Cardiovascular Screening in Athletes: Is ECG Recommended?

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University of Washington

DISCLOSURE

Neither I, Jonathan Drezner, nor any family member(s), have any relevant financial relationships to be discussed, directly or indirectly, referred to or illustrated with or without recognition within the presentation.
Sudden Death in Athletes
“The fragility of life”

Hank Gathers
March 4, 1990

Too many... Too young

Garrett Uekman
November 20, 2011

Fred Thompson
December 7, 2011

Matthew Tautulo
January 10, 2012

Tyrone Duplessis
February 2, 2012

Gary Tinsley
April 6, 2012
Not So Rare!

Matthew Hammerdorfer
March 6, 2011

Robert Garza
March 12, 2011

Wes Leonard
March 4, 2011

Sarah Landauer
March 9, 2011

Javaris Brinkley
March 7, 2011

Sudden Cardiac Arrest in Young Athletes

• Leading cause of death in exercising young athletes

• Exercise is trigger for SCA in athletes with underlying heart disease
  • Largely genetic/congenital structural or electrical disorders
Curtis High School football player dies after collapsing at practice in Staten Island
Miles Kirkland-Thompson, 16, collapsed shortly after doing sprints, his father said. He was rushed to Staten Island University Medical Center, where he died. Miles, a defensive tackle from West Brighton, was set to start his junior year.

By STEPHENA. / NEW YORK DAILY NEWS / MONDAY, SEPTEMBER 2, 2013, 9:30 PM

Youth football player dies after collapsing during practice
by THE Globe September 30, 2013 at 6:00 AM

Gone but Never Forgotten

Student collapses, dies during P.E. at Meadowdale High School
By KOIN Staff / Published Sep 13, 2013 at 4:48 PM PDT / Last Updated: Sep 16, 2013 at 7:07 AM PDT

A Mile for Matthew

September 17, 2013 at 3:52 PM

Lynnwood teen who died in PE class had a heart problem
Posted by Cole Conrado

Heart problems caused the death of Matthew Truax, the 16-year-old Lynnwood boy who collapsed and died during physical education class last week at Meadowdale High School, the Snohomish County Medical Examiner’s Office reported Tuesday.

The medical examiner said Truax had hypertrophic cardiomyopathy, a condition that involves a thickening of the heart muscle that makes it more difficult for it to pump blood.

Teachers and paramedics tried unsuccessfully to revive Truax when he collapsed on Friday while running outside on the school’s track. Meadowdale principal Kevin Allen wrote a letter to parents calling the junior a “respectful, hard working young man who was serious about his education, an all-around nice kid who we will miss.”
SCA in Young Athletes
July 2014 – March 2015

- 73 cases
- Overall mortality 56%
- 19% middle school; 52% high school; 22% college

SCA Cases by Primary Sport

74%
SCD represents 75% of sudden death during exercise.

**SCD in NCAA Athletes**

- 45 cardiac-related deaths
- NCAA athletes (2003-2008) = 1,994,962
- Incidence = **1:43,000** per year
  - Male 1:33,000 / Female 1:76,000
  - Black 1:17,000 / White 1:58,000
  - Male/black 1:13,000
  - Male/basketball 1:7,000

All these athletes were screened!
Purpose?

Pre-Participation Cardiovascular Screening

“The ultimate objective of pre-participation screening of athletes is the detection of ‘silent’ cardiovascular 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; BJSM 2009

“...to prospectively identify or raise suspicion of previously unrecognized and largely genetic/congenital cardiovascular diseases known to cause sudden cardiac arrest (SCA) and sudden death in young people.”

Maron; Circulation 2014

AHA/ACC Scientific Statement

Prevalence of Cardiovascular Disorders at Risk for SCD

<table>
<thead>
<tr>
<th>Study</th>
<th>Population</th>
<th>Prevalence</th>
</tr>
</thead>
<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>
</tr>
<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>
</tbody>
</table>

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.
Etiology of SCD in Athletes

Causes of SCD in the NCAA 2003-2013

Harmon et al; 2015
Cardiovascular Screening in Athletes
Unravelling the Puzzle

• Universal agreement that screening for silent disease is important
• The “best” screening protocol remains highly controversial
• Goal: Promote a scientifically based screening strategy
History & Physical
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 H&P alone is effective in detecting athletes at risk or preventing 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 4 (3%) suspected of CV disease and 1 (0.9%) diagnosed correctly on PPE
  • PPE failed to identify 47 of 48 cases of HCM
• PPE required by all 3 Divisions upon athlete’s entrance to intercollegiate athletics program
  – Standardized, comprehensive health history
  – Cardiovascular exam
• Health history repeated annually

Cardiovascular Screening

The question is not: “Should we screen?”

