Cardiac Evaluation and Risk of the Young Athlete

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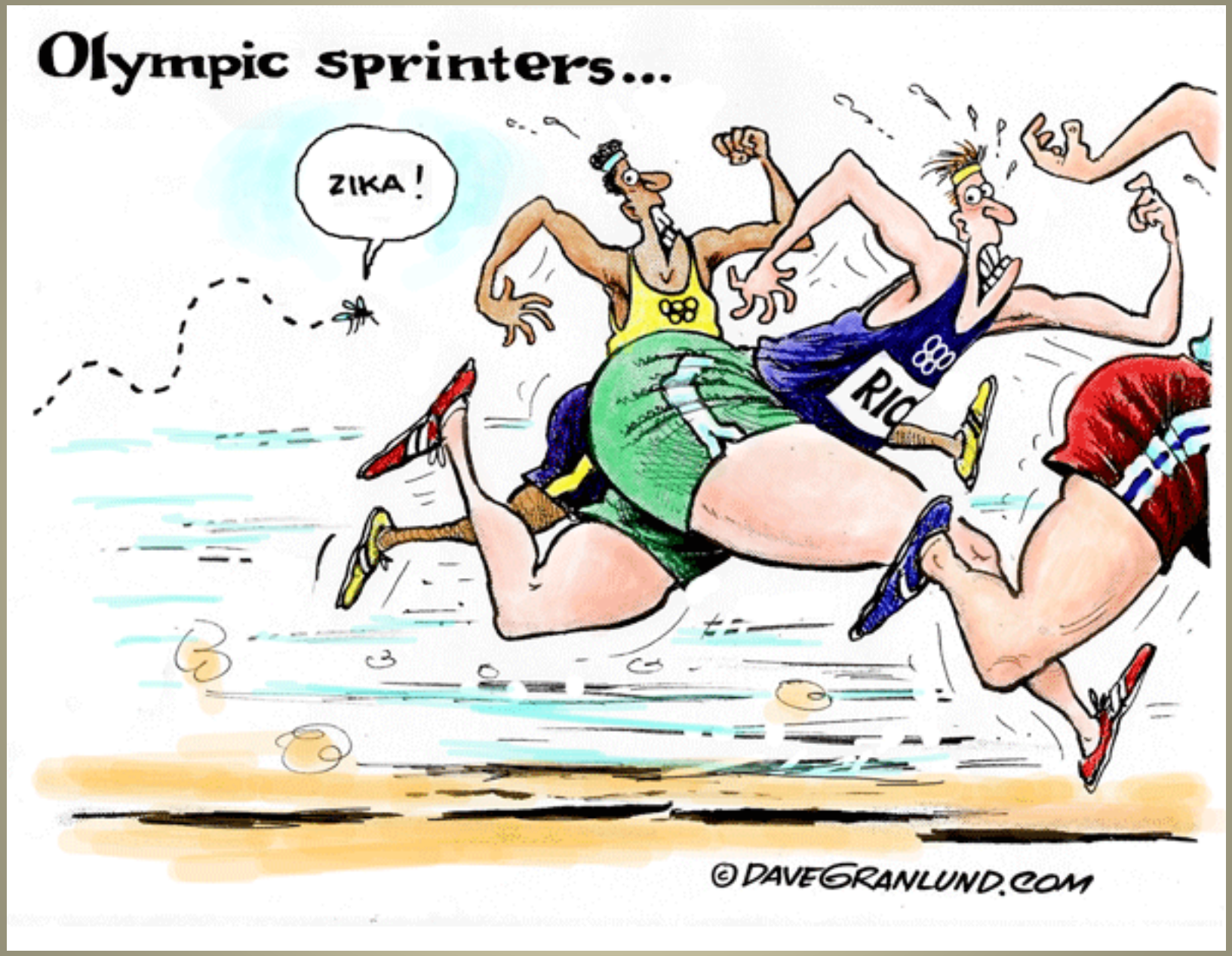
Jerod Harris
492346590

Objectives

- Review the incidence and risks for sudden death in athlete, particularly Sudden Cardiac Death (SCD)
- Elaborate the causes of SCD in athletes
- Describe the current recommendations for Preparticipation screening
- Compare views on utilizing ECG testing in the Preparticipation screen
- Briefly cover the common diagnoses associated with SCD
- I have no disclosures or conflict of interest


Olympic sprinters...
ZIKA!
RIO
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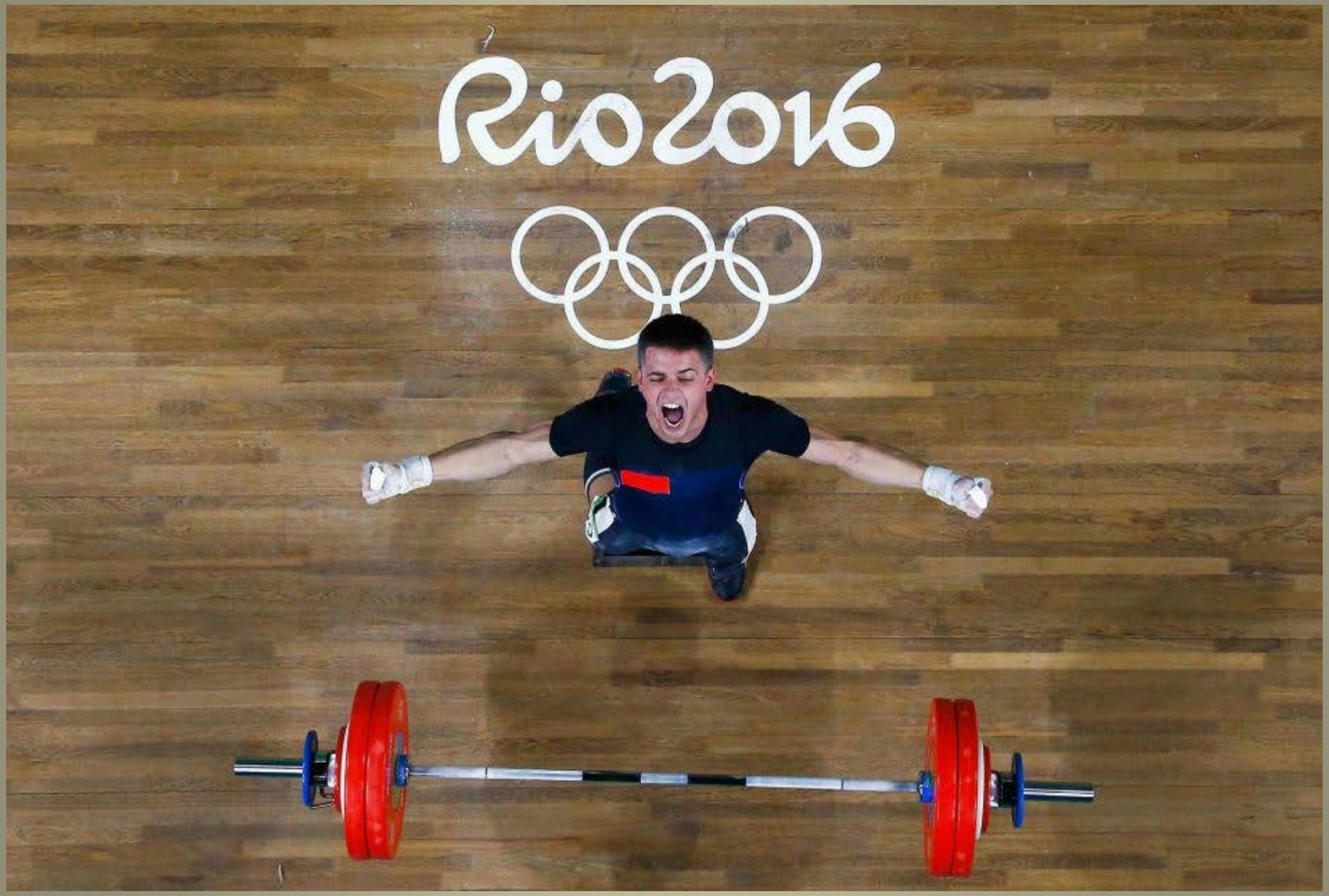
? Positive Aspects of Sudden Death ?

- The modern use of the word dates back to Philippides the dispatch-runner. Bringing the news of Marathon, he found the archons seated, in suspense regarding the issue of the battle. 'Joy, we win!' he said, and died upon his message, breathing his last in the word Joy ... – Lucian *Pro lapsu inter salutandum* (translated by F.G. and H.W. Fowler, 1905)[4]

Sudden Cardiac Death in the Media

- Jim Fixx 1984 marathon runner
- Flo Hyman 1986 olympic volleyball
- Pete Maravich 1988 LSU basketball
- Hank Gathers 1990 college basketball
- Reggie Lewis 1993 pro basketball
- Sergei Grinkov 1995 olympic figure skater
- Recent olympic SCD in Claire Squires (32 year old marathon runner), Fabrice Muamba (soccer), Piermario Morosini (Italian soccer) Alexander Dale-Oen (Norwegian swimmer), and Nemanja Nesic (Serbian rower) has provoked widespread media attention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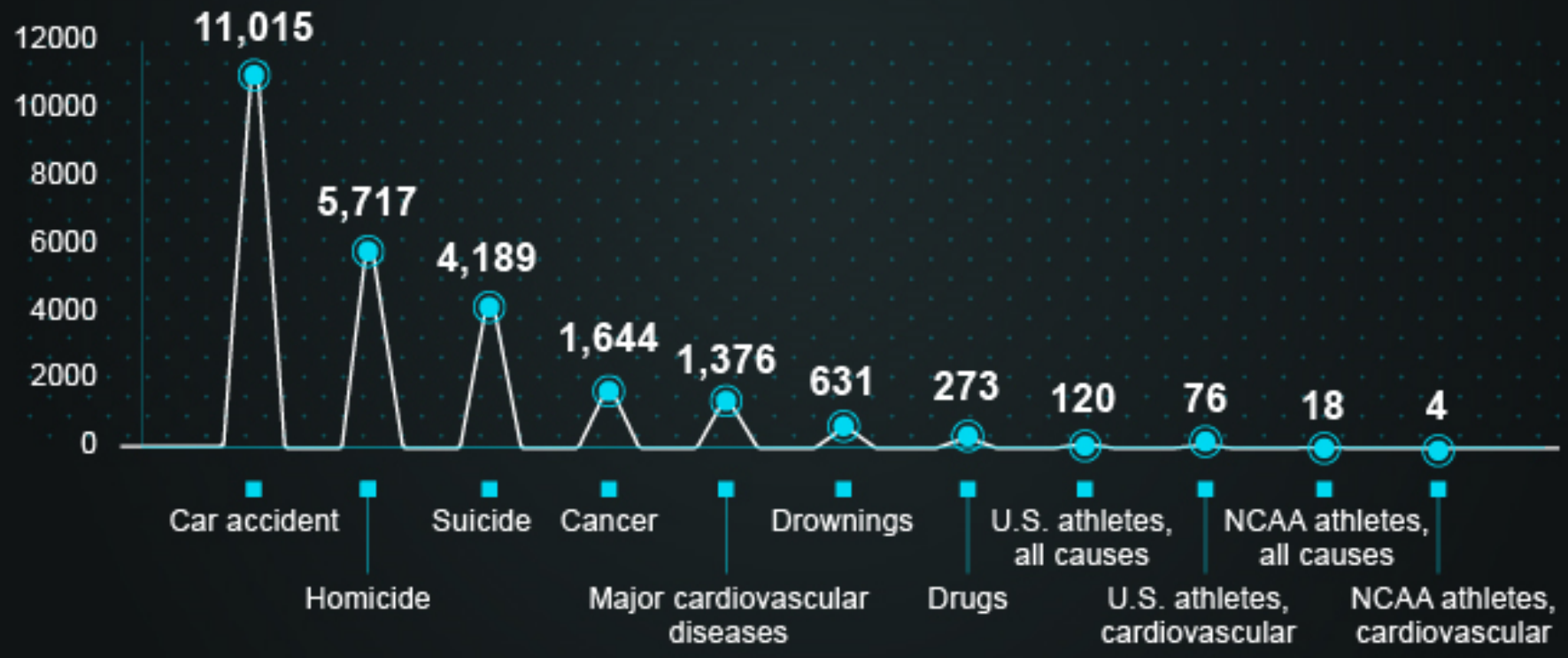
How Common a Problem Is It?

- SCD (sudden cardiac death) estimated to occur in older studies from 0.8-6.2/100,000 annually
- More recent studies:
  - Maron registry data 2009 – 0.61/100,000 patient years
  - Maron Minnesota study 1998 – 0.46/100,000 or 0.93/100,000 patient years
  - Corrado Veneto study 2005 – 0.87/100,000 patient years
  - Steinvil Isreal 2011 – 2.66/100,000 patient years
  - Tasaki Japan 1973 – 1.32/100,000 patient years
- 2007 estimates of 10-12 million middle and high school athletes annually
- Cardiac risk lesions estimated to have a prevalence of 0.3% in the athlete population
- Variable 0.5-2% of athletes disqualified from participation
- Compare to the 2006 average teen death rate from auto accidents of 49/100,000 (1/2000)

CAUSES OF DEATH

A breakdown of how many high school-age and college-age Americans die each year from select causes. The highest number of young U.S. athletes to die from heart-related causes in a single year is 76.



Source: 2014 American Heart Association/American College of Cardiology Scientific Statement

Scope of Problem

- The rate of SD has increased 6% each year in the past 3 decades
- 11% were female and the proportion has increased over time
- 11% middle school, 59% high school, 17% collegiate, 7% over 26 years age
- Most commonly occurs during or just after physical exertion (80%)
- 22% related to blunt trauma, mostly to head and neck
- Estimated that 30% of causes cannot be identified by screening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Prevalence of Sudden Cardiac Death During Competetive Sports Acitivities in Minnesota High School Athletes Maron et al. *JACC* 32:1881, 1998

- Over 12 years review of records from mandatory insurance program for all students participating in interscholastic sports
- 651,695 students in 1,453,280 sports participations
- 3 deaths – 1 anomalous coronary artery origin, 1 aortic stenosis, 1 myocarditis
- Calculated risk of 0.46/100,000 annually or 1:72,500 for 3 year participation in high school

Comparison of Frequency of Sudden Cardiovascular Deaths in Young Competitive Athletes vs Non-Athletes Maron et al, abstract, 2016.

