Preventing Sudden Death of Athletes with Electrocardiographic Screening:

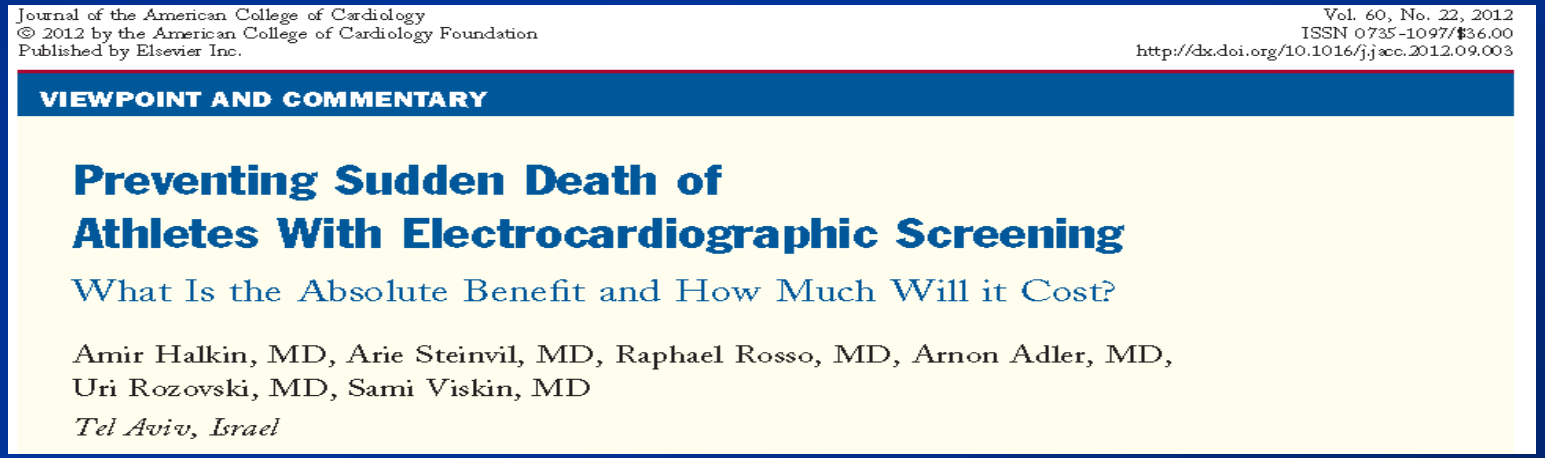
What is the Absolute Benefit and How Much Will it Cost?

Amir Halkin, Arie Steinvil, Raphael Rosso, Arnon Adler, Uri Rozovski, Sami Viskin

Department of Cardiology
The Tel Aviv Sourasky Medical Center and Sackler Faculty of Medicine, Tel-Aviv University, Tel Aviv, Israel

The authors declare no conflict of interest

Accepted for publication JACC



Journal of the American College of Cardiology
© 2012 by the American College of Cardiology Foundation
Published by Elsevier Inc.

Vol. 60, No. 22, 2012
ISSN 0735-1097/$36.00
http://dx.doi.org/10.1016/j.jacc.2012.09.003

VIEWPOINT AND COMMENTARY

Preventing Sudden Death of Athletes With Electrocardiographic Screening

What Is the Absolute Benefit and How Much Will it Cost?

Amir Halkin, MD, Arie Steinvil, MD, Raphael Rosso, MD, Arnon Adler, MD, Uri Rozovski, MD, Sami Viskin, MD

