Care of the Athletic Heart

March 28\textsuperscript{rd} 2018

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Cleveland Cavaliers Cardiologist,
Staff Cardiologist,
Heart and Vascular Institute
Cleveland Clinic

No Disclosures
The Athlete is a Unique CV Patient
How do we define an athlete?

“One who participates in an organized team or individual sport that requires regular competition against others as a central component, places a high premium on excellence and achievement, and requires some form of systematic (and usually intense) training.”
Sports and Exercise Cardiology Section & Leadership Council

A section for all interested in sports and exercise cardiology, open to all ACC members with an interest in the cardiovascular care of the athlete and exercising individuals of all ages.

European Association of Preventive Cardiology (EAPC)

Sports Cardiology Section
Cardiac screening, education and science evolution in Sports Cardiology

Sports Cardiology Center
A multi-disciplinary team of specialists in cardiology, vascular medicine, heart and vascular surgery, pulmonary medicine, genetics, orthopedics, psychology, nutrition and athletic performance.
Care of the Athletic Heart: A comprehensive Sports Cardiology Program.

- Pre-participation screening
- Exercise induced cardiac remodeling vs cardiac pathology
- Evaluate the symptomatic athlete
- Manage athletes with CV disease
- Discuss risk of extreme exercise
Are athletes at higher risk of sudden cardiac death than their sedentary counterparts?
Are athletes at higher risk of sudden cardiac death than their sedentary counterparts?

Does Sports Activity Enhance the Risk of Sudden Death in Adolescents and Young Adults?

Domenico Corrado, MD, Pr;D,* Cristina Basso, MD, Pr;D,† Giulio Rizzoli, MD,‡ Maurizio Schiavon, MD,§ Gaetano Thiene, MD†

Padua, Italy

• 21 year prospective study 1979-1999
• ~1.3 million between ages of 12-35 years
• 300 SCD cases
  • 55 athletes (2.3:100,000/yr)
  • 245 non-athletes (0.9:100,00/yr)

<table>
<thead>
<tr>
<th>SD per 100,000 Person-Year</th>
<th>Athlete</th>
<th>Non-Athlete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiovascular</td>
<td>RR=2.8</td>
<td></td>
</tr>
<tr>
<td>Noncardiovascular</td>
<td>RR=1.7</td>
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</tr>
</tbody>
</table>

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What is the risk of sports related sudden cardiac death?

- The true incidence of SrSCD is controversial with estimates ranging from 0.12 to 13/100,000 person-years (PY).

- Calculated incidence depends on the **numerator** and method of identifying this number: media reports and insurance claims have been shown to underestimated the true incidence.

- Depends on the **denominator** – often estimated from surveys and census documents.
What is the risk of sports related sudden cardiac death?

- Meta-analysis of 21 studies showed the incidence of SrSCD was 0.72 (95% CI 0.58-0.86) per 100,000 PY (~1 in 140,000).\(^1\)

- No significant difference between USA v Europe, prospective or retrospective studies, high school/collegiate vs others.\(^1\)

- Differs greatly in certain sub-groups:
  - Men are 10-20 times more likely to suffer SCD than women
  - SrSCD is 3-5 times more common in black versus white athletes
  - Reported incidence of SCD in Division one black basketball players is high as 1:5200.\(^2\)

\(^1\) Mahananey et al JACC 2017  
\(^2\) Harmon et al Circulation 2015
Comparison of Pre-Participation Evaluations
<table>
<thead>
<tr>
<th>Components</th>
<th>Last updated</th>
<th>ECG recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHA: 14-element recommendations for pre-participation screening of competitive athletes</td>
<td>2014</td>
<td>No</td>
</tr>
<tr>
<td>Pre-participation Physical Evaluation Monograph 4th Edition</td>
<td>2010</td>
<td>+/-</td>
</tr>
<tr>
<td>ESC Questionnaire and Physical Examination Components for Pre-Participation Cardiovascular Screening of Competitive Athletes.</td>
<td>2005</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Considerations

- No questions are evidence based – all are based on consensus opinion.
- 24-43% of college athletes and 68% of high-school athletes answered positively to at least one PPE question.
- High positive responses create medicolegal dilemma – No standardized follow up questions.
- Downstream testing is not standardized.
- No details on how to perform physical examinations.
- No data showing screening with a H&P reduces the risk of SCD on athletes.
The effectiveness of screening history, physical exam, and ECG to detect potentially lethal cardiac disorders in athletes: A systematic review/meta-analysis

Kimberly G. Harmon, M.D., a, b, * Monica Zigman, M.P.H., a Jonathan A. Drezner, M.D. a

a Department of Family Medicine, University of Washington, Seattle, WA, USA
b Department of Orthopaedics and Sports Medicine, University of Washington, Seattle, WA, USA

15 studies with ~47,000 athletes screened.

