Children's National

Pre-participation Cardiac Screening of Teenage Athletes: Goals, Challenges, and Pitfalls

Jared Hershenson, MD
Director of Cardiac Exercise and Rehabilitation
Children's National Hospital, Division of Pediatric Cardiology

Disclosures

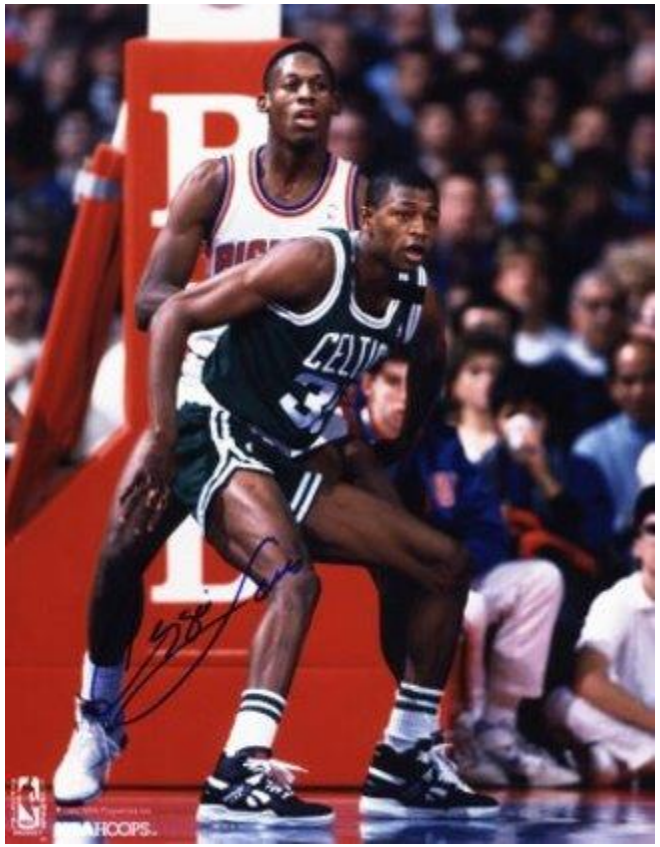
No financial disclosures

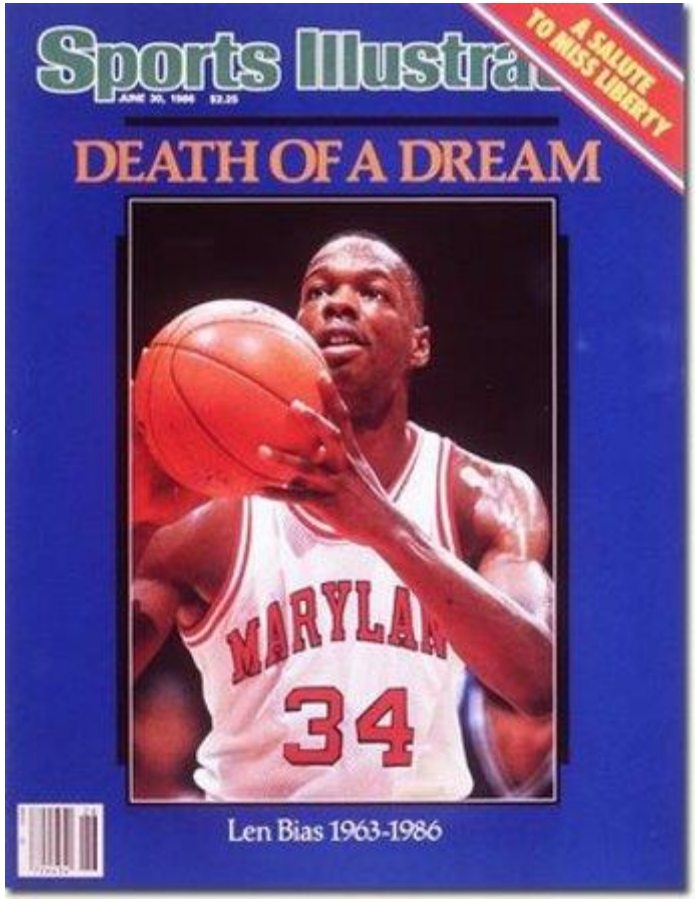
Objectives

- Understand the rationale of the pre-participation cardiac history and physical exam (PPE)
- Obtain a detailed understanding of the PPE
- Appreciate the debate on whether EKG screening should be added to the PPE
- Advance secondary prevention of sudden cardiac death (SCD) in the community
- Partner with pediatric cardiologists to promote safe physical activity in patients with (pre-existing) cardiac conditions

Why worry about healthy teens?

- Rare incidence of sudden cardiac death
- Uncommon, but outcome is devastating
- Usually occurs in healthy, asymptomatic children and young adults
- Attracts attention from schools, media





Children's National

Home > News

Medway High lacrosse player dies

The Boston Globe

Second area death in sport at schools

By Erin Conroy, Globe Correspondent | April 29, 2007

A Medway High School sophomore collapsed yesterday during lacrosse practice and was pronounced dead at a nearby hospital. It was the second sudden death in a week of a young lacrosse player in the area.

Nick Souza, who would have turned 16 on

ARTICLE TOOLS

COLORADO SPRINGS, Colo. (AP) – A 17-
old player from Harrison High School
collapsed during the third quarter of a
Friday night and died after bein
Memorial Hospital.

Center Fermin Vialpando, a sen
running down the field when he
fell, apparently after a seizure,
reported. The game was halted

His mother, Sundae Vialpando,
Denver Post on Saturday that he
known health problems. "Doctor
sometimes with an athlete – it n

Search

News

High

Autop

POSTE
UPDAT

---

ajc.com > Metro > Gwinnett

EMAIL THIS PRINT REPRINTS SHARE

player found dead had torn aorta, says

tion

Collins Hill High School who was found dead over the weekend had a tear in his aorta that killed him, an investigator said Tuesday.

It's not yet clear what caused the tear that killed Terrell Wilson, an Honors Student and football player at Collins Hill High School in Suwanee.

RELATED:
• More Gwinnett news

The tear could have occurred naturally or as a result of an injury that Wilson sustained, said Ted Bailey, chief forensic investigator for the Gwinnett County Medical Examiner's office.

Gwinnett medical examiner's staff are interviewing Wilson's family and football coaches, he said.

"We're interviewing his family and his football coaches, to see if he got an injury," Bailey said.

Cpl. Illana Spellman, a spokeswoman for the Gwinnett County Police Department, said Tuesday that detectives do not believe that Wilson's death is suspicious and that they are not investigating it.

Terrell was a lineman on the freshman football team.

unselors visited Terrell's classes at the start of each class period Monday to talk with nnett County Schools district spokesman Jorge Quintana.

HOME > NEWS > LOCAL > MASS.

Medfield boy, 14, dies at lacrosse practice

The Boston Globe

Needham school to offer counseling

By David Abel and Michael Naughton, Globe Correspondent | April 25, 2007

An eighth-grader at St. Sebastian's School in Needham died yesterday while practicing lacrosse on a school field, officials said.

---

otball team members participated in a
in which players strap on helmets and
cting each other. That was when 16-
collapsed, stunning players and

nteer coach, who is also a police
tt's side when he collapsed and
started CPR. They said the first patrol car on the scene had a
defibrillator that was used on the teenager before he was taken away.

Video: Egg Harbor High Scho
Football Player Dies

Children's National.

Teen Hockey Player Dies After Collapsing At Game

16-Year-Old Player Remembered As Great Kid

POSTED: 5:06 pm EST February 10, 2007
UPDATED: 6:38 pm EST February 10, 2007

FISHERS, Ind. -- Grief counselors were at a skating
in Fishers on Saturday after a 16-year-old hockey play
collapsed during a game Friday and died later that nigl

Steve Scotton, 16, captain of the Hamilton Southeaste
Hockey Club, collapsed during the first period of a gar
the Forum at Fishers.

Mike Berger, the team's coach, said he immediately
recogni

Email Print

High school lacrosse player dies

BINGHAM
lacrosse
night ha

A schoo
old John
support

Mack ha

E-Mail News Alerts

Get breaking news and daily headlines

Enter E-Mail Ad

Browse all e

FAZOL

17-Year-old hockey player died of 'underlying cardiac condition'

Coroner's office

National Post

Alonso baseball player dies after tryout

The former Tampa Catholic student collapsed working out for the team. Coaches and paramedics tried to revive him, but he later died at the hospital.

By SAUNDRA AMRHEIN, Times Staff Writer
Published January 20, 2005

TAMPA - Baseball was Matthew Miulli's life.

The 17-year-old Alonso High School junior had played since he was a little boy, friends said.

So it was no surprise after he transferred from Tampa Catholic High School this school year that he'd be on the field, trying out for Alonso's baseball team this week.

But for Miulli, who had a pre-existing medical problem, his passion for baseba turned fatal late Wednesday afternoon when he collapsed during tryout conditioning. His coach and emergency rescue personnel tried to revive him, but he was later pronounced dead at the hospital, officials said.

Within an hour, more than 100 shocked and grief-stricken students and friends

emingly
roblem." Dr.
ould have

UH

An 18-year-old University of H
submerged in 5 feet of water
Complex pool.

Members of the UH swim tea
Complex yesterday to mourn t

Eugene Tanner • The Honolul
Mike Sheldt, of Charlotte, N.C.
afternoon.

It was the first death of a UH a
according to UH officials.

This morning, the city medical
spokeswoman said last night that unless the cause of death is obvious, it could
take weeks for the tests to be completed.

"We're all shocked and numb at the loss of Mike Sheldt," UH head swimming coach Mike Anderson said in a written statement. "We are very concerned at taking care of his family and our kids and trying to go forward one step at a time."

Sheldt, a freshman who competed in the individual medley, and other teammates were training for a qualifying meet for the NCAA championships, scheduled for Friday through Sunday at UH.

At 2:45 p.m., Emergency Medical Services received a call for a drowning at the UH

Autopsy uncovers heart condition

Freshman Mike Sheldt likely suffered a heart attack while swimming warm-up laps at the university

By Dave Reardon
dreardon@starbulletin.com

A heart condition called hypertrophic cardiomyopathy contributed to the drowning death of 18-year-old University of Hawaii swimmer Mike Sheldt on Tuesday, according to the findings of an autopsy yesterday.

A Honolulu cardiologist said the condition can easily go unnoticed.

"It's an unusual situation where the heart muscle is much thicker than normal," Dr. Raymond Itagaki said. "It is totally hidden. You might have a heart murmur, you might not have any. It's got nothing to do with blocked arteries or valve problems. It's an over-muscled heart. I don't think anyone knows why it occurs."

Itagaki said the condition is not caused by physical training.

"That's different. When you have a trained, conditioned athlete, that enlargement is not due to thickening of the heart muscle," Itagaki said. "In that case, the size of the heart cavity increases."

How to SAVE a LIFE - Recognize Sudden Cardiac Arrest in Athletes
YouTube
UW Medicine Center for Sports Cardiology Jun 12, 2023

Children's National

Goal of the Pre-participation Screen

Prevent SCD!

But what conditions are we trying to diagnose?

In whom? (What is the definition of athlete?)

How good is the PPE or other testing at detecting these conditions?