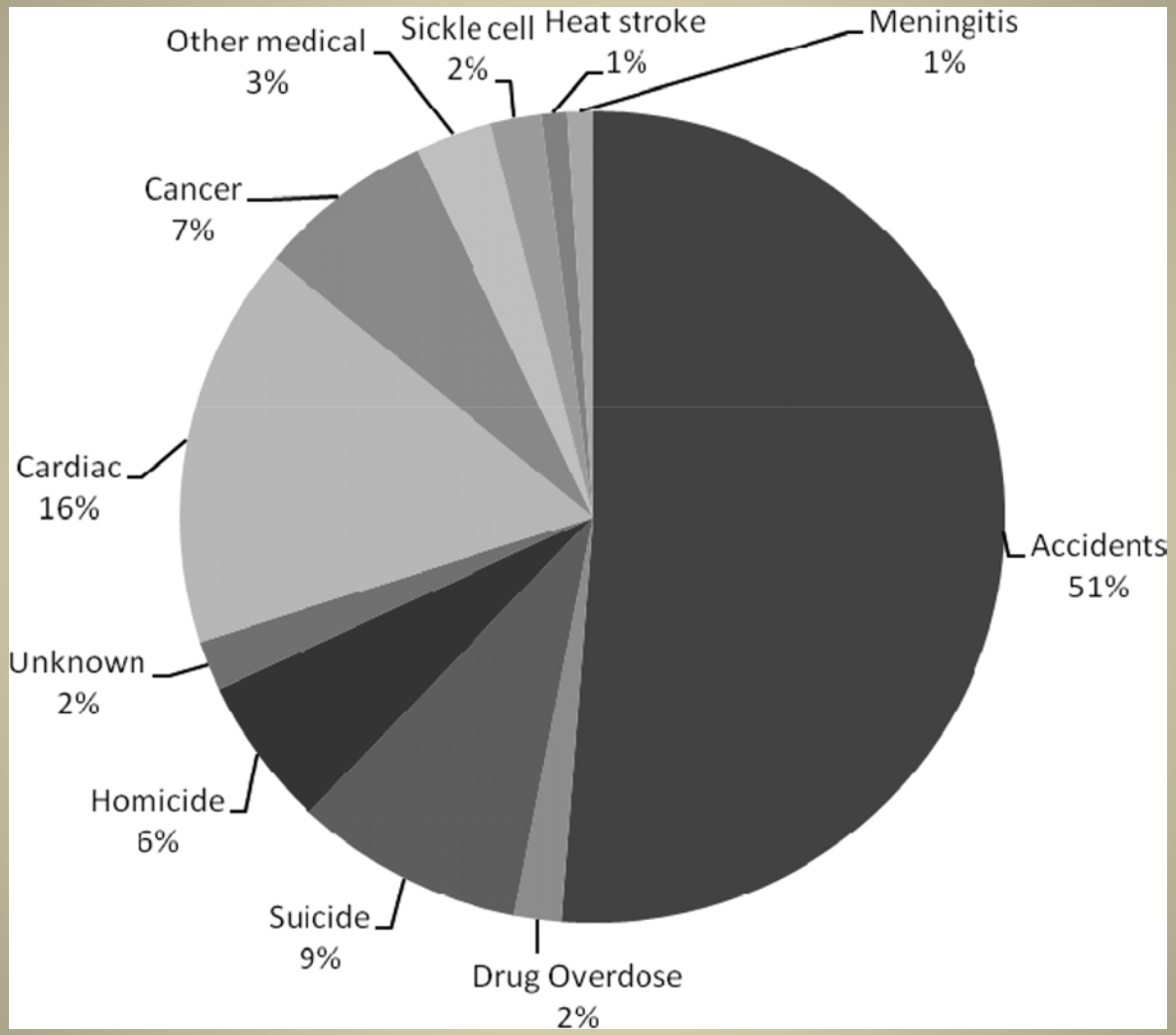
- Accessed medical examiner records from the largest Minnesota County where all sudden deaths undergo forensic evaluation
- Ages 14-23 years from 200-2014
- 39 cases were identified (12 excluded due to prior CHD or positive toxicity)
- Of 27 sudden deaths, 3 were in formal athletics and 24 were not
- 21 deaths associated with structural disease (HCM, ARVD, coronary occlusion, ruptured aorta, anomalous coronary, and myocarditis) and 6 were not
- SD in non-athletes were 3 fold more likely than athletes
- Conclusion ?ethical limitations in confining screening to athletes?

Incidence of SCD in National Athletic Association Athletes

Harmon et al. Circulation 123: 1594, 2011

- Jan 2004 –Dec 2008
- 273 deaths for 1,969,663 athlete years aged 17-23 years
- 68% (187) non-medical or traumatic; 29% (80) medical; 2% unknown
- Cardiac related in 56% (45) medical cases
- Incidence of SCD of 1:43,770
- Most common sports – basketball (1:11,394), swimming (1:21,293), lacrosse (1:23,357), football (1:38,497), and cross country (1:41,695)
- Male risk nearly 3 times more common than female
- Black athlete risk over 3 times at risk compared to white athlete

Causes of sudden death in National Collegiate Athletic Association athletes, 2004 to 2008.



Harmon K G et al. Circulation 2011;123:1594-1600

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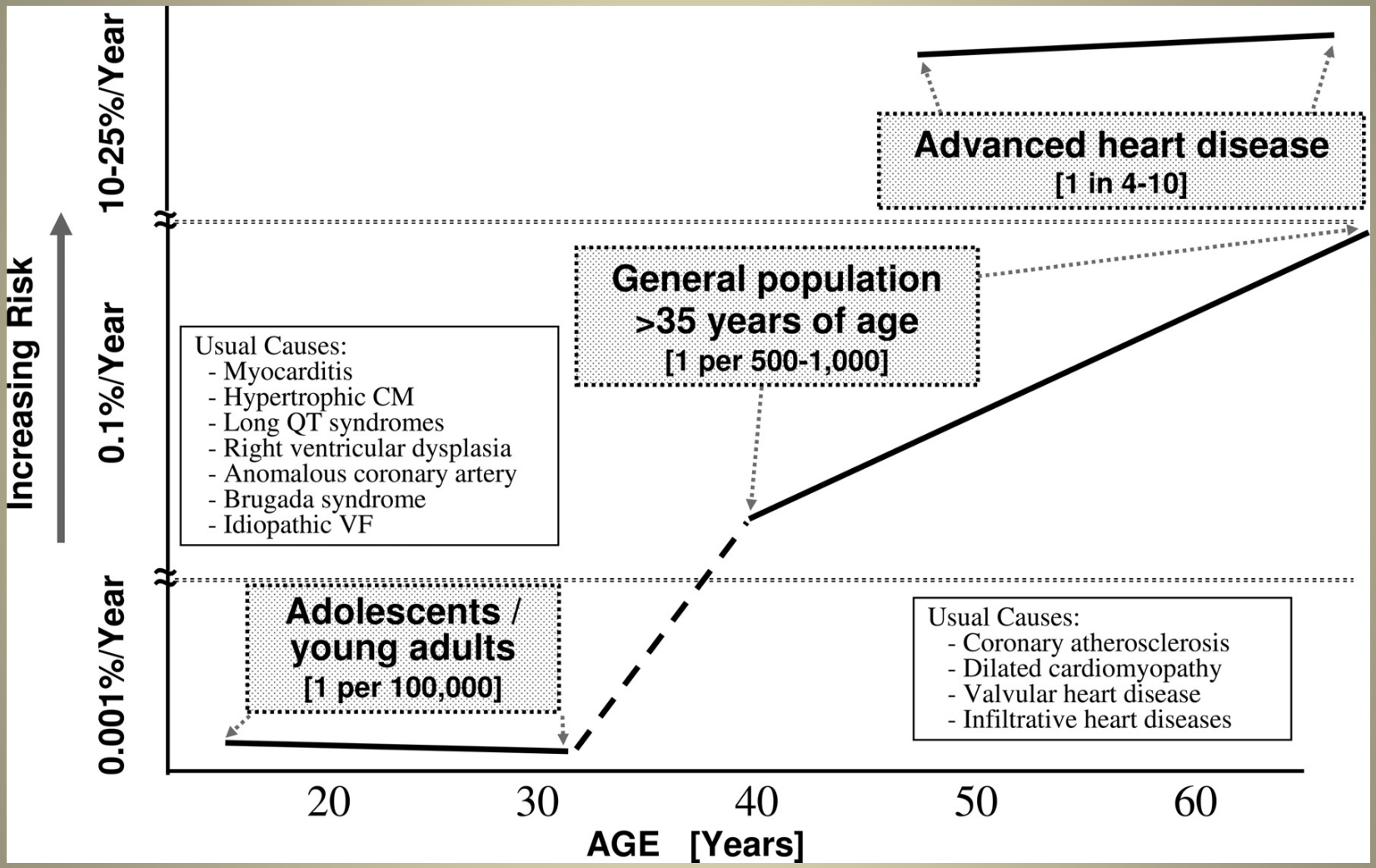
Figure 1. Age-related and disease-specific risk for SCD. For the general population ≥35 years of age, SCD risk is 0.1% to 0.2% per year (1 per 500 to 1000 population).



Myerburg R J , Vetter V L Circulation 2007;116:2616-2626

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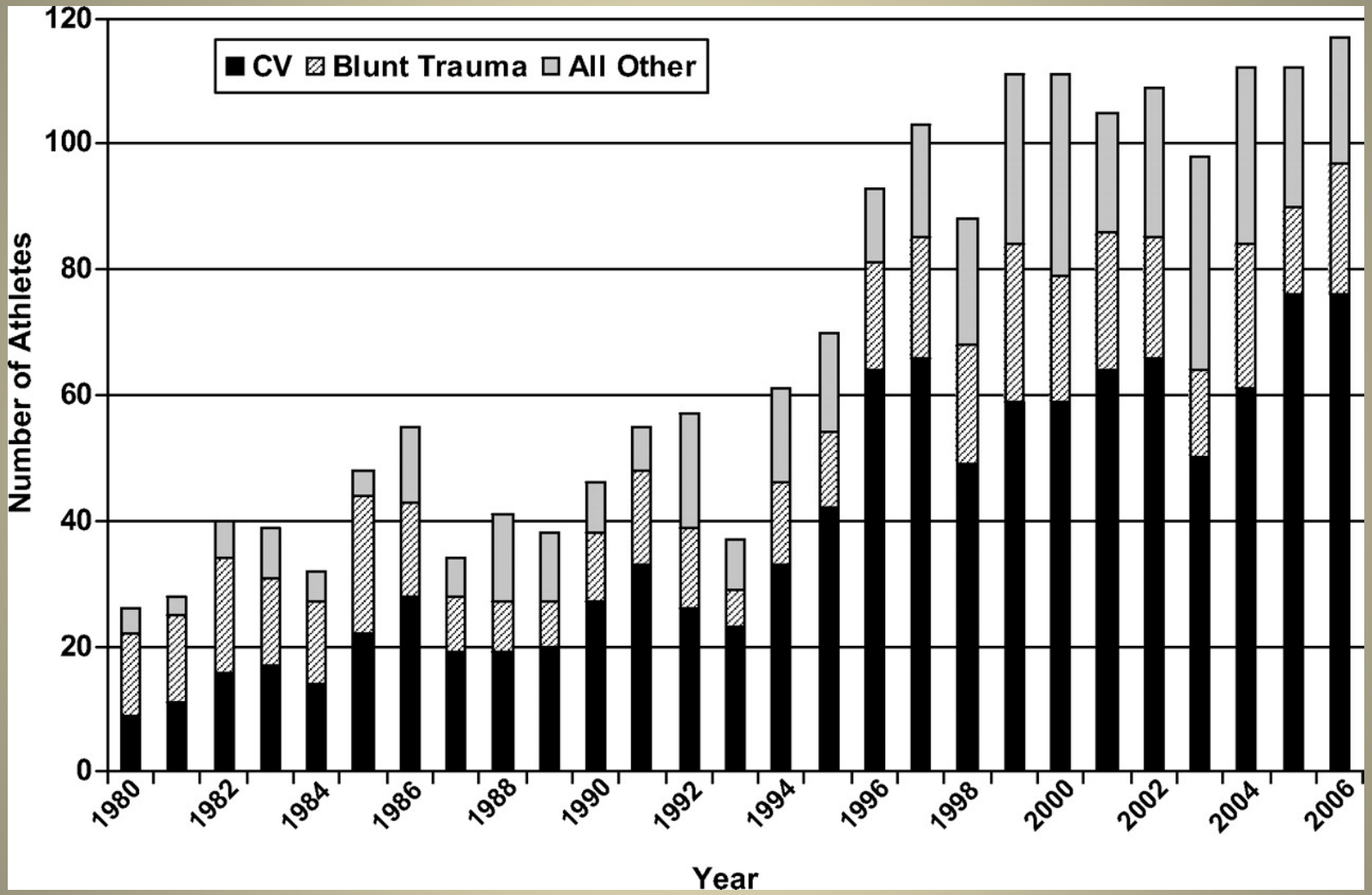
Figure 1. Number of cardiovascular (CV), trauma-related, and other sudden death events in 1866 young competitive athletes, tabulated by year.