Meta-Analysis of Pooled Data

<table>
<thead>
<tr>
<th></th>
<th>History</th>
<th>Physical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>20% (7%-44%)</td>
<td>9% (3%-24%)</td>
</tr>
<tr>
<td>Specificity</td>
<td>94% (89%-96%)</td>
<td>97% (95-98%)</td>
</tr>
</tbody>
</table>

Harmon et al. Journal of Electrocardiology 2015
# How does ECG perform?

## Meta-Analysis of Pooled Data

<table>
<thead>
<tr>
<th></th>
<th>ECG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>94% (79%-98%)</td>
</tr>
<tr>
<td>Specificity</td>
<td>93% (90%-96%)</td>
</tr>
</tbody>
</table>

Harmon et al. Journal of Electrocardiology 2015
Does screening using ECG reduce the risk of SCD?

Sudden Death per 100,000 Person-Years

- Screened Athletes
- Unscreened Non Athletes


Corrado et al JAMA 2006
May not be that simple?

Italian Sport Law

Israel Sport Law

Years

Veneto (Italy)  Israel  Minnesota (USA)
Considerations

- Meta-analysis of ~47,000 athletes revealed 0.3% of athletes had a potentially life threatening disease (1 in 294) identified.\(^1\)
- In the Veneto region 2% of athletes were disqualified.\(^2\)
- Number of athletes found to have a cardiac pathology based on positive ECG much higher than risk of SCD – many athletes will receive apparently appropriate but ultimately unnecessary interventions.

\(^1\) Harmon et al Journal of Electrocardiology 2015
\(^2\) Corrado et al JAMA 2006
Exercise Paradox

• In normal individuals and those with heart disease the risk of cardiac arrest is transiently increased during vigorous exercise, but habitual exercise is associated with an overall decreased mortality.

Desai M JACC imaging 2014
Evolution of Guidelines for the Interpretation of ECG’s in the Athlete

Arbitrary Classification of Abnormal findings on ECG

ESC Guidelines 2010

Seattle Criteria 2012

Refined Criteria 2014

International Recommendations 2017
ECG Changes in Athletes

Vagotonia
- 1st degree HB ~5-13%
- Sinus brady ~80%
- Sinus arrhythmia ~70%
- Mobitz Type 1, ~30%
- Junctional rhythm, ~20%
- Sinus pauses, ~40%
- Early Repol, ~60%

Morphological Changes
- LVH, ~70%
- LAE
- RAE
- Partial RBBB, ~30%
Sinus Arrhythmia and bradycardia

1st Degree HB

LVH

Early Repolarization
2017 International Recommendations

Normal ECG Findings
- Increased QRS voltage for LVH or RVH
- Incomplete RBBB
- Early repolarization/ST segment elevation
- ST elevation followed by T wave inversion V1-V4 in black athletes
- T wave inversion V1-V3 in patients aged <16 years old
- Sinus bradycardia or arrhythmia
- Ectopic atrial or junctional rhythm
- 1° AV block
- Mobitz Type I 2° AV block

Abnormal ECG Findings
- T wave inversion
- ST segment depression
- Pathologic Q waves
- Complete LBBB
- QRS ≥ 140 ms duration
- Epsilon wave
- Ventricular pre-excitation
- Prolonged QT interval
- Brugada Type 1 pattern
- Profound sinus bradycardia < 30 bpm
- PR interval ≥ 400 ms
- Mobitz Type II 2° AV block
- 3° AV block
- ≥ 2 PVCs
- Atrial tachyarrhythmias
- Ventricular arrhythmias

Borderline ECG Findings
- Left axis deviation
- Left atrial enlargement
- Right axis deviation
- Right atrial enlargement
- Complete RBBB

No further evaluation required in asymptomatic athletes with no family history of inherited cardiac disease or SCD

Further evaluation required to investigate for pathologic cardiovascular disorders associated with SCD in athletes

Sharma et al JACC/EHJ 2017
Interassociation consensus statement on cardiovascular care of college student-athletes

- PPE is performed to identify conditions that may put the student-athlete at unreasonable risk of death or catastrophic injury with the potential to modify and reduce the risk through individualized management.

