Should You be Doing ECGs with Your Sports Physicals?
The Debate Over Cardiac Screening

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Learning Objectives
• Review standard of care for pre-participation physical evaluation specific to cardiac screening
• Review the etiology and prevalence of sudden cardiac death in young athletes
• Analyze the pros and cons of including ECGs as a routine part of pre-participation physical evaluations

Disclosures
I have no disclosures

Test Your Knowledge
What is the overall incidence of non-traumatic out-of-hospital cardiac arrest in CHILDREN?

a. 8 per 100,000 person years
b. 30 per 100,000 person years
c. 50 per 100,000 person years
d. 90 per 100,000 person years

The number of events divided by the amount of person-time observed

Incidence of Cardiac Arrest
The overall incidence of non-traumatic out-of-hospital cardiac arrest in

Children is 8 per 100,000 person years
Adults is 127 per 100,000 person years

(Dandeles & Ohler, 2012)
Incidence by Age Group

Within the pediatric population, the incidence varies by age group:

- **Infants**: 73 per 100,000 person-years
- **Adolescents**: 6 per 100,000 person-years

(Dandeles & Ohler, 2012)

Test Your Knowledge

Which age group has the highest survival to hospital discharge?

- a. Infant
- b. Adolescent
- c. Adult

Survival to Hospital Discharge

- **Infants**: 3.4%
- **Adolescents**: 8.9%
- **Adults**: 4.5%

(Atkins et al., 2009)

Since the introduction of PALS over 25 years ago, outcomes for in-hospital cardiac arrest have improved... but overall survival is still poor.

Survival to Hospital Discharge

After in-hospital arrest:

- Pre PALS 9% (1987)
- Post PALS 27% (2005)
- Post PALS 27.9 – 34.8% (2013)

19% favorable neuro outcomes (2013)

(Circulation, 2013; Girotra, 2013)

Survival to Hospital Discharge

After out-of-hospital arrest

<table>
<thead>
<tr>
<th></th>
<th>2009</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overall Survival</strong></td>
<td>6.4%</td>
<td>8.3%</td>
</tr>
<tr>
<td>Infants</td>
<td>3.3%</td>
<td></td>
</tr>
<tr>
<td>Children</td>
<td>9.1%</td>
<td>10.5%</td>
</tr>
<tr>
<td>Adolescents</td>
<td>8.9%</td>
<td>15.8%</td>
</tr>
</tbody>
</table>

(Atkins, 2009; AHA, 2015)
Etiology of Cardiac Arrest

Majority of arrests are non-cardiac with preceding respiratory insufficiency.

Cardiac related arrests are preceded by:
- Arrhythmias
- Hypotension

(Dandeks & Other, 2012)

Presenting Rhythm and Outcome

<table>
<thead>
<tr>
<th>Initial Rhythm</th>
<th>Infant</th>
<th>Child</th>
<th>Adolescent</th>
</tr>
</thead>
<tbody>
<tr>
<td>V-fib / V-tach</td>
<td>275</td>
<td>154</td>
<td>192</td>
</tr>
<tr>
<td>Asystole / PEA</td>
<td>172</td>
<td>108</td>
<td>102</td>
</tr>
</tbody>
</table>

Out-of-hospital Cardiac Arrests (Atkins, 2009)

Pediatric patients with V-fib or V-tach as initial rhythm were more likely to survive than children presenting with asystole / PEA (30% vs 5% p = 0.004)

Test Your Knowledge

What is the incidence of sudden cardiac death in athletes in the United States?

a. 1: 50,000 athletes
b. 1: 75,000 athletes
c. 1: 100,000 athletes
d. 1: 150,000 athletes

Exact Incidence of SCD Unknown

1: 75,000 athletes

- The US Sudden Death in Young Athletes Registry has identified more than 100 cases of SCD per year in young competitive athletes participating in organized sports at the middle school, high school, college and professional level
- ~80% of these occur in a HS or college athlete