Maron B J et al. Circulation 2009;119:1085-1092

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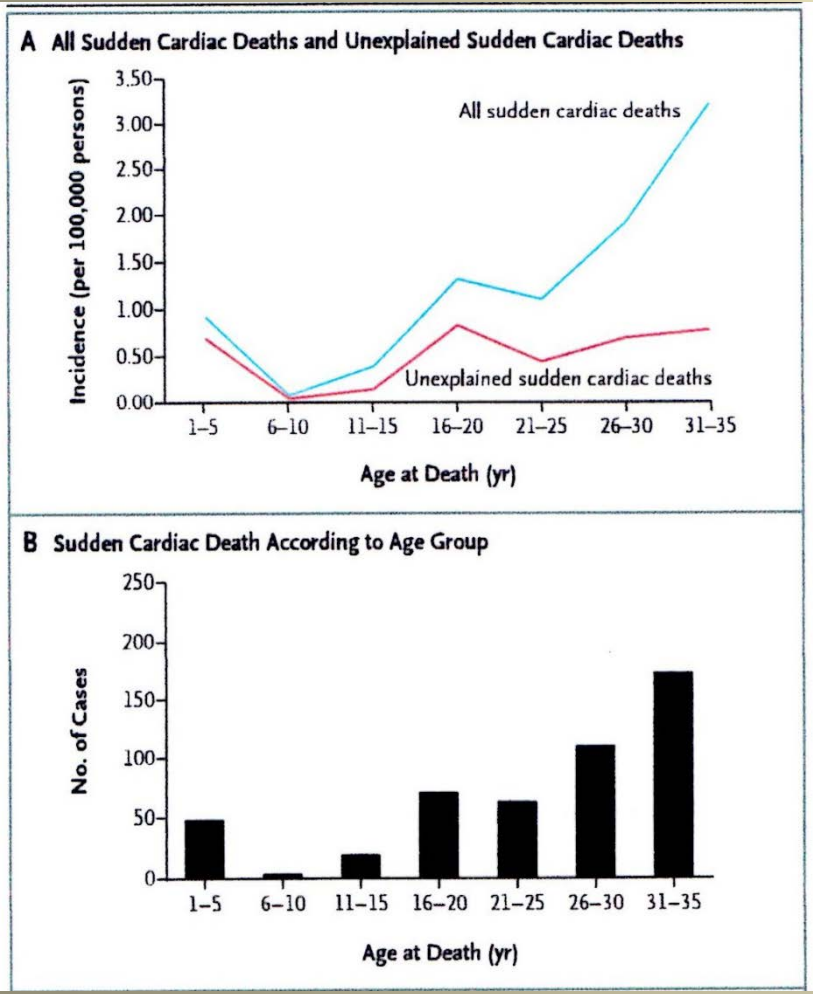
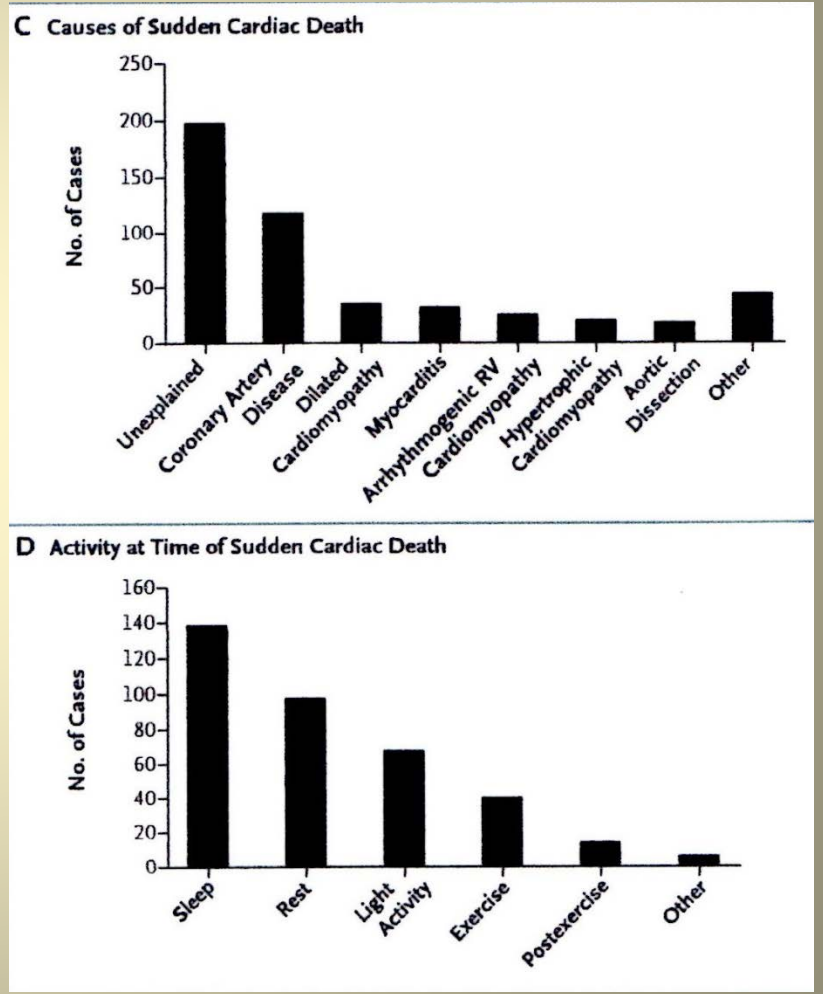
A Prospective Study of Sudden Cardiac Death Among Children and Young Adults

Bagnall et al. NEJM 374:25, 2016 (New Zealand 2010-2012)





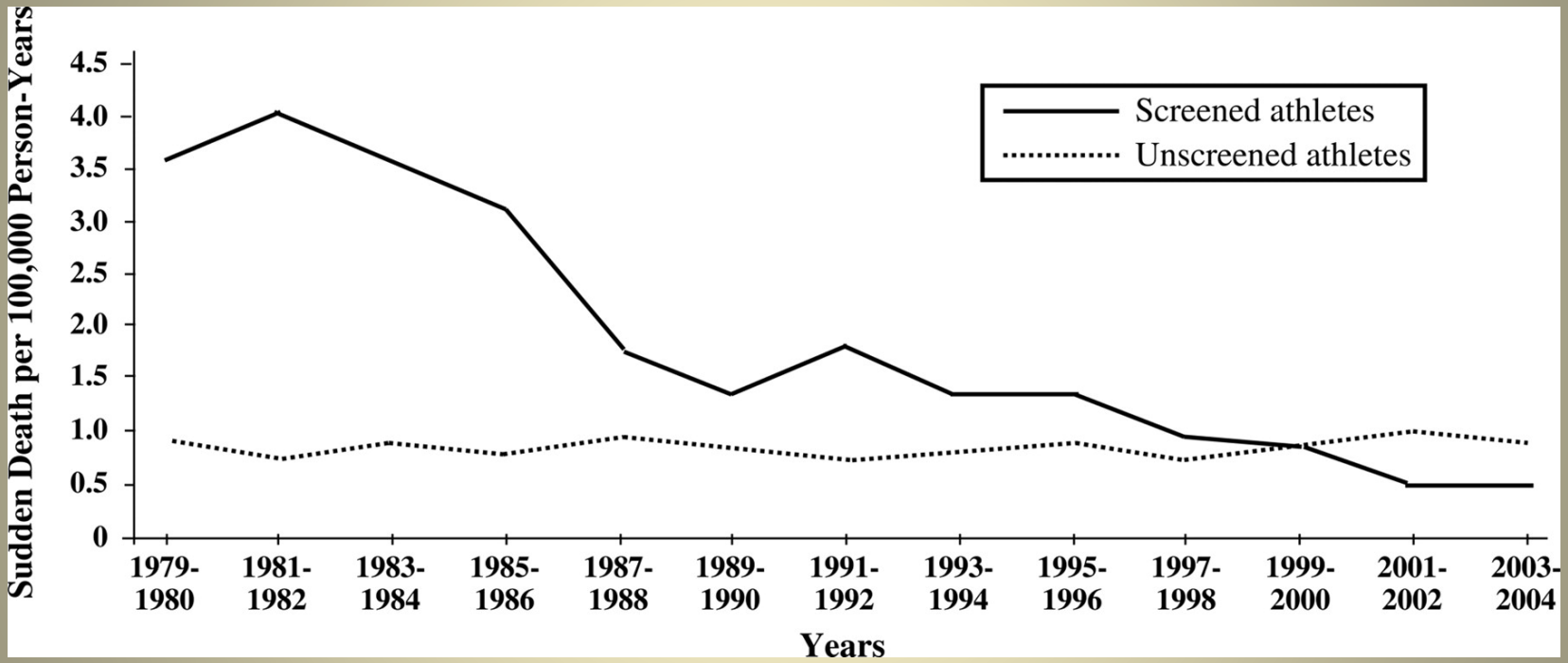
27% were found to have clinically relevant gene mutations of those tested!

The Italian Experience

Corrado et al, Eur Heart J 26:516, 2005 (JAMA 296: 1593, 2006)

- In 1982 a government mandated pre-participation screen for athletes was instituted including an ECG
- From 1979 to 2004 the incidence of sudden death dropped from 3.6/100,000 to 0.4/100,00 person years (89% decrease
- 1.9/100,000 athlete deaths vs 0.79/100,000 non athletes
- Decrease in deaths primarily due to decrease in cardiomyopathies as cause of death (primarily ARVD) in a specific population (only 9% of Italian population)
- 55 sudden deaths during study period; 44% had 1 or more positive pre-participation risks (Hx, PE, or ECG) noted
- 9% of athletes referred for further evaluation and 7% allowed to participate (false positives?)
- 2% of athletes were disqualified – 39% for rhythm, 23% for Htn, 21% for valve disease, 6.8% for cardiomyopathy, and 1.3% for coronary abnormality

Figure 4. Annual incidence rates of cardiovascular death in screened competitive athletes and unscreened nonathletes, 12 to 35 years of age, in the Veneto region of Italy (1979–2004).



Myerburg R J , Vetter V L Circulation 2007;116:2616-2626

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

Steinvil et al. JACC 57:1291, 2011

- In 1997 the Isreal Sport Regulations on Athletes Medical Testing mandated medical questionaire, PE, ECG, Bruce exercise test for all athletes
- 1985-2009 survey of sudden death reported in major newspapers
- 24 documented sudden deaths in competitive athletes – 11 prior to legislation and 13 after (12 deaths excluded secondary to trauma)
- Rate of SCD was 2.54/100,000 prior and 2.66/100,000 after ECG mandate
- Estimated $1,320,000 cost for each life saved (ECG cost only at $40 and not including secondary referral costs)
- Conclusion – screening ECG and exercise testing do not impact the incidence of SCD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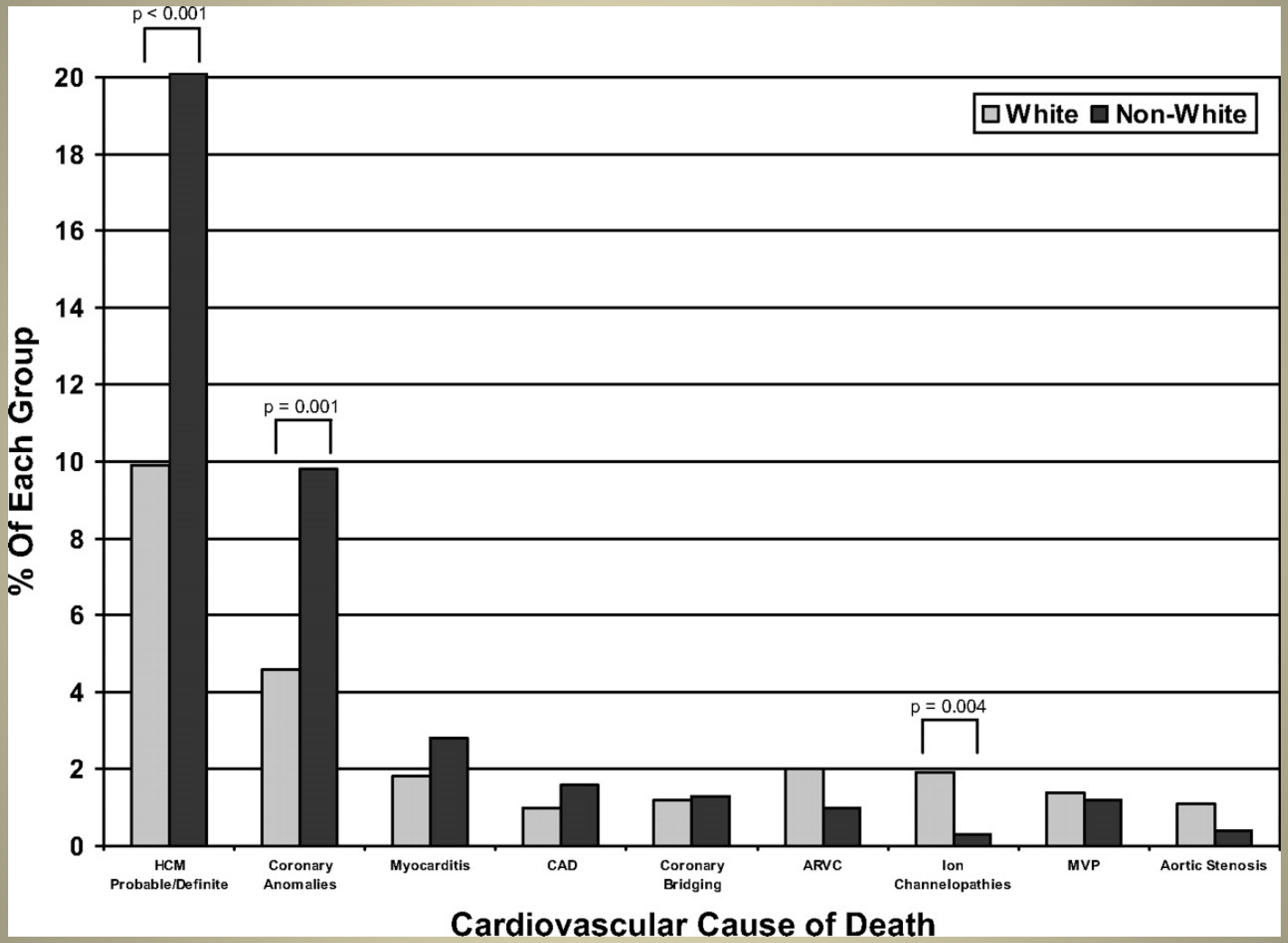
Why do Young Athletes Die Suddenly?

