SPORTS CARDIOLOGY AND EXERCISE

Vivek N. Dhruva, DO, FACC
Medical Director, ECHO Labs – UM UCH
Upper Chesapeake Cardiology, LLC
Disclosures

- None
Objectives

1. To understand the evaluation of a patient prior to athletic activity
2. To understand the possible causes of morbidity and mortality associated with exercise in certain disease processes
3. To understand the health benefits of exercise
INTRODUCTION
Statistics – Why Do We Care?

- Marathon runners > 35 YOA -- 353k in 2000 to 500k in 2011
- Triathletes > 35 YOA -- 21k to 146k
- Exercise can \textit{acutely} raise risk of MI, dissection, arrhythmia, SCD
- SCD rate is .39 per 100k in marathon/half-marathon runners
- There is CV screening performed at NBA, NFL, MLS combines yearly
- 30-47% NCAA schools perform some sort of testing
- The number of finishers in U.S. running events in 2012 surpassed 15.5 million
Introduction – What You Do

- The vast majority of medical conditions that prompt athletes to seek medical care are *musculoskeletal* in origin.
- Most of these conditions are *symptomatic, self-limiting, and non-life threatening*.
- Treated by PCPs and sports medicine clinics (who have advanced training in sports medicine).

Introduction 2 – What Sports Cardiologists Do

- In contrast to sports medicine conditions, many of the cardiovascular diagnoses are *sporadic*.
- These conditions frequently are *chronic or permanent* and may be *potentially life-threatening* with major implications affecting athletic participation.
- Distinguishing a truly pathologic entity from the effects of athletic training (e.g., myocardial hypertrophy) can be challenging.

<table>
<thead>
<tr>
<th></th>
<th>Reasons CV Specialists See Athletic Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Help create and implement cardiac policy.</td>
</tr>
<tr>
<td>2.</td>
<td>Perform and interpret CV screening tests.</td>
</tr>
<tr>
<td>3.</td>
<td>Make immediate participation and return-to-play decisions.</td>
</tr>
<tr>
<td>4.</td>
<td>Determine whether there is a CV cause of symptoms.</td>
</tr>
<tr>
<td>5.</td>
<td>Evaluate finding(s) suggestive of underlying CV pathology during non-CV medical encounters or dedicated pre-participation CV screening.</td>
</tr>
<tr>
<td>6.</td>
<td>Provide work-up and treatment after nonfatal sudden cardiac arrest.</td>
</tr>
<tr>
<td>7.</td>
<td>Participation recommendation and exercise prescription with known or corrected CV disease.</td>
</tr>
<tr>
<td>8.</td>
<td>Assist in transition from cardiac rehabilitation to higher level of exercise.</td>
</tr>
</tbody>
</table>
Sports Cardiology - Purpose

• To serve a specific patient population that is often overlooked for cardiovascular (CV) morbidity and mortality and in whom we can make the most difference.
• Within this population (generally those aged 30-65) we hope to evaluate for CV risk and disease, advocate healthy lifestyles, and advocate exercise regimens.
• The goal is to prevent heart disease and if diagnosed, minimize its progression and/or prevent sudden cardiac death (SCD).
EVALUATIONS AND SCREENINGS
Sports Cardiology - Evaluations and Screenings

- Pre-participation athletic cardiovascular screening
- Evaluation of symptoms such as chest pain, palpitations, or dyspnea during training or competition
- Evaluation of an unexplained deterioration in performance
- Evaluation of impaired athletic performance, due to a previous medical treatment
- Clearance to continue sports participation after cardiac event or CV surgery
- Discussion of concerns about family history of cardiovascular disease
- Advice on controlling cardiovascular risk factors
- Desire for a comprehensive cardiovascular screening
- Lessen lifestyle factors that may affect the athletic heart
- Establish preventative treatment
- Receive expert advice on cardiovascular health
Table 1 - American Heart Association (AHA) 12 points