Incidence of SCD

TABLE 1 Epidemiology of SCD and SCA in Athletes

First Author	Year	Country	Case Identification	SCD/SCA	Years Studied	Annual Incidence	Number of Years	Age Range, y	Number of Deaths
Van Camp et al[114]	1995	United States	National Center for Catastrophic Injury Research and media database	SCD	1983-1998	0.3:100,000	10	17-24	160
Corrado et al[29]	2003	Italy	Mandatory death reporting	SCD	1979-1999	2.3:100,000	20	12-35	55
Maron et al[2]	2009	United States	USA Registry for Sudden death in Athletes	SCA + SCD	1980-2006	0.6:100,000	27	8-39	690
Drezner et al[102]	2009	United States	1,710 high schools with AEDs surveyed for SCA or SCD	SCA + SCD	2006-2007	4:100,000 SCA + SCD 2.2:100,000 SCD	Within 6 months of survey	14-17	14
Harmon et al[114]	2011	United States	Parent Heat Watch database, NCAA Resolutions list, insurance claims	SCD	2004-2008	2.3:100,000	4	18-26	37
Marijon et al[115]	2011	France	Emergency medical response to confirmed cardiac cases	SCA + SCD	2005-2010	1:100,000	5	12-75	820
Steinvil et al[100]	2011	Israel	Retrospective review (2 Israeli newspapers by 2 media researchers)	SCD	1985-2009	1st 2.5:10,000 2nd 2.6:100,000	24	12-44	24
Roberts et al[71]	2013	United States	Minnesota State High School League records	SCD	1993-2012	0.24:100,000	19	12-19	4
Maron et al[116]	2013	United States	USA Registry for Sudden Death in Athletes and NCAA resolutions list for cardiac cases	SCD	2002-2011	1.6:100,000 presumed 1.2:100,000 confirmed	9	17-26	64
Maron et al[99]	2013	United States	USA Registry of Sudden Death in Athletes	SCD	1986-2011	0.6:100,000	26	12-18	13
Toresdahl et al[117]	2014	United States	2,149 school students—events occurred on school campus	SCA + SCD	2009-2011	1.1:100,000	2	14-18	18 SCA 2 SCD
Harmon et al[4]	2015	United States	NCAA database	SCD	2003-2013	1.9:100,000	10	17-24	79
Marijon et al[118]	2015	United States	Population the Oregon-Sudden Unexpected Death Study (Oregon-SUDS)	SCA	2002-2013	2.2:100,000 (during sports activities)	11	35-65	1,247 SCA cases, 63 SCA during sports activities
Malhotra et al[72]	2018	United Kingdom	Football association registry	SCD	1996-2016	6.8:100,000	20	16	8
Peterson et al[14]	2021	United States	National Center for Catastrophic Sports Injury Research in collaboration with national sports organizations	SCD + SCA	2014-2018	1.5:100,000 (high school) 1.9:100,000 (NCAA level)	4	11-29	331 SCA, 173 SCD

NCAA = National Collegiate Athletic Association; SCA = sudden cardiac arrest; SCD = sudden cardiac death.

- Rare
- Incidence varies amongst studies
- 1.2-1.9/100,000 (NCAA 17-24 yrs)
- 3.6/100,000 --> 0.9/100,000 after screening initiated (Italy)
- 0.47-1.21/100,000 (age < 35) vs. 6.64/100,000 (age > 35)

Finocchiaro et al, JACC 2023

Children's National

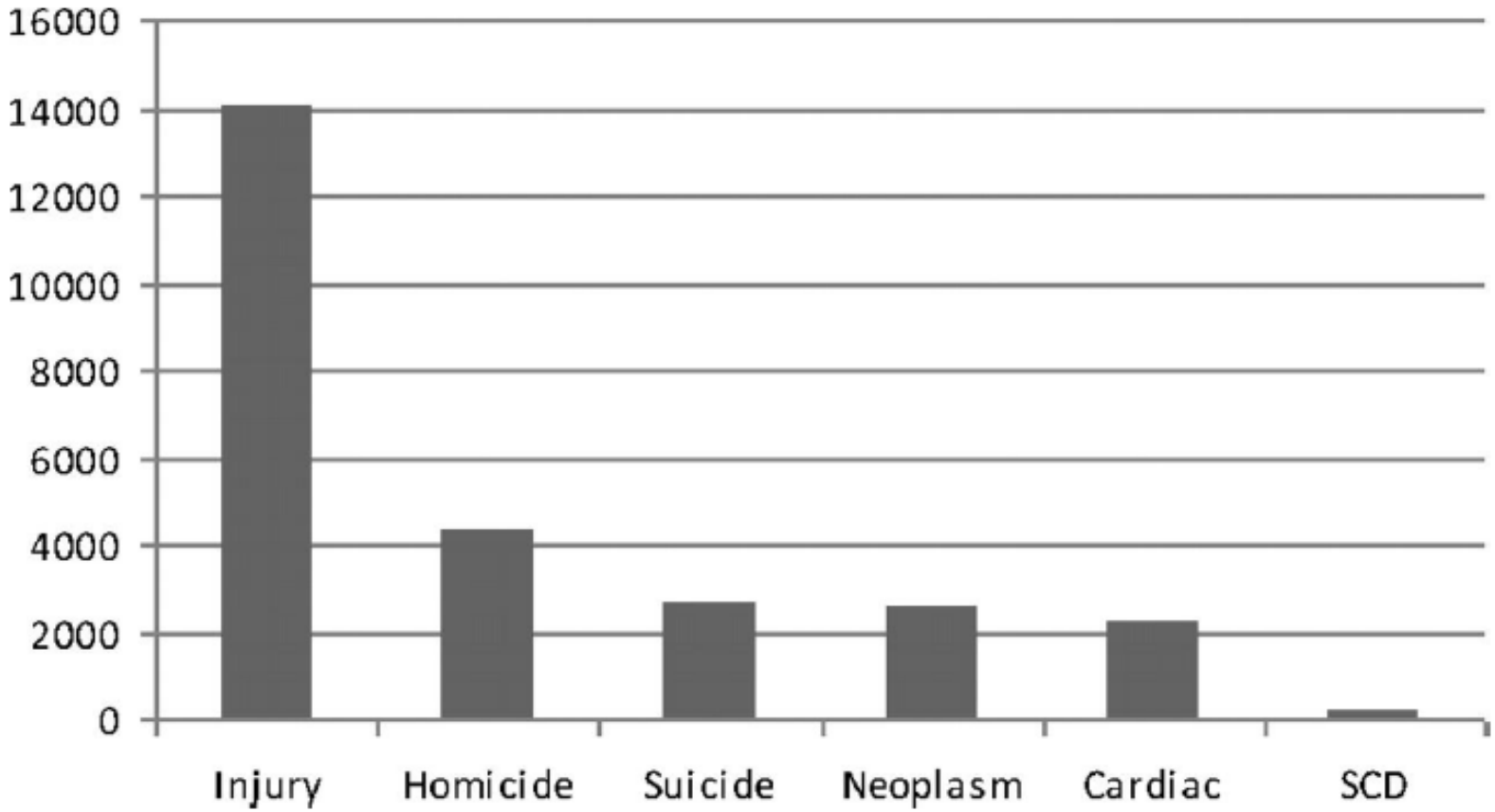
SCD – Young Incidence and Prevalence– Young athletes (< 35 years of age)

- High school: 1:50,000-1:80,000 athlete years (AYs)
- College 1:63682 AYs (newest data from 2024)
  - Men 1:43348 AYs
    - » incidence rate ratio of 3.8 compared to women
  - African American athletes 1:26,704 AYs
    - » incidence rate ratio of 2.8 compared to Caucasian athletes (NCAA)
  - Basketball players
    - » Division I, male basketball players 1:8188 AYs (1:2000 over a 4-year career), white>black
  - Men's basketball and football account for 50-61% of all identified cases

- Asif I, Harmon K. Incidence and Etiology of Sudden Cardiac Death: New Updates for Athletic Departments. Sports Health. 2017;9(3):268-279.
- Drezner JA, O'Connor FG, Harmon KG, Fields KB, Asplund CA, Asif IM, et al. AMSSM Position Statement on Cardiovascular Preparticipation Screening in Athletes: Current Evidence, Knowledge Gap, Recommendations, and Future Directions. Clin J Sport Med. 2016; 26(5): 347-361.
- Peterson DF, Kucera K, Thomas LC, et al. Aetiology and incidence of sudden cardiac arrest and death in young competitive athletes in the USA: a 4-year prospective study. Br J Sports Med. 2021;55(21):1196–1203. https://doi.org/10.1136/ bjsports-2020-102666
- Finocchiaro G, Sharma S, et al. Sudden Cardiac Death in Young Athletes, JACC state of the art review. JACC. 2024;83(2):350-370.
- Petek BJ, Harmon KG, et al. Sudden Cardiac Death in National Collegiate Athletic Association Athletes: A 20-year study. Circulation. 2024;149:80-90.

SCD in Context

Fig. 1 Causes of death in the US population aged 1 to 21 years. Data from the Centers for Disease Control and Prevention (http://webappa.cdc.gov/sasweb/ncipc/leadcaus10.html) [2]