The question is: “How should we screen?”
Can We Do Better?

The ECG Debate

- American Heart Association
- Learn and Live

- Size of athlete cohort
- Low prevalence of disease
- Poor cost-efficiency
- Absence of physician infrastructure
- False positive results

The ECG Debate

Continual focus on the problems of a national (federal), mandatory screening program has diverted our focus from the care of the individual athlete and the guidance of the individual physician.

Are Athletes at Greater Risk to Justify More Intensive Screening?

<table>
<thead>
<tr>
<th>Country</th>
<th>Age Range</th>
<th>Non-Athlete (18-35)</th>
<th>Athlete (18-35)</th>
<th>RR</th>
</tr>
</thead>
<tbody>
<tr>
<td>France Non-competitive Athlete (10-35)</td>
<td>0.22</td>
<td>0.98</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td>France Competitive Athlete (10-35)</td>
<td>0.28</td>
<td>4.0</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>Italy Non-Athlete (18-35)</td>
<td>0.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italy Athlete (18-35)</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Marjion 2011
Corrado 2003
High School Student-Athlete vs. Non-Athlete

- 2,149 high schools followed for 2 years
- > 1.5 million athlete years
- > 2.5 million non-athlete years

Toresdahl et al; Heart Rhythm 2014

Evaluating Models of CV Screening

- False-positive / False-negative
- Sensitivity / Specificity
- PPV / NPV
- Cost / Cost-effectiveness
- Feasibility / Infrastructure
- Benefits / Harms

1) Published studies in college athletes
2) New/emerging data
3) Institutional experiences
964 athletes underwent Hx, PE, ECG, & Echo
22.8% + symptom, fam/hx, or PE
10% distinctly abnormal ECG (2001 criteria)
9 athletes with important CV conditions
LQTS, WPW (7), aortic root dilation

Am J Med 2011

<table>
<thead>
<tr>
<th></th>
<th>Hx</th>
<th>PE</th>
<th>ECG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sens</td>
<td>44%</td>
<td>11%</td>
<td>100%</td>
</tr>
<tr>
<td>Spec</td>
<td>75.2%</td>
<td>94.5%</td>
<td>90.9%</td>
</tr>
<tr>
<td>FP</td>
<td>24.7%</td>
<td>5%</td>
<td>9%</td>
</tr>
<tr>
<td>PPV</td>
<td>1.7%</td>
<td>1.2%</td>
<td>9.5%</td>
</tr>
</tbody>
</table>

Am J Med 2011
Pre-participation Cardiovascular Screening:
“The Harvard Experience”

Aaron L. Baggish MD, F.A.C.C., F.A.C.S.M

Harvard University Team Physician
Cardiovascular Performance Program
Massachusetts General Hospital
Boston, MA


Annals of Internal Medicine

Cardiovascular Screening in College Athletes With and Without Electrocardiography
A Cross-sectional Study
Aaron L. Baggish, MD; Adolph M. Hutter Jr., MD; Francis Wang, MD; Elisa Vehed, MD; Rory B. Weiner, MD; Eli Rappaport, BA; Michael H. Picard, MD, and Melissa J. Wood, MD

Conclusion: Adding ECG to medical history and physical examination improves the overall sensitivity of preparticipation cardiovascular screening in athletes. However, this strategy is associated with an increased rate of false-positive results when current ECG interpretation criteria are used.

2005 ESC criteria

Performance of the 2010 European Society of Cardiology criteria for ECG interpretation in the athlete
Rory B. Weiner,1 Adolph M. Hutter,1 Francis Wang,2 Jonathan H. Kim,1 Melissa J. Wood,1 Thomas J. Wang,1 Michael H. Picard,1 Aaron L. Baggish1

Ann Intern Med 2010
Heart 2011

50% reduction in false positive rate
Harvard Athlete Initiative (2010-2013): Studying Screening

Freshman Athletes (300-350 / year)

AHA/ACC 12-step H&P +

12 - lead ECG (Revised Criteria)
Isolated Axis Dev., AE, RBBB

On-site TTE

~97%

Cleared for Play

<1%

~3%

MORE... (n=9)

Cardiomyopathy (n=3)
Electrical (n=5)
Normal (n=1)

1 in 120 or 1 in 4 with an abnormal ECG

Electrocardiographic Screening in NCAA Athletes: A 2-year Prospective, Multicenter Feasibility Trial

- 35 institutions
  - Year 1: 13 Div I programs
  - Year 2: 12 Div I programs
  13 Div II/III programs
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