<table>
<thead>
<tr>
<th>Personal history</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exertional chest pain/discomfort</td>
</tr>
<tr>
<td>Unexplained syncope/near-syncope</td>
</tr>
<tr>
<td>Excessive exertional dyspnea/fatigue or unexplained dyspnea</td>
</tr>
<tr>
<td>Prior recognition of a heart murmur</td>
</tr>
<tr>
<td>Elevated systemic blood pressure</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Family history</th>
</tr>
</thead>
<tbody>
<tr>
<td>Premature cardiovascular death before age 50 years in at least 1 relative</td>
</tr>
<tr>
<td>Disability due to heart disease in at least 1 relative younger than 50 years</td>
</tr>
<tr>
<td>Family history of hypertrophic cardiomyopathy, long-QT syndrome, or significant arrhythmia</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart murmur</td>
</tr>
<tr>
<td>Diminished femoral pulses</td>
</tr>
<tr>
<td>Signs of Marfan syndrome</td>
</tr>
<tr>
<td>Elevated brachial blood pressure</td>
</tr>
</tbody>
</table>

Any positive response or finding of the following 12 elements should prompt further cardiovascular testing.
SERVICES AND TESTING
Sports Cardiology - Services and Testing

- Consultation with CV physician
- Electrocardiogram (ECG)
- Echocardiogram (ECHO)
- Stress Testing
  - Exercise Treadmill Testing (ETT)
  - Nuclear Testing
- Calcium Score
- Coronary CTA
- Cardiac Catheterization (Cath)
- Event Recording/Holter
- Cardiac Rehabilitation
- CPEX (via Pulmonary)
- PFTs (via Pulmonary)
Value of ECG for Screening

- Considerable debate in US
  - Lack of specialized practitioners
  - Cost of conducting
  - Low mortality rates in the US (HS 1:100-300K)
  - No randomized trials in support
  - Lack of standardization for ECG interpretation in athletes

- Not required by governing bodies of state, local, or collegiate groups (including the NCAA)
- Has been adopted by NFL, NBA, and MLS
- NFL Combine screening
<table>
<thead>
<tr>
<th>Normal ECG findings in athletes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sinus bradycardia (≥30 bpm)</td>
</tr>
<tr>
<td>2. Sinus arrhythmia</td>
</tr>
<tr>
<td>3. Ectopic atrial rhythm</td>
</tr>
<tr>
<td>4. Junctional escape rhythm</td>
</tr>
<tr>
<td>5. 1° AV block (PR interval &gt; 200 ms)</td>
</tr>
<tr>
<td>6. Mobitz Type I (Wenckebach) 2° AV block</td>
</tr>
<tr>
<td>7. Incomplete RBBB</td>
</tr>
<tr>
<td>8. Isolated QRS voltage criteria for LVH</td>
</tr>
<tr>
<td>• <strong>Except</strong>: QRS voltage criteria for LVH occurring with any non-voltage criteria for LVH such as left atrial enlargement, left axis deviation, ST segment depression, T-wave inversion or pathological Q waves</td>
</tr>
<tr>
<td>9. Early repolarization (ST elevation, J-point elevation, J-waves or terminal QRS slurring)</td>
</tr>
<tr>
<td>10. Convex (&quot;domed&quot;) ST segment elevation combined with T-wave inversion in leads V1-V4 in black/African athletes</td>
</tr>
</tbody>
</table>

These common training-related ECG alterations are physiological adaptations to regular exercise, considered normal variants in athletes and do not require further evaluation in asymptomatic athletes.

AV, atrioventricular; bpm, beats per minute; LVH, left ventricular hypertrophy; ms, milliseconds; RBBB, right bundle branch block.
## Abnormal ECG findings in athletes