- Process should be formalized and in writing
  - Clear roles
  - Management of medical records.

Hainline B et al BMJ/JACC 2016
Interassociation consensus statement on cardiovascular care of college student-athletes

• In addition, the PPE can be used to:
  – Ensure current health problems are being managed appropriately.
  – Identify conditions that serve as barriers to performance.
  – Opportunity to build a relationship between student and people involved in medical care.
  – Assess for characteristics that increase risk of future injury.
  – Review medications and supplements.
  – Educated regarding health risks, health related behaviour and pertinent issues regarding safe play.

Hainline B et al BMJ/JACC 2016
Interassociation consensus statement on cardiovascular care of college student-athletes

• Recommend either AHA 14 element or 4th monograph +/- ECG

• If ECGs are to be performed:
  – Decide a priori who will be screened.
  – Identify a CV specialist who will coordinate.
  – Provide information to the athlete regarding rationale for ECG testing and possible risks and benefits.
  – Interpret with modern standards.
  – Skilled cardiology oversight required.

Hainline B et al BMJ/JACC 2016
Interassociation consensus statement on cardiovascular care of college student-athletes

“The management of identified cardiac disorders and all sport eligibility decisions are ultimately the responsibility of the institutional primary athletics healthcare providers in consultation with subspecialty consultants.”

Hainline B et al BMJ/JACC 2016
Care of the Athletic Heart: A comprehensive Sports Cardiology Program.

- Pre-participation screening
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Athletic Heart

- Athlete’s Heart (Syndrome) refers to **physiological** cardiac changes that occur as a result of **hemodynamic stress** of regular strenuous exercise.
Morphological Changes of the Athlete’s Heart

- 10-20% increase in LV wall thickness
- 10% increase in LV cavity dimension
- Biatrial enlargement – LA is on average 7ml/m2 or 4mm larger in athletes
- There is balanced enlargement of the RV
- Aorta is slightly larger in athletes but very rarely >4cm
Factors Which Influence the Athlete’s Heart

- Sport type
- Race
- Age
- Sex
- Size
49 year old male Ironman presents with murmur
Care of the Athletic Heart: March 28th 2018.

- HCM
- DCM/LVNC
- ARVC

Athletes Heart
Left Ventricular Wall Thickening

HCM

Athletes Heart

Care of the Athletic Heart: March 28th 2018.
How do I differentiate HCM from Athletes Heart in 2018?

Frequently Useful
- Distribution of hypertrophy
- Chamber size
- Chamber shape
- Mitral valve structure and function
- DGE on MRI
- Family history

Occasionally Useful
- Diastolic function
- Exercise capacity
- Strain Imaging
- Genetic testing
- Abnormal ECG

Rarely Useful
- LA size
- Deconditioning
Chamber Size, Shape and Pattern of Hypertrophy

Athlete with Mild Eccentric LVH

Chamber is frequently dilated in athletes
Uniform pattern of thickening

Athlete with HCM

Chamber is very rarely dilated in HCM
Asymmetric pattern of thickening
Diastolic Function

Lateral e' = 15m/s  Medial e' = 12m/s

Lateral e' = 15m/s  Medial e' = 11m/s
Which of the Following 2 Cases is an Athlete and Which as HCM?
Case Number 1

ECG COMPOUND WITH INTERPRETATION

Technician: 914
Test nd.

Test Type: ECG COMP W INTERP

I  aVR  V1  aVR  V4
II  aVL  V2  V5  V5
III aVF  V3  V6

I  V1  V5
II  aVL  II
III aVF  V3

Care of the Athletic Heart: March 28th 2018.
Case Number 1

Case Number 2
Case Number 2
Mitral Valve Morphology

**A**
- Apex
- Lateral Wall
- LV
- Septum
- Ao
- LA

**B**
- Anteroapically Displaced Papillary Muscle
- Leaflet Slack
- Asymmetrical Septal Hypertrophy
- LVOT Turbulence

**C**
- Bifurcated Papillary Muscle
- Leaflet Slack
- Asymmetrical Septal Hypertrophy

Kwon D H et. al. Heart

Care of the Athletic Heart: March 28th 2018.
My 10 Step Approach to the Athlete in the Grey Zone with Increased Wall Thickness

1. What is the clinical presentation: family history of HCM, symptomatic, abnormal ECG, or was this discovered incidentally?