(as reported in PPE 4th edition, 2010)

Test Your Knowledge

What is the leading cause of Sudden Cardiac Deaths in US athletes younger than 30 years?

a. Coronary artery anomalies
b. Myocarditis
c. Arrhythmogenic RV cardiomyopathy
d. Hypertrophic cardiomyopathy

1/3 of Sudden Cardiac Deaths

- Coronary artery anomalies = 17%
b. Myocarditis = 6%
c. Arrhythmogenic RV cardiomyopathy = 4%
d. Hypertrophic cardiomyopathy = 33%

(Maron et al., 2007)
Opinion Survey
If screening tests / procedures are valuable for those who participate in organized sports, should those same tests / procedures be offered to all children (if we promote exercise for all children with a goal of long-term health)?

A. Yes
B. No

Did You Know?
• 75% of all fatalities that occur during sports in the US are cardiovascular related
• Occur more commonly in:
  – Males: 5:1
  – Sports: Basketball and Football
  – African American Athletes

Did You Know?
• The risk of SCD ↑ with increasing peak intensity of exercise and increasing level of competition

(Thompson et al., 2007; Van Camp, et al., 2000)

• The underlying autopsy-proven cardiac abnormality has been appropriately diagnosed during life in only a small minority of young athletes who have SCD

(Tanaka et al., 2006; Maron et al., 1996)

Sudden Cardiac Arrest

Causes of SCD in Young Athletes
• Structural / Functional
• Electrical
• Other

ELIMINATE PREVENTABLE DEATHS
From Sudden Cardiac Arrest in Youth by 2030

https://www.youtube.com/watch?v=FXYlaaKBjW8

https://parentheartwatch.org/the-solution/
**Structural / Functional**

- Hypertrophic cardiomyopathy*
- Idiopathic LV hypertrophy
- Coronary artery anomalies
- Myocarditis
- Arrhythmogenic RV cardiomyopathy*
- Dilated cardiomyopathy*
- Aortic rupture / Marfan syndrome*
- Aortic stenosis
- Coronary artery atherosclerotic disease*
- Postoperative congenital heart disease

* familial / genetic

**Hypertrophic Cardiomyopathy**

- Accounts for 1/3 of all SCD in US athletes younger than 30 years
- Morphologic features:
  - Asymmetric LV hypertrophy
  - LV wall thickness
  - Non-dilated LV
  - Impaired diastolic function

**Hypertrophic Cardiomyopathy**

**Prevalence:**
- 1:500 in the general population
- 1:1,000 to 1:500 in competitive athletes

Inherited autosomal dominant disorder

http://www.genedx.com/test-catalog/cardiology/hypertrophic-cardiomyopathy/

Morphologic expression may appear in childhood, typically develops in early adolescence to young adulthood – present by the end of physical maturity

Rationale for every other year CV screening in HS

**So What Causes SCA in HCM?**

- Lethal heart rhythm disturbances that originate from the disorganized heart muscle structure:
  - Ventricular tachycardia
  - Ventricular fibrillation

This is why fluttering, pounding, or skipping beats, palpitations, dizziness, and fainting should always be reported and evaluated
Hypertrophic Cardiomyopathy

Physical exam:
- Most athletes will have a normal cardiac exam
- 25% will have a murmur
- Characteristic murmur → harsh systolic ejection murmur heard best at the RUSB; increases with maneuvers that ↓ venous return (Valsalva, moving from squat to stand) and diminishes with maneuvers that ↑ venous return (lying supine) Usually grade 3/6

http://www.cardiologysite.com/auscultation.html#ejection_murmurs.html
http://www.easyauscultation.com/cases/viewcaseorder?courseid=26

Heart Sounds

Hypertrophic Cardiomyopathy

What about an ECG?
- ECG will be abnormal in up to 95% of patients with HCM (Melacini, et al, 2007)
- Prominent Q waves, deep negative T waves or dramatic increases in QRS voltage associated with ST depression or T-wave inversion

