

ECG Screening in Athletes: How does the Seattle Criteria Help?

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Objectives

- Define the Seattle Criteria.
- Identify scope of problem.
- Understand how we got “here.”
- Review new ECG screening criteria pearls.
- Identify a few current programs.
- **Understand how the Seattle Criteria may help practitioners interpret ECG’s in students/athletes and how to learn to apply the Criteria.

Question:

- What is the goal, reduction of sudden cardiac death (ultimately) or finding athletes at higher risk for sudden cardiac death?

Seattle Criteria

- Feb 13/14 2012 an international group of experts in sports cardiology and sports medicine convened in Seattle, Washington to define contemporary standards for ECG screening in athletes.
- Objective of meeting was to develop a comprehensive training resource to help physicians distinguish normal ECG alterations in athletes from abnormal ECG findings that require additional evaluation for conditions associated with SCD.

- Drezner JA, Ackerman MJ, Anderson J, Br J Sports Med 2013;47:122-124.

Basis for Meeting

- Sudden cardiac death is the leading cause of death in athletes during sport.
- Whether obtained for screening or diagnostic purposes, an ECG increases the ability to detect underlying cardiovascular conditions that may increase the risk of SCD.
- In most countries, there is a shortage of physician expertise in the interpretation of an athlete's ECG.
- A critical need exists for physician education in modern ECG interpretation that distinguishes normal physiologic adaptations in athletes from abnormal findings suggestive of pathology.

- Drezner JA, Ackerman MJ, Anderson J, Br J Sports Med 2013;47:122-124.

Attendees/Groups

- AMSSM
- European Section on Sports Cardiology (EACPR)
- European Society of Cardiology (ESC)
- FIFA Medical Assessment and Research Center (F-MARC)
- Pediatric & Congenital Electrophysiology Society (PACES)
- U of Washington, Mayo Clinic, Stanford, U Conn, Mass General, UCLA, Emory University, Children's Hospital of Philadelphia, Italy, Belgium, Brazil, Switzerland, UK

Recommendations and Considerations Related to Preparticipation Screening for Cardiovascular Abnormalities in Competitive Athletes: 2007 Update

“Although the ESC proposal is innovative and based on a generally favorable long-term experience in Italy, it cannot easily be translated into the US medical system and environment. On the other hand, the panel does not arbitrarily oppose volunteer-based athlete screening programs with noninvasive testing performed selectively on a smaller scale in local communities if well designed and prudently implemented.”

• Maron BJ et al. *Circulation*. 2007;115:1643-1657.

Preparticipation Cardiovascular Screening in Young Athletes: Current Guidelines and Dilemmas

2007 AHA Consensus Guideline Update

- AHA 12—key elements of the screening cardiovascular examination.
- National standard for cardiovascular screening.
- Against the use of ECG for routine screening but noted “The AHA panel agreed that non-invasive testing such as the ECG can improve the diagnostic power of the history and physical exam. . . .”

• Seto CK, Pendleton ME. *Curr Sport Med Rep*. 2009;8:59-64.

The 12-Element AHA Recommendations for Preparticipation Cardiovascular Screening of Competitive Athletes

Medical history*

Personal history

1. Exertional chest pain/discomfort
2. Unexplained syncope/near-syncope*
3. Excessive exertional and unexplained dyspnea/fatigue, associated with exercise
4. Prior recognition of a heart murmur
5. Elevated systemic blood pressure

Family history

6. Premature death (sudden and unexpected, or otherwise) before age 50 years due to heart disease, in ≥1 relative
7. Disability from heart disease in a close relative <50 years of age
8. Specific knowledge of certain cardiac conditions in family members: hypertrophic or dilated cardiomyopathy, long-QT syndrome or other ion channelopathies, Marfan syndrome, or clinically important arrhythmias

Physical examination

9. Heart murmur*
10. Femoral pulses to exclude aortic coarctation
11. Physical stigmata of Marfan syndrome
12. Brachial artery blood pressure (sitting position)¹

- *Parental verification is recommended for high school and middle school athletes.
- †Judged not to be neurocardiogenic (vasovagal); of particular concern when related to exertion.
- ‡Auscultation should be performed in both supine and standing positions (or with Valsalva maneuver), specifically to identify murmurs of dynamic left ventricular outflow tract obstruction.
- §Preferably taken in both arms.