Link & Estes, Circulation 2012

Children's National

Petek et al, Circulation 2024
Cardiac etiology in 13% of sudden death

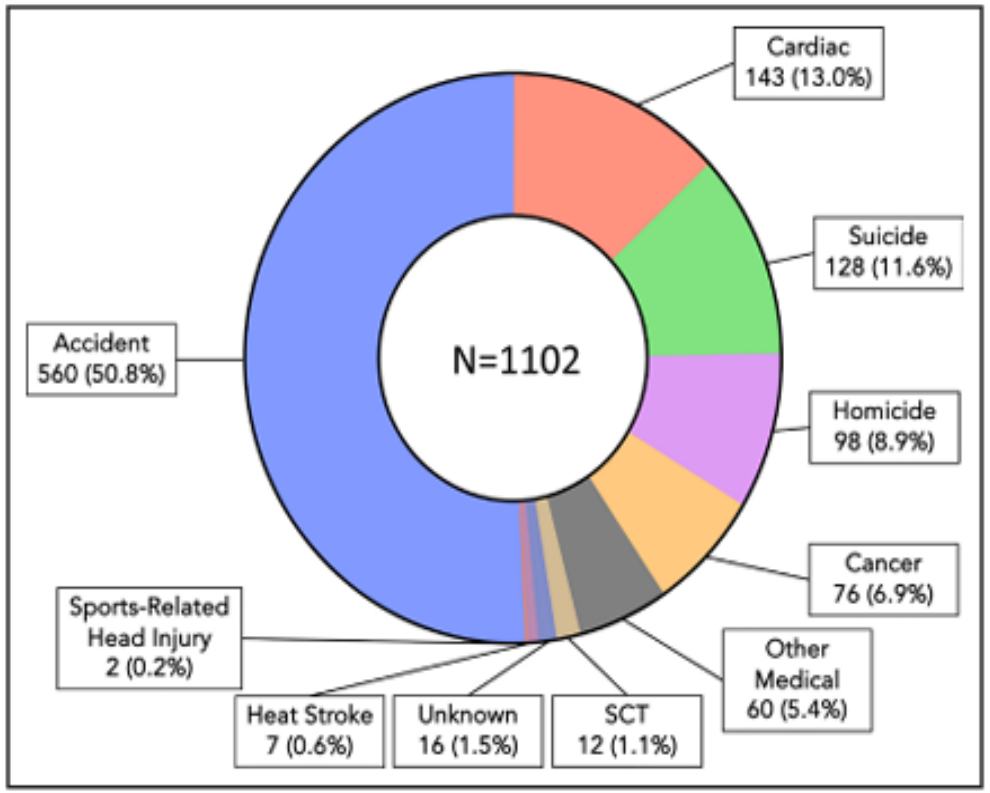
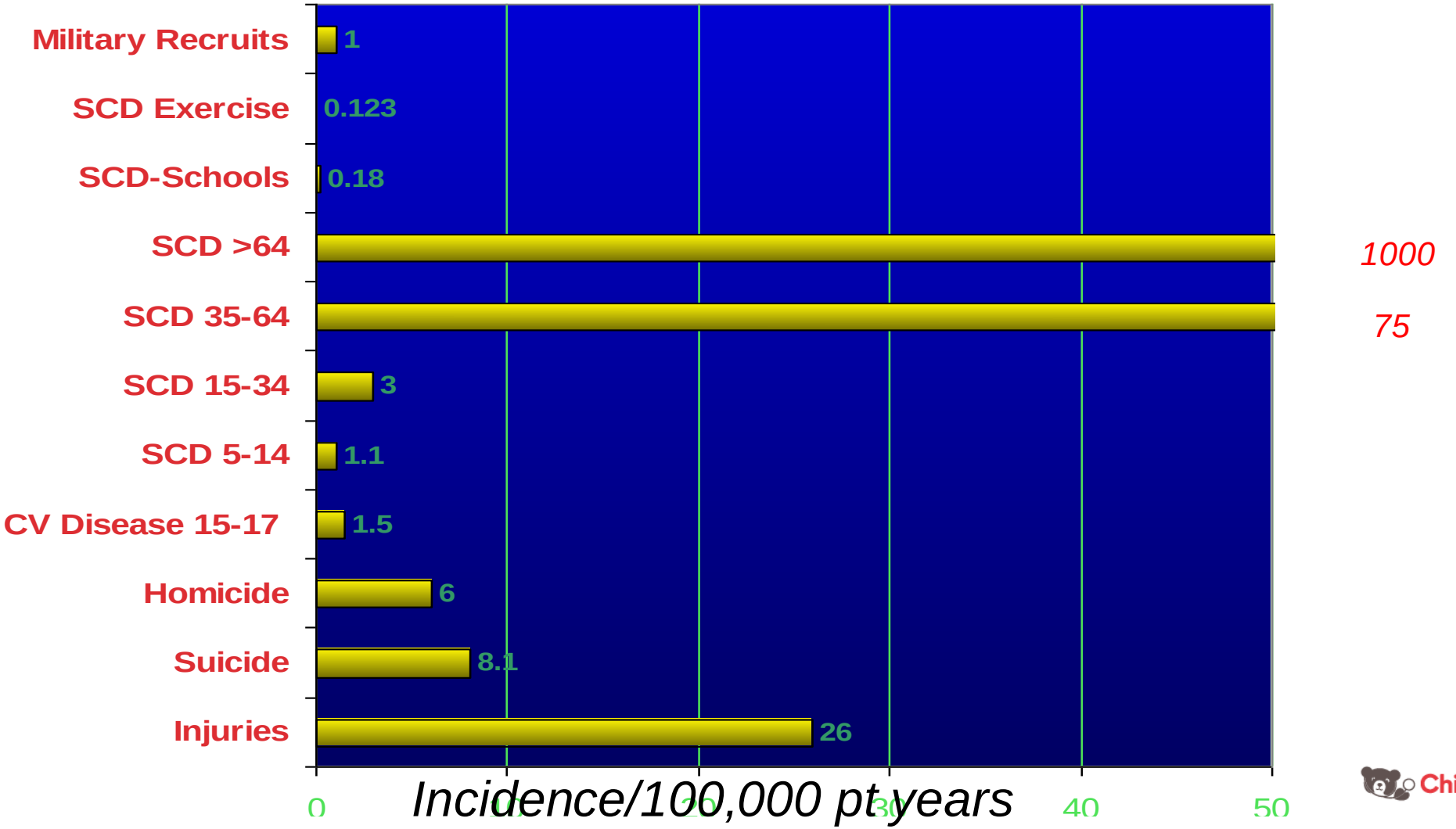


Figure 1. Causes of death among National Collegiate Athletic Association athletes (n=1102).
SCT indicates sickle cell trait.

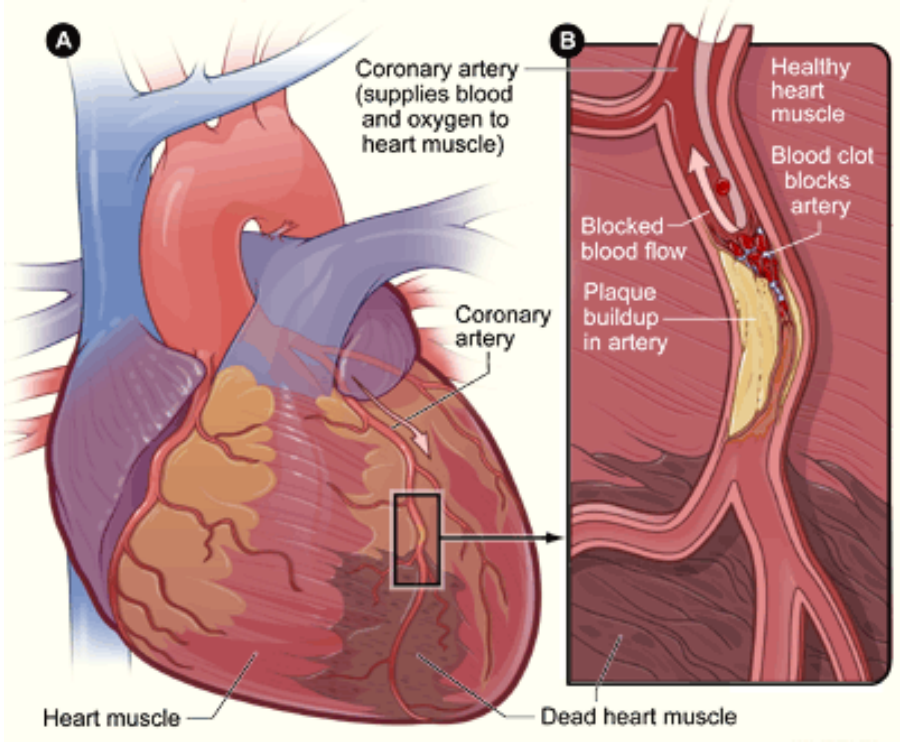
Children's National

Adolescent SCD in Context



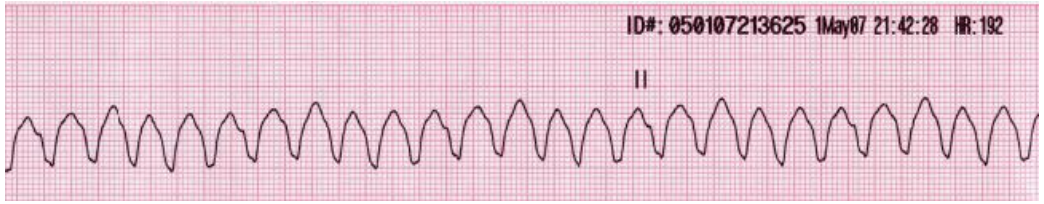
Children's National

Sudden Death in Adults vs. Children: The Biggest Difference



Kids don't get CAD

...most pediatric VT non-ischemic



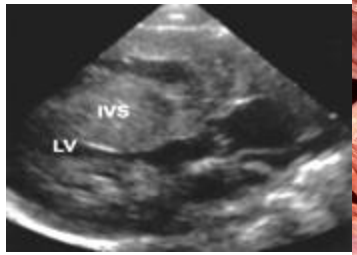
Children's National

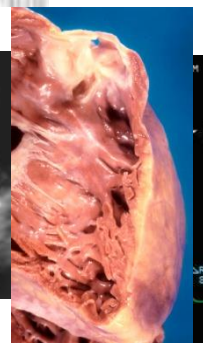
Causes of Pediatric Sudden Death

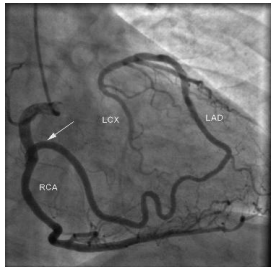
- Cardiac arrhythmias
- Congenital and acquired heart diseases
- Neurological or neurovascular abnormalities (aneurysms)
- Pulmonary diseases, incl. asthma, anaphylaxis
- Drug toxicities

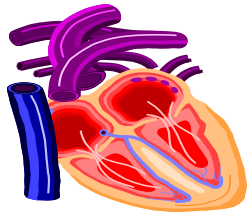
Screening: What are We Screening For?

- Arrhythmia Vulnerability Syndromes
  - LQTS
  - BrS/ARVC/CPVT/SQTS/PCCSD
  - WPW
  - CCHB
- Cardiomyopathies
  - HCM, DCM, LVNC, RCM
- Coronary artery abnormalities
- Congenital heart disease