What about an Echo?
Remains the standard to confirm the diagnosis

Electrical Causes of SCD
- Long QT syndrome*
- Catecholaminergic polymorphic ventricular tachycardia*
- Wolff-Parkinson-White syndrome
- Brugada syndrome*
- Short QT syndrome*

* familial / genetic

Other Causes of SCD
- Drugs and stimulants
- Primary pulmonary hypertension*
- Commotio cordis (blunt trauma to the heart)
  *familial / genetic

Now What...PREVENTION !
- Who’s the Expert?
- What’s the Standard of Care?
- Where’s the Evidence?
The Pre-participation Physical Evaluation

Pre-participation Physical Evaluation
- The American Academy of Family Physicians
- American Academy of Pediatrics
- American College of Sports Medicine
- American Medical Society for Sports Medicine
- American Orthopaedic Society for Sports Medicine
- American Osteopathic Academy of Sports

The Standard
- Pre-participation Physical Evaluation
  - 1st edition → 1992
  - 4th edition → 2010
  - 6 authoring societies (previous slide)
- Endorsed by:
  - American Heart Association
  - National Athletic Trainers’ Association

PPE Goals
- “…promote the health and safety of the athlete in training and competition.”
  - Standardized approach
  - Uncover conditions that might require further investigation or treatment
  - Identify conditions that would interfere with safe or optimal athletic performance
  (AAP, 2010)

To be Effective, PPE
- Identify diseases or processes that will affect the athlete
- Be sensitive and accurate
- Be practical and affordable

Research demonstrates that the PPE has little effect on the overall morbidity or mortality of athletes

PPE
- Every state requires some level of PPE for scholastic athletes
- Adopting a standard format across all 50 states would improve the ability to determine efficacy and develop an evidence base to improve the exam
**Who’s Following the Standard?**
- 23 states (45%) used the PPE 4th edition form
- 27 states (53%) used outdated forms
- 10 states (20%) not revised forms in > 5 years
- 22 states (43%) addressed all 12 of the personal and family history CV screening items

**Current Results of PPE**
- Most studies report that 0.3% to 1.3% of athletes are denied clearance to participate during a PPE
- 3.2% to 13.9% require further evaluation prior to participation

**Routine Screening Tests**
- Routine lab, cardiac, and pulmonary screening tests remain controversial
- Supportive evidence is lacking
- PPE working group concurs that no routine screening tests are required during the PPE for clearance of asymptomatic athletes (AAP, 2010)

**Cardiac Screening?**
- Decision to ↑ the level of screening for sudden cardiac death prevention is controversial and difficult
- Currently, ECG screening is not recommended by the AHA
- Studies are looking at the sensitivity and specificity of ECG screening

**Current Guideline**
- In 2007, AHA updated its consensus statement on pre-participation cardiovascular screening in athletes with specific recommendations for a detailed personal and family history and physical exam

**AHA and American College of Cardiology**

“...the ultimate objective of pre-participation screening of athletes is the detection of silent cardiovascular abnormalities that can lead to sudden death.”
Current Standard – Cardiac

12 point history and physical exam
– Personal history questions
– Family history questions
– Physical exam points

http://learn.pediatrics.ubc.ca/videos/cardiology-exam/
NAPNAP website – Cardiology Exam

Ohio High School Athletic Association

Heart Health Questions About You

Heart Health Questions About You

Ominous Sign

Unexplained syncope in a young athlete during exercise should be considered an aborted sudden death until proven otherwise

(Firoooi et al., 2002)

Warning Symptoms

Require cardiac workup before returning to exercise:
• Exertional chest pain
• Exertional syncope or near syncope during or after exercise; prodomes?
• Unexplained seizures
• Excessive dyspnea or fatigue disproportionate to level of exertion
• Palpitations or irregular heart beats

Near Syncope AFTER exercise

• Much more common
• Unlikely to represent underlying CV disease
• Syncope preceded by lightheadedness, diaphoresis, nausea, tunnel vision suggests a neurally mediated event (vasovagal, neurocardiogenic)
• Many triggers → orthostatic stress, emotional stress, exercise
• Most common mechanism of syncope in young adults
Excessive...