Tel Aviv, Israel

Prevalence of sudden death in athletes

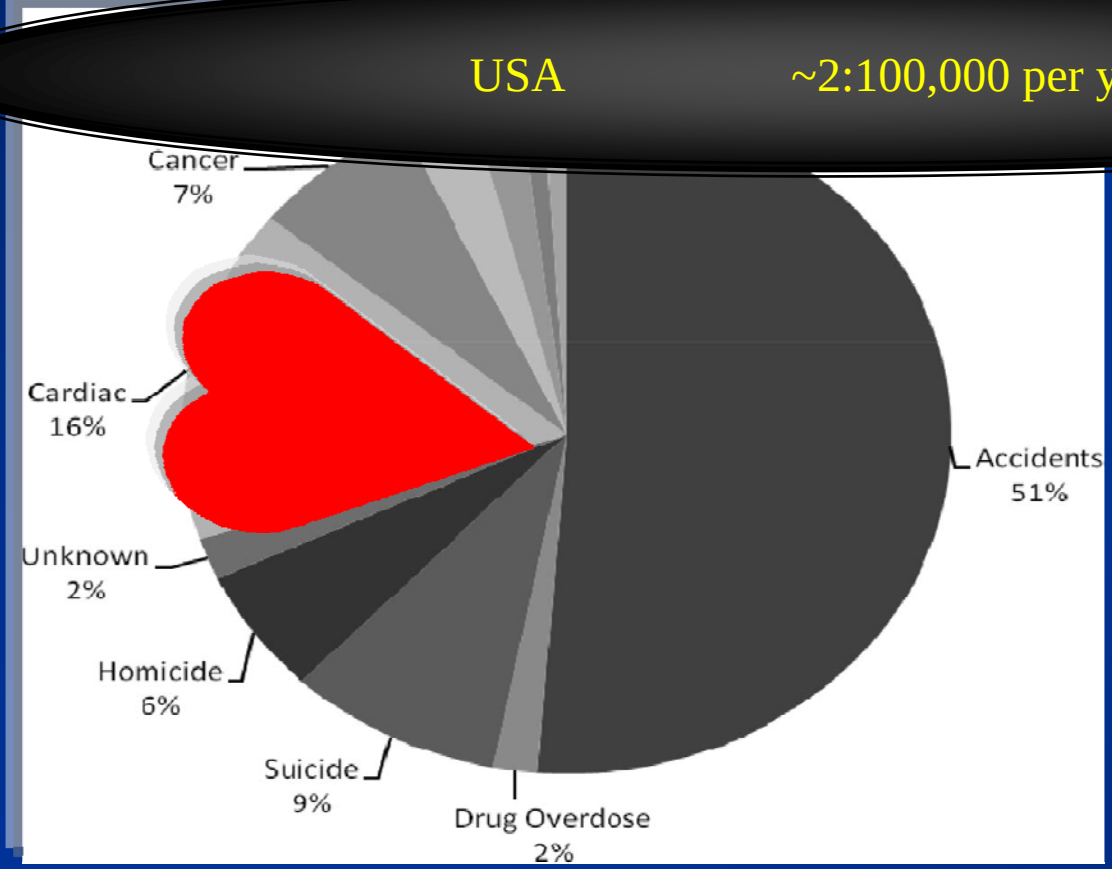
USA	1:100,000
Denmark	1.2:100,000
Italy	0.4:100,000
France	6.5:100,000
Israel	2.6:100,000

