Cardiac Evaluation of Athletes and Highly Active Individuals.

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American athlete as any individual who engages in routine vigorous physical exercise in the settings of competition, recreation, or occupation
Exercise Physiology and Cardiac Effects

### Static Exercise
- short and forceful skeletal muscle contractions
- Increased SVR and BP
- Increased myocardial contractility

### Dynamic Exercise
- Repetitive large muscle contraction and relaxation
- Increase in oxidative metabolism
- Increase CO, Increase HR, SV, Decrease SVR.

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**A. Low (<50%)**
- Archery
- Auto racing
- Cross-country skiing
- Ice hockey
- Basketball
- Baseball
- Badminton
- Cycling

**B. Moderate (50-75%)**
- Bobsledding
- Downhill skiing
- Skiing
- Snowboarding
- Boxing
- American football
- Field events
- Rugby
- Running (sprint)
- Synchronized swimming
- "Ultra" racing

**C. High (>75%)**
- Martial arts
- Rock climbing
- Kayaking
- Cycling
- Cross-country skiing
- Skating techniques
- Lacrosse
- Running (cross country)
- Swimming
- Handball
- Tennis
- Baseball/Softball
- Table tennis
- Badminton
- Cross-country skiing
- (classic technique)
- Orienteering
- Race walking
- Squash
- Soccer

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Aaron L. Baggish et al. JACC 2017;70:1902-1918
EICR VS Pathology

**Thick LV Walls**
- **Key Differential Diagnosis**
  - Hypertrophic CMP
  - Hypertensive heart disease
  - Infiltrative heart disease
  - Valvular heart disease
- **Clinical Factors c/w EICR**
  - High static sport background
  - No subjective symptoms
  - Benign family history
- **Imaging Findings c/w EICR**
  - Mild symmetric LVH (walls <15 mm)
  - Normal RV dimensions
  - Normal/mildly enlarged LA
  - Normal aortic & mitral valves

**Dilated LV Chamber**
- **Key Differential Diagnosis**
  - Idiopathic dilated CMP
  - Toxins (ETH, drugs) CMP
  - Acute/Chronic myocarditis
  - Nutritional deficiency
  - CMP 2nd tachyarrhythmia
  - Valvular heart disease
- **Clinical Factors c/w EICR**
  - High dynamic sport background
  - No subjective symptoms
  - Benign family history
  - No history of prior illness
  - No history substance abuse
- **Imaging Findings c/w EICR**
  - Concomitant RV dilation
  - +/- Mild LV wall thickening
  - Normal/low normal systolic function
  - Supra-normal LV diastolic indices
  - Normal/mildly enlarged LA & RA
  - Normal aortic & mitral valves

**Dilated RV Chamber**
- **Key Differential Diagnosis**
  - Arrhythmogenic RV CMP
  - Toxins (ETH, drugs) CMP
  - 1st or 2nd pulmonary HTN
  - Congenital heart disease
  - Valvular heart disease
- **Clinical Factors c/w EICR**
  - High dynamic sport background
  - No subjective symptoms
  - Benign family history
- **Imaging Findings c/w EICR**
  - Concomitant LV dilation
  - Normal RV morphology
  - Normal/low normal systolic function
  - Supra-normal LV diastolic indices
  - Normal/mildly enlarged LA & RA
  - Normal RV systolic pressure
  - Normal tricuspid and pulmonic valves

Aaron L. Baggish et al. JACC 2017;70:1902-1918
Etiology of Sudden Cardiac Death in Athletes.