- Excessive unexplained dyspnea or fatigue associated with exercise may indicate:
  - Myocarditis
  - Hypertrophic or dilated cardiomyopathy

Palpitations

- Clear history of abrupt increase in heart rate disproportional to activity
- Palpitations associated with syncope or near syncope
- May signify arrhythmias or conduction abnormalities:
  - Supraventricular Tachycardia
  - Ion channel disorders
  - Wolff-Parkinson-White syndrome

Further Testing Prior to Clearance

- ECG
- Echocardiogram
- Cardiac Event Monitoring
- Stress ECG
- Consultation with:
  - Cardiologist or
  - Electrophysiologist

Heart Health Questions About Your Family

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Has any family member or relative died of heart problems or had an unexpected or unexplained sudden death before the age of 50 (including drowning, unexplained car accident, or sudden infant death syndrome)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does anyone in your family have hypertrophic cardiomyopathy, Marfan syndrome, arrhythmogenic right ventricular cardiomyopathy, long QT syndrome, short QT syndrome, Brugada syndrome, or catecholaminergic polymorphic ventricular tachycardia?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does anyone in your family have a heart problem, pacemaker, or implanted defibrillator?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has anyone in your family had an unexplained fainting, unexplained syncope, or near drowning?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Family History

- May help identify asymptomatic athletes with underlying cardiac disease
- Family history of sudden death before the age of 50 (not trauma related) most likely cardiac related and may be familial concern for genetic cardiovascular disorder

Katie

Swimmer

Yaroslavl, Russia
mCORE was created in response to the rising number of SCA deaths on the field of play at high schools across the country.

mCORE aims to increase awareness of Sudden Cardiac Death and provide dependable, low-cost screenings to every student athlete in the hopes of saving lives.

**Physical Exam**

- **Heart murmur** – auscultation should be performed in both supine and standing positions (or with Valsalva maneuver) specifically to identify murmurs of dynamic LVOT obstruction
- **Femoral pulses** to exclude aortic coarctation
- **Physical stigmata of Marfan syndrome**
- **Brachial artery BP** (sitting) taken in both arms

**Resources for Physical Exam**

- **Physical Exam**
- **Normal Heart Sounds**
  [https://www.youtube.com/watch?v=v0jQJ448YxA](https://www.youtube.com/watch?v=v0jQJ448YxA)
- **Heart Sounds (Comprehensive with quizzes!**)

**Significance of Murmurs**

<table>
<thead>
<tr>
<th>TABLE</th>
<th>SIGNIFICANCE OF ABNORMAL HEART MURMURS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart乡土</td>
<td>Abnormal heart sounds are associated with ventricular abnormalities or disease.</td>
</tr>
<tr>
<td>Valsalva</td>
<td>Murmurs heard with Valsalva maneuver are dynamic LVOT obstruction.</td>
</tr>
<tr>
<td>Marfan syndrome</td>
<td>Marfan syndrome: partial or complete dissection of the aorta, mitral valve prolapse, bicuspid aortic valve.</td>
</tr>
</tbody>
</table>

**Skeletal Characteristics of Marfan Syndrome**

- Tall, thin build
- Long arms, legs, fingers, toes
- Flexible joints
- Arm span greater than height
- Scoliosis
- Pectus excavatum
- Pectus carinatum (pigeon chest)
- Teeth that are too crowded
- Flat feet

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**Report**

Dear Mary Jean,

Thank you for participating in mCORE’s recent cardiac risk screening.

Katie’s screening results indicate no abnormalities. ECG and Echocardiogram are NORMAL.

Please note that the results of this screening test do not exclude all potentially serious heart conditions. It is designed to detect many of the common underlying causes of sudden cardiac death in young athletes. It is not designed to detect all conditions or all abnormalities that may cause sudden cardiac death.