Retrospective; Media reports; Various sources

Bove, JACC *2011*

SCD is the leading medical cause of death

USA ~2:100,000 per year



1,969,663 athlete years
273
deaths
187
non medical
80
medical
45
cardiac

Causes of sudden death in NCAA athletes, 2004-2008

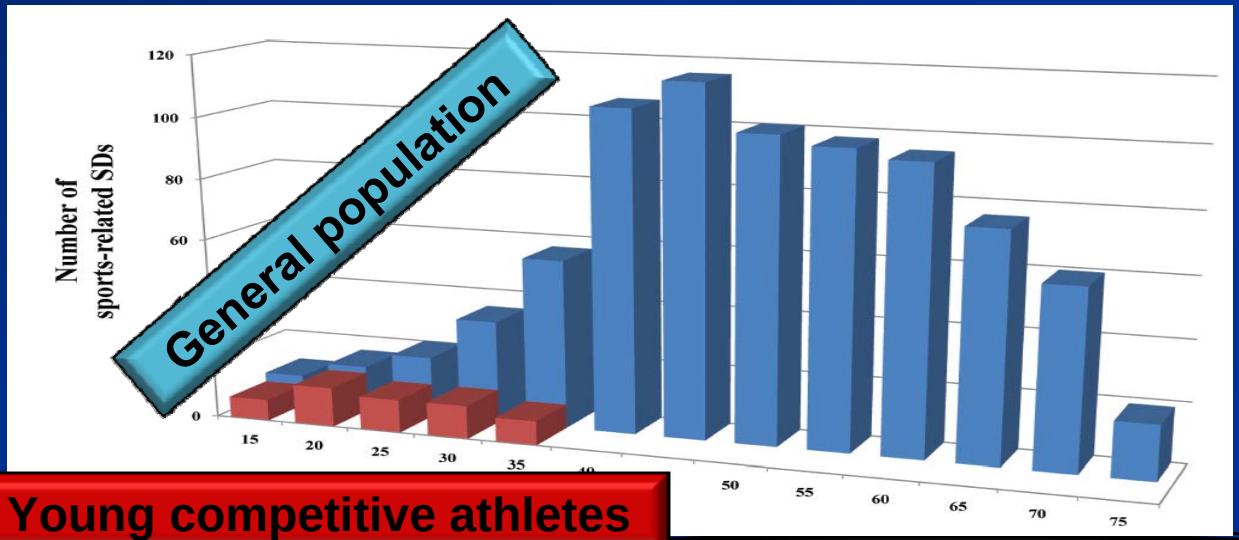
Retrospective analysis of death reports

Harmon, Circulation *2011*

Sports-Related Sudden Death in the non athletes

First prospective national survey

French athletes and non-athletes 2005-2010



169,742,000 person-years

770 Non athletes

50 athletes

Young competitive athletes

French Athletes ~ 1:100,000 per year

French non-Athletes ~ 0.2:100,000 per year

Marijon, Circulation *2011*

SCD in marathon runners

marathon runners ~ 0.5:100,000 runners

Table 1. Participant Numbers, Absolute Number of Cardiac Arrests, and Incidence of Cardiac Arrest during Long-Distance Running Races in the United States, 2000–2010.

Variable	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009–2010*	Total
All participants (in thousands)											
Marathon — total no. (% men)	353 (65)	334 (64)	354 (64)	365 (62)	386 (59)	395 (60)	410 (60)	412 (59)	425 (59)	515 (59)	3949 (61)
Half-marathon — total no. (% men)	482 (53)	515 (52)	550 (51)	572 (52)	612 (51)	658 (47)	724 (47)	796 (45)	900 (44)	1113 (42)	6922 (48)
Total — no.	835	849	904	937	998	1053	1134	1208	1325	1628	10,871
Cardiac arrests											
Marathon — total no. (no. of men)	3 (3)	3 (1)	3 (1)	3 (2)	1 (1)	2 (2)	9 (9)	5 (5)	6 (5)	5 (5)	40 (34)
Half-marathon — total no. (no. of men)	0	0	1 (1)	4 (4)	1 (1)	0	1 (1)	2 (2)	0	10 (8)	19 (17)
Total — no. (no. of men)	3 (3)	3 (1)	4 (2)	7 (6)	2 (2)	2 (2)	10 (10)	7 (7)	6 (5)	15 (13)	59 (51)
	2000–2004			2005–2010*			P Value			2000–2010*	
Incidence of cardiac arrest — no./100,000 (95% CI)†											
Marathon‡	0.73 (0.39–1.24)			1.25 (0.83–1.82)			0.11			1.01 (0.72–1.38)	
Half-marathon‡	0.22 (0.08–0.48)			0.31 (0.17–0.53)			0.48			0.27 (0.17–0.43)	
Male sex§	0.55 (0.30–0.93)			1.17 (0.83–1.62)			0.02			0.90 (0.67–1.18)	
Female sex§	0.27 (0.09–0.63)			0.09 (0.02–0.27)			0.15			0.16 (0.07–0.31)	
Total	0.42 (0.25–0.66)			0.63 (0.45–0.86)			0.15			0.54 (0.41–0.70)	

Jonathan H. Kim Et al. NEJM 2012 366;2

In spite of the public outcry athlete SD are rare

Can we prevent them?

Effectively?

Safely?

Cost-effectively?

Pre participation guidelines

The AHA

TABLE. 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)§

The ESC

Box. Criteria for a Positive History, Physical Examination, and 12-Lead Electrocardiogram at Preparticipation Screening

Family History

Close relative(s) with premature myocardial infarction or sudden death at <50 years

Family history of cardiomyopathy, coronary artery disease, Marfan syndrome, long QT syndrome, severe arrhythmias, or other disabling cardiovascular diseases

Personal History

Syncope or near-syncope

Exertional chest pain or discomfort

Shortness of breath or fatigue out of proportion to the degree of physical effort

Palpitations or irregular heartbeat

Physical Examination

Musculoskeletal and ocular features suggestive of Marfan syndrome

Diminished and delayed femoral artery pulses

Mid- or end-systolic clicks

Abnormal second heart sound (single or widely with respiration)