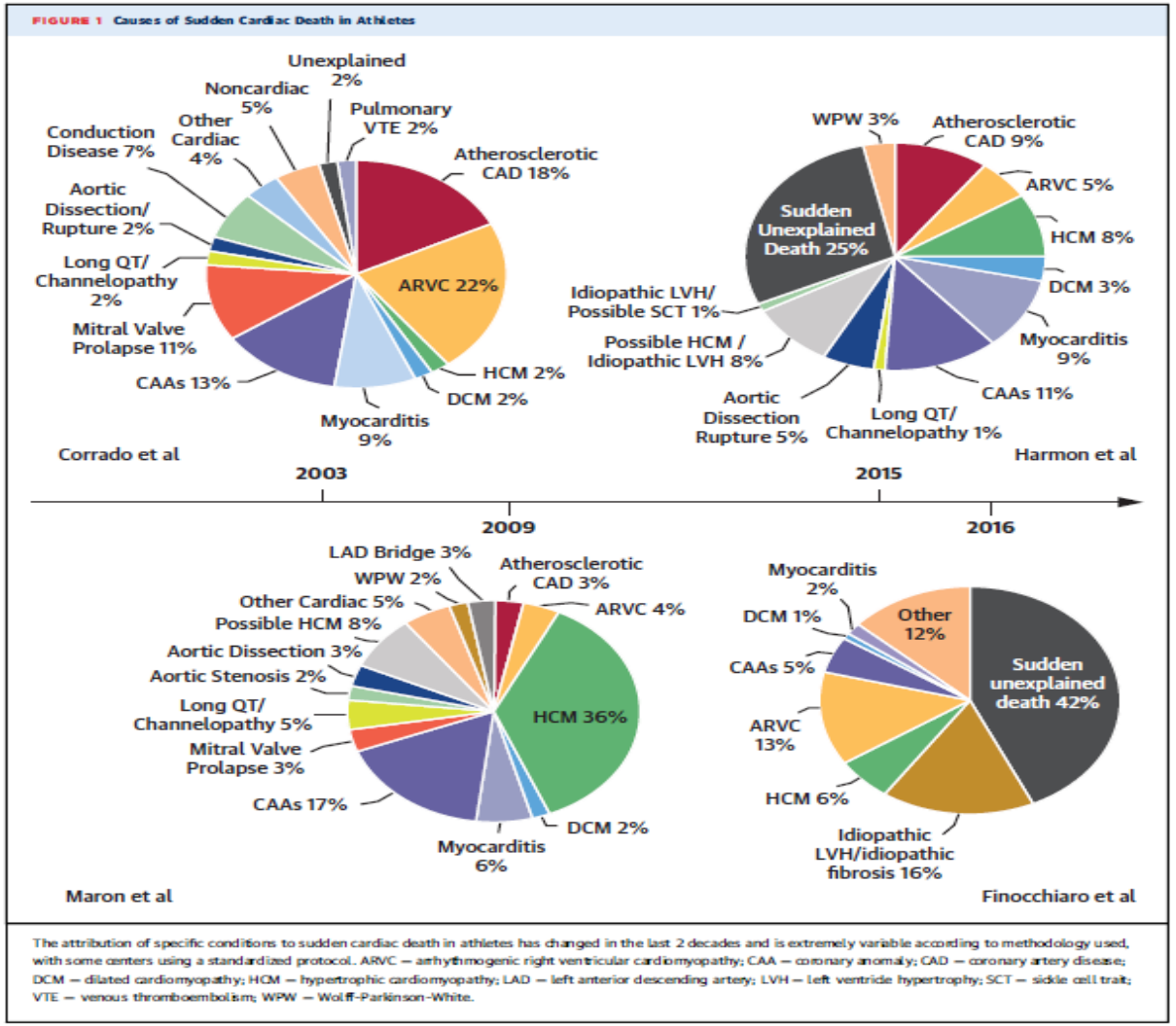




Children's National

Etiologies of SCD in Athletes over time

Finocchiaro et al, JACC 2023



Children's National

Exertional status of SCD

Petek et al. Circulation, 2024
Overall, ~50% exertional

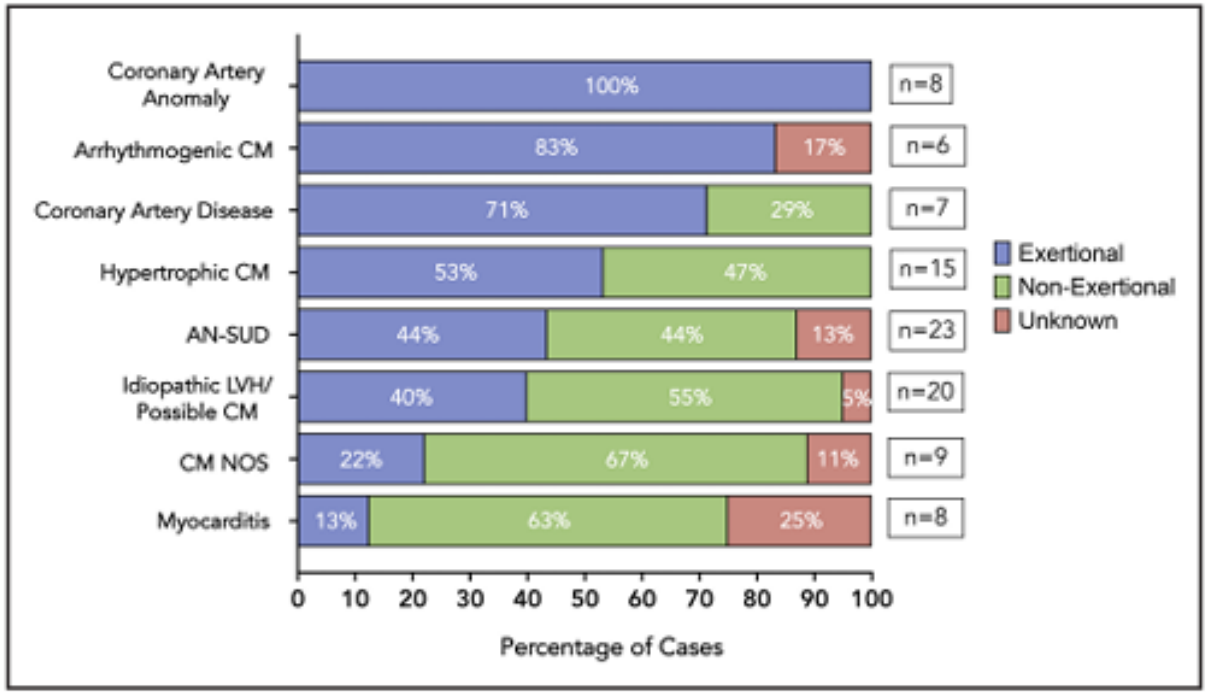
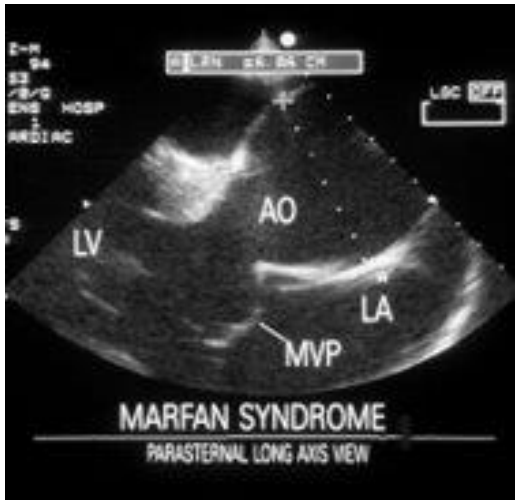


Figure 4. Exertional status at time of death by common causes of sudden cardiac death.
AN-SUD indicates autopsy-negative sudden unexplained death; CM, cardiomyopathy; LVH, left ventricular hypertrophy; NOS, not otherwise specified; and SCD, sudden cardiac death.

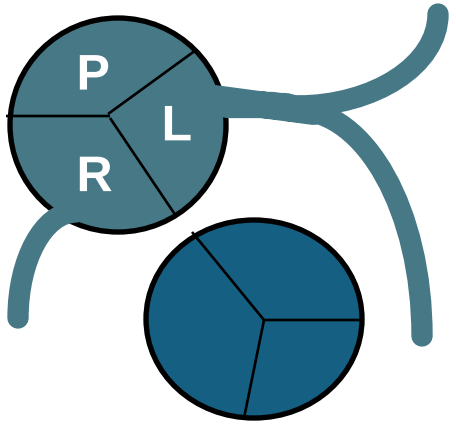
Children's National

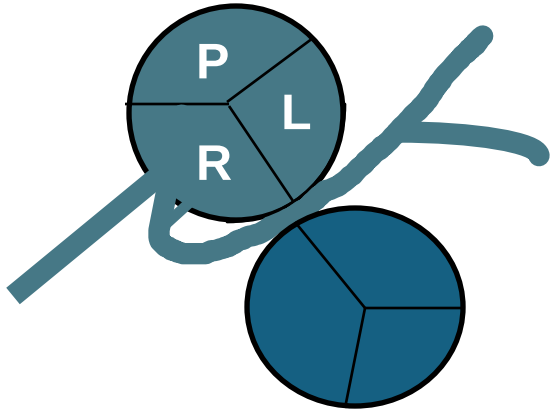
Etiologies and screening

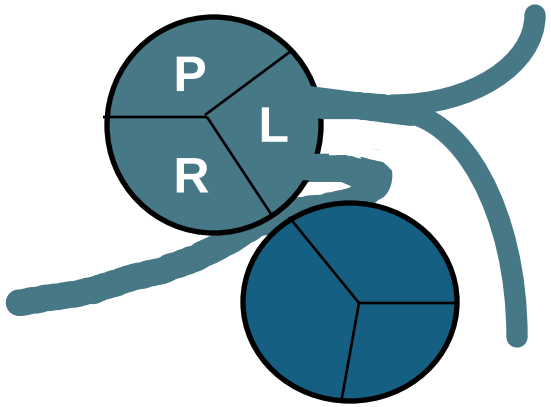
- Arrhythmogenic
  - EKGs may have more value (eg. LQTS, WPW)
  - CPVT: normal EKG at baseline, ventricular ectopy with exercise (burst)
- Cardiomyopathy
  - HCM: family history, usually (~90%) with EKG abnormalities (some false negatives, voltage criteria for LVH is not HCM)
  - ARVC: more common in certain regions/ethnicities
- CT disorder
  - Marfan Syndrome, Loeys-Dietz: family hx, PE findings
- SUD
  - Family history?
  - Post-mortem genetic testing?



Coronary Artery Abnormalities



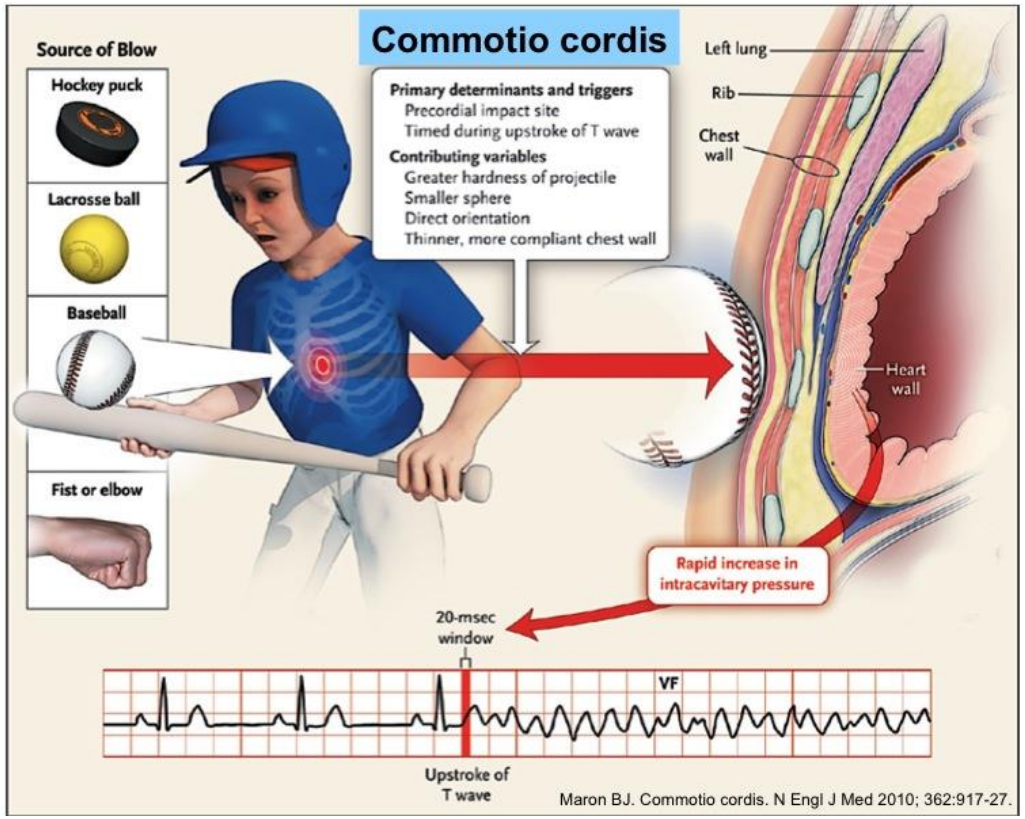




- Asymptomatic, nl EKG
- Often incidental finding on echo
- AAORCA management is challenging

Other etiologies

- Commotio Cordis
- Performance enhancing drugs



Children's National

What are We Screening With?