<table>
<thead>
<tr>
<th></th>
<th>The 14-Element AHA Recommendations for Preparticipation Cardiovascular Screening of Competitive Athletes</th>
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</thead>
<tbody>
<tr>
<td></td>
<td><strong>Medical history</strong></td>
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<tr>
<td></td>
<td><strong>Personal history</strong></td>
</tr>
<tr>
<td>1.</td>
<td>Chest pain/discomfort/tightness/pressure related to exertion</td>
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<tr>
<td>2.</td>
<td>Unexplained syncope/near-syncope†</td>
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<td>3.</td>
<td>Excessive and unexplained dyspnea/fatigue or palpitations, associated with exercise</td>
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<td>4.</td>
<td>Prior recognition of a heart murmur</td>
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<td>5.</td>
<td>Elevated systemic blood pressure</td>
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<td>6.</td>
<td>Prior restriction from participation in sports</td>
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<td>7.</td>
<td>Prior testing for the heart, ordered by a physician</td>
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<td></td>
<td><strong>Family history</strong></td>
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<tr>
<td>8.</td>
<td>Premature death (sudden and unexpected, or otherwise) before 50 y of age attributable to heart disease in ≥1 relative</td>
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<tr>
<td>9.</td>
<td>Disability from heart disease in close relative &lt;50 y of age</td>
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<td>10.</td>
<td>Hypertrophic or dilated cardiomyopathy, long-QT syndrome, or other ion channelopathies, Marfan syndrome, or clinically significant arrhythmias, specific knowledge of genetic cardiac conditions in family members</td>
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<tr>
<td></td>
<td><strong>Physical examination</strong></td>
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<tr>
<td>11.</td>
<td>Heart murmur†</td>
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<tr>
<td>12.</td>
<td>Femoral pulses to exclude aortic coarctation</td>
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<tr>
<td>13.</td>
<td>Physical stigmata of Marfan syndrome</td>
</tr>
<tr>
<td>14.</td>
<td>Brachial artery blood pressure (sitting position)§</td>
</tr>
</tbody>
</table>
Chest Discomfort

- Cardiac etiology < 6% in patients < 35 yo, (Reflux, Asthma),
- In older athletes, cardiogenic (16%) “warm-up angina”, musculoskeletal (36%) and gastrointestinal reflux (13%).
- accompanying symptoms, palpitations, near-syncope or syncope, or decline in exercise performance are concerning

• Anomalous coronaries
• Exercise-induced bronchoconstriction
• Valvular heart disease
• HCM
• Ischemic heart disease
• Pulmonary embolism
• Aortic dissection
• Peri/Myocarditis
• Congenital heart disease
• Arrhythmias

Syncope

- Neurally Mediated syncope
  - Warning symptoms, feeling of warmth, flushing, lightheadedness -> syncope
  - gradual onset of symptoms , injury uncommon.
  - Brief unconsciousness, with minimal residual confusion
  - persistent vagal symptoms including flushing, warmth, fatigue, and nausea.
- Recurrent Syncope

- Cardiogenic Syncope
  - syncope or collapse that occurs during or prior to completion of an event.

Trauma.

- Cardiomyopathies: HCM, DCM, RCM, LVNC
- ARVC
- Valvular heart disease
- Anomalous coronaries
- Congenital heart disease
- Brugada syndrome
- Long QT syndrome
- Catecholaminergic polymorphic ventricular tachycardia
- Atrial and ventricular tachyarrhythmias
- Ischemic heart disease
Palpitations

Concerning for Arrhythmia.
Palpitations absent triggers or during exercise are more likely to be caused by arrhythmias.

Palpitations characterized by sudden heart rate acceleration or deceleration at rest.

PVC’ greater than 2000/24 hours more significant

- Premature atrial and ventricular contractions
- Atrial and ventricular tachyarrhythmias
- AV block, 2nd or 3rd degree
- Anemia
- Electrolyte disturbances
- Thyroid and other endocrine disorders
Dyspnea

- Anomalous coronaries
- Asthma
- Exercise-induced bronchoconstriction
- Valvular heart disease
- Cardiomyopathies
- Ischemic heart disease
- Pulmonary embolism
- Congenital heart disease
- Anemia
EKG vs AHA Evaluation
Sixteen (0.4%) athletes were identified with cardiac conditions associated with SCD:
9 Wolff-Parkinson-White,
3 long QT syndrome,
2 hypertrophic cardiomyopathy,
1 dilated aorta,
1 anomalous origin of the right coronary artery.
The AHA 14-point evaluation was flagged as abnormal in 10 of 16 (63%) cases.
The ECG was flagged as abnormal in 15 of 16 (93.8%) cases.

Conclusions
The AHA 14-point evaluation performs poorly compared with ECG for cardiovascular screening of high school athletes. The use of consensus-derived history questionnaires as the primary tool for cardiovascular screening in athletes should be reevaluated.
There is No Reason to Adopt ECGs and Abandon American Heart Association/American College of Cardiology History and Physical Screening for Detection of Cardiovascular Disease in the Young