5,258 athletes
55% male; 45% female
17 intercollegiate sports

73% Caucasian
16% Afro-American
Mean Age: 20.1

SOB 13%
Syncpe 11%
CP 7%

(+) screen

Hx
1,750 (33.3%)

PE
108 (2.1%)

ECG
192 (3.7%)

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

False-Positive Rate

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hx</td>
<td>15.4%</td>
<td>73%</td>
</tr>
<tr>
<td>PE</td>
<td>7.6%</td>
<td>98%</td>
</tr>
<tr>
<td>ECG</td>
<td>100%</td>
<td>96.6%</td>
</tr>
</tbody>
</table>
## ECG Abnormalities

<table>
<thead>
<tr>
<th>ECG Abnormality</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q Waves</td>
<td>72</td>
<td>36.2%</td>
</tr>
<tr>
<td>T Wave Inversion</td>
<td>38</td>
<td>19.1%</td>
</tr>
<tr>
<td>Left Axis Deviation</td>
<td>25</td>
<td>12.6%</td>
</tr>
<tr>
<td>ST Depression</td>
<td>15</td>
<td>7.5%</td>
</tr>
<tr>
<td>PVC’s</td>
<td>13</td>
<td>6.5%</td>
</tr>
<tr>
<td>WPW</td>
<td>12</td>
<td>6.0%</td>
</tr>
<tr>
<td>Left Atrial Abnormality</td>
<td>8</td>
<td>4.0%</td>
</tr>
<tr>
<td>Prolonged QRS</td>
<td>3</td>
<td>1.5%</td>
</tr>
<tr>
<td>RVH Pattern</td>
<td>5</td>
<td>2.5%</td>
</tr>
<tr>
<td>Prolonged QTc</td>
<td>4</td>
<td>2.0%</td>
</tr>
<tr>
<td>Other</td>
<td>4</td>
<td>2.0%</td>
</tr>
</tbody>
</table>

- **192 (3.7%) → 82 (1.6%)**
- 57% reduction in false positives
- 1 in 6 abnormal ECGs represent true disease

### Revised criteria

- 82
- 57% reduction in false positives

## Limitations

- Low ECG false-positive rate may not be reproducible with less experienced interpretation
- Evaluation of ECG abnormalities not standardized
  - 9 athletes with inferolateral TWI and ST depression
  - all male, black, with normal BP
  - 6 basketball, 3 football
  - 50% cardiac MRI
790 athletes

(+)

screen

History
294 (37.2%)

Exam
28 (3.5%)

ECG
22 (2.8%)

Disorders Associated with Sudden Cardiac Death: 5 (0.6%)
- Hypertrophic Cardiomyopathy (1)
- Long QT type 1 (1)
- Wolff-Parkinson-White (3)

All detected by abnormal ECG

No unjustified disqualification from sport

56% male; 44% female
Mean age: 18 years
19 intercollegiate sports

59% Caucasian
15% Afro-American
26% Mixed/other race

Mean age: 18 years
19 intercollegiate sports

Evaluating our choices...

False-positive
False-negative
Sensitivity
Specificity
PPV
NPV
Cost
Cost-effectiveness
Feasibility
Infrastructure
Benefit
Harms

H&P

H&P +

ECG
Added Value of ECG Screening

• The addition of ECG when properly interpreted and with skilled cardiology resources improves CV screening if the measurable endpoint is considered the detection of silent/congenital cardiac conditions associated with SCD

“To prospectively identify or raise suspicion of previously unrecognized and largely genetic/congenital cardiovascular diseases known to cause sudden cardiac arrest (SCA) and sudden death in young people.”
Maron; Circulation 2014
AHA/ACC Scientific Statement

Ongoing Concerns

• ECG may cause harms
  • Unnecessary testing or disqualification
  • Undue anxiety and psychological harm
  • Adverse medical events
• Will the benefit outweigh the potential harm?
  • Natural disease course is poorly understood
  • Not all athletes with disease will go on to SCA
• Poor infrastructure to provide quality screening
  • ECG interpretation
  • Cardiology resources
Do you believe in early detection?

- Why do you conduct PPEs?
- Do you auscultate for pathologic murmurs?
- Difficult to support early detection on exam, but criticize early detection by ECG

MILLION DOLLAR QUESTION

Does early detection reduce morbidity and mortality?
Early Detection of HCM
Does it matter?

The New England Journal of Medicine

SCREENING FOR HYPERTROPHIC CARDIOMYOPATHY IN YOUNG ATHLETES
DOMENICO CORrado, M.D., CHERIBA BASSO, M.D., MAURO Scheck, M.D., AND GIANPAGI THEONE, M.D.