- <u>Sudden Death in Young Competitive Athletes</u>

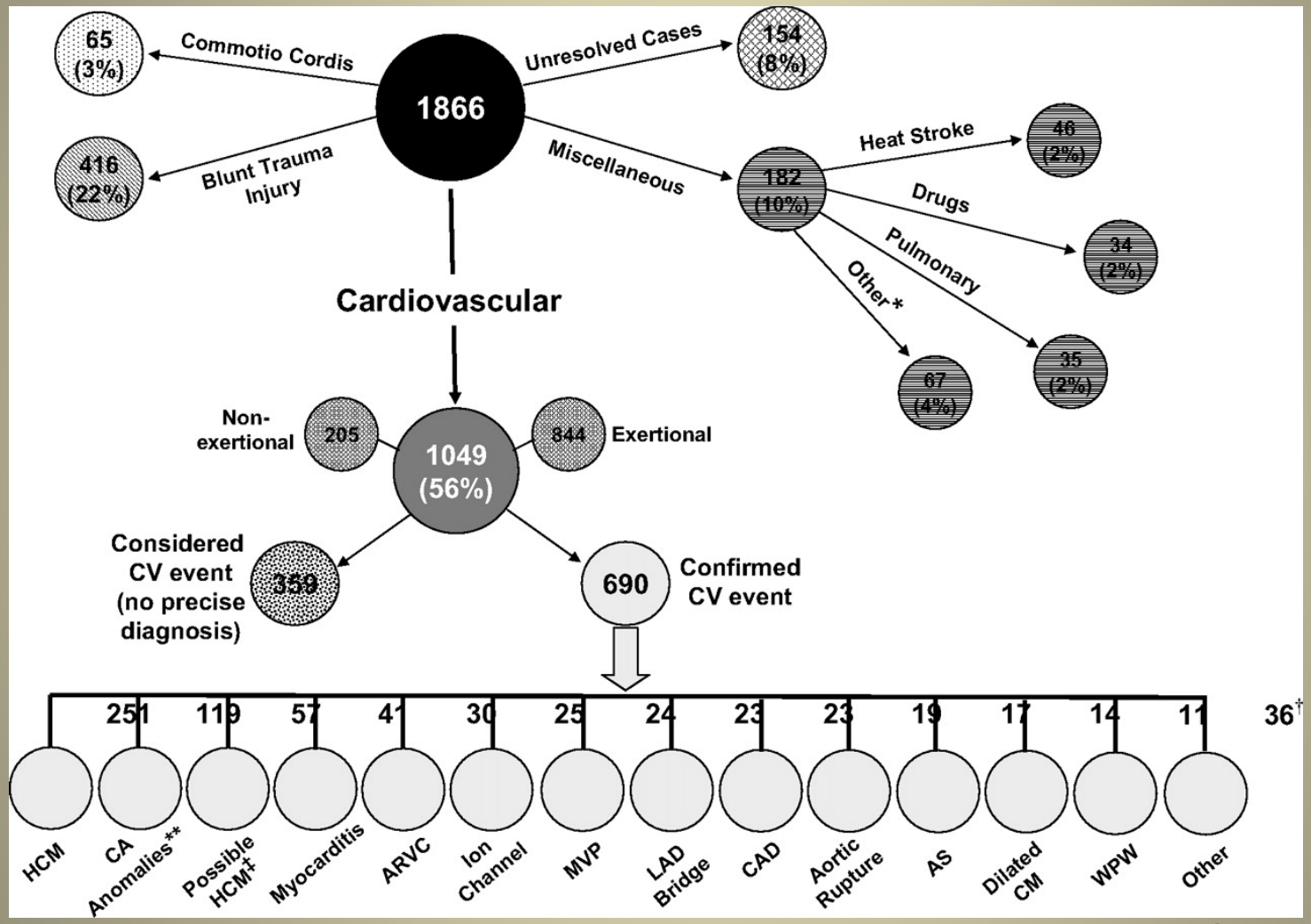
  Maron et al. Circulation 119:1085, 2009
- 1866 deaths from 1980-2006
- 8-39 years age (mean 18)
- 11% female athletes
- CAUSES:
  - 56% probable or definite cardiac
  - 22% from blunt trauma
  - 3% commotio cordis
  - 2% heat related
  - 17% (513/1866) etiology undetermined
- 85 athletes survived sudden arrest
- Top states were CA, TX, FL, NY (accounted for nearly half)
- Overall incidence of 0.61/100,000 person years

Figure 3. Cardiovascular deaths according to race, with respect to the number of white and nonwhite athletes with each disease.



Maron B J et al. Circulation 2009;119:1085-1092

Figure 2. Flow diagram summarizing causes of death in 1866 young competitive athletes. *Suicide (n=22); lightning (n=12); drowning (n=10 and 3 during the swimming segment of triathlon events); cerebral aneurysm (n=9); rhabdomyolysis (n=8); epilepsy (n=2); a...



Maron B J et al. Circulation 2009;119:1085-1092

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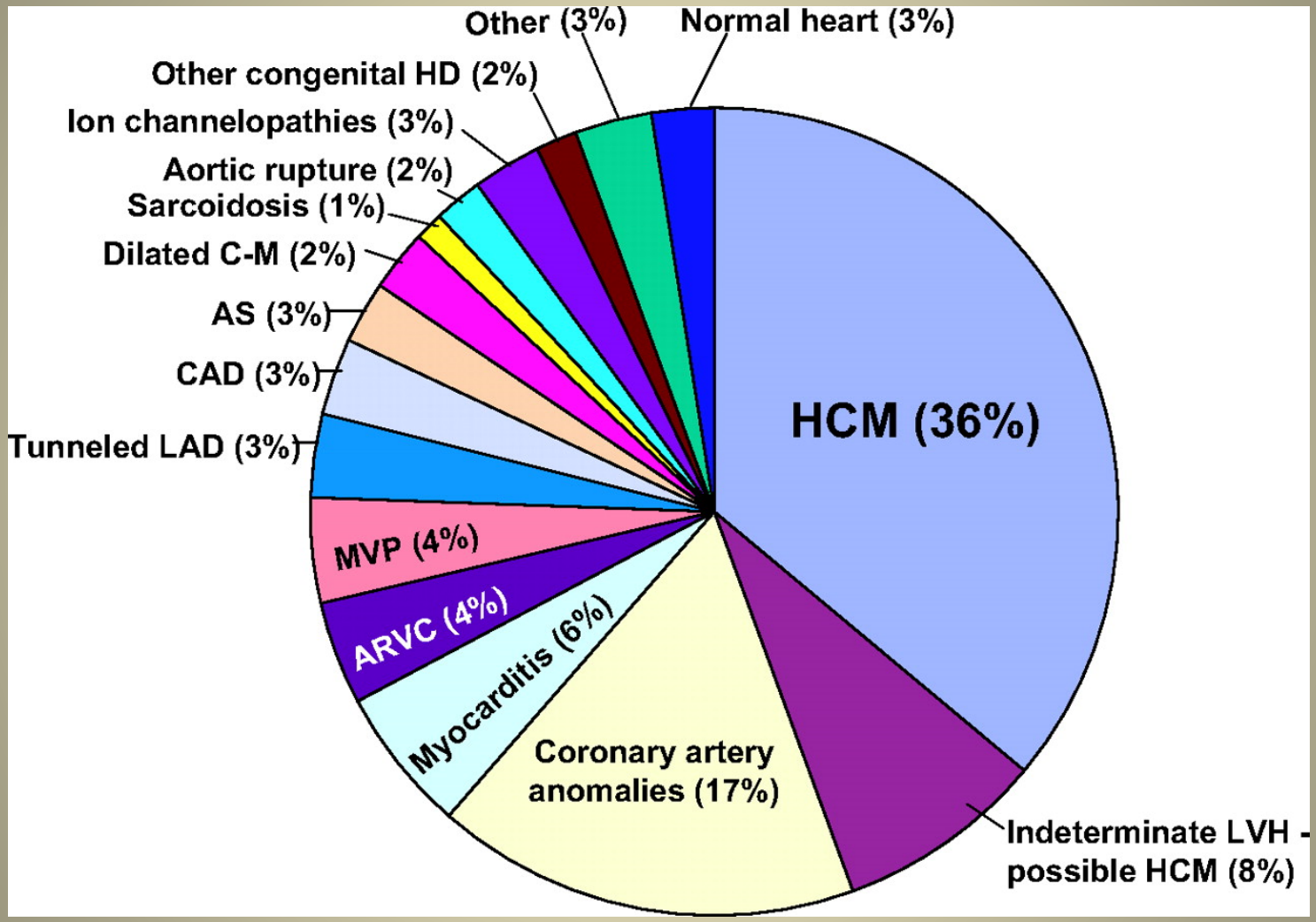
Figure. Distribution of cardiovascular causes of sudden death in 1435 young competitive athletes.



Maron B J et al. Circulation 2007;115:1643-1655

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Hypertrophic Cardiomyopathy

- ***Genetic cardiac disease with heterogeneous expression, unique pathophysiology and a diverse clinical course caused by several distinct disease-causing mutations in genes encoding the sarcomeric (MBPC3 gene and beta myosin heavy chain gene most common) and non sarcomeric proteins***

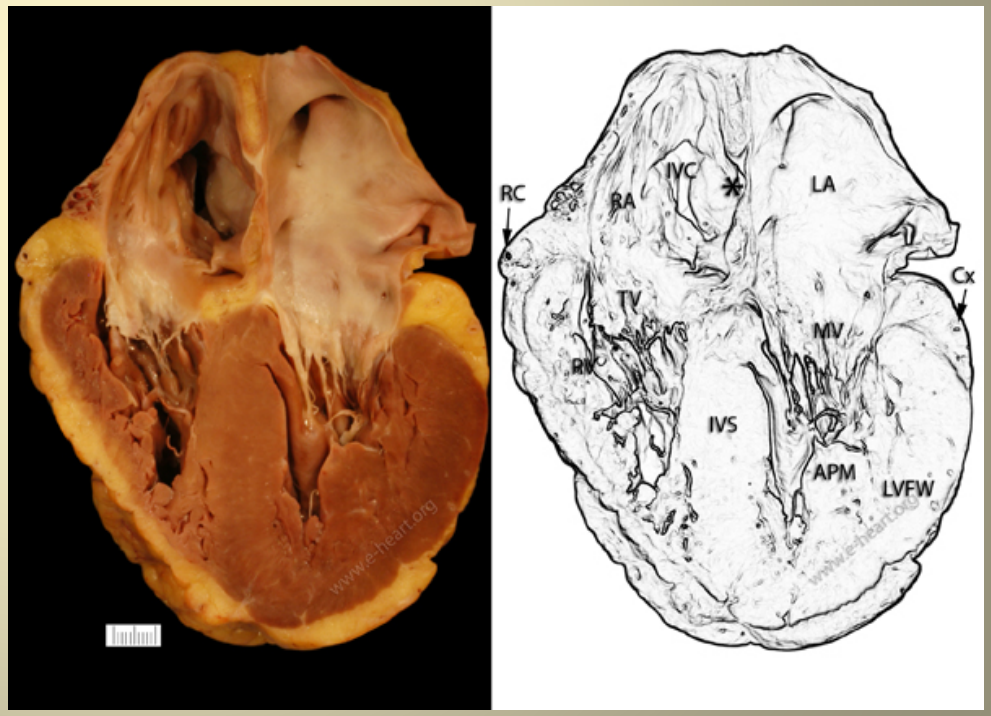
- **The most common cause of sudden cardiac death in the young, including competitive athletes**
- **Estimated in at least 0.2% in the population (1:500)**
- **May result in disability and death at virtually any age including early childhood and infancy**

Circulation. 1995;92:785-789.) Prevalence of Hypertrophic Cardiomyopathy in a General Population of Young Adults
Barry J. Maron, MD; Julius M. Gardin, MD; John M. Flack, MD, MPH; Samuel S. Gidding, MD; Tom T. Kurosaki, MS; Diane E. Bild, MD, MPH

Morphology of HCM

1) Left Ventricular Hypertrophy : Thickened but non-dilated LV in the absence of another cardiac or systemic disease capable of producing the magnitude of hypertrophy (e.g., AS, systemic hypertension, or some phenotypic expressions of athlete's heart)

LVH is determinant of many important clinical features

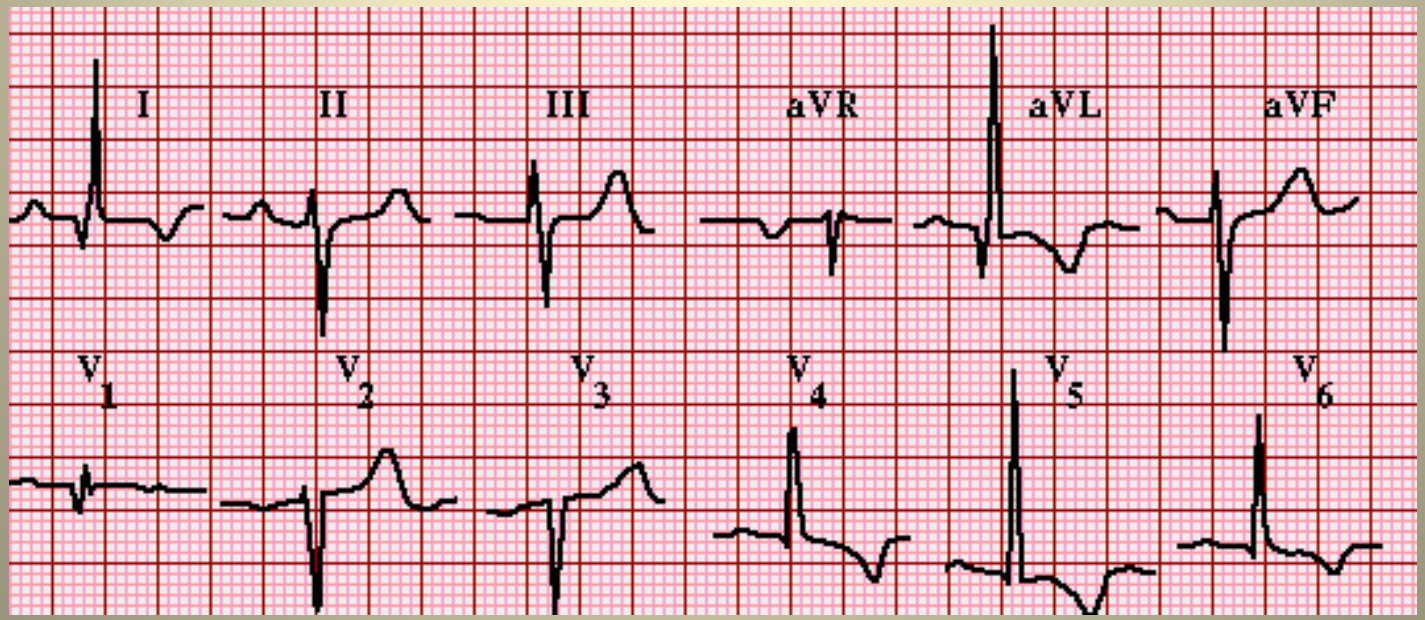


J Am Coll Cardiol 1995;26:1699–1708
Klues HG, Schiffers A, Maron BJ. Phenotypic spectrum and patterns of left ventricular hypertrophy in hypertrophic cardiomyopathy: Morphologic observations and significance as assessed by two-dimensional echocardiography in 600 patients.

Diagnosis

EKG ..

- Abnormal in about 90% to 95%
- wide variety of abnormal patterns (bizarre in appearance)
- No characteristic ECG pattern or prognostic of future events
- LVH ,ST-T changes,Abnormal deep Q wave in the Lt precord. Leads ,Arrhythmia and 1st degree heart block .