- History & Physical
- Pre-participation Forms
  - (AHA/AAP 14-point evaluation)
- ECG?
- Echo?
- More?

"Off hand, I'd say you're suffering from an arrow through your head, but just to play it safe, I'm ordering a bunch of tests."

History

This section is to be carefully completed by the student and his/her parent(s) or legal guardian(s) before participation in interscholastic athletics in order to help detect possible risks.

Explain "YES" answers in the space provided. Circle questions you don't know the answer to.

		Yes	No
1.	Has a doctor ever denied or restricted you participation in sports for any reason?	☐	☐
2.	Do you have an ongoing medical condition (like diabetes or asthma)?	☐	☐
3.	Are you currently taking any prescription or nonprescription (over-the-counter) medicines or pills?	☐	☐
4.	Do you have allergies to medicines, pollens, foods, or stinging insects?	☐	☐
5.	Do you think you are in good health?	☐	☐
6.	Have you ever passed out or nearly passed out DURING exercise?	☐	☐
7.	Have you ever passed out or nearly passed out AFTER exercise?	☐	☐
8.	Have you ever had discomfort, pain, or pressure in your chest during exercise?	☐	☐
9.	Does your heart race or skip beats during exercise?	☐	☐
10.	Has a doctor ever told you that you have (check all that apply): ☐ High Blood Pressure ☐ A heart murmur ☐ High Cholesterol ☐ A heart infection		
11.	Has a doctor ever ordered a test for your heart? (for example, ECG, echocardiogram)	☐	☐
12.	Has anyone in your family died for no apparent reason?	☐	☐
13.	Does anyone in your family have a heart problem?	☐	☐
14.	Has any family member or relative died of heart problems or of sudden death before age 50?	☐	☐
15.	Does anyone in your family have Marfan syndrome?	☐	☐
16.	Have you ever spent the night in a hospital?	☐	☐
17.	Have you ever had surgery?	☐	☐
18.	Have you ever had an injury, like a sprain, muscle or ligament tear, or tendinitis, that caused you to miss a practice or game? If yes, circle affected area below:	☐	☐
19.	Have you had any broken or fractured bones or dislocated joints? If yes, circle below:	☐	☐
20.	Have you had a bone or joint injury that required x-rays, MRI, CT, surgery, injections, rehabilitation, physical therapy, a brace, a cast, or crutches? If yes, circle below:	☐	☐

Head	Neck	Shoulder	Upper Arm	Elbow	Forearm	Hand / Fingers	Chest
Upper back	Lower back	Hip	Thigh	Knee	Calf/shin	Ankle	Foot / Toes

21.	Have you ever had a stress fracture?	☐	☐
22.	Have you been told that you have or have you had an x-ray for atlantoaxial (neck) instability?	☐	☐
23.	Do you regularly use a brace or assistive device?	☐	☐
24.	Has a doctor ever told you that you have asthma or allergies?	☐	☐
25.	Do you cough, wheeze, or have difficulty breathing during or after exercise?	☐	☐
26.	Is there anyone in your family who has asthma?	☐	☐
27.	Have you ever used an inhaler or taken asthma medicine?	☐	☐
28.	Were you born without or are you missing a kidney, an eye, a testicle, or any other organ?	☐	☐
29.	Have you had infectious mononucleosis (mono) within the last month?	☐	☐
30.	Do you have any rashes, pressure sores, or other skin problems?	☐	☐
31.	Have you had a herpes skin infection?	☐	☐
32.	Have you ever had a head injury or concussion?	☐	☐
33.	Have you been hit in the head and been confused or lost your memory?	☐	☐
34.	Have you ever had a seizure?	☐	☐
35.	Do you have headaches with exercise?	☐	☐
36.	Have you ever had numbness, tingling, or weakness in your arms or legs after being hit or falling?	☐	☐
37.	Have you ever been unable to move your arms or legs after being hit or falling?	☐	☐
38.	When exercising in the heat, do you have severe muscle cramps or become ill?	☐	☐
39.	Has a doctor told you that you or someone in your family has sickle cell trait or sickle cell disease?	☐	☐
40.	Have you had any problems with your eyes or vision?	☐	☐
41.	Do you wear glasses or contact lenses?	☐	☐
42.	Do you wear protective eyewear, such as goggles or a face shield?	☐	☐
43.	Are you happy with your weight?	☐	☐
44.	Are you trying to gain or lose weight?	☐	☐
45.	Has anyone recommended you change your weight or eating habits?	☐	☐
46.	Do you limit or carefully control what you eat?	☐	☐
47.	Do you have any concerns that you would like to discuss with a doctor?	☐	☐
48.	Record the dates of your most recent immunizations (shots)		

Tdap _____ MMR _____ Hepatitis B _____

Chicken Pox _____ Meningococcal _____

FEMALES ONLY

49.	Have you ever had a menstrual period?	☐	☐
50.	How old were you when you had your first menstrual period?	_____	
51.	How many periods have you had in the last 12 months?	_____	

Explain "Yes" Answers Here: (Attach additional sheets as needed)

_____

_____

_____

_____

NAME_____ DATE OF BIRTH_____ SCHOOL_____

Height		Weight		Sex Assigned at Birth		
BP /	RR	Resting pulse	Vision R 20/	L 20/	Corrected ☐ Yes	☐ No
Pediatric Population > 13 years and older within normal limits =			BP (F) 102-121/64-79 mmHg		BP (M) 102-124/64-80 mmHg	
			RR 12-20 breaths per minute		Pulse 55-90 bpm	

MEDICAL	NORMAL	ABNORMAL FINDINGS
Appearance (Marfan stigmata: kyphoscoliosis, high-arched palate, pectus excavatum, arachnodactyly, hyperlaxity, myopia, mitral valve prolapse, and aortic insufficiency)		
Eyes/ears/nose/throat (Pupils equal, hearing)		
Neck - Lymph nodes, thyroid enlargement		
Heart (Murmurs: auscultation standing, supine, +/- Valsalva)		
Pulses (radial, femoral, pedal)		
Lungs		
Abdomen		
Skin (Herpes simplex virus, lesions suggestive of MRSA or tinea corporis)		
Neurologic (cranial nerve and gait)		

HEART HEALTH QUESTIONS ABOUT YOU	YES	NO
9. Have you ever passed out or nearly passed out DURING or AFTER exercise?	☐	☐
10. Have you ever had discomfort, pain, tightness, or pressure in your chest during exercise?	☐	☐
11. Does your heart race, flutter in your chest or skip beats (irregular beats) during exercise?	☐	☐
12. Has a doctor ever ordered a test for your heart? For example, electrocardiography or echocardiography.	☐	☐
13. Has a doctor ever told you that you have any heart problems, including: ☐ High blood pressure ☐ A heart murmur ☐ High cholesterol ☐ A heart infection ☐ Kawasaki Disease ☐ Other _____	☐	☐
14. Do you get light-headed or feel shorter of breath than your friends during exercise?	☐	☐
15. Have you ever had a seizure?	☐	☐
HEART HEALTH QUESTIONS ABOUT YOUR FAMILY	**YES**	**NO**
16. Does anyone in your family have a heart problem?	☐	☐
17. Has any family member or relative died of heart problems or had an unexpected or unexplained sudden death before age 50 (including drowning or unexplained car crash)?	☐	☐
18. Does anyone in your family have a genetic heart problem such as hypertrophic cardiomyopathy (HCM), Marfan syndrome, arrhythmogenic right ventricular cardiomyopathy (ARVC), long QT syndrome (LQTS), short QT syndrome (SQTS), Brugada syndrome, or catecholaminergic polymorphic ventricular tachycardia (CPVT)?	☐	☐
19. Has anyone in your family had a pacemaker or an implanted defibrillator before age 50?	☐	☐

Children's National

Screening Children for Cardiac Risk

Primary Physician/Caretaker Screening - ***Annual***

•Detailed history, inquiring about pertinent symptoms (Syncope, chest pain, palpitations, dizziness, rapid heart rate)
•Exercise history (endurance, types of exercise, exercise-associated symptoms)
•Discussions regarding illicit drug use, alcohol, caffeine, smoking, medications (including over-the-counter, “health/nutritional supplements”, anabolic steroids)
•Family history of congenital heart disease, arrhythmias, sudden death, inherited cardiac diseases (Long QT, HCM, Marfan)
•Physical exam: vital signs (BP), cardiac exam, 4-extremity pulses, perfusion, weight, general overall health and fitness

When do I need a subspecialist?

•*Referral suggested if*:

•Exercise-associated symptoms or serious-sounding symptoms at rest
•Suspicious history, physical, malignant family history or other potential risk factors

PPE Tips

- History:
  - Get their attention!
  - Skill in asking questions
  - Document as many details as possible
  - Low threshold to contact parent
  - Seizures vs syncope?
- PE
  - Murmur
  - Reproducible chest pain

How good is the PPE?

- Limited data
  - Very low sensitivity and only “ok” specificity
- Sudden death (or arrest) is often 1st symptom
- Lack of uniformity
- Non-physicians?
- Pre-test probabilities, “non-cardiac” chest pain, syncope, murmur, etc.
- Family history questions (broad) vs. screening guidelines

PPE should be done, but be thoughtful and discerning!

Should an EKG be done?

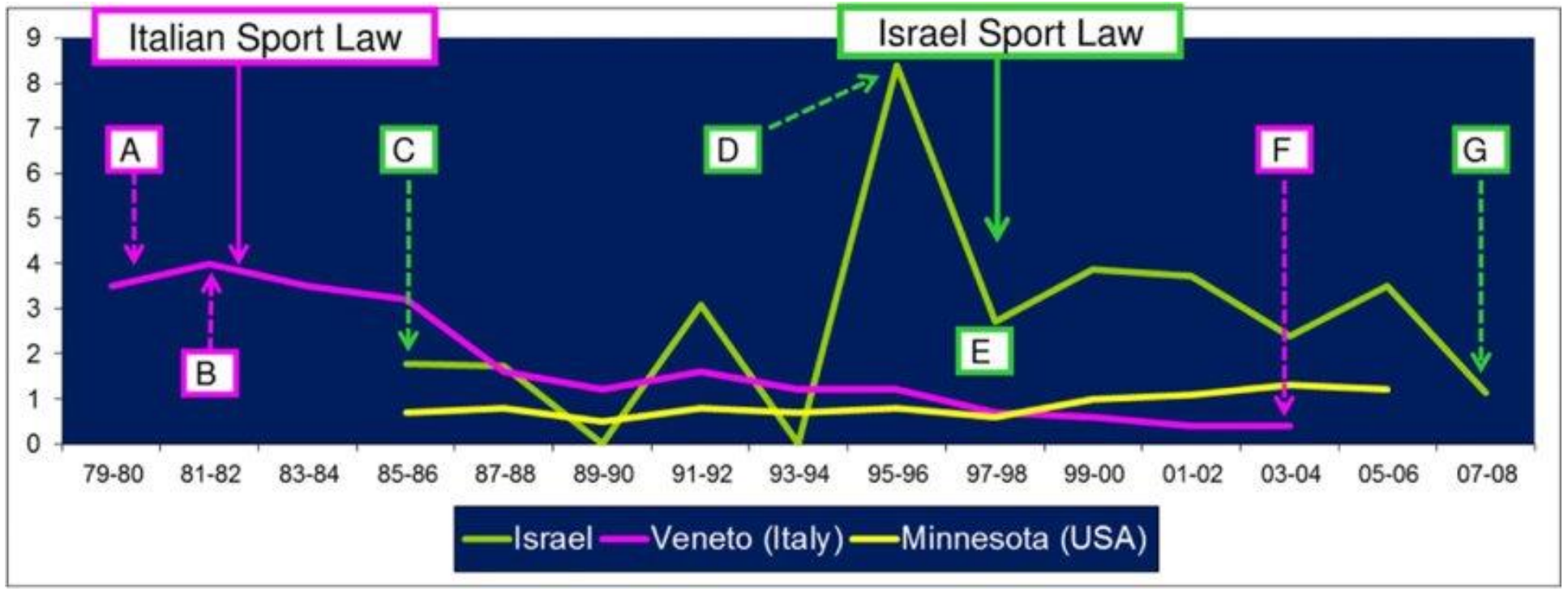
- Not currently recommended in the US
- Various local or national organizations may have specific requirements for other testing (ekg, echo, etc.)
- Better sensitivity and specificity than the PPE alone, but…
    - With cardiologist-read EKGs, 1-3% false positives
    - In black patients, up to 6-7% false positives
    - Computer read has a 2-5% false positive (possibly higher, eg. QTc)
    - HCM may have up to 10% false negative EKG and ARVC > 30% false negative
    - Yearly EKG? With higher SUD diagnoses (EKG findings preceding echo changes)