The ECG and Echocardiogram can be inaccurate depending on many factors in image acquisition and test interpretation. Not all abnormalities found on a screening test will be confirmed with more detailed testing and evaluation. Regardless of the results of this screen, immediate medical attention should be sought if concerning symptoms develop.

We at mCORE thank you for participating in this risk reduction program.

Sincerely,

Dr. Kenneth Berkovitz, M.D.
Medical Director
mCORE, LLC
Marfan Syndrome Cardiovascular

Major
• Dilation of the ascending aorta
• Dissection of the ascending aorta

Minor
• Mitral valve prolapse
• Dilatation of the PA
• Calcification of the mitral annulus
• Dilatation or dissection of the descending thoracic or abdominal aorta

Famous People with Marfan Syndrome

Michael Phelps
Abraham Lincoln (1809-1865)
Osama Bin Laden (1957-2011)
Julius Caesar (100 BC – 44 BC)

You Decide...
Should ECG be added to routine pre-participation cardiac screening?
Here’s the evidence...

What’s the Debate?
• Research, Evidence, Expert Opinion
• Cost
• False Positives / Athletic Heart Syndrome
• Resources

Should Screening Include ECG?
• There is overwhelming evidence that exercise can trigger ventricular arrhythmias and cardiac arrest in individuals with preexisting heart conditions, even in well conditioned athletes
• The majority of these sudden deaths are caused by previously unidentified and asymptomatic underlying cardiovascular conditions
**Argument Against ECG – Evidence**

- Existing scientific evidence is insufficient to prove that adding an ECG to the screening process will adequately identify athletes at risk
- Randomized trial of pre-participation screening of high risk (males in high-intensity contact sports) athletes is needed before supporting this recommendation (Chaitman, 2007)

**Argument For ECG – Evidence**

- A high percentage of athletes at risk for SCA can be identified or suspected from a screening ECG (ECG abnormal in ~95% - HCM)
- Early recognition of risk is important: 30% of all SCD are “fateful first event”
- Identifying an athlete with a genetically based SCA condition may serve many others in the family

**Italian Law**

In 1982 Annual Pre-participation Screening:

- General physical exam
- 12-lead ECG
- Submaximal exercise test

**Etiology of SCD in Italy**

<table>
<thead>
<tr>
<th>Etiology</th>
<th>ITALY</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertrophic cardiomyopathy</td>
<td>2%</td>
<td>33%</td>
</tr>
<tr>
<td>Arrhythmogenic RV dysplasia</td>
<td>22%</td>
<td>4%</td>
</tr>
<tr>
<td>Coronary Atherosclerosis</td>
<td>18%</td>
<td>*</td>
</tr>
<tr>
<td>Coronary anomalies</td>
<td>12%</td>
<td>17%</td>
</tr>
</tbody>
</table>

0.4 deaths / 100,000 

(Corsado et al., 2006)

**ECG Required by Law in ITALY**

Sudden Cardiac Death in athletes prior to the implementation of the screening program

3.6 deaths / 100,000 person-years

by 2004, SCD decreased to

0.4 deaths / 100,000 person-years

(Corsado et al., 2006)

**ECG Recommendations**

- European Society of Cardiology
- International Olympic Committee
- US Olympic Committee – no ECG
Argument Against ECG – \( \uparrow \text{False +} \)

- ECG abnormalities are more common in athletes – cardiac remodeling from training = high false positives -16.9% - (Baggish, et al., 2010)

- ECG interpretation in athletes requires careful analysis to distinguish physiological changes related to athletic training from underlying pathology

- Potential anxiety created by false positive
  (Maron, 2007)

Argument For ECG – \( \uparrow \text{False +} \)

- ECG has 98.8% sensitivity (true +) for identifying abnormal CV findings – Italian Study (Pelliccia, 2006)