Prevalence of Hypertrophioc Cardiomyopathy in Highly Trained Athletes

Basavarajaiah et al. *JACC* 51:1033, 2008

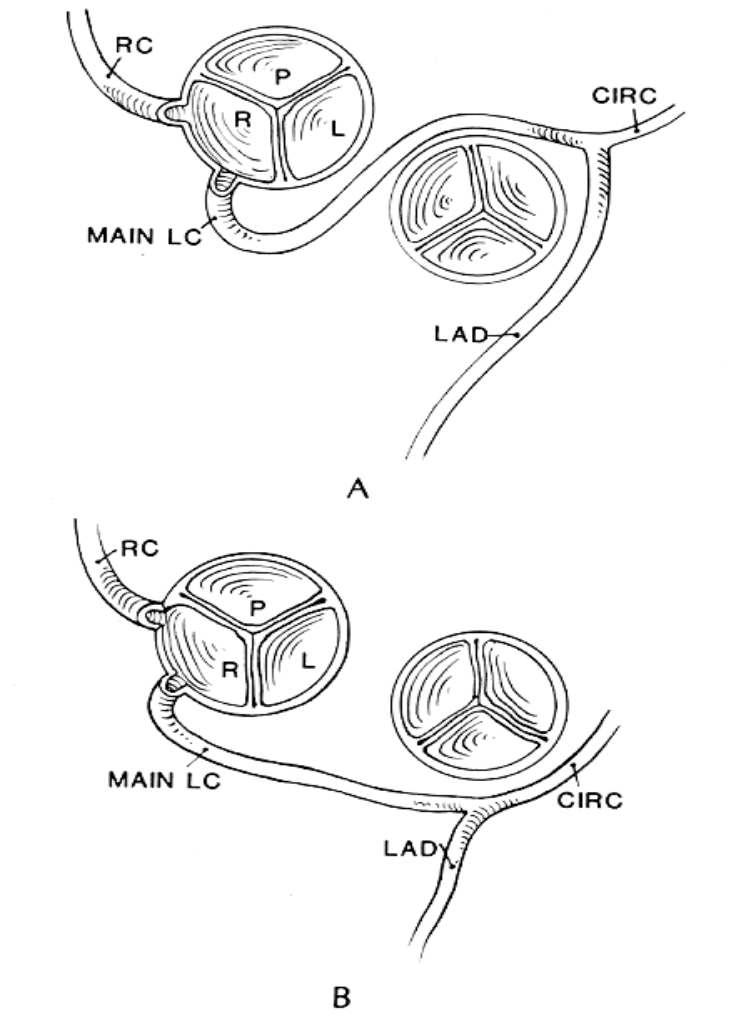
- 3,500 asymptomatic trained athletes - 75% male, mean age 20.5 years – screened with 12 lead ECG and echocardiography
- 1.5% with LVH, 50/53 with physiologic changes
- 3/3500 or 0.08% with ECG and echo findings consistent with HCM; no other phenotypic features and 1 resolved on de-training
- Conclusions – HCM in trained athletes is rare (prior estimates of 1:500) and echo not cost effective but ECG may be helpful

Major Coronary Artery Anomalies in a Pediatric Population: Incidence and Clinical Importance

(Davis JA, et al. JACC 37:593, 2001.)

- 4/2388 (0.17%) of children and adolescents who underwent echocardiographic evaluation were found to have major coronary artery anomalies
- Anomalous origin of the left main coronary artery from the right sinus of Valsalva (ALMCA) & anomalous origin of the right coronary artery from the left sinus (ARCA) were the significant findings
- Anomalous origin of the coronary artery found in up to 20% of athletes dying suddenly (may be first sign)
- Physical exam, ECG, echocardiogram, and cardiac stress may be normal as shown in retrospective studies. Prior symptoms of chest pain or syncope in <30%
- If discovered <35 years age, surgery is mandatory if symptomatic or evidence of ischemia, and should be considered otherwise

Anomalous Origin of the Left Coronary Artery from the Right Sinus of Valsalva



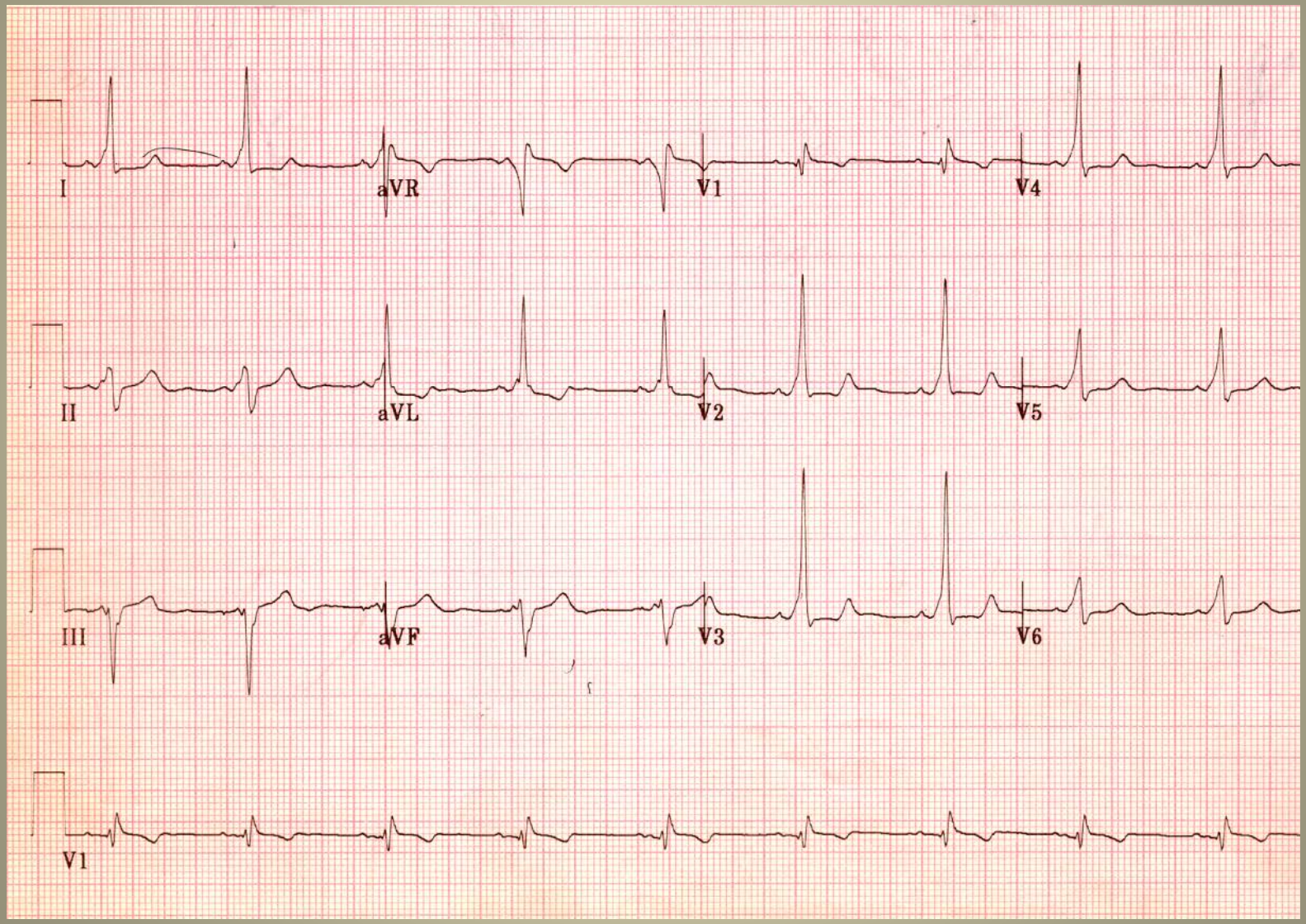
Clinical Profile of Congenital Coronary Anomalies With origin from the Wrong Aortic Sinus Leading to Sudden Death Basso et al. JACC 35:1493, 2000.

- Reviewed 27 sudden deaths in young athletes from anomalous origin of the coronary artery
- All died immediately or just after intense exertion
- 10 had prior symptoms – 1 palpitation,4 with syncope and 5 with chest pain
- 9 had ECG prior – all normal
- 6 had exercise testing prior - all normal
- 2 with echo prior – neither detected anomaly
- CONCLUSION – standard ECG and PE are unlikely to detect potentially fatal coronary anomalies; preceding symptoms may be a red flag

Wolff-Parkinson-White Syndrome

- WPW syndrome is present when a patient manifests an accessory pathway on the surface ECG and has symptoms of abnormal tachycardia
- ECG findings include a short PR interval and aberrant initial QRS depolarization in the form of a delta wave
- Is seen in 20-35% of children with SVT with prevalence estimated at 1-3/1000 pediatric patients
- Incidence of sudden death with WPW estimated at 0.1-0.3% during childhood or 1-4% lifetime risk
- Sudden death results when atrial flutter or fibrilllation is present and resultant conduction via the accessory pathway degenerates into ventricular fibrillation

Wolff-Parkinson-White Syndrome

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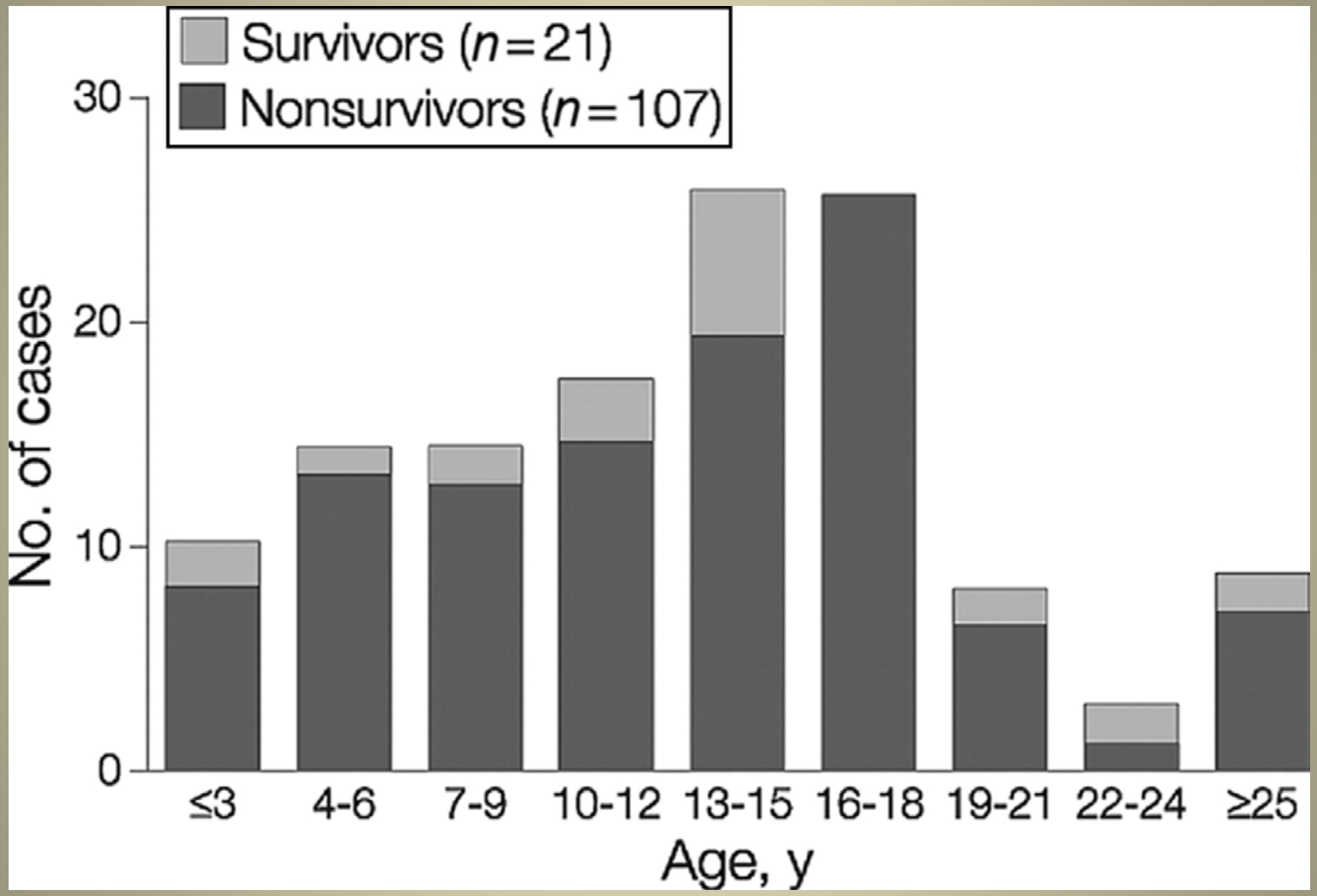
Epidemiology of Sudden Death in Young, Competitive Athletes Due to Blunt Trauma

Pediatrics 128: 2010, 2011.