• Maron BJ et al. *Circulation*. 2007;115:1643-1657.

Scope of Problem

- Risk: 2 per 100,000 persons per year
- 2.5X higher than age-matched non-athletes
- Risk increases with increasing peak intensity of exercise and increasing level of competition
- Athletes with underlying but undiscovered heart disease may have 100-fold higher risk

• Wheeler MT et al. *Ann Intern Med*. 2010;152:272-286.

Incidence of Sudden Cardiac Death in Young Athletes

- Initial estimates put number at 1:200,000 to 1:300,000 in the US.
- More recent US studies put the number closer to 1:50,000.
- The United States Sudden Death in Young Athletes Registry has identified approx 115 cases of SCD per year, or about 1 case of sudden cardiac death every 3 days in US organized youth sports.

• Drezner JA. *Current Opinion in Cardiology*. 2008;23:494-501.

Recommendations and Considerations Related to Preparticipation Screening for Cardiovascular Abnormalities in Competitive Athletes: 2007 Update

- **Prevalence** of cardiovascular diseases that predispose to sudden cardiac death in the general athletic population is estimated to be 0.3% (3/1000).

• Maron BJ et al. *Circulation*. 2007;115:1643-1657.

- This is confirmed by several other ECG studies with reported true-positive rates of 0.2-0.4%.

• Drezner JA. *Current Opinion in Cardiology*. 2008;23:494-501.

The Athlete's Heart: Remodeling, Electrocardiogram and Preparticipation Screening

- **2002**
- “However, such false-positive, abnormal ECG patterns in athletes are an important limitation to the diagnostic power of the ECG testing in preparticipation cardiovascular screening of large athletic populations.”

• Pelliccia A, Di Paolo FM, Maron BJ. *Card in Rev*. 2002;10:85-90.

Electrocardiography and the Preparticipation Physical Examination: Is It Time for Routine Screening?

- **2006**
- Against including ECG due to cost and high incidence of false-positive results.
- “These limitations may lead to unnecessary disqualifications and added testing, causing much stress and anxiety for athletes, parents and coaches.”
- Advocated standardization of PPE on national level.

• Donnelly DK, Howard TM. *Cur Sport Med Rep*. 2006;5:67-73.

ECG added to PPE

- 1998 study suggested 77% greater power to detect HCM than than history and physical examination.
 - Corrado D et al. Screening for Hypertrophic Cardiomyopathy in Young Athletes. *NEJM* 1998;339:364-369.
- 2006 report of 25 year study of 42,386 athletes in Italy using history/physical/ECG showed 10-fold reduction in the incidence of sudden cardiac death.
 - Corrado D et al. Trends in Sudden Cardiac Death in Young Competitive Athletes After Implementation of a Preparticipation Screening Program. *JAMA* 2006;296:1593-1601.

Evidence for Efficacy of the Italian National Pre-participation Screening Programme for Identification of Hypertrophic Cardiomyopathy in Competitive Athletes

- 2006 study of 4450 elite athletes.
- Initial screening with history/physical/ECG.
- Follow-up with echo.
- No definite cases of HCM identified (after ECG before echo) although 5-10 would be expected given prevalence of 0.1-0.2%.

Evidence for Efficacy of the Italian National Pre-participation Screening Programme for Identification of Hypertrophic Cardiomyopathy in Competitive Athletes

Authors suggest:

- ECG screening is effective in leading to the diagnosis of HCM.
 - Reason for negligible SCD due to HCM in Italy is due to ECG screening and H&P.
 - Not absolutely necessary to utilize echocardiography as a routine diagnostic test for the detection of HCM. May aid in identifying other cardiac issues.
- Pelliccia A, Di Paolo FM, Maron BJ et al. *Eur Heart J.* 2006;27:2196-2200.

