, Sven Plein11, Steffen E. Petersen12, Bogdan A. Popescu13, Stephen Schroeder14, Christof Burgstahler15, and Patrizio Lancellotti17

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

Table 4 - Average and upper limits of the multiple echocardiographic LV parameters in elite athletes (*sample size: 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>
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</thead>
<tbody>
<tr>
<td>Piscione et al.</td>
<td>Am J Cardiol 1995;122:1-10</td>
<td>128</td>
<td>Endurance</td>
<td>LV end-diastolic diameter (adult male) (mm)</td>
<td>35</td>
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<tr>
<td>Myhre et al.</td>
<td>J Appl Physiol 2004;96:152-147</td>
<td>139</td>
<td>Endurance</td>
<td>LV end-diastolic diameter (adult male) (mm)</td>
<td>40</td>
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<tr>
<td>Cuttica et al.</td>
<td>J Am Coll Cardiol 2002;39:200-201</td>
<td>232</td>
<td>Endurance</td>
<td>LV end-diastolic diameter (adult male) (mm)</td>
<td>40</td>
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<tr>
<td>Cappelletti et al.</td>
<td>J Am Coll Cardiol 2004;44:301-306</td>
<td>230</td>
<td>Endurance</td>
<td>LV wall and diastolic thickness (adult male) (mm)</td>
<td>60</td>
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<td>Avendano et al.</td>
<td>J Am Coll Cardiol 2003;41:157-158</td>
<td>350</td>
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Exercise Physiology Basics

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

• Exercise requires oxygen
• Increased pulmonary oxygen uptake
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• Increased peripheral oxygen extraction

Cardiac Output = HR × 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'Acconzio, MD, PhD, FESC, Antonio Pelliaccia, MD, FESC, Marco Goliat, MD, Pietro Pisa, PhD, Fernando Leiscono, MD, Francesca Asnelli, MD, Stefano Casseli, MD, PhD, FASE, FESC, Marti Focardi, MD, PhD, Marco Bonifazi, MD, and Sergio Mondillo, MD, Sien and Rome, Italy
Wall thickness

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 data Courtesy of Dr Kovacs ACC 2013
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


LVEDD

14%
Pro Cyclists LV chamber size

LVIDd > 60mm (51%)

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 Bhatia, MBBS, Andrew D’Etime, MBBS, Anwit Malhotra, MBBS, Karthik Sreedhar, MD, PhD, Lynne Miller, MBBS, Koerdi Prakash, MBBS, Rajiv Niran, MBBS, Michael Papadakis, MD, MBBS, Rajan Sharma, MD, MBBS, Sanjay Sharma, MD, MBBS

Morristown Medical Center
Atlantic Health System

Relative Wall Thickness

Concentric Remodeling
Concentric Hypertrophy
Normal Geometry
Eccentric Hypertrophy

Left Ventricular Mass (g/m²)

≤ 95 in Males
< 115 in Females
> 95 in Males
> 115 in Females
Average training impulse (TRIMP) scores per month for all subjects over the training year.
Changes in left ventricular (LV) mass (left) and right ventricular (RV) mass (right) measured by magnetic resonance imaging every 3 months during the 1-year training program.

Mean±SD changes in left ventricular end-diastolic volume (LVEDV; left) and right ventricular end-diastolic volume (RVEDV; middle) by magnetic resonance imaging measured every 3 months during the training program.
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
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

Diastolic abnormalities may be present prior to hypertrophy
Individual data points showing septal and lateral Sa and Ea velocities at baseline and follow-up in both groups: the 12 subjects who had inherited the causal mutations for HCM and the 12 individuals in the control group.

Aorta

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

From: Athletic Cardiac Remodeling in US Professional Basketball Players
Engel et al.
A word about complementary modalities
EKG

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

Proposed Approach
Galderisi EACVI Recommendation

**Suspicion of HCM or IDCM**

- **ECHO**
  - Maximal LV wall thickness:
    - ≤ 12 mm: E/A > 2
    - > 12 mm: E/A < 1
  - CMR: LV diastolic wall-to-volume ratio ≤ 0.15 mm/m^2
  - CMR: LGE +

**ATHLETE**

**HCM**

**IDCM**

*Persistent after deconditioning*

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**Galderisi EACVI Recommendation**

**Suspicion of ARVC**

- **ECHO**
  - Global and regional RV function:
    - Normal
    - Abnormal

**ATHLETE**

**ARVC**

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**Suspicion of CAD**

- **Exercise ECG**
  - Normal
  - Abnormal

- **Exercise Stress ECHO**
  - Normal
  - Abnormal

**Stress CMR**

**CCT**

**ATHLETE**

**CAD**

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*Major Criterion:
- Regional RV akinesia, dyskinesia or dysynchrony in RV contraction
- End of the study:
  - 2D or 3D echocardiography:
    - RV ejection fraction ≤ 30%
  - RV angiography:
    - RV ejection fraction ≤ 30%
  - RV pressure measurements:
    - RV systolic pressure > 50 mmHg
- RV pressure measurements:
  - RV systolic pressure > 50 mmHg

*Minor Criteria:
- Regional RV akinesia, dyskinesia or dysynchrony in RV contraction
- RV systolic pressure > 50 mmHg
- RV systolic pressure > 50 mmHg
- RV systolic pressure > 50 mmHg

*If myocardial ischemia is detected by a noninvasive coronary angiography, it may be assessed without the performance of other tests.
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
CIRCULATIONAHA/2008/811273 [R2]
Figure 1. LV basal and apical circumferential and radial strains and LV longitudinal strains before (•) and after (○) the race.


Sports Cardiologist
Athlete Cardiac Assessment
Sports Medicine Team
ATC / Ex Phys
CV Imaging
EP
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