- From US National Registry of Sudden Death in Young Athletes (1980-2009)
- 14% or 261/1827 trauma related
- Mortality rate was 0.11/100,000
- 89% due to head and neck injuries
- Most common in football (57%) more common in defensive players (although running back the single most common position)
- 6/1827 due to chest injury with commotio cordis
- Protective chest equipment is not protective

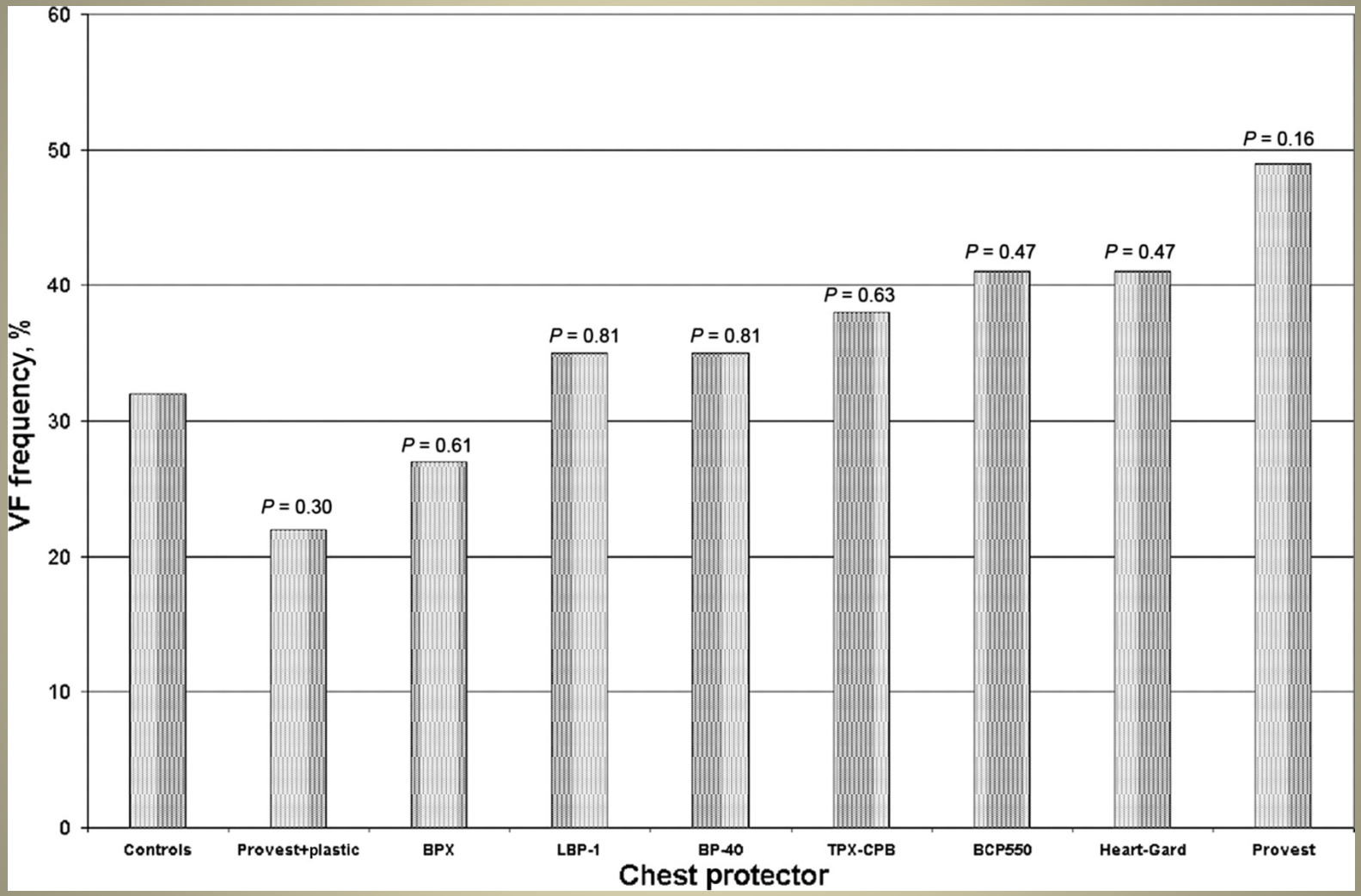
Age at which commotio cordis occurred in cases reported to the Commotio Cordis Registry.



Link M S et al. Pediatrics 2008;122:437-439

PEDIATRICS®

Incidence of ventricular fibrillation (VF) with baseball precordial blows for each of 8 commercially available chest-protector materials and for controls without chest protectors.



Link M S et al. Pediatrics 2008;122:437-439

Role of the Physician in Clearance for Athletic Competition

- The physician must have the patient's best interest at heart
- Perform an appropriate history and physical examination
- Refer for appropriate tests and consultation
- Maintain physician-patient confidentiality (private vs team physician?)
- Maintain straightforward communication with the patient/athlete, family, and team/institution (with patients knowledge and agreement)
- Media statements are best left to hospital and team spokespersons and any communication with the media should be agreed on by the athlete and/or family

Potentially Conflicting Perspectives for Participation in Athletics

- **Physician**

1. Athlete's health, emotional, and physical well being
2. Desire to allow full potential for athlete and school/team
3. Liability concerns

- **Athlete**

1. Strong personal desire to compete and excel
2. Financial /reward incentive
3. Feeling of invincibility

- **School/Professional Team**

1. Protect health and safety of the athlete
2. Desire for team/institution to be successful, media visible and financially profitable
3. Liability concerns

Decision Making for Athletic Participation

Ideally, the ultimate decision for an athlete with a cardiovascular abnormality to participate in a sport should be the result of mutual agreement between the team or screening physician, consulting cardiologists, team/school officials, and the athlete and his/her family.

Cardiovascular Participation Screening of Competitive Athletes: 2011 Update

A Statement for Health Professionals From the Sudden Death Committee and Congenital Cardiac Defects Committee, American Heart Association. Circulation 132: e267, 2011.

1. The American Heart Association recommends that some form of preparticipation cardiovascular screening for high school and collegiate athletes is justifiable and compelling, based on ethical, legal, and medical grounds.
2. A complete and careful personal and family history and physical examination designed to identify (or raise suspicion of) those cardiovascular lesions known to cause sudden death or disease progression in young athletes is the best available and most practical approach of screening populations of competitive sports participants, regardless of age.
3. Screening should be repeated every 2 years during high school (but not collegiate).
4. A national standard for preparticipation medical evaluations should be developed.
5. ECG is not recommended as routine

Cardiovascular Participation Screening of Competitive Athletes: 2011 update

A Statement for Health Care Professionals From the Sudden Death Committee and Congenital Cardiac Defects Committee, American Heart Association. Circulation 132:e267, 2011.

1. Athletic screening be performed by a healthcare worker with the requisite training, medical skills and the background to reliably obtain a detailed cardiovascular history, perform a physical examination, and recognize heart disease.
2. Athletic screening evaluations should include a complete medical history and physical examination, including brachial artery blood pressure measurement.

Recommendations from the AHA/ACC 2014 Initiative

- It is recommended that the AHA's 14-point screening guidelines and those of other societies, such as the American Academy of Pediatrics' Preparticipation Physical Evaluation, be used by examiners as part of a comprehensive history taking and physical examination to detect or raise suspicion of genetic/congenital cardiovascular abnormalities *(Class I; Level of Evidence C)*.
- It is recommended that standardization of the questionnaire forms used as guides for examiners of high school and college athletes in the United States be pursued *(Class I; Level of Evidence C)*.

Recommendations from the AHA/ACC 2014 Initiative

- Screening with 12-lead ECGs (or echocardiograms) in association with comprehensive history-taking and physical examination to identify or raise suspicion of genetic/congenital and other cardiovascular abnormalities may be considered in relatively small cohorts of young healthy people 12 to 25 years of age, not necessarily limited to competitive athletes (eg, in high schools, colleges/universities or local communities). Close physician involvement and sufficient quality control is mandatory. If undertaken, such initiatives should recognize the known and anticipated limitations of the 12-lead ECG as a population screening test, including the expected frequency of false-positive and false-negative test results, as well as the cost required to support these initiatives over time *(Class IIb; Level of Evidence C)*.

Recommendations from the AHA/ACC 2014 Initiative

- Mandatory and universal mass screening with 12-lead ECGs in large general populations of young healthy people 12 to 25 years of age (including on a national basis in the United States) to identify genetic/congenital and other cardiovascular abnormalities is not recommended for athletes and nonathletes alike *(Class III, no evidence of benefit; Level of Evidence C)*.
- Consideration for large-scale, general population, and universal cardiovascular screening in the age group 12 to 25 years with history taking and physical examination alone is not recommended (including on a national basis in the United States) *(Class III, no evidence of benefit; Level of Evidence C)*.

14 Element AHA Recommendations for Screening

1) Personal history
   a) Exertional chest pain/discomfort
   b) Unexplained syncope/near-syncope (judged not to be vasovagal)
   c) Excessive exertional and unexplained dyspnea/fatigue, associated with exercise
   d) Prior recognition of a heart murmur
   e) Elevated systemic BP
   f) Prior restriction from participation in sports
   g) Prior testing for the heart, physician ordered
2) Family history
   a) Premature death (sudden or unexpected, or otherwise) before age 50 due to heart disease in 1 or more relative
   b) Disability from heart disease in a close relative < 50 years age
   c) Specific knowledge of certain conditions in family members: HCM or DCM, long QT syndrome or other channelopathies, Marfan syndrome, or clinically important arrhythmias

14 Element AHA Recommendations for Screening Athletes

Physical Examination

1) Heart murmur, auscultation supine and standing (or with Valsalva)
2) Femoral pulses to exclude coarctation
3) Physical stigmata of Marfan
4) Brachial artery BP sitting (preferably in both arms)

(Keep in mind that not all require discontinuing current sports participation)

The 14-Element Cardiovascular Screening Checklist for Congenital and Genetic Heart Disease

Personal history:

1. Chest pain/discomfort/tightness/pressure related to exertion
2. Unexplained syncope/near-syncope*
3. Excessive exertional and unexplained dyspnea/fatigue or palpitations, associated with exercise
4. Prior recognition of a heart murmur
5. Elevated systemic blood pressure
6. Prior restriction from participation in sports
7. Prior testing for the heart, ordered by a physician

Family history

8. Premature death (sudden and unexpected, or otherwise) before age 50 attributable to heart disease in ≥1 relative
9. Disability from heart disease in close relative <50 y of age
10. Hypertrophic or dilated cardiomyopathy, long-QT syndrome, or other ion channelopathies, Marfan syndrome, or clinically significant arrhythmias; specific knowledge of certain cardiac conditions in family members

Physical examination

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

*Judged not to be of neurocardiogenic (vasovagal) origin; of particular concern when occurring during or after physical exertion.

**Refers to heart murmurs judged likely to be organic and unlikely to be innocent; auscultation should be performed with the patient in both the supine and standing positions (or with Valsalva maneuver), specifically to identify murmurs of dynamic left ventricular outflow tract obstruction.

***Preferably taken in both arms.

Preparticipation Physical Evaluation

HISTORY FORM

DATE OF EXAM _____

Name _____ **Sex** _____ **Age** _____ **Date of birth** _____

Grade ____ **School** _____ **Sport(s)** _____

Address _____ **Phone** _____

Personal physician _____

In case of emergency, contact

Name _____ **Relationship** _____ **Phone (H)** _____ **(W)** _____

Explain "Yes" answers below.
Circle questions you don't know the answers to.

	Yes	No
1. Has a doctor ever denied or restricted your 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. Have you ever passed out or nearly passed out DURING exercise?	☐	☐
6. Have you ever passed out or nearly passed out AFTER exercise?	☐	☐
7. Have you ever had discomfort, pain, or pressure in your chest during exercise?	☐	☐
8. Does your heart race or skip beats during exercise?	☐	☐
9. Has a doctor ever told you that you have (check all that apply): ☐ High blood pressure ☐ A heart murmur ☐ High cholesterol ☐ A heart infection		
10. Has a doctor ever ordered a test for your heart? (for example, ECG, echocardiogram)	☐	☐
11. Has anyone in your family died for no apparent reason?	☐	☐
12. Does anyone in your family have a heart problem?	☐	☐
13. Has any family member or relative died of heart problems or of sudden death before age 50?	☐	☐
14. Does anyone in your family have Marfan syndrome?	☐	☐
15. Have you ever spent the night in a hospital?	☐	☐
16. Have you ever had surgery?	☐	☐
17. 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:	☐	☐
18. Have you had any broken or fractured bones or dislocated joints? If yes, circle below:	☐	☐
19. 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

	Yes	No
20. Have you ever had a stress fracture?	☐	☐
21. Have you been told that you have or have you had an x-ray for atlantoaxial (neck) instability?	☐	☐
22. Do you regularly use a brace or assistive device?	☐	☐
23. Has a doctor ever told you that you have asthma or allergies?	☐	☐
24. Do you cough, wheeze, or have difficulty breathing during or after exercise?	☐	☐
25. Is there anyone in your family who has asthma?	☐	☐
26. Have you ever used an inhaler or taken asthma medicine?	☐	☐
27. Were you born without or are you missing a kidney, an eye, a testicle, or any other organ?	☐	☐
28. Have you had infectious mononucleosis (mono) within the last month?	☐	☐
29. Do you have any rashes, pressure sores, or other skin problems?	☐	☐
30. Have you had a herpes skin infection?	☐	☐
31. Have you ever had a head injury or concussion?	☐	☐
32. Have you been hit in the head and been confused or lost your memory?	☐	☐
33. Have you ever had a seizure?	☐	☐
34. Do you have headaches with exercise?	☐	☐
35. Have you ever had numbness, tingling, or weakness in your arms or legs after being hit or falling?	☐	☐
36. Have you ever been unable to move your arms or legs after being hit or falling?	☐	☐
37. When exercising in the heat, do you have severe muscle cramps or become ill?	☐	☐
38. Has a doctor told you that you or someone in your family has sickle cell trait or sickle cell disease?	☐	☐
39. Have you had any problems with your eyes or vision?	☐	☐
40. Do you wear glasses or contact lenses?	☐	☐
41. Do you wear protective eyewear, such as goggles or a face shield?	☐	☐
42. Are you happy with your weight?	☐	☐
43. Are you trying to gain or lose weight?	☐	☐
44. Has anyone recommended you change your weight or eating habits?	☐	☐
45. Do you limit or carefully control what you eat?	☐	☐
46. Do you have any concerns that you would like to discuss with a doctor?	☐	☐