<table>
<thead>
<tr>
<th>Abnormal ECG finding</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-wave inversion</td>
<td>&gt;1 mm in depth in two or more leads V2-V6, II and aVF, or I and aVL (excludes III, aVR and V1)</td>
</tr>
<tr>
<td>ST segment depression</td>
<td>≥0.5 mm in depth in two or more leads</td>
</tr>
<tr>
<td>Pathologic Q waves</td>
<td>&gt;3 mm in depth or &gt;40 ms in duration in two or more leads (except for III and aVF)</td>
</tr>
<tr>
<td>Complete left bundle branch block</td>
<td>QRS ≥120 ms, predominantly negative QRS complex in lead V1 (QS or rS), and upright monophasic R wave in leads I and V5</td>
</tr>
<tr>
<td>Intraventricular conduction delay</td>
<td>Any QRS duration ≥140 ms</td>
</tr>
<tr>
<td>Left axis deviation</td>
<td>−30° to −90°</td>
</tr>
<tr>
<td>Left atrial enlargement</td>
<td>Prolonged P wave duration of &gt;120 ms in leads I or II with negative portion of the P wave ≥1 mm in depth and ≥40 ms in duration in lead V1</td>
</tr>
<tr>
<td>Right ventricular hypertrophy pattern</td>
<td>R−V1+S−V5 &gt;10.5 mm AND right axis deviation &gt;120°</td>
</tr>
<tr>
<td>Ventricular pre-excitation</td>
<td>PR interval &lt;120 ms with a delta wave (slurred upstroke in the QRS complex) and wide QRS (&gt;120 ms)</td>
</tr>
<tr>
<td>Long QT interval*</td>
<td>QTc ≥470 ms (male)</td>
</tr>
<tr>
<td></td>
<td>QTc ≥480 ms (female)</td>
</tr>
<tr>
<td></td>
<td>QTc ≥500 ms (marked QT prolongation)</td>
</tr>
<tr>
<td>Short QT interval*</td>
<td>QTc ≤320 ms</td>
</tr>
<tr>
<td>Brugada-like ECG pattern</td>
<td>High take-off and downsloping ST segment elevation followed by a negative T wave in ≥2 leads in V1–V3</td>
</tr>
<tr>
<td>Profound sinus bradycardia</td>
<td>&lt;30 bpm or sinus pauses ≥3 s</td>
</tr>
<tr>
<td>Atrial tachyanrhythmias</td>
<td>Supraventricular tachycardia, atrial fibrillation, atrial flutter</td>
</tr>
<tr>
<td>Premature ventricular contractions</td>
<td>≥2 PVCs per 10 s tracing</td>
</tr>
<tr>
<td>Ventricular arrhythmias</td>
<td>Couples, triplets and non-sustained ventricular tachycardia</td>
</tr>
</tbody>
</table>

*Seen in 14% of screening ECGS in a study of 1005 patients (Pellica, et al 2000)*
### Group 1: Common and training-related ECG changes

- Sinus bradycardia
- First-degree AV block
- Incomplete RBBB
- Early repolarization
- Isolated QRS voltage criteria for left ventricular hypertrophy

### Group 2: Uncommon and training-unrelated ECG changes

- T-wave inversion
- ST-segment depression
- Pathological Q-waves
- Left atrial enlargement
- Left-axis deviation/left anterior hemiblock
- Right-axis deviation/left posterior hemiblock
- Right ventricular hypertrophy
- Ventricular pre-excitation
- Complete LBBB or RBBB
- Long- or short-QT interval
- Brugada-like early repolarization
SYMPTOMS AND DIAGNOSES
Sports Cardiology Symptoms

- Chest pain
- Dyspnea
- Palpitations
- Syncope/Presyncope
- Murmurs
Sports Cardiology Diagnoses

- HTN
- CAD
- CHF/Cardiomyopathy
- HCM
- Anomalous coronaries
- Congenital Heart Disease
- Arrhythmia
- Commotio Cordis
- Marfan’s
Sudden Cardiac Death
Sudden Cardiac Death - Definitions

- **Incidence**: 1:50,000 per year
- **Young < 35 YOA** → due to congenital heart disease
- **Older/Masters > 35 YOA** → due to CAD
- **Competitive athlete** → organized team or in which there is regular competition, high levels of exertion (placing a premium on achievement). This most frequently applies to high school, college, or professional sports.
- **Recreational athlete** → do not generally require systematic training and do not involve the same pressures to excel. Activity levels may still be vigorous, and the distinction from competitive athletics is not always clear.
Sudden Cardiac Death - Causes

Study of 1435 young competitive athletes – post mortem:

- Hypertrophic cardiomyopathy (HCM) – 36 percent
- Anomalous origin of a coronary artery – 17 percent
- Myocarditis – 6 percent
- ARVC – 4 percent
- Mitral valve prolapse – 4 percent
- Aortic stenosis – 3 percent
- Coronary atherosclerosis – 3 percent
- Ion channelopathies – 3 percent
- Idiopathic dilated cardiomyopathy – 2 percent
- Ruptured aortic aneurysm – 2 percent
Hypertrophic Cardiomyopathy (HCM)

- Incidence: 0.16-0.29% in general population (1 per 350-625)
- More in African Americans in the US
- Diagnosis:
  - ECG: “pseudo-infarct pattern” in inferior/lateral leads, LAA/RAA, LVH, “giant” inverted T waves in anterior leads
  - ECHO: LVH (various forms), SAM, LVOT obstruction
  - MRI: better characterization of LVH and MV, ID of myocardial fibrosis
  - Genetic testing: over 1400 mutations identified, not generally recommended
Sudden Cardiac Death