Cardiovascular Screening in College Athletes With and Without

Electrocardiography

- Prospective study.
- 508 Harvard collegiate athletes.
- Each received hx/physical/ECG/TTE.
- Those doing H&P blinded to ECG/TTE results.
- H&P found 5/11 abnormalities, adding ECG moved it to 10/11 (sensitivity up from 45% to 90%).
- False-positive rate went from 5.5% to 16.9%.
• Baggish AL et al. *Ann Int Med.* 2010; 152:269-275.

Performance of the 2010 European Society of Cardiology Criteria for ECG Interpretation in Athletes

- 508 university athletes.
- 11 had findings suggestive of or diagnostic for cardiac disease relevant to sport participation risk.
- 3 met criteria for restricted sports participation.
- 505/508 cleared were followed for 2 years without any cardiac events.

Performance of the 2010 European Society of Cardiology Criteria for ECG Interpretation in Athletes

- 62/508 were found to have abnormal findings
 - 13: H&P
 - 29: ECG
 - 20: H&P and ECG
- 49 (9.6%) had abnormal ECG with 2010 criteria (down from 83 (16.3%) with 2005 criteria).
- Sensitivity (low rate of false negatives) remained high (.909) and specificity (false positives) improved (from .169 to .100) or from 83% to 90%.
• Weiner RB et al. *Heart.* 2011;97:1573-1577.

ESC Criteria for ECG Interpretation in Athletes: Better But Not Perfect

- “False positive results raise concerns about the unnecessary investigations, erroneous disqualification and psychological harm to the athlete. Conversely, SCDs in sport are highly visible, claiming young lives.”
- “In a cost-prohibitive financial climate the ECG is probably the most effective tool for identifying conditions predisposing to SCD in young athletes.”

• Sharma S et al. *Heart*. 2011;97:1540-1541.

Addition of the Electrocardiogram to the Preparticipation Examination of College Athletes

- 2010 study--Stanford University
- “Considering the prevalence of diseases potentially associated with SCD. . .it has been the consensus of the cardiologists at our institution to recommend that ECG screening becomes mandatory for our athletes. . .”

• Le VV et al. *Clin J Sport Med*. 2010;20:98-105.

Cost Effectiveness Analysis of Screening of High School Athletes for Risk of Sudden Cardiac Death

- 2000 cost-analysis
- “Preparticipation cardiovascular mass screening of HAS appears to be best accomplished through performance of ECGs that are twice as cost effective as the American Heart Association-recommended specific cardiovascular history and physical examination. Two-dimensional echocardiography is the least cost effective method. . .”

• Fuller CM. *Med Sci Sports Exer*. 2000;32:887-890.

Cost-Effectiveness of Preparticipation Screening for Prevention of Sudden Cardiac Death in Young Athletes

- Design: Decision-analysis, cost effectiveness model.
- "...ECG plus cardiovascular-focused history and physical examination is reasonable in cost and is effective at saving lives."
- Similar cost effectiveness as dialysis, public access to defibrillation, and implantable cardioverter-defibrillator implantation.
- Dedicated CV screening with H&P is much more costly and marginally more effective than no screening.

• Wheeler MT et al. *Ann Intern Med.* 2010;152:272-286.

Recommendations for Interpretation of 12-lead Electrocardiogram in the Athlete

Group 1: common and training related ECG changes

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

Corrado D et al. *Eur Heart J.* 2010;31:243-259.

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 RBBB or LBBB
- Long or short QT interval
- Brugada-like early repolarization

Accuracy of ECG Interpretation in Competitive Athletes: The Impact of Using Standardized ECG Criteria (Drezner et al BJSM 2012)

- 40 ECG's (12 abnormal/28 normal).
- 60 docs (22 PC residents, 16 PC attendings, 12 SM attendings, 10 cardiologists).
- Sensitivity improvement from 89-94%
- Specificity improvement from 70-91%
- PPV 69-91%
- NPV 86-94%

“Normal Abnormals”

Joseph Marek MD SCD Conference 1/2013

- 60% of athletes have changes on ECG that may be misconstrued as abnormal.
- Regular and sustained exercise can lead to changes that are a reflection of:
 - Autonomic nervous system adaptations: sinus brady and junctional escape rhythms, sinus arrhythmia, AV blocks.
 - Structural/electrical remodeling: IRBBB, early repolarization, increased voltage.