FEMALES ONLY

	Yes	No
47. Have you ever had a menstrual period?	☐	☐

48. How old were you when you had your first menstrual period? _____

49. How many periods have you had in the last 12 months? _____

Explain "Yes" answers here: _____

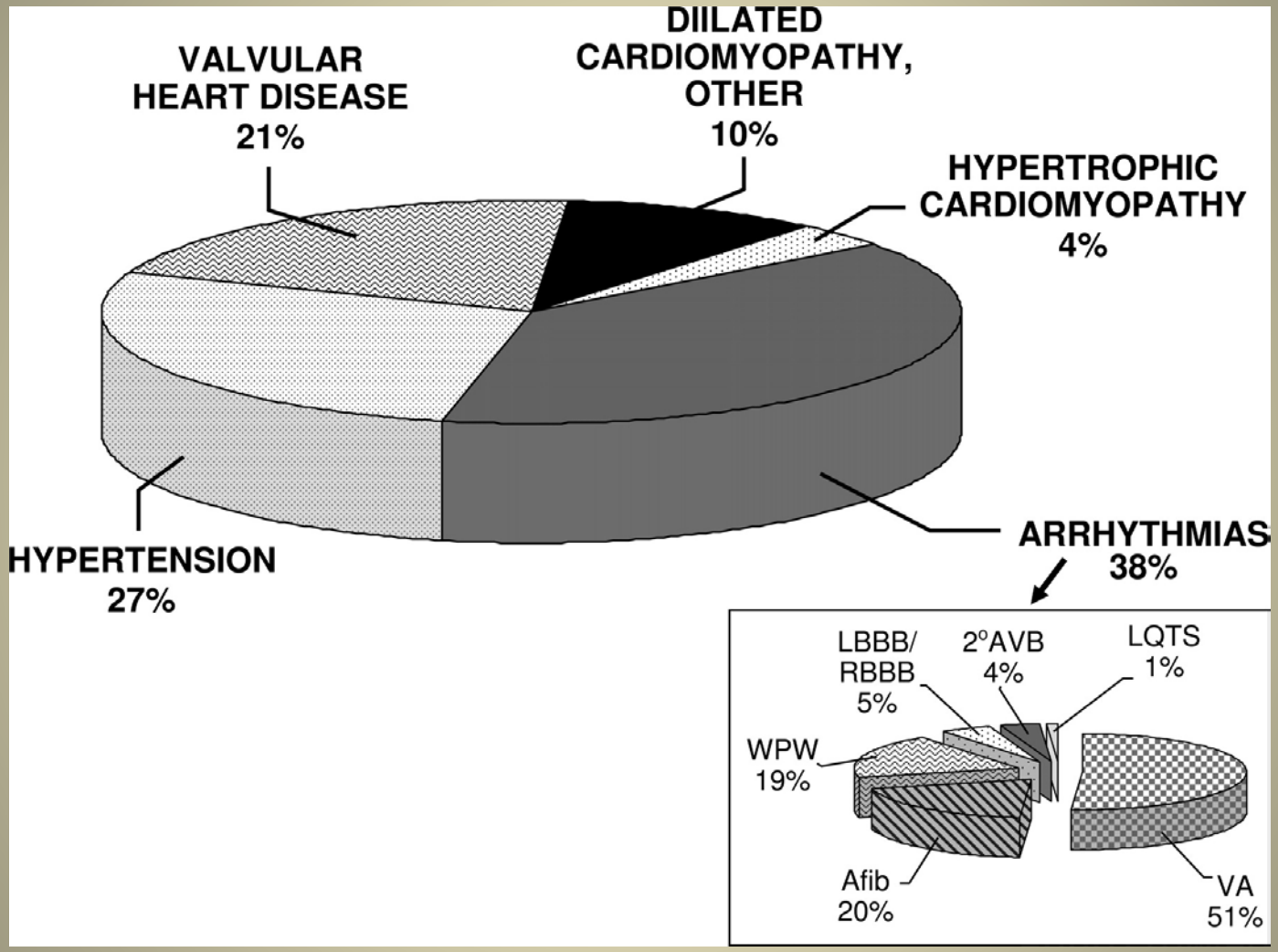
I hereby state that to the best of my knowledge, my answers to the above questions are complete and correct.

Signature of athlete _____ Signature of parent/guardian _____ Date _____

Preparticipation Screening Risks

- Screening allows patients at risk to continue participation
- Screening restricts participation in patients without cardiac disease
- Screening restricts participation in patients with heart disease and no indication of risk (many congenital lesions)
- Screening results in excessive expense

Figure 3. Cardiovascular disqualifications in large screened athlete population.



Myerburg R J , Vetter V L Circulation 2007;116:2616-2626


ARG
ARG
ARG

Sports Preparticipation – the ECG Question

PROS

- Recommended by ESC and IOC
- Decrease in SCD by 89% in Italian experience (Corrado et al)
- Cost effectiveness of Nevada screening study - $44,000 per year of life with ECG vs $84,000 with H&P
- Japanese study estimates $8,800 per year of life saved (3 deaths in 68,000 and 2 with normal ECG)
- Medical legal concerns
- Supported by recommendations for "cut rate" reimbursment
- Research benefits

CONS

- Low risk rates – 0.44/100,000
- Does not catch all risk lesions (coronary anomalies, etc)
- Cost 2007 estimate cost of $330,00 to capture 1 cardiac risk or $2 billion annually for mass screening (payors and many parties often expect benevolence by the medical community – free care)
- Indirect cost with false positives
- Medical legal risks of restricting athletes

European society of Cardiology Recommendations…

N Engl J Med. 1998 Aug 6;339(6):364-9.

Screening for hypertrophic cardiomyopathy in young athletes.

Corrado D, et al

Over 20 years period
32,652 competitive athletes were screened
1058 were disqualified
621 cardiovascular disease
38 % arrhythmias and conduction abnormalities
27% hypertension
21% MV disease
9% referred for echo

22 patients had HCM
18 had an abnormal ECG
5 had abnormalities on initial history and PE


A new world
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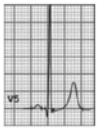
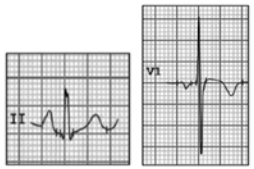
Summary of recommendations for screening PPE ECG. PPE indicates preparticipation examination; RAA, right atrial abnormality; LAA, left atrial abnormality; RVH, right ventricular hypertrophy; RAD, right axis deviation; RBBB, right bundle branch block; ...

ECG Abnormality	Criteria for further evaluation	Example
Q waves	>3 mm in depth or >40 ms duration in any lead except III, aVR, aVL and V1	
ST depression	>0.5 mm below PR isoelectric line between J-junction and beginning of T waves in V4, V5, V6, I, aVL >1 mm in any lead	
T wave inversion	>1 mm in leads other than III, aVR and V1 (except V2 and V3 in women <25 years)	
Atrial abnormalities	Right: P wave amplitude >2.5 mm Left: i) Negative portion of P wave in V1, V2 of >40 ms duration and 1 mm in depth; or ii) total P wave duration >120 ms	
Right ventricular hypertrophy	>30 years: i) R wave >7 mm in V1; or ii) R/S ratio >1 in V1; or iii) sum of R wave in V1 and S wave in V5 or V6 >10.5 mm <30 years: above plus right atrial enlargement, T wave inversion in V2, V3, or right axis deviation >115°	

Uberoi A et al. Circulation 2011;124:746-757

American Heart Association
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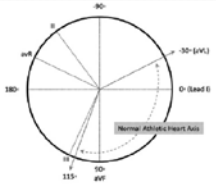
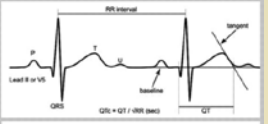
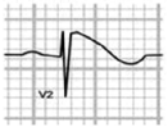
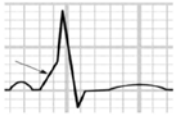
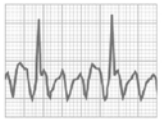
Summary of recommendations for screening PPE ECG. PPE indicates preparticipation examination; RAA, right atrial abnormality; LAA, left atrial abnormality; RVH, right ventricular hypertrophy; RAD, right axis deviation; RBBB, right bundle branch block; ...

LBBB RBBB IVCD	Any QRS >120 ms	
QRS axis deviation	More leftward than -30◦ More rightward than 115◦	
QTc interval	>470 ms in males >480 ms in females <340 ms in any athlete	
Brugada pattern	Presence of Type 1 pattern: coved ST segment in V1 and V2 gradually descending into inverted T wave	
Pre-Excitation	Delta wave and PR interval <120 ms	
Ventricular extrasystoles, heart block, and supraventricular arrhythmia	Atrial fibrillation/flutter, supraventricular tachycardia, complete heart block or ≥2 PVCs in one 12 lead ECG	

RBBB – right bundle branch block; LBBB – left bundle branch block, IVCD – intra- ventricular conduction delay, PVC – premature ventricular contraction. Measurements are by visual analysis.

Uberoi A et al. Circulation 2011;124:746-757

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Interpretation of the ECG

- Primary obstacle is differentiating the physiologic patterns from pathologic changes (variabilities related to age, gender, ethnicity, and sport training)
- Traditional interpretations resulted in 40-60% of ECG considered abnormal
- More recent European Society of Cardiology (ESC) recommendations decrease the abnormal findings to about 10-15% of those screened.

ECG Changes Related to Athletic Training

- Increased QRS voltage
  - In absence of other LVH criteria (axis deviation, repolarization changes, increased QRS width) isolated increased QRS voltage should not lead to further evaluation
- Early repolarization
  - Noted in >50% of trained athletes
  - Distinguish from Brugada
  - ST elevation > 2mm is unusual
- Sinus bradycardia (as low as 30/min), prolonged PR (up to 0.3 seconds) and Wenkebach are common in athletes due to high vagal tone and needs no further evaluation, although exercise testing can resolve any concern

ECG Evaluation in Athletes

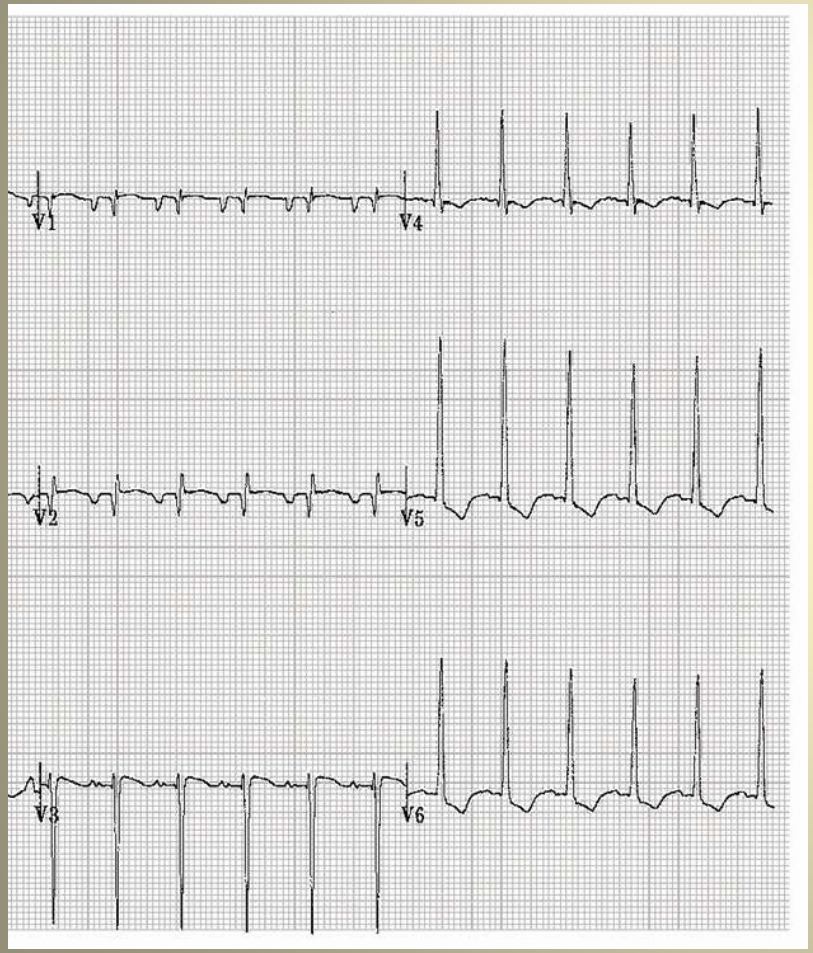
Uberoi et al. Circulation 124:746, 2011

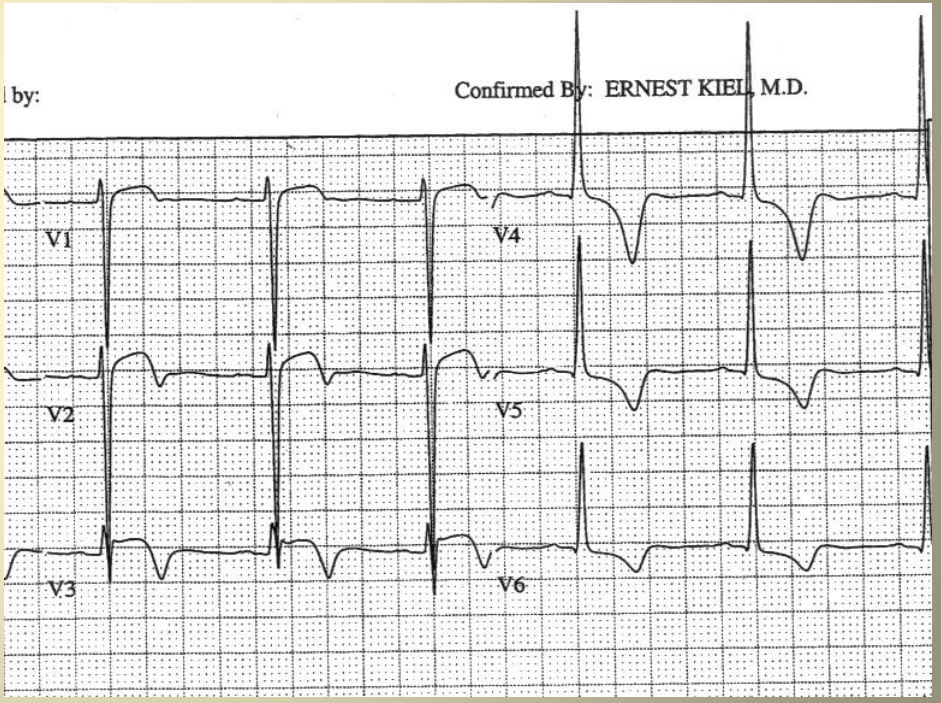
- Q waves
  - Abnormal criteria for HCM include >3 mm and/or >40 msec duration in at least 2 leads excluding AVR, III, V1
  - Abnormal Q waves should be further evaluated including detailed H&P and an echocardiogram
- Conduction delay
  - QRS durations >120 msec need further evaluation
  - LBBB patterns are less common and more ominous
  - Incomplete RBBB need not be referred but must consider the possible association with ASD or PS
- QRS axis deviation
  - Axis varies by age and an acceptable range for teens is -30 to +115 degrees
  - Mild isolated axis deviation needs no further evaluation

ECG Evaluation in Athletes

- Atrial abnormalities
  - RAA and LAA are seen in 1-18% but debate regarding criteria
  - In collegiate and adult level need further evaluation but not specifically in the young
  - ESC recommends further evaluation
- T wave inversion
  - Same incidence as non-athlete (2-14%) and more common in black population
  - Changes in V2-V4 need no further evaluation
  - 2 mm inversion in 2 adjacent leads needs further evaluation
  - Echocardiography and possible MRI imaging as next step