- Strong family history of sudden cardiac death
- Non-sustained ventricular tachycardia
- Unexplained syncope or prior episode of sudden cardiac death
- Severe hypertrophy (>3cm)
- Abnormal blood pressure response to exercise
- Severe LVOT obstruction
Pathologic LVH vs Physiologic LVH

"Gray zone" of LV wall thickness

HCM

Athlete’s heart

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Pathologic LVH</th>
<th>Physiologic LVH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focal LVH pattern</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>LV cavity &lt;45 mm</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>LV cavity &gt;55 mm</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>LA enlargement</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Bizarre ECG patterns</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Abnormal LV filling</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Female gender</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Family history of HCM</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Thickness with deconditioning</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>VO₂ ↑ &gt;110 percent</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Late gadolinium enhancement</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Pathogenic sarcomere mutation</td>
<td>+</td>
<td>0</td>
</tr>
</tbody>
</table>
Anomalous Coronary Artery

- Most significant is LM from RCC with course “behind” the PA
- Presumed mechanism of SCD involves ischemia secondary to a sharp takeoff angle with a “slit orifice” that worsens with exercise
Sudden Cardiac Death – Recreational Athletes

- In general, patients with known genetic disorders that predispose to SCD (e.g., HCM, ARVC, Marfan syndrome, long QT syndrome) should avoid recreational activities with the following characteristics:
  - "Burst" exertion, involving rapid acceleration and deceleration, as is common in sprints, basketball, tennis, and soccer. Activities with stable energy expenditure, such as jogging, biking on level terrain, and lap swimming are preferred.
  - Extreme environmental conditions (temperature, humidity, and altitude) that impact blood volume and electrolytes.
  - Systematic and progressive training focused on achieving higher levels of conditioning and excellence.
Sudden Cardiac Death – Recreational Athletes (2)

• Patients with unusual or high-risk clinical features may require greater restriction → history of syncope/presyncope, prior cardiac surgery, prior arrhythmic episodes, or an implantable cardioverter-defibrillator (ICD)

• ICD/PPM patients should not engage in sports with a danger of bodily collisions that may damage the device.

• Patients with an ICD were advised to be limited to low intensity activities.
EXERCISE
“What fits your busy schedule better, exercising one hour a day or being dead 24 hours a day?”
### Biological mechanisms for benefit of exercise

<table>
<thead>
<tr>
<th>Antiatherogenic effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduction of adiposity, particularly in those with excess upper body and abdominal fat</td>
</tr>
<tr>
<td>Reduction of elevated blood pressure</td>
</tr>
<tr>
<td>Reduction of elevated plasma triglycerides (and associated small dense LDL particles)</td>
</tr>
<tr>
<td>Increase in HDL cholesterol levels</td>
</tr>
<tr>
<td>Improvement in insulin sensitivity and glucose use and reduction in risk of type 2 diabetes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Antithrombotic effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endothelial function alteration</td>
</tr>
<tr>
<td>Autonomic functional changes</td>
</tr>
<tr>
<td>Anti-ischemic effects</td>
</tr>
<tr>
<td>Antiarrhythmic effects</td>
</tr>
</tbody>
</table>

# Possible biologic mechanisms for exercise-induced reductions in all-cause and cardiac mortality

## Cardiovascular influences
- Reduction of resting and exercise heart rate
- Reduction of resting and exercise blood pressure
- Reduction of myocardial oxygen demand at submaximal levels of physical activity
- Expansion of plasma volume
- Increase in myocardial contractility
- Increase in peripheral venous tone
- Favorable changes in fibrinolytic system
- Increased endothelium-dependent vasodilation
- Increased gene expression for nitric oxide synthase
- Enhanced parasympathetic tone
- Possible increases in coronary blood flow, coronary collateral vessels, and myocardial capillary density

## Metabolic influences
- Reduction of obesity
- Enhanced glucose tolerance
- Improved lipid profile

## Lifestyle influences
- Decreased likelihood of smoking
- Possible reduction of stress
- Short-term reduction of appetite