Normal ECG Findings in Athletes

- Low voltage
- Sinus arrhythmia
- Sinus bradycardia (>30)
- Ectopic atrial rhythm
- Short PR without delta waves
- 1° AVB
- 2° AVB Mobitz 1 (Wenckebach)
- IRBBB
- Isolated increased voltage
- Early repolarization pattern

SCD Pearls

- Increased QRS amplitude is not a good distinguisher of disease when interpreting an athlete's ECG.
- Early repol in Black/African athletes: elevated ST-segment with an upward (“domed”) convexity, followed by T-wave inversion in V2-V4 (6-12% prevalence).
- Suspect Long QT Syndrome in family with unexplained drowning, sudden death <50, car accidents.

SCD Pearls (HCM)

- >16 mm thickness always pathologic
- Physiologic hypertrophy
 - Concentric
 - Normal cavity size
 - Normal diastology
 - No scar on MRI
- Physiologic dilation—normal function with exercise
- If unsure detrain and repeat results

SCD Pearls (WPW)

- 1-3/1,000
- Accessory connection bypassing AV node
- Risk of reentrant SVT and SCD
- Red flags include:
 - Younger age (<30)
 - Male gender
 - History of A-fib
 - Congenital heart disease
 - Syncope

Management of SCA in Sport

- Must have emergency action plan and access to AED's.
- Practice the plan!
- Suspect SCA in any collapsed and unresponsive athlete.
- Seizure=SCA until proven otherwise.
- AED programs save lives.

NCAA ECG Study—Multicenter Feasibility Trial in DI Schools

- PPE insensitive for conditions associated with SCD.
- Incidence of SCD in DI athletes 4-5 times higher than previously thought (Harmon 2011).
- ECG has potential to increase detection of athletes at risk.
- Concerns for false-positive results, unnecessary secondary investigations or disqualification, and cost.

NCAA ECG Study—Multicenter Feasibility Trial in DI Schools

- Purpose: to evaluate and compare the accuracy of cardiovascular screening in NCAA athletes using a standardized history, physical exam, and ECG (using Seattle Criteria).
- Ongoing—14 NCAA DI schools-now expanding to DII and III.
- Any athlete without prior ECG screening was eligible.

NCAA ECG Study—Multicenter Feasibility Trial in DI Schools

- 2,471 male and female athletes screened.
- 7 athletes (.28%) diagnosed with serious cardiac conditions.
- All 7 had abnormal ECG's.
- 2 had abnormal H or P.
- 4 athletes were upperclassmen with previous normal H&P.
- More data coming in but it appears false positive rate about 3% with ECG and 30% with H.

NCAA ECG Study—Multicenter Feasibility Trial in DI Schools

- Limitations: larger sample size needed for accurate prevalence, potential for false-negatives, low false-positive rate may not be reproducible with less experienced interpretation.
- Conclusions: feasible, low false-positive with new criteria, superior accuracy compared to H&P alone.
- Greater physician infrastructure needed to apply accurate use of ECG.

Incidence of SCA In HS Athletes

(Toresdahl 2013)

- There is no reliable SCD registry in the US.
- Many “studies” use media reports, ins. claims... to determine incidence, and often look at SCD.
- Recent 2 year prospective study using National Registry for AED Use in Sports and 2,149 high schools.
- Data suggests 1:58,000—more than previously suspected—likely underreported.
- Males 5 times higher than females.
- Athletes 3 times higher than non-athletes.