LV Strain on ECG

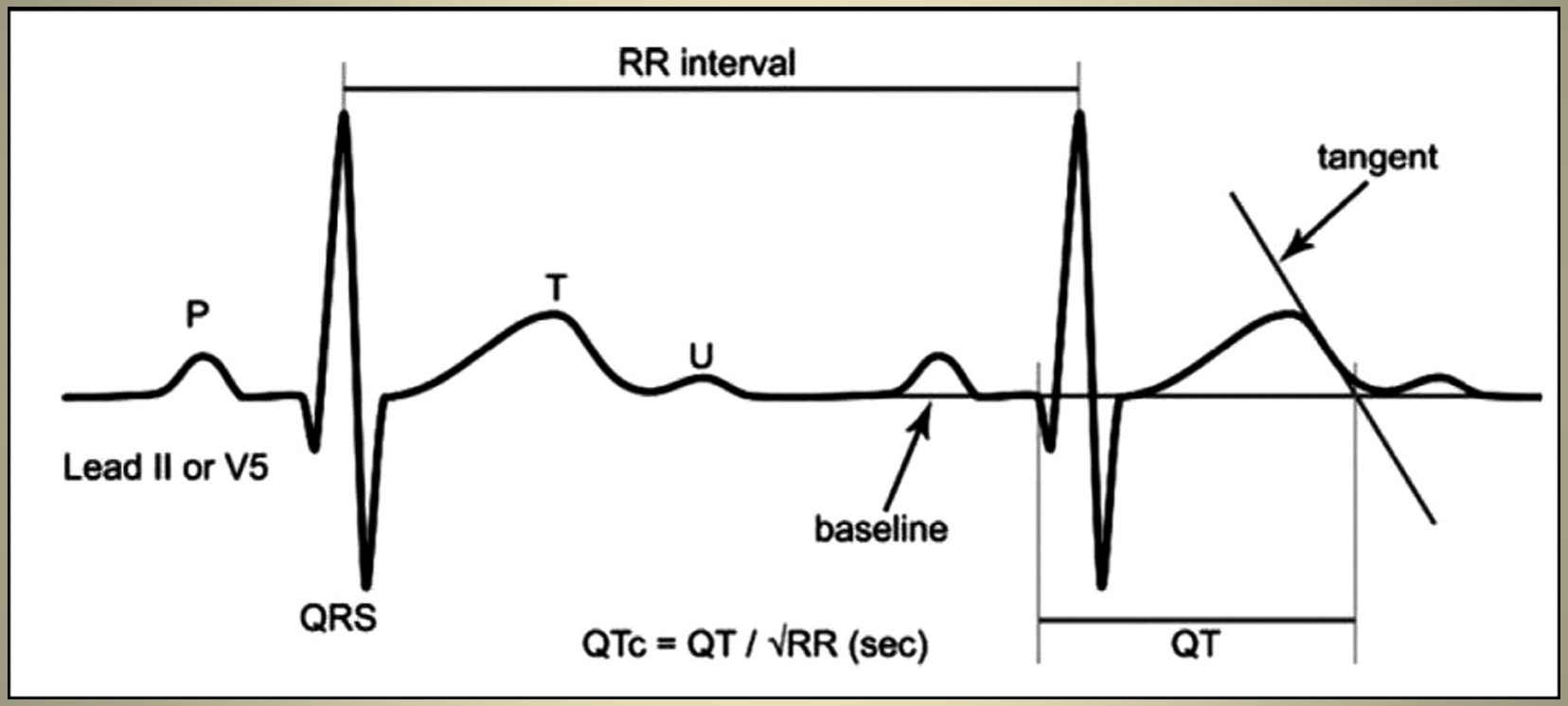




ECG Evaluation in Athletes

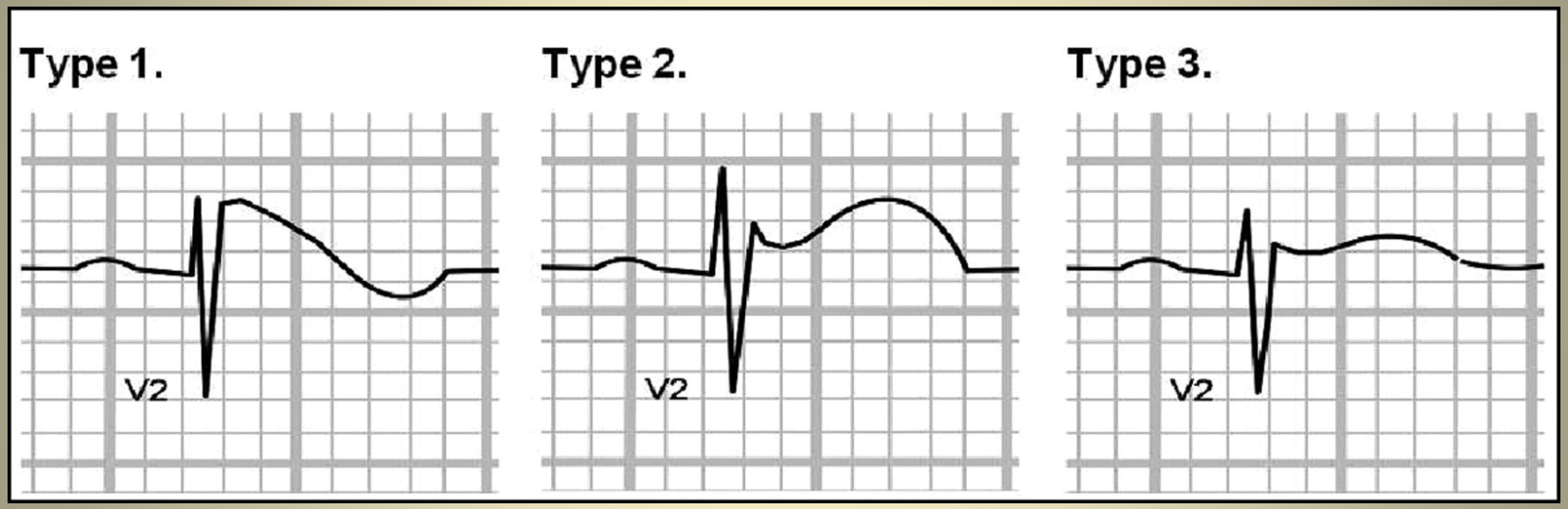
- QT abnormalities (long and short)
  - QTc>470 msec (male) and >480 msec (female) or QTC <340 msec need further evaluation
  - Further evaluation consists of more extensive family history, exercise testing, extended rhythm monitoring , and consideration of genetic testing
- Brugada Like ECG abnormalities
  - Asymptomatic with type 1 findings need further evaluation
  - More extensive family history, cardiac MRI, holter and exercise testing, possible genetic testing.
- Ventricular preexcitation
  - Seen in 0.1-0.3% in athletes with PPE
  - Report of 1 WPW in 1101 sudden death in athletes , 35 years
  - If seen further evaluation is recommended

Illustration of a manual method of measuring QT interval.



Uberoi A et al. Circulation 2011;124:746-757

Illustration of the 3 types of Brugada pattern.



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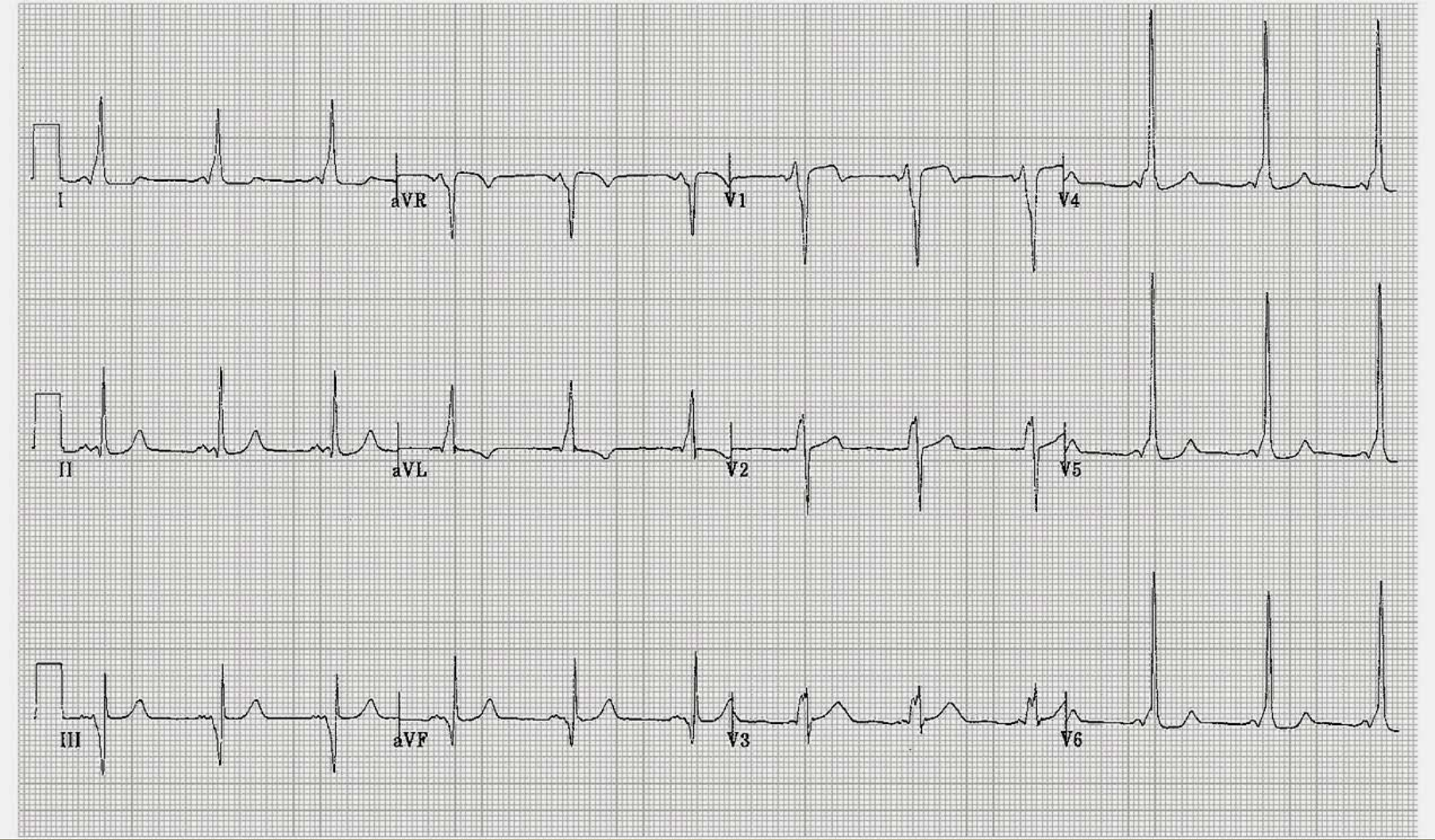
Ventricular Preexcitation - WPW



ECG Evaluation in Athletes

- PVC's and supraventricular arrhythmias
  - 2 or more PVC's on isolated ECG, SVT, atrial fib/flutter or complete AV block warrant further investigation

- It is wise to have your "ECG contacts" whom you may utilize to know who need to stop current participation.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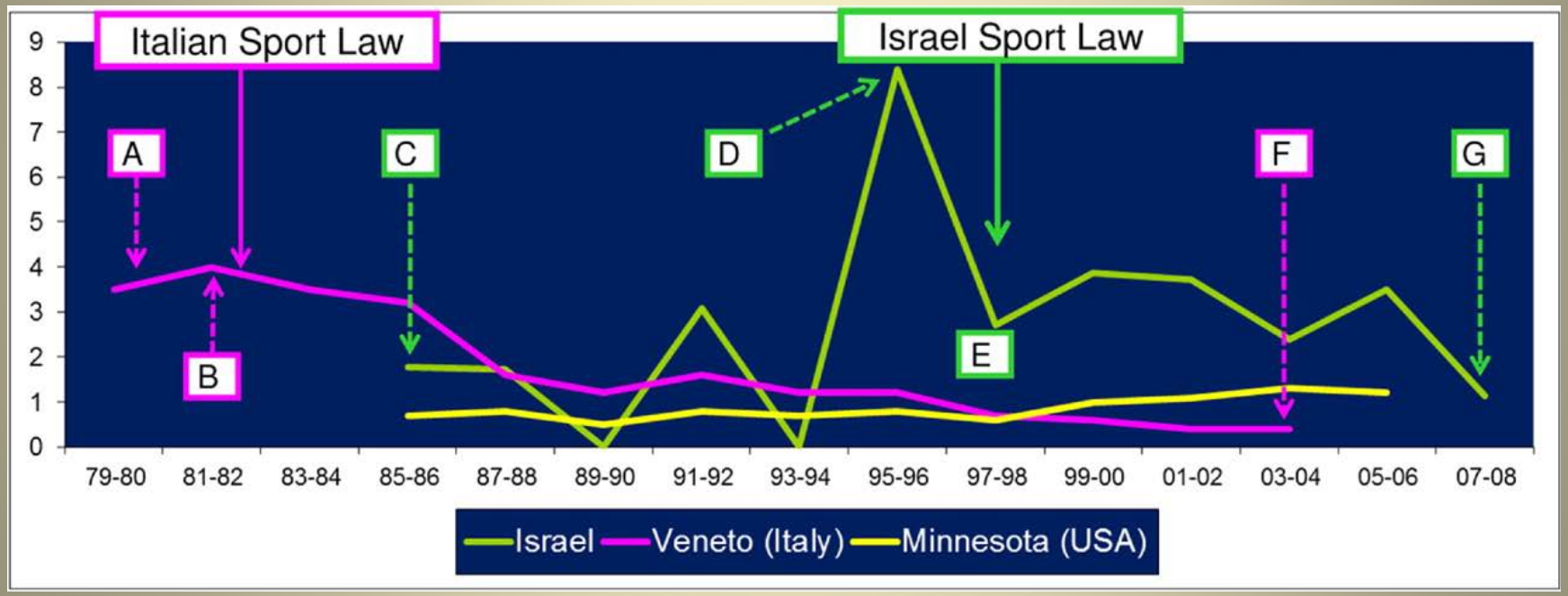
TOP TEN

Incidence of Sudden Cardiac Death Over Time



Final Comments and Summary

- Although rare, the presence of SCD in athletes is always a hot topic and awareness is a key when evaluating the pediatric patient. The incidence of SCD is no greater in the athlete population than the general pediatric population and selective screening of this group is questioned by some authorities.
- There are other screening concerns for athletes besides sudden cardiac death (concussion, sickle cell, hypertension, asthma, etc)
- Increased compliance with recommended screening protocols are needed

Final Comments and Summary

- The use of ancillary testing remains controversial (but will likely be implemented at some time due to social/political pressure despite costs)
- SCD will not be completely prevented no matter what extent of screening is utilized
- Just as important as screening may be the education of personnel in CPR and placement of automated defibrillators on site at sports settings! 2012 a Pennsylvania law was enacted to "prevent" SCD with mandatory training for schools and parental education
- Consider screening early in summer or throughout the year – the STAT need for evaluation just prior to school or a football game is not always feasible and may lead to a superficial evaluation