*Data from: Shepard RJ, Balady GJ. Circulation 1999; 99:963.*
Migraines 57% resolved
Pseudotumor Cerebri 96% resolved
Dyslipidemia Hypercholesterolemia 63% resolved
Non-Alcoholic Fatty Liver Disease 90% improved steatosis
37% resolution of inflammation
20% resolution of fibrosis
Metabolic Syndrome 80% resolved
Type II Diabetes Mellitus 83% resolved
Polycystic Ovarian Syndrome 79% resolution of hirsutism
100% resolution of menstrual dysfunction
Venous Stasis Disease 95% resolved
Depression 55% resolved
Obstructive Sleep Apnea 74-98%
Asthma 82% improved or resolved
Cardiovascular Disease 82% risk reduction
Hypertension 52-92% resolved
GERD 72-98% resolved
Stress Urinary Incontinence 44-88% resolved
Degenerative Joint Disease 41-76% resolved
Gout 77% resolved
Quality of Life improved in 95% of patients
Mortality 89% reduction in 5-year mortality

http://saradunphy.wordpress.com
The Exercise Prescription – “Think FITT”

F = Frequency
   Most days of the week; 5 or more.

I = Intensity
   Moderate; 50-70% of max HR or use “sing-talk” test.

T = Type
   Use large muscle groups; something enjoyable.

T = Time
   30 minutes.
In a cohort of 44,452 men (age 40-75) enrolled in the Health Professionals' Follow-up Study (475,755 patient-years of follow-up), several types of physical activity were associated with a significant reduction in CHD risk:

- Running for one hour or more per week – RR 0.58; 95% CI 0.44-0.77
- Rowing for one hour or more per week – RR 0.82; 95% CI 0.68-0.99
- Brisk walking for 30 minutes or more per day – RR 0.82; 95% CI 0.67-1.00
- Lifting weights for 30 minutes or more per week – RR 0.77; 95% CI 0.61-0.98
<table>
<thead>
<tr>
<th>Level of Intensity</th>
<th>Type of Aerobic Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate-Intensity</td>
<td>- Brisk walking (3 miles-per-hour or faster, but not race walking)</td>
</tr>
<tr>
<td></td>
<td>- Water aerobics</td>
</tr>
<tr>
<td></td>
<td>- Bicycle riding slower than 10 miles per hour</td>
</tr>
<tr>
<td></td>
<td>- Tennis (doubles)</td>
</tr>
<tr>
<td></td>
<td>- Ballroom dancing</td>
</tr>
<tr>
<td></td>
<td>- General gardening</td>
</tr>
<tr>
<td>Vigorous-Intensity</td>
<td>- Race walking, jogging, or running</td>
</tr>
<tr>
<td></td>
<td>- Swimming laps</td>
</tr>
<tr>
<td></td>
<td>- Tennis (singles)</td>
</tr>
<tr>
<td></td>
<td>- Aerobic dancing</td>
</tr>
<tr>
<td></td>
<td>- Bicycling 10 miles per hour or faster</td>
</tr>
<tr>
<td></td>
<td>- Jumping rope</td>
</tr>
<tr>
<td></td>
<td>- Heavy gardening (continuous digging or hoeing with heart rate increases)</td>
</tr>
<tr>
<td></td>
<td>- Hiking uphill or with a heavy backpack</td>
</tr>
</tbody>
</table>
What about Older Adults >65, or those with chronic diseases?

- **Aerobic exercise**: same
- **Strength exercise**: same, except 10-15 reps
  - Slightly lighter weights
- **Flexibility activity**: 2 days/wk, 10 min
- **Balance exercise**: if at risk for falls, 3x/wk

RECENT STUDIES

- Prospective and randomized
- Aged 45-74 from 2006-2009
- ~ 200K participants followed for 6.52 years
- MVPA: moderate to vigorous physical activity
- End-point was all-cause mortality

**FINDINGS:**
- 93.9% were undertaking MVPA (52% moderate only)
- 7,435 deaths (8.34%)
- Highest mortality was in those not performing MVPA
- Lowest risk was in those performing >30% MVPA

**CONCLUSION:** some exercise within the vigorous range is protective against all-cause mortality

http://www.acc.org/latest-in-cardiology/articles/2015/09/30/07/52
The Relationship Between Exercise Volume and Intensity {Arem, et al. JAMA Intern Med, 2015}

- 661,137 patients
- Six population cohorts in US and Europe
- “Low levels of leisure time physical activity were associated with lower mortality”
- “…higher levels of moderate-to-vigorous intensity were associated with even lower risk, with the lowest risk (HR 0.61) seen in those undertaking three to five times the recommended minimum level of physical activity”
Thank You!