ECG Screening
Should we screen?

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No Disclosures

ECG Screening in Athletes?

1. Explore the purpose of pre-participation screening
2. Review scientific evidence regarding CV screening protocols
3. Identify current challenges to ECG screening
Pre-Participation Screening

Is the athlete medically suitable to engage in a particular sport?

Periodic Health Evaluation
IOC Consensus Statement 2009

• Protect the health of the athlete
• Method to decrease injuries and diseases in elite athletes

Purpose of the PHE

• Assessment of current health status
• Management of current health problems
• Entry point for medical care of athletes
• Opportunity for education regarding other health risks and health-related behavior
• Assessment of risk of future injury

"...the main purpose of the PHE is to screen for injuries or medical conditions that may place an athlete at risk for safe participation."
Purpose of Screening

...recommend systematic pre-participation cardiovascular screening of young competitive athletes for the timely detection of cardiovascular abnormalities predisposing to sport-related cardiac death...”
Corrado; Euro Heart J 2005
ESC

“Preparticipation cardiovascular screening is the systematic practice of evaluating athletes before participation in sports... for the purpose of identifying or raising suspicion of abnormalities that could promote disease progression or sudden death.”
PPE 4th Edition Monograph 2010

abnormalities that can lead to SCD.”
ACC, 36th Bethesda Conference; 2005

...to detect potentially lethal cardiovascular disease in elite athletes and start appropriate management to reduce the risk of SCD and/or disease progression.”
Ljungqvist; BSM 2009
IOC

Epidemiology and Prevention

Incidence of Sudden Cardiac Death in National Collegiate Athletic Association Athletes
Kennedy G. Blume, MD; Hata M. Acl; MB; David Kline, MD; ESC, PhD; Inukhu, K. Davis, MD

SCD represented 75% of sudden death during exercise

Circulation 2011

What is screening?

• Definition: Screening is a strategy to detect disease in individuals without signs or symptoms of that disease

• The intention is to:
  – Identify pathologic conditions early
  – Early intervention and management
  – Reduce future morbidity and mortality
Prevalence of Cardiovascular Disorders Associated with SCD

<table>
<thead>
<tr>
<th>Study</th>
<th>Population</th>
<th>Prevalence</th>
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<tbody>
<tr>
<td>AHA (2007)</td>
<td>Competitive athletes age 12-35 (US)</td>
<td>0.3%</td>
</tr>
<tr>
<td>Fuller (1997)</td>
<td>5,617 high school athletes (US)</td>
<td>0.4%</td>
</tr>
<tr>
<td>Corrado (2006)</td>
<td>42,386 athletes age 12-35 (Italy)</td>
<td>0.2%</td>
</tr>
<tr>
<td>Wilson (2008)</td>
<td>2,720 athletes &amp; children age 10-17 (UK)</td>
<td>0.3%</td>
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<tr>
<td>Bessem (2009)</td>
<td>428 athletes age 12-35 (Netherlands)</td>
<td>0.7%</td>
</tr>
<tr>
<td>Hevia (2009)</td>
<td>1,220 amateur athletes (Spain)</td>
<td>0.16%</td>
</tr>
<tr>
<td>Baggish (2010)</td>
<td>510 college athletes (US)</td>
<td>0.6%</td>
</tr>
<tr>
<td>Price (2013)</td>
<td>2,017 high school athletes (US)</td>
<td>0.25%</td>
</tr>
<tr>
<td>Judge (2014)</td>
<td>1,339 high school athletes (US)</td>
<td>0.4%</td>
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Perhaps it is the prevalence of potentially lethal CV disease, rather than the incidence of SCD, that should guide the rigor of our screening strategies.

World Health Organization
Wilson-Jungner Criteria

- Condition screened for is an important health problem
- Disease detectable at an early stage
- Treatment at an early stage is of more benefit than at a later stage
- Suitable test is available to detect the disease at an early stage
  - Reliable, sensitive, specific, affordable, acceptable

Best Protocol for Pre-Participation Screening?

- History questionnaire
- Physical exam
- Non-invasive testing
  - ECG
  - Echo
  - Exercise ECG
  - Concussion baseline testing
- Laboratory tests
  - Hgb/Hct
  - Ferritin
  - Electrolytes/creatinine
  - Lipid profile
  - Vitamin D
  - Sickle cell trait
- Performance testing
  - Functional movement screen
  - Injury prevention
History & Physical Exam

Challenges and Limitations

- Poor sensitivity and specificity
- Will miss the majority of athletes at risk
- Has no future predictive value
- No study exists that demonstrates a PPE based on history and physical exam alone is effective in detecting or preventing athletes at risk for sudden death

Limitations of the Pre-participation Evaluation

- Maron; JAMA 1996
  - 134 athletes with SCD
  - 115 had PPE
  - Only 18% had CV symptoms in 36 months preceding death
  - Only 3% suspected of CV disease and 1% diagnosed correctly by PPE

Athletes are affected by conditions that do not have overt signs or symptoms
Can we do better?