2. Is the LV wall thickened? Ensure not including RV trabeculation and good alignment – MRI can be helpful.

3. What is the pattern of thickness? Is there >2mm difference between contiguous segments or is it homogenous?

4. What is the LV dimension?

5. Is the wall thickness/LV dimension appropriate for that athlete (consider sport type/race/sex/age/size)?

6. Is the mitral valve normal is structure and function?

7. Is there DGE on MRI?

8. Is the exercise capacity consistent that individual athlete?

9. Review diastolic function and strain

10. Usually the answer is within – rarely is genetic testing/detraining necessary.
Left Ventricular Dilation

DCM/LVNC  Athletes Heart

No. Athletes

LVEDD (mm)

14%
Distribution of LVEF and LV dimensions in 286 Tour de France cyclists

Figure 1. Plot of left ventricular ejection fraction (LVEF) against left ventricular internal diameter at end diastole (LVId) in all cyclists (solid circles = 1995; open circles = 1998). The solid vertical bar represents the normality threshold (60 mm) for LVId, and the solid horizontal bar represents the normality threshold (52%) for LVEF. Numbers in italics in front of each axis value are cumulative numbers of cyclists with a value below the corresponding axis value.
Peak oxygen uptake in relation to total heart volume discriminates heart failure patients from healthy volunteers and athletes.
My Approach to the Athlete in the “Gray Zone”.

- Generally, LV dilation is not isolated in athletes heart accompanied by eccentric LVH, RV and LA dilation

- Diastolic function and strain should be normal.

- Exercise testing is useful
  - LV augments normally
  - Should have supranormal exercise capacity
Right Ventricular Dilation

Athletes Heart

ARVC

Care of the Athletic Heart: March 28th 2018.
### Revised Task Force criteria

#### 1. Global or regional dysfunction and structural alterations

**Major**
- By 2D echo:
  - Regional RV akinesia, dyskinesia, or aneurysm
  - and 1 of the following (end diastole):
    - PLAX RVOT $\geq 32$ mm (corrected for body size $[\text{PLAX/BSA}] \geq 19$ mm/m²)
    - PSAX RVOT $\geq 36$ mm (corrected for body size $[\text{PSAX/BSA}] \geq 21$ mm/m²)
    - or fractional area change $\leq 33$ percent

- By MRI:
  - Regional RV akinesia or dyskinesia or dyssynchronous RV contraction
  - and 1 of the following:
    - Ratio of RV end-diastolic volume to BSA $\geq 110$ mL/m² (male) or $\geq 100$ mL/m² (female)
    - or RV ejection fraction $\leq 40$ percent

- By RV angiography:
  - Regional RV akinesia, dyskinesia, or aneurysm

**Minor**
- By 2D echo:
  - Regional RV akinesia or dyskinesia
  - and 1 of the following (end diastole):
    - PLAX RVOT $\geq 29$ to $< 32$ mm (corrected for body size $[\text{PLAX/BSA}] \geq 16$ to $< 19$ mm/m²)
    - PSAX RVOT $\geq 32$ to $< 36$ mm (corrected for body size $[\text{PSAX/BSA}] \geq 18$ to $< 21$ mm/m²)
    - or fractional area change $> 33$ percent to $\leq 40$ percent

- By MRI:
  - Regional RV akinesia or dyskinesia or dyssynchronous RV contraction
  - and 1 of the following:
    - Ratio of RV end-diastolic volume to BSA $\geq 100$ to $< 110$ mL/m² (male) or $\geq 90$ to $< 100$ mL/m² (female)
    - or RV ejection fraction $> 40$ percent to $\leq 45$ percent

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*AVCD confirmed pathologically at autopsy or surgery in a first-degree relative
  + Identification of a pathogenic mutation categorized as associated or probably associated with ARVC/D in the patient under evaluation
  + Premature sudden death (≤35 years of age) due to suspected ARVC/D in a first-degree relative
  + AVCD confirmed pathologically or by current Task Force Criteria in second-degree relative