- number of false positives, expensive downstream noninvasive testing;
- false negatives.
- logistical challenges in interpreting ECGs in large populations
- overall cost burden;
- failure to demonstrate that ECG screening reduces cardiovascular mortality
EKG ( > 16yo)
- Sinus bradycardia (44 beats/min),
- Early repolarization in I, II, aVF, V₂ to V₆ (arrows),
- Voltage criterion for left ventricular hypertrophy (S-V₁ + R-V₅ >35 mm),
- Tall, peaked T waves (circles).
Asymptomatic black athlete

left ventricular hypertrophy,
J-point elevation,
convex (‘domed’) ST-segment elevation followed by T-wave inversion in $V_1$ to $V_4$
31yo asymptomatic black athlete
51yo Cyclist with syncope 3 years prior

6/15/2015

DISCHARGE DIAGNOSES:
1. Syncope, suspect secondary to transient hypotension from insect sting.
2. History of recurrent syncope - three episodes in two years - will need event monitor as an outpatient to be arranged by Dr.
3. Abnormal troponin - suspect secondary to transient hypotension.
   Normal cardiac echocardiogram.
5. Hypothyroidism.

Echo

INTERPRETATION SUMMARY
The left ventricle is normal in size.
Physiologic mitral regurgitation is noted.
No aortic regurgitation is present.
There is mild tricuspid regurgitation.
The left ventricular ejection fraction is normal.

LEFT VENTRICLE
The left ventricle is normal in size. There is borderline concentric left ventricular hypertrophy. The left ventricular ejection fraction is normal.
ECHO
Contrast Echo
21y/o Asymptomatic Professional Rugby Player

WPW pattern occurs in up to 1 in 250 of athletes,
PR interval <120 ms,
delta wave (slurring of the initial QRS
QRS duration >120 ms
Brugada

Coved rSr’ pattern,
ST-segment elevation ≥2 mm,
inversion of the terminal portion of the T-wave in leads V₁, V₂, and V₃
22 y/o Marine with Syncope
**HPI**

- 22M in Marine Corps was completing a physical fitness test when he passed out
- He had just finished a 3-mile run then immediately syncopized
- No prodromal symptoms

- **ROS**: history of sporadic, exertional chest discomfort

- **FHx** – no history of SCD
- **SHx** – Married; Marine Corps; occasional EtOH
- **Meds** - None

- **T 98.7, BP 127/68, HR 88, RR 16, O2 99%**
- **General**: No distress, AAOx3
- **HEENT**: Moist oral mucosa
- **PULM**: Clear lungs
- **CV**: RRR, Normal S2, S2. No murmurs/r/b
- **EXT**: 2+ pulses throughout. No pitting edema.
- **SKIN**: No abrasions

- **Troponin T 0.148 → 0.2 → 0.119** (nl <0.01)
Congenital TTE

1. Unable to visualize the left main coronary artery.

2. **RCA origin is normal.** Proximal RCA measures 3mm with normal flow velocity. Left aortic arch with normal branching.

3. The left ventricular size is normal. The left ventricular systolic function is normal.

4. The right ventricular size is normal and systolic function is normal.

5. A **patent foramen ovale** is detected by Doppler with predominantly left to right shunting across the atrial septum.

6. No significant valvular abnormalities.
Coronary Artery Anomalies
Normal Cardiac CT
Diagnosis

1. Absent left main artery
2. Patent foramen ovale
Normal Coronary Angiogram
Marine Coronary Angiogram
International consensus standards for ECG interpretation in athletes.

**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 age <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

Lampert, Heart 2018;104:1037-1043
69 yo M

- CC: tachycardia and SOB with biking 20 miles
- Usually bikes 100 miles weekly. Had difficulty with biking his usual route due to SOB. Wife checked pulse and noted tachycardia
- No chest pain or palpitations
- No prior cardiac history
- Found to be Atrial flutter upon arrival, self converted to NSR

- PMHx: HLD
- PSHx: None
- Medications: None. Stopped ASA 1 year ago
- **Family Hx:** Father with MI at age 43, mother with MI at age 55
- Social: Never smoker, social EtOH, no other drug use, retired fire captain

Lipids
LDL 112, Tchol 195, Non-HDL 123, HDL 72

HgA1c 5.6%

Trop (over 24 hours)
71 -> 77 -> 82 -> 88 -> 74 -> 68
CKMG: 6 -> 5 -> 4
EKG
1. Severe three-vessel obstructive coronary artery disease involving the right coronary artery, left circumflex coronary artery and D1.
2. Agatston calcium score = 1843 (94\textsuperscript{th} percentile)
3. Partial anomalous pulmonary venous return from the right upper lobe draining into the SVC.
Coronary Angiogram
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• Thank You