EKG Screening

- Italy vs. USA
  - What's different? (other than food and football)
  - Ethnic and racial heterogeneity; impacts test accuracy
  - Genetic and phenotypic differences (ARVD vs HCM)
  - Size of population to be screened (15M+ athletes in US)
- Cost of screening and payor ($750 million in 2007 estimate)
- Inappropriate disqualification
- Unnecessary additional testing, with associated costs (over $2 billion)
- Unnecessary anxiety
- Huge increase in physician manpower and other resources

Mandatory Electrocardiographic Screening of Athletes to Reduce Risk for Sudden Death: Proven Fact or Wishful Thinking?

Steinvil et al. JACC 2011



"Mandatory ECG screening of athletes had no apparent effect on risk for SCD"

Children's National

Accuracy of ECG-inclusive preparticipation screening in athletes: more work to be done

Expert Rev. Cardiovasc. Ther. 10(6), 671–673 (2012)

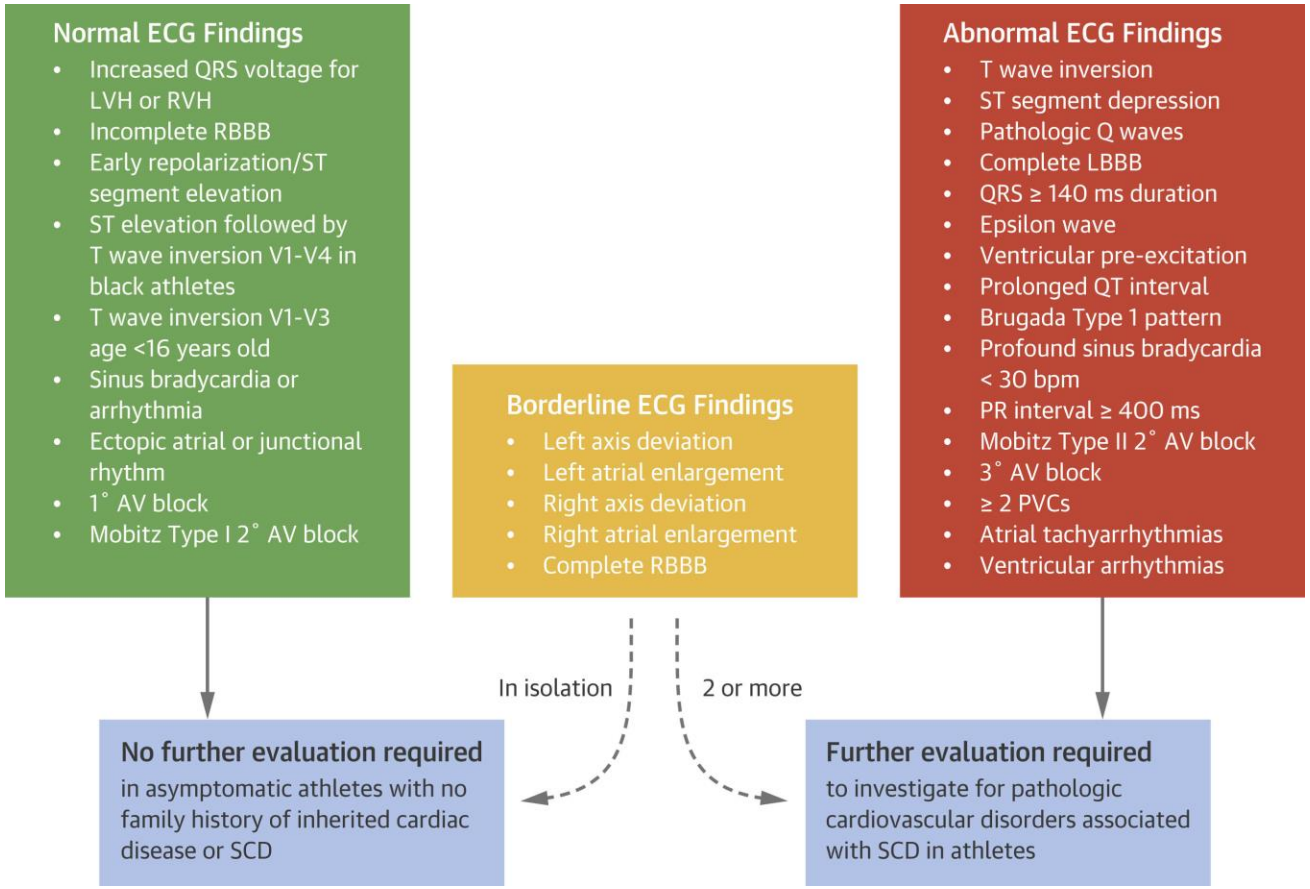
"The controversial role of ECG during preparticipation screening remains one of the most widely and passionately debated areas in cardiovascular and sports medicine."

"Only with more data will we be able to responsibly determine the merits of adding ECG to the basic foundation of medical history and physical examination."

Children's National

International EKG Criteria

Sharma, S, Drezner, J, Baggish, A. et al. International Recommendations for Electrocardiographic Interpretation in Athletes. *JACC*. 2017 Feb, 69 (8) 1057–1075.

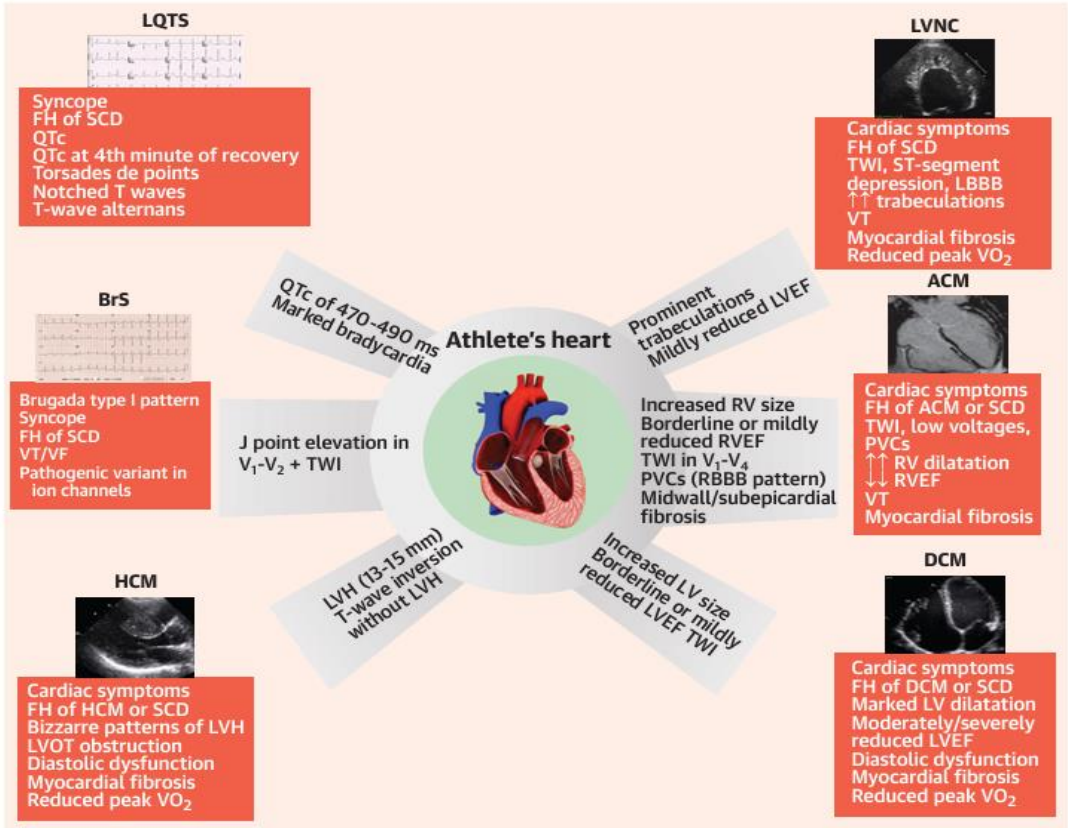


- Reduces false positives and unnecessary testing
- Athletes
- Cardiology-trained readers
- Unclear if will improve the PPE at a population level

Children's National

It gets complicated…

FIGURE 3 Overlap Between "Athlete's Heart" and Predominant Causes of SCD



Physiological electrical, structural, and functional changes in athletes may overlap with cardiac disease with a gray area that often needs clarification through second line cardiac investigations. ACM = arrhythmogenic cardiomyopathy; BrS = Brugada syndrome; DCM = dilated cardiomyopathy; FH = family history; HCM = hypertrophic cardiomyopathy; LQTS = long QT syndrome; RV = right ventricle; LVNC = left ventricular noncompaction; LVOT = left ventricular outflow tract; MV = mitral valve; RVEF = right ventricular ejection fraction; SCD = sudden cardiac death; TWI = T-wave inversion; VF = ventricular fibrillation; VT = ventricular tachycardia.

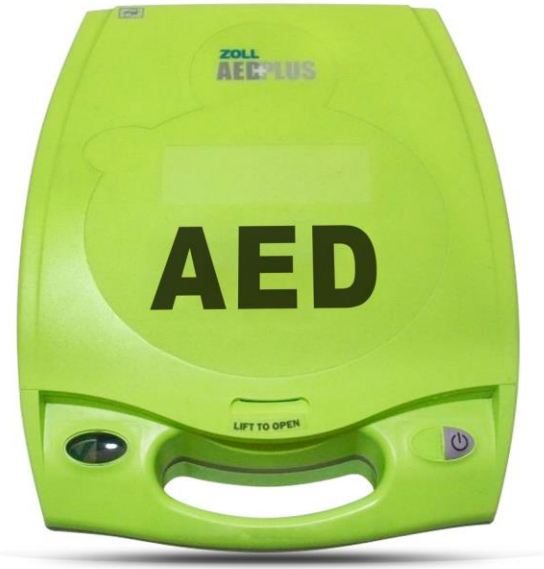
Children's National

Secondary Prevention of SCD

- Emergency Action Plan
  - Identifying key personnel and roles
  - Ensuring access to life saving equipment (eg. AEDs)
  - Coordinating a multi-disciplinary team for a well-rehearsed response
- Coaches/staff (and teammates?) trained in BLS
  - Nearest to the player/allows for immediate resuscitation

AED

- Device that looks for shockable heart rhythms
- Delivers a defibrillation shock if needed
- Small, portable
- Simple, automatic
- Relatively inexpensive
- In children:
    - AEDs are readily available (no Rx), easy to use
    - AED algorithms are proven accurate in children
    - Some AEDs come with pediatric pads
    - Some AEDs have attenuated pediatric output
    - AEDs are safe and effective in children
    - (…and have been life-saving!)