Diagnostic terminology for revised criteria:
- **Definite diagnosis:** 2 Major, Or 1 Major and 2 Minor criteria, Or 4 Minor from different categories
- **Borderline diagnosis:** 1 Major and 1 Minor, Or 3 Minor criteria from different categories
- **Possible diagnosis:** 1 Major, Or 2 Minor criteria from different categories
Right Ventricular Dimensions in Highly Trained Athletes

To meet ARVC criteria there must also be regional akinsia, dyskinesia or aneurysm

Zaidi et al Circulation 2013
My Approach to the Athlete in the “Gray Zone”.

• In endurance athletes the RV is commonly dilated.
• Associated with LV dilation
• MRI is helpful to assess for regional dyskinesia/akinesia and aneurysm.
• Response to exercise and long term monitor may be necessary
Care of the Athletic Heart: A comprehensive Sports Cardiology Program.

- Pre-participation screening
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Evaluating the symptomatic athlete

- Chest Pain
- Short of Breath
- Collapse/syncope
- Palpitations
- Performance decrement
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Management of the Athlete with CV Disease

- Listen and respect their athletic ambitions.
- Use best practice guidelines for underlying condition wherever possible.
- Try to use medications that won’t interfere with performance – so long as they are equally efficacious.
- Ensure medications are permissible by the governing sporting body – apply for exemptions if necessary.
- Use a shared decision making model for sporting participation.
Eligibility and Disqualification Recommendations for Competitive Athletes With Cardiovascular Abnormalities: Preamble, Principles, and General Considerations

A Scientific Statement From the American Heart Association and American College of Cardiology

- No of recommendations in the document: 241

- Level of evidence A: 3 (1%)  
- Level of evidence B: 46 (19%)  
- Level of evidence C: 192 (80%)
Changing Guidelines and Recognizing Limitations.

Sports participation with ICD

Safety of Sports for Athletes With Implantable Cardioverter-Defibrillators
Results of a Prospective, Multinational Registry

Sports participation with Long QT

Sports Participation in Genotype Positive Children With Long QT Syndrome

Peter F. Aziz, MD, Tammy Sweeten, MS, Ramon L. Vogel, MD, William J. Bonney, MD, Jacqueline Henderson, RN, Akash R. Patel, MD, Maully J. Shah, MBBS
Changing Guidelines and Recognizing Limitations.

• Symptoms develop at an earlier age in athletes (~30 vs 40 years)
• Athletes have a lower lifetime survival free of VT/VF than non-athletes.
Interassociation consensus statement on cardiovascular care of college student-athletes

• “The ACC/AHA provides recommendations for safe participation in athletes with cardiovascular conditions that can be used as an initial guideline.
• A model that uses a comprehensive evaluation, extensive patient/family counselling, and prudent medical management for risk reduction and informed decision-making that involves all key stakeholders in the oversight of the athlete (eg, coaches, athletic trainers, team physicians and athletic directors) provides a sensible strategy to structure difficult cardiac clearance decisions.”

Hainline B et al BMJ/JACC 2016
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Exercise at the Extremes

Biomarkers of Cardiac Stress and Injury in Athletes: What Do They Mean?

Eoin Donnellan¹ · Demot Phelan¹

Prevalence of Subclinical Coronary Artery Disease in Masters Endurance Athletes With a Low Atherosclerotic Risk Profile

Figure 3. Delayed gadolinium enhancement in five athletes. Images of five athletes in whom focal delayed gadolinium enhancement (DGE) was identified in the interventricular septum (indicated with arrows) when compared with an athlete with a normal study (top left).

Is the risk of atrial fibrillation higher in athletes than in the general population? A systematic review and meta-analysis

Jawdat Abdulla and Jens Rokkedal Nielsen

Exercise-induced right ventricular dysfunction and structural remodelling in endurance athletes

André La Gerche¹, Andrew T. Burns¹, Don J. Mooney¹, Warrick J. Inder¹, Andrew J. Taylor¹, Jan Bogaert², Andrew I. Madsaae³, Hein Heidbüchel³, and David L. Prior¹,³

Cleveland Clinic
Care of the Athletic Heart: A comprehensive Sports Cardiology Program.

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Thank you for your attention