Incidence Pearls

- Incidence estimates are highly variable and largely dependent on study methodology, age, and demographics.
- SCD in athletes is higher in:
 - M>F
 - College>HS
 - Black/African>Caucasian
 - Athletes>non-athletes(Exercise is a risk for persons with CV disease)

Public Health Perspective

- Meningococcal vaccine of all incoming college freshmen may prevent 2-5 deaths a year with a cost per death of \$22 to \$48 million.
• MMWR Recomm Rep 2005;54:1-21.
- Disease prevalence of all cardiovascular disorders that predispose young athletes to SCD is 1:333. In US standard newborn screening for phenylketonuria and cystic fibrosis; prevalence of these is 1:15,000 and 1:3500 respectively.
• Wash State Dept of Health 2008.

Societal Factors

- High “shock” value of sudden cardiac death.
- “Pressure” from parents/coaches/administrators to start a program.
- With obesity rates increasing in young people, are we “helping” by looking for athletes to disqualify?

Contemporary Approaches to the Identification of Athletes at Risk for Sudden Cardiac Death

- 2008 Review
1. All athletes should undergo a comprehensive preparticipation evaluation using a detailed personal and family history questionnaire, along with a properly conducted physical examination, beginning at age 12 and repeated every 2 years.
 2. A questionnaire should be administered in interval years to assess the development of any new cardiovascular symptoms. Blood pressure also should be evaluated at that time.
 3. ECG screening should be performed (at minimum) upon athlete matriculation to high school and college.
Drezner JA. Current Opinion in Cardiology. 2008;23:494-501.

Other Supportive Articles

- Ma JZ et al. Cardiovascular Pre-participation Screening of Young Competitive Athletes for Prevention of Sudden Death in China. *J Sci Med Sport*. 2007;10:227-233. **“The 12-lead electrocardiogram and echocardiogram should be considered and have the potential to enhance the sensitivity of the screening process for detection of cardiovascular diseases...”**
- Lawless CE and Best TM. Electrocardiograms in Athletes: Interpretation and Diagnostic Accuracy. *Med Sci Sports Exerc*. 2008;40:787-798. **“ECG evolving as an adjunct to the standard PPE.”**

Other Supportive Articles

- Sofi F et al. Cardiovascular evaluation, including resting and exercise electrocardiography, before participation in competitive sports: cross sectional study. *BMJ*. 2008;337:a346. **“The inclusion of resting and exercise electrocardiography to the standard medical evaluation of sports participation helps to identify those at high risk.”**
- Basavarajaiah S et al. Prevalence of Hypertrophic Cardiomyopathy in Highly Trained Athletes: Relevance to Pre-Participation Screening. *J Am Coll Cardiol*. 2008;51: 1033-1039. **“Screening athletes with echocardiography is not cost effective. However, electrocardiography is useful in selecting out those individuals who may have pathological left ventricular hypertrophy for subsequent echocardiography.”**

Articles Against

- Shephard RJ. Preparticipation screening of young athletes: an effective investment? In: Shephard RJ, Alexander MJL, Cantu RC, et al, eds. *Year Book of Sports Medicine, 2005*. Philadelphia, PA: Elsevier/Mosby; 2005:xix-xvi.
- Chaitman R. An electrocardiogram should not be included in routine preparticipation screening of young athletes. *Circulation*. 2007;116;2610-2615.
- Shephard RJ. Mass ECG screening of young athletes. *Br J Sports Med*. 2008;42;707-708.

Is Electrocardiogram Screening of North American Athletes Now Warranted?

- 2011 editorial questioning several studies (Corrado 2006, Wheeler 2010, and Baggish 2010) related to efficacy and cost.
- “Sudden exercise-induced death in young athletes is an extremely rare event and attempts to detect those individuals at risk using a resting ECG face severe problems from limited test sensitivity and specificity.”

• Shephard R.J. *Clin J Sports Med.* 2011;21:189-190.