Are Athletes at Greater Risk to Justify More Intensive Screening?

Incidence of sudden cardiac arrest in high school student athletes on school campus

- 2,149 high schools followed for 2 years
- > 1.5 million athlete years
- > 2.5 million non-athlete years
The Role of ECG in the Cardiovascular Evaluation of Athletes

• ECG used for both screening and diagnosis
• Most athletes with conditions associated with SCD are asymptomatic
• ECG increases the detection of athletes at risk
• Concerns for false-positive results, unnecessary secondary investigations or disqualification, and cost

Cardiovascular Screening in College Athletes: the University of Washington Experience

Timeline

• 2008-2009:
  – Developed ECG criteria in collaboration with cardiology team
  – Pilot testing in select athlete populations
• 2010:
  – Systematic ECG screening in all athletes during PPE
Personnel

- ATC’s trained in and perform 12-lead ECGs
- Primary care sports medicine physicians conduct PPE
  - History questionnaire = PPE-4th Edition Monograph
  - All team physicians experienced in ECG interpretation in athletes
- Cardiology overread of ECG
  - $14 per athlete

Results

- 2010 – 2013
- N = 789
- 56% male; 44% female
- 59% Caucasian; 14% AA; Asian 3%; Other 24%
- 19 intercollegiate sports + cheer

Abnormal Results

- History: 37% (any positive response)
  - Male 32.5%; Female 43.4%
  - Syncope 7.3%; Chest pain 5%; FamHx 20%
- Physical exam: 3.6%
  - Murmur 3.3; Marfans 0.3%
  - BP >140/90 11%; >160/100 1.3%
- ECG: 3.3%
ECG Abnormalities

• Male 3.8%; Female 2.6%
• Caucasian 3.6%; AA 5.3%
• Men’s basketball 12%
• Women’s basketball 11%

Follow-up Testing and Diagnoses

• 52 athletes (6.6%) underwent additional evaluation
• Identified disorders associated with SCD:
  – HCM (1); LQTS (1); WPW (3)
    • All 5 with abnormal ECGs
    • All asymptomatic
    • 1 with benign murmur (WPW)
• Prevalence of potentially lethal cardiac disorder: 0.6% (1 in 167)

Cardiac Disorders Associated with SCD

1. HCM: men’s bball; AA; markedly abnormal ECG; CMR → 20 mm mid-septum with LGE
2. LQTS: men’s crew; prolongation of QT interval on ETT; confirmed KCNQ1 gene mutation
3. WPW: baseball; ?palpitations (not reported on PPE) → ablation
4. WPW: baseball; ETT → abrupt loss of pre-excitation
5. WPW: women’s bball; ETT → abrupt loss of pre-excitation; palpitations/near-syncpe → ablation
The UW Experience

- ECG screening greatly increases our ability to identify athletes with disorders associated with SCD and meet the objective of pre-participation screening
- ECG is the only objective test of the screen
- CV screening inclusive of ECG represents “best practice”

ECG Screening in NCAA Athletes: A 2-year Multicenter Feasibility Trial

- To evaluate and compare cardiovascular screening in NCAA athletes using a standardized history, physical exam, and electrocardiogram (ECG)
- To address key questions to assist the NCAA in the consideration of a more advanced CV screening program

Methods

- Prospective, multicenter trial
  - Year-1 (2012-13): Div I programs
- Inclusion: Any athlete without prior ECG screening was eligible
- Exclusion: Known or pre-existing heart condition; prior ECG screening
Methods

• Screening procedure:
  – AHA H&P and resting 12-lead ECG
  – ECG overread at single institution (UW) by experienced cardiologists
  – ECG interpretation guided by international consensus standards (Seattle criteria)
  – Evaluation of abnormal screens directed by the host institution medical team with consultation as requested

Results

• 35 institutions participated
  – Year 1: 13 Div I programs
  – Year 2: 12 Div I programs
  13 Div II/III programs

• Total athletes screened: N = 5,258
  – Year 1: 2,465
  – Year 2: 2,793

73% Caucasian
16% Afro-American
Mean Age: 20.1
5,258 athletes
55% male; 45% female
17 intercollegiate sports

Hx
1,750 (33.3%)
PE
108 (2.1%)
ECG
192 (3.7%)

SOB 13%
Syncpe 11%
CP 7%

Serious cardiac disorder: 13 (0.25%)
  – WPW (11)
  – Large ASD with RV dilatation requiring surgery (1)
  – Hypertrophic Cardiomyopathy (1)