Treatment of Cardiac Emergencies

- Be Prepared (CPR Training, Equipment, Staff)
- Remain Calm
- Emergency Readiness – Crash Cart, Meds, Phone
- Call for Help ASAP - Activate EMS
- Identify Problem (ABCs: Airway, Breathing, Circ.)
- Check Medical History, if known
- Cardiac Arrhythmia?: AED – Utilize if Available

Decreasing incidence of SCD

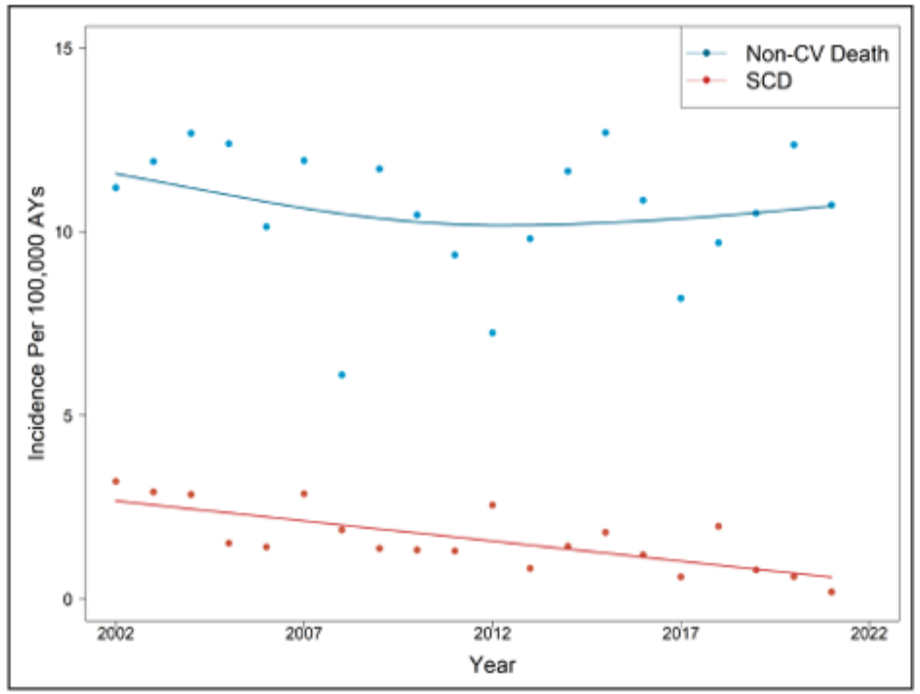


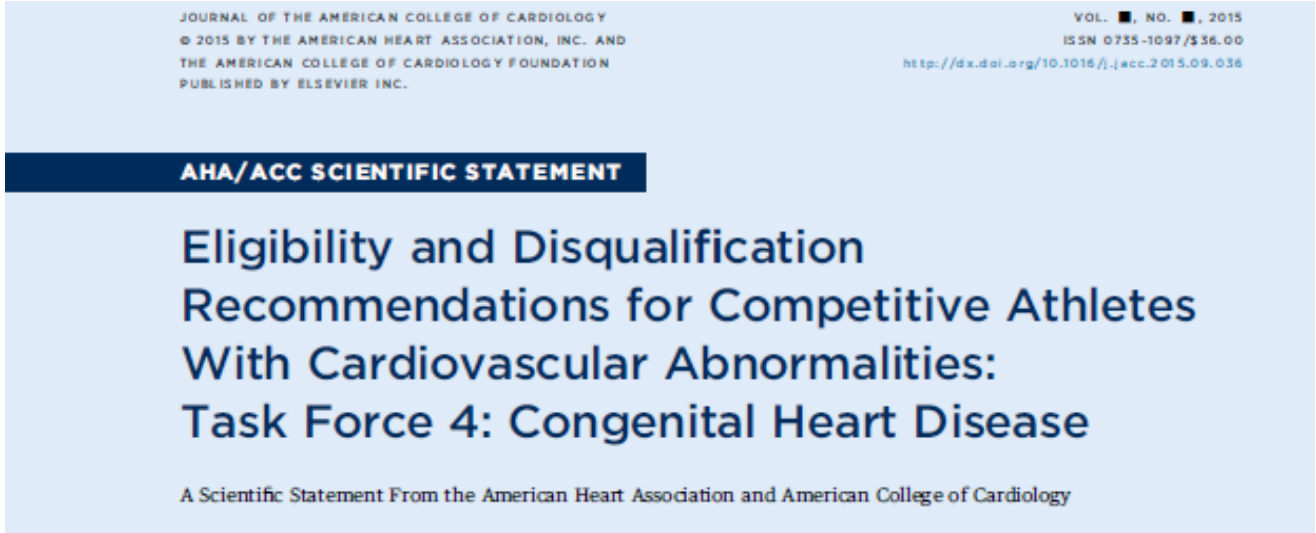
Figure 2. Yearly non–cardiovascular death and sudden cardiac death incidence among National Collegiate Athletic Association athletes.
Blue dots indicate non–cardiovascular death yearly incidence rate; blue line, cubic smoothing spline curve of non–cardiovascular (CV) death incidence over the study period; red dots, sudden cardiac death (SCD) yearly incidence rate; and red line, cubic smoothing spline curve of SCD incidence over the study period. AY indicates athlete-year.

- Possibly due to greater use of emergency action plans (EAPs) and AEDs
- No increase seen with COVID-19

Petek et al. Circulation, 2024.

Children's National

Eligibility Recommendations for Athletes with CHD



The level of sports participation recommended includes consideration of both the training and the competitive aspects of the activity but must be individualized to the particular patient, taking into account the patient's functional status and history of surgery. Noninvasive testing, such as formal exercise testing, Holter monitoring, echocardiography, and cardiac magnetic resonance imaging studies, is also often useful.

Children's National

Problems with Eligibility Guidelines for CHD

- Dealing with competitive and contact team sports
- Situations where patient and coach may push beyond comfort zones/pressure to perform: organized, emphasis on performance, high intensity
- May unnecessarily restrict patients from beneficial (and fun!) physical activity
    - These activity restrictions are based on the inherent risk of the activity rather than the intensity of a specific patient performing that activity
- Lack of published guidelines for non-competitive sports

*** Do not conflate recreational/leisure physical activity with these guidelines!

✓ Leisure activities are typically submaximal!

✓ Aerobic (submaximal) exercise capacity is normal in most CHD patients even when maximal exercise capacity is decreased

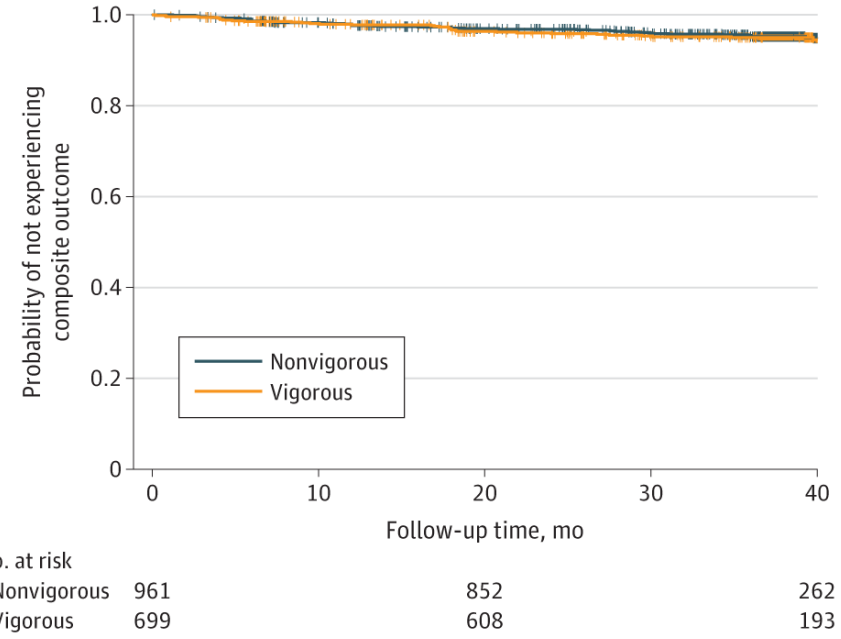
✓ Numerous studies showing safety of exercise training in CHD, specifically at submaximal levels

Change in Focus?

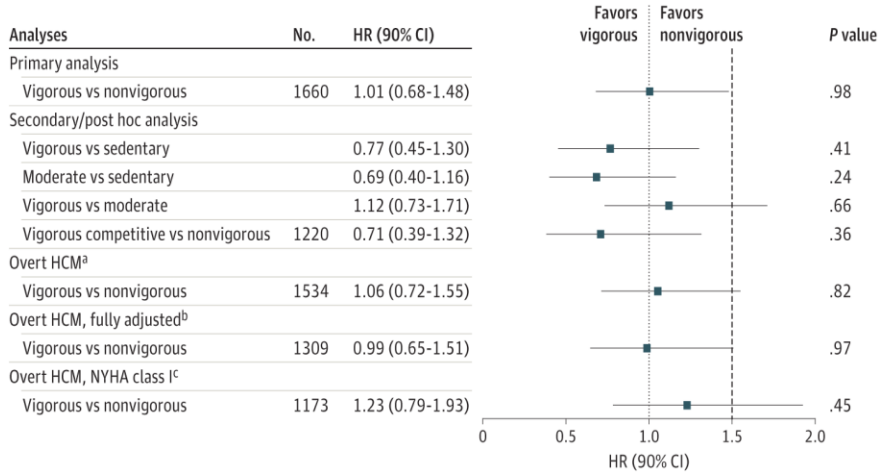
- **As surgical outcomes and long-term prognosis (with longer life expectancy) improve, we need to shift our focus to long-term physical functioning and quality of life**
- **More rapid decline in exercise capacity over time in CHD patients than age and sex-matched controls and possibly starting out somewhat impaired exercise capacity means we need to do more earlier in life**
- **Recent data in (risk assessed and treated) patients with HCM (LIVE-HCM) – no difference in event rate with exercise, long QT syndrome (LIVE-LQTS) – 2 SCA, not with exertion, and nearly all cardiac rehab/exercise testing studies in children with known cardiac issues show a relatively low risk of SCA with physical activity**

Lampert R, Ackerman MJ, et al. Vigorous Exercise in patients with HC. JAMA Cardiol. 2023 Jun; 8(6): 595–605.
Lampert R, et al. Vigorous Exercise in patients with LQTS. Circulation, 2024 Aug; 150(7): 516-530.