Prospective study 33,735 screened athletes
Comparison to unscreened non-athletes
HCM detected in 22 athletes (21 +ECG, 3 +FamHx, 2 +murmur)
None of the disqualified athletes with HCM died during 8 year follow-up
HCM in athletes (undetected) → 1 death (2% of SCD)
HCM in non-athletes → 16 deaths (7.3% of SCD)
Early detection of HCM → 73% risk reduction in mortality

Exercise and ARVC

• Exercise increases the risk of ventricular arrhythmia and impairs cardiac function in patients with ARVC
LQTS

Individualized management → extremely low event rate
• Informed decision-making
• Avoidance of QT prolonging meds
• Beta-blockers
• Sympathetic denervation
• ICDs

Return to play? Athletes with congenital long QT syndrome
Jonathan N Johnson,1 Michael J Ackerman1,2,3

JAMA 2012
BJSM 2013

36TH BETHESDA CONFERENCE

Introduction: Eligibility Recommendations for Competitive Athletes With Cardiovascular Abnormalities—General Considerations
Barry J. Maron, MD, FACC, Co-Chair
Douglas P. Zipes, MD, MACC, Co-Chair

The recommendations in this report should also be viewed in perspective. Appropriate sports disqualification is only one component of potentially reducing risk, and each relevant cardiovascular disease has its own treatment algorithms, which can include selective implantation of a cardioverter-defibrillator in high-risk patients (16). Second, the availability of a free-standing automatic external defibrillator at a sporting event should not be considered either as absolute protection against a sudden death event, a prospectively designed treatment strategy for athletes with known cardiovascular disease, or justification for participation in competitive sports that otherwise would be restricted owing to underlying cardiac abnormalities and the risk of life-threatening ventricular tachyarrhythmias. Nonetheless, the increased risk of sudden death associated with intense athletic participation is a controllable risk factor, and the devastating impact security from these activities.
• Medical screening prior to military service obligated by law in all Swiss males
• ECG added to protocol in 2004 → significant (44%) reduction in CV death among males age 20-24
  - 1997-2004: 2.6/100,000
  - 2004-2011: 1.5/100,000
  - Odds ratio 0.56, 95% CI 0.35-0.91
• “Demonstrates the potential for effective implementation of an ECG screening program and risk reduction in the targeted population.”

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The ECG Debate

- False-positive results
- Size of athlete cohort
- Poor cost-effectiveness
- “Mandatory” or “national” program
- Unnecessary disqualification
- Undue anxiety
- Absence of physician infrastructure
- Low prevalence of disease
The ECG Debate

Evidence supports that if you are trying to screen for CV disease that you should use ECG

Recognition that our traditional model for CV screening is inadequate

Absence of physician infrastructure

AHA 2014 on ECG screening at universities:
“Such screening efforts have benefited some young individuals through identification of potentially life-threatening cardiovascular disorders. Such initiatives have been supported consistently by the 1996 and 2007 AHA Scientific Statements, as well as the present document.”

Conclusions

1) The primary objective of pre-participation CV screening is the identification of disorders associated with SCD

2) Different screening models have the same purpose and to be internally consistent all screening tools must be evaluated by the same standards

3) Disease-specific outcomes data suggests early detection can mitigate risk for disease progression and sudden death
Conclusions

4) Standardized cardiac screening questionnaires demonstrate a markedly high positive response rate in college athletes and fail to detect the majority of ECG detectable cardiac disorders.

5) ECG as an objective test outperforms H&P on all statistical measures of performance when using modern standards for interpretation.

“Both AHA and ESC consensus panels have agreed previously that screening to detect cardiovascular abnormalities in asymptomatic young competitive athletes is justifiable in principle on ethical, legal, and medical grounds.”

AHA 2014

Who is calling for a mandate?

Mandatory, Nationalized ECG Screening

No Screening

Highly insensitive
Low specificity

Middle Ground

History & Physical Exam

CV Screening in Athletes
Should ECG be recommended in the CV screening of athletes?

YES

In targeted high-risk groups
Where proper ECG interpretation and adequate cardiology resources are available

Cardiovascular Screening in Athletes
Bridging the Gap

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
UW Medicine
Center for Sports Cardiology

1. Heart screens
2. PPE with ECG
3. Athletes with CV symptoms

206-520-5000

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

- Albert Einstein
www.quotesworthrepeating.com
Thank You

UW Medicine
Center for Sports Cardiology

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uwsportscardiology.org