Mandatory Electrocardiographic Screening of Athletes to Reduce Their Risk for Sudden Death

- 2011 Israeli study.
- Retrospective media-information study.
- Looked at sudden cardiac death in young athletes during two 12 year periods, one without ECG (1985-1997) and one with ECG (and exercise testing) added to PPE (1998-2009).
- 11 events '85-'97 and 13 '98-'09.
- Authors suggest Corrado 2006 study noted decrease because the pre-ECG study period was too short (2 years) and the number of deaths during that period were higher than statistics suggest it should have been.
- Against mandated ECG screens.

• Steinvil A et al. *JAM Coll Cardiol.* 2011;11:1291-1296.

Is There Evidence for Mandating Electrocardiogram as Part of the Pre-Participation Examination?

2011 review article looking at many of the aforementioned studies.

- Sensitivity of H&P alone very low. Adding ECG increases sensitivity with a very high negative predictive value.
- Specificity of an abnormal ECG is low, but when taking into account gender, level of training, and ethnicity, this goes up.
- Studies from Japan, Italy, and the US suggest cost-effectiveness appears to be improving.

Is There Evidence for Mandating Electrocardiogram as Part of the Pre-Participation Examination?

- Things like liability, erroneously restricting ones ability to make a living, and negatively impacting public perception of exercise by not reducing SCD or over-restricting participation need to be taken into account.
- “Thus, cardiac pre-participation screening without ECG cannot be recommended given our current knowledge. . . On ethical grounds the reasons (logistical, legal, economic) for *not* screening individual athletes should be very clearly stated.
 - Borjesson M and Dellbourg M. *Clin J Sport Med.* 2011;1:13-17.

Electrocardiograms Should Be Included in Preparticipation Screening of Athletes

“ . . the consequence of delays in implementing ECG screening until more research data are available would come at the cost of failure to prevent deaths from occurring during the period of time that the study effort is being conducted.”

- Myerburg RJ and Vetter VL. *Circulation.* 2007;116:2616-2626.

Final Thoughts

- In 2013 it appears that consensus is mounting for the use of ECG as part of the PPE (local non-mandated efforts).
- Addition of ECG to PPE in a local/team/school setting appears to be the best method at this time.
- While cost and logistics are important factors, we need to be creative in working around these issues.
- Improvements in screening criteria will likely occur over next few years, reducing the false-positive ECG's—this has happened—the Seattle Criteria.
- More physicians need to take advantage of the BMJ ECG training module...

ECG Module

- Published through the British Medical Journal:
 - learning.bmj.com
 - There will be a click-through to “ECG interpretation in athletes”
 - Free

Examples

The community heart screens are organized by the Nick of Time Foundation (Mill Creek WA), targeted at area high schools, free, and offered about once per month.

<http://nickoftimefoundation.org/>

Full PPE with ECG. Team of Physicians for Students (TOPS--Phoenix AZ).

<http://www.aztops.org/>

Key Reference Articles

- 12-lead ECG in the Athlete: Physiological versus pathological abnormalities. Corrado D et al. *Br J Sports Med* 2009;43:669-676.
- Recommendations and Considerations Related to Preparticipation Screening for Cardiovascular Abnormalities in Competitive Athletes: 2007 Update. Maron BJ et al. *Circulation*. 2007;115:1643-1657.
- 36th Bethesda Conference:
Eligibility Recommendations for Competitive Athletes With Cardiovascular Abnormalities
Barry J. Maron, MD, FACC, *Conference Co-Chair*
Douglas P. Zipes, MD, MACC, *Conference Co-Chair*.
JACC 2005.

Key Reference Articles

- Is There Evidence for Mandating Electrocardiogram as Part of the Pre-Participation Examination? Borjesson M and Dellbourg M. *Clin J Sport Med.* 2011;1:13-17.
- Contemporary Approaches to the Identification of Athletes at Risk for Sudden Cardiac Death. Drezner JA. *Current Opinion in Cardiology.* 2008;23:494-501.
- Normal electrocardiographic findings: recognising physiological adaptations in athletes. Drezner JA, Froelicher V, et al. *Br J Sports Med.* 2013;47: 125-136.
- February 2013 issue of the British Journal of Sports Medicine has several other related articles.

Thank-you

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