LIVE-HCM



Kaplan-Meier Survival Curve for Freedom From Composite End Point (Death, Cardiac Arrest, Appropriate Implantable Cardioverter Defibrillator Shock, or Arrhythmic Syncope) by Exercise GroupVigorous and nonvigorous groups did not differ in freedom from composite end point.



Forest Plot for Hazard Ratio (HR) (1-Sided 95% CI) Comparing Composite Outcomes Between Exercise GroupsHRs for primary, secondary, and post hoc analyses comparing the composite outcome (death, cardiac arrest, appropriate implantable cardioverter defibrillator [ICD] shock, arrhythmic syncope) between those exercising vigorously and those exercising nonvigorously. Presented are 90% 2-sided CIs. The upper limits of these intervals correspond to a 1-sided .05 significance level used to evaluate noninferiority. Primary analysis is shown followed by 2 secondary analyses: pairwise comparisons of the 3 groups and after excluding noncompetitive vigorous individuals to compare vigorous-competitive vs nonvigorous. Post hoc analyses are shown of subgroups.

[a]The first subgroup included those with overt hypertrophic cardiomyopathy (HCM), ie, phenotype-positive only, and controlled for prespecified covariates age, sex, race, recruitment method (site or self), age at diagnosis, and presence of an ICD.

[b]The next model added sudden cardiac death risk factors that differed by an effect size of at least 12% between the groups (history of sudden cardiac arrest and septal thickness).

[c]The final subgroup excluded those with exercise-related symptoms (ie, asymptomatic, phenotype-positive only).

Children's National

LIVE-LQTS

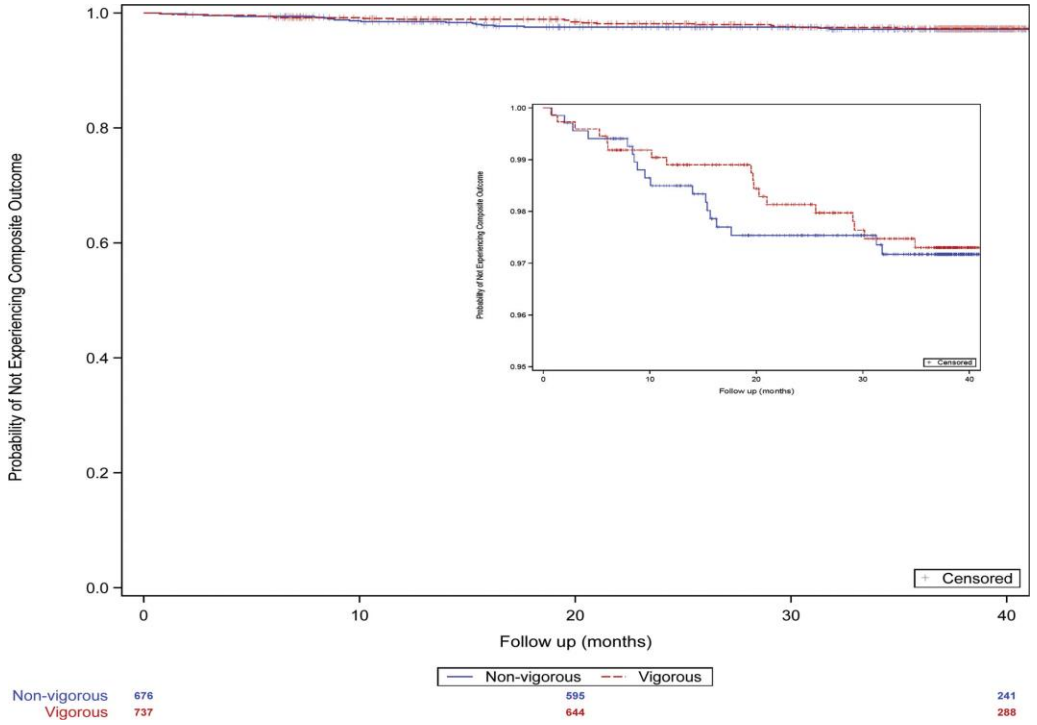


Figure 2.Kaplan-Meier survival curve for freedom from composite end point (death, sudden cardiac arrest, appropriate implantable cardioverter defibrillator shock, or arrhythmic syncope) by exercise group. There was no statistically significant difference in freedom from composite end points between the those exercising vigorously and those exercising nonvigorously. Inset shows a magnified y axis.

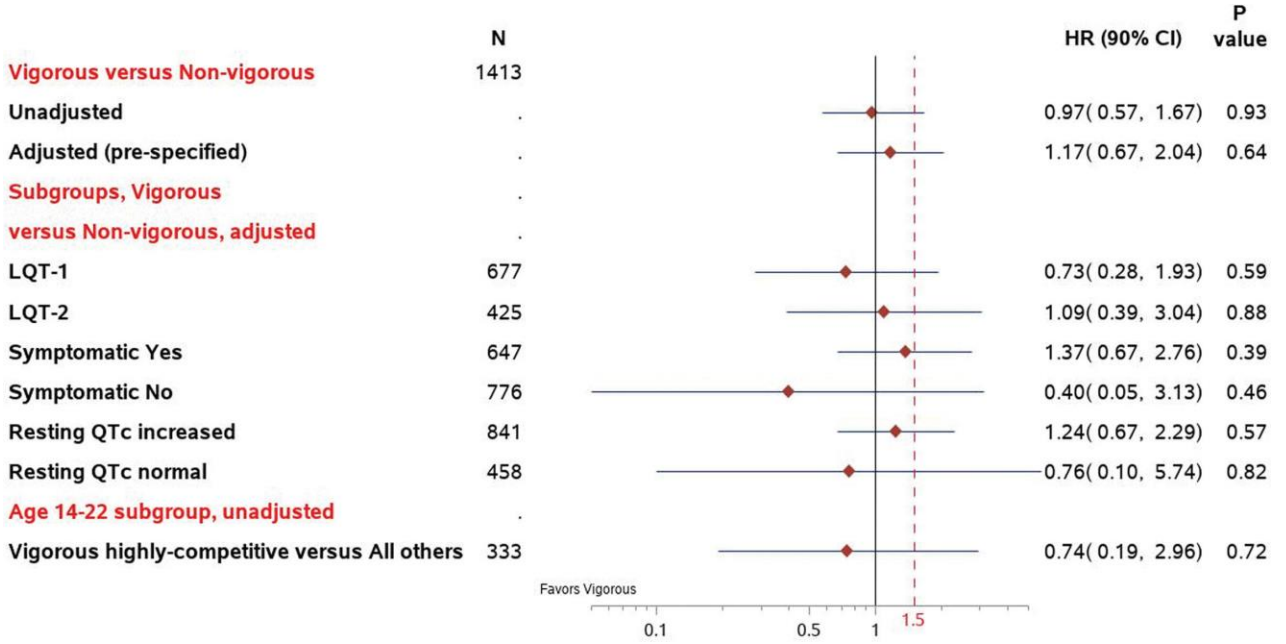
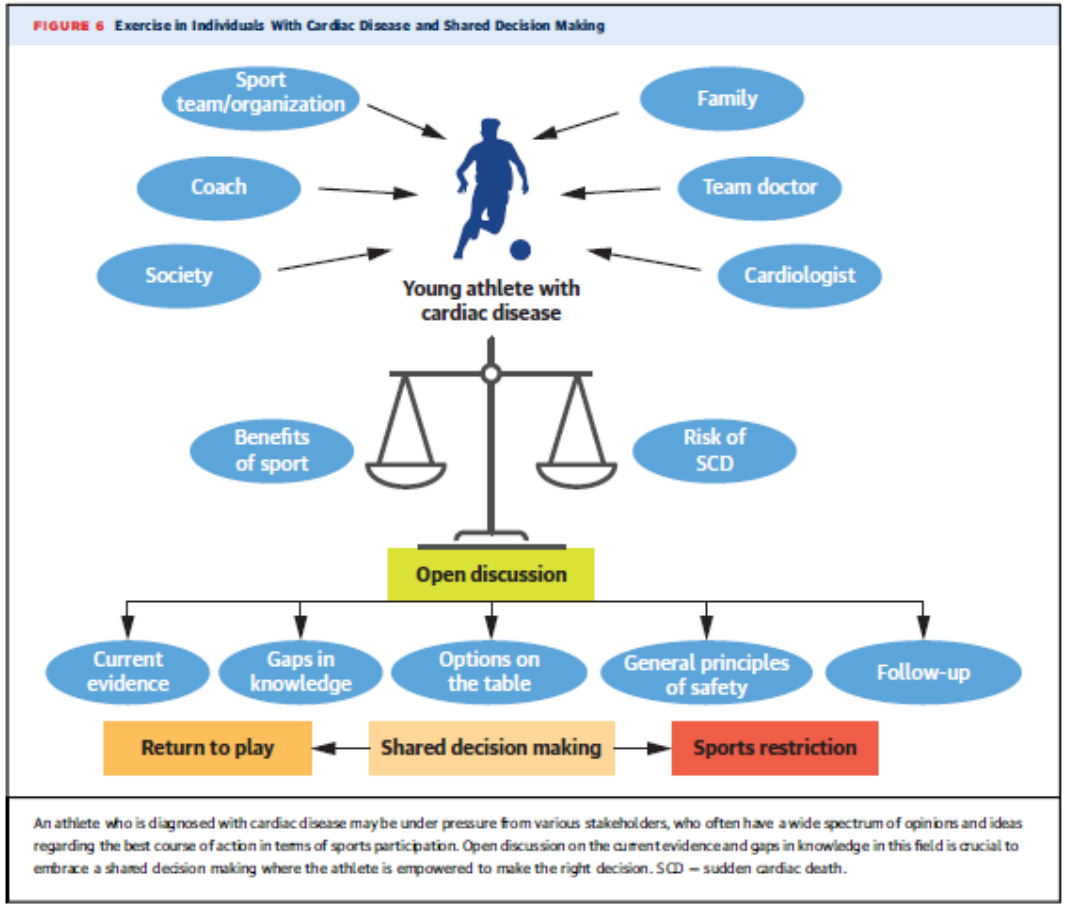


Figure 3.Forest plot for HR (one-sided 95% CI) comparing composite outcomes between exercise groups. Hazard ratios (HRs) for primary, secondary, and post hoc analyses comparing the composite outcome (death, sudden cardiac arrest, appropriate implantable cardioverter defibrillator shock, arrhythmic syncope) between those exercising vigorously and those exercising nonvigorously. The 90% 2-sided CIs are presented. Upper limits of these intervals correspond to a one-sided 0.05 significance level used to evaluate noninferiority. Primary analysis is shown followed by post hoc analysis including clinical factors (QTc and presence of previous symptoms) and then post hoc analyses of subgroups known to differ in outcome rates: first, those with the 2 most common long QT (LQT) genotypes, LQT1 and LQT2; next, those with and without previous symptoms (syncope or cardiac arrest); and then those with and without prolonged resting QTc (≥470 ms for male participants or 480 ms for female participants). Finally, the subgroup of individuals from 14 to 22 years of age participating in vigorous-competitive exercise (varsity/junior varsity/traveling team) is compared with others in this age group.

Children's National

Need to focus on promotion of activity instead of only discussing restricting activity!!

Shared Decision Making



Children's National

Thank You!