- ECG has 70% sensitivity compared to 3% for H&P alone in identifying CV abnormalities – US study (Glover & Maron, 1998)

Argument For ECG – \( \uparrow \text{False +} \)

- To reduce the number of false positives / false negatives in ECG interpretation, cardiologists with experience in sudden cardiac death and the “athlete’s heart” should review the ECG (Wilson, 2008)

- False positives (and additional testing) can be decreased with revised criteria:
  Seattle Criteria (Drezner, 2013)

  European Society of Cardiology (Corrado, 2010)

Abnormal ECG findings in athletes

Seattle Criteria (Drezner, 2013)

Common ECG changes due to cardiac adaptation to physical exertion

Seattle Criteria (Drezner, 2013)

European Society of Cardiology Section of Sports Cardiology, 2010

Uncommon and not sports-related require further diagnostic work-up
Online E-Learning ECG Training Module

- The Seattle Criteria will be used to develop a comprehensive online training module for physicians to acquire a common foundation in ECG interpretation in athletes (Drezner, 2013)

http://learning.bmj.com/ECGathlete

British Journal of Sports Medicine

Argument Against ECG – COST

- AHA estimated costs:
  - $330,000 for each athlete detected with cardiac disease
  - $3.4 million for each death prevented
  - $2 billion a year for a mass CV screening program for an estimated 10 million student athletes at a cost of $50 per ECG (AHA, 2007)

Argument For ECG – COST

- Negotiated cost of a screening ECG done on a large scale may be as low as $10
- New ECG criteria would result in a 5-10% referral rate for further testing
- ECG should be done every other year (Myerburg & Vetter, 2007)
- Cost estimate per year of life saved $42,000 which is below $50,000 the traditional threshold to consider an intervention cost effective (Wheeler, 2010)

ECG Screen for all Youth

- 26,900 subjects 14-35 years of age
- H&P by Cardiologist and 12-lead ECG (Cardiology News, 2017)

ECG Screen for all Youth

- 3.5% - abnormal H&P
- 8.1% - abnormal ECG
- 0.5% - abnormal H&P and ECG
- 87 individuals (0.3%) diagnosed with serious cardiac disease (Cardiology News, 2017)

COST per individual for H&P / ECG = $110

COST per serious cardiac condition identified = $33,927

40% ↓ in current process of screening ($56,597 / serious cardiac diagnosis) (Cardiology News, 2017)
**Argument Against ECG – Absolute Dx**

- ECGs may not detect all conditions associated with SCA (i.e. Marfan syndrome, coronary anomalies)

**Argument For ECG – Absolute Dx**

- ECG intended only as first line in screening process - no single strategy is effective in diagnosis / prevention
- Conditions that the ECG cannot identify are not always identified by currently recommended screening
- 12-lead ECG will diagnose Wolff-Parkinson-White syndrome, ion channelopathies which cannot be detected with imaging

**Argument Against ECG - Resources**

- Poor use of resources for a rare occurrence → focus on risk of obesity, DM, etc... (Chaitman, 2007)
- Not practical for universal screening due to the large number of athletes
- Limited resources
- Inadequate number of physicians to interpret ECGs

**Argument For ECG – Resources**

- Standardized education of ECG interpretation will increase the number of physicians qualified to interpret athletes’ ECGs
- Full implementation can occur over a period of 3-5 years (Myerburg & Vetter, 2007)

**Argument Against ECG – H&P**

- ~80% of non-traumatic sudden deaths in athletes are caused by inherited or congenital functional CV abnormalities
- False positive rate with H&P alone = 5.5%
- True positive (sensitivity) H&P alone = 45.5%
  
  (Baggish, 2010)

**Argument For ECG: H&P**

- Personal symptoms are poor predictors of CV abnormalities (false negative)
- Ominous symptoms (syncope during exercise) are not always predictive (Wilson, 2008)
- Addition of ECG to H&P increased the screening sensitivity from 45.5% to 90.9% (Baggish, 2010)
References