No unjustified disqualification from sport
False-Positives

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<thead>
<tr>
<th></th>
<th>False-Positive Rate</th>
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<tbody>
<tr>
<td>Hx</td>
<td>10%</td>
</tr>
<tr>
<td>PE</td>
<td>2%</td>
</tr>
<tr>
<td>ECG</td>
<td>0.2%</td>
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Statistical Performance Measures

<table>
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<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
</tr>
</thead>
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<tr>
<td>Hx</td>
<td>15.4%</td>
<td>73%</td>
<td>0.1%</td>
</tr>
<tr>
<td>PE</td>
<td>7.6%</td>
<td>98%</td>
<td>1.8%</td>
</tr>
<tr>
<td>ECG</td>
<td>100%</td>
<td>96.6%</td>
<td>6.8%</td>
</tr>
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</table>

Value of an “Integrated Screen”

- 8 of 12 serious findings were discovered in upperclassman with prior screening by H&P alone
- Inclusion of ECG as part of an integrated CV screen may raise awareness to abnormal history and physical exam findings that otherwise go unreported, unrecognized, or uninvestigated

Bottom line:
An abnormal ECG facilitates ACTION!
Study Conclusions

- ECG screening in NCAA athletes provides a low false-positive rate using modern standards for interpretation
- Superior sensitivity, specificity, and PPV compared to the AHA H&P to detect athletes with potentially dangerous CV conditions

The ECG Debate

Let’s get this straight...

False-positive results
- “Mandatory” or “national” program
- Unnecessary disqualification

Size of athlete cohort
- Undue anxiety
- Absence of physician infrastructure

Poor cost-effectiveness
- Low prevalence of disease

More ownership.
More knowledge.
More training.
More experience.

Sensitivity: H&P vs. ECG

<table>
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<tr>
<th>Ref.</th>
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<th>H&amp;P</th>
<th>ECG</th>
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<tr>
<td>Wilson (2008)</td>
<td>9/2,720 athletes and children age 10-17 (U.K.)</td>
<td>0</td>
<td>9 (100%)</td>
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<td>Bessem (2009)</td>
<td>3/428 athletes age 12-35 (Netherlands)</td>
<td>1 (33%)</td>
<td>2 (66%)</td>
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<td>2/1,220 athletes age 15-29 (Spain)</td>
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</tr>
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<td>3/510 collegiate athletes (U.S.)</td>
<td>1 (33%)</td>
<td>2 (66%)</td>
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Bias is an inclination of temperament or outlook to present or hold a partial perspective, often accompanied by a refusal to even consider the possible merits of alternative points of view.
Significance of False Negative Electrocardiograms in Preparticipation Screening of Athletes for Hypertrophic Cardiomyopathy
Rowin et al. AJC 2012

- 114 asymptomatic patients < 35 yo with HCM confirmed by cardiac MRI
- 2010 ESC criteria for ECG interpretation
- 90% ≥ 1 pathologic ECG abnormality

“In conclusion, a substantial minority of young asymptomatic patients with HCM with phenotypically expressed LVH have nonpathologic ECG findings on the basis of the 2010 ESC guidelines. In principle, this high false-negative rate of 10% represents an important limitation in applying 12-lead ECG to large, apparently healthy athletic populations for the detection of HCM.”

Not So Rare!

Purpose of Pre-Participation Screening

- Primary objective
  - Evaluate for disorders at risk for sudden death, catastrophic injury or illness
- Secondary objectives
  - General health assessment
  - Health behavior counseling
  - Injury prevention and performance
Time for a Change

“Screening”

“Cardiovascular Evaluation in Athletes”

History
Physical Exam
ECG

Tenets of Cardiovascular Screening

1) Detect potentially lethal CV disease in athletes to reduce the risk of SCD and/or disease progression
2) In a largely asymptomatic population, screening must target symptomatic and silent disease
3) Early detection allows risk stratification, early intervention and management to reduce morbidity and mortality

ECG Screening Is Not Perfect...
Strategies for Prevention of SCD

All truth passes through three stages. First, it is ridiculed. Second, it is violently opposed. Third, it is accepted as being self-evident.

-- Arthur Schopenhauer

ECG Screening: Should We Screen?
The Elephant in the room

ECG should be a standard part of our CARDIOVASULAR TOOL KIT.
History & Physical
• Model is inadequate to fulfill the primary objective of screening

ECG
• Competence and experience in interpretation
• Knowledge of the disorders causing SCD
• Cardiology resources to conduct proper secondary investigations and management of identified disorders

Insanity: doing the same thing over and over again and expecting different results.
- Albert Einstein

Thank You