Heart murmurs (systolic grade ≥2/6 and any

Irregular heart rhythm

Brachial blood pressure ≥140/90 mm Hg on more than

Electrocardiogram

Left atrial enlargement: negative portion of the wave in lead V1 ≥0.1 mV in depth and ≥0.04 s in duration

Right atrial enlargement: peaked P wave in leads II and III or V1 ≥0.25 mV in amplitude

Frontal-plane QRS axis deviation: right ≥+120° or left −30° to −90°

Increased voltage: amplitude of R or S wave in a standard lead ≥2 mV, S wave in lead V1 or V2 ≥3 mV, or R wave in lead V5 or V6 ≥3 mV

Abnormal Q waves ≥0.04 s in duration or ≥25% of the height of the ensuing R wave, or QS pattern in ≥2 leads

Right or left bundle-branch block with QRS duration ≥0.12 s

R or R′ wave in lead V1 ≥0.5 mV in amplitude and R/S ratio ≥1

ST-segment depression or T-wave flattening or inversion in ≥2 leads

Electrocardiogram

...ventricular preexcitation: short PR interval (<0.12 s) with or without delta wave

First-degree (PR ≥0.21 s, not shortening with hyperventilation), second-degree, or third-degree atrioventricular block

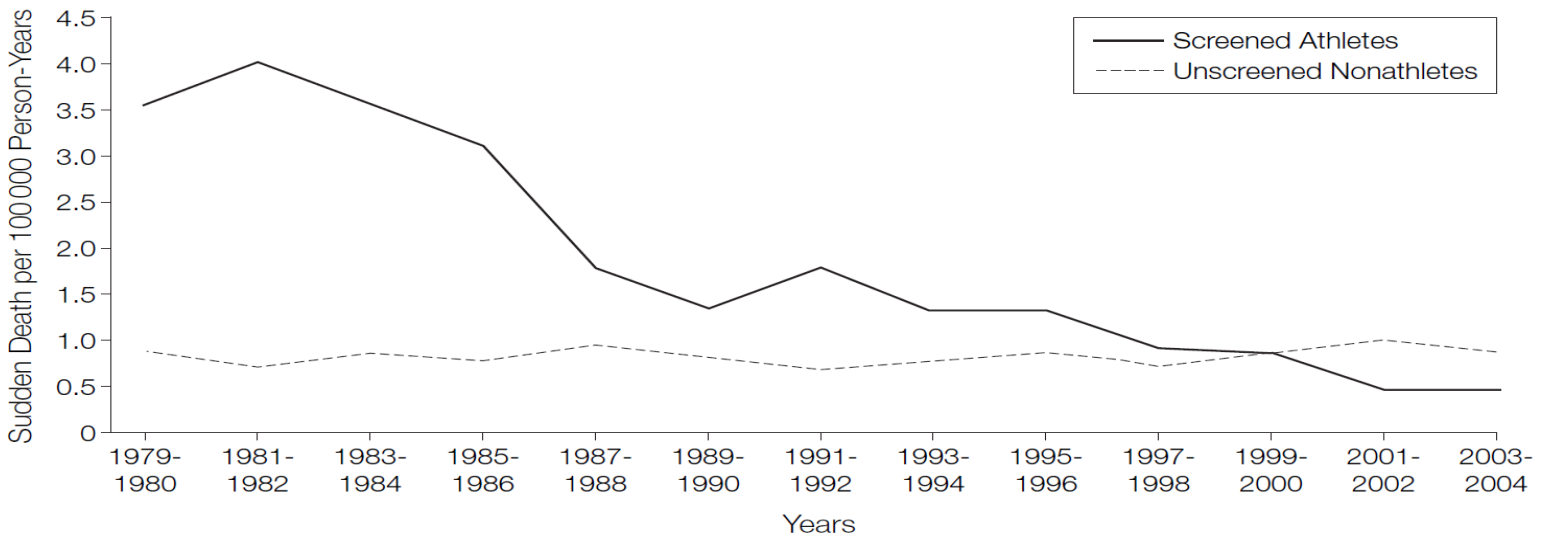
Corado et al. Trends in Sudden Cardiovascular Death in Young Competitive Athletes After Implementation of a Pre-participation Screening JAMA 2006

Maron et al. Recommendations and Considerations Related to Pre-participation Screening for CVD Abnormalities in Competitive Athletes. Circulation 2007

Introduction

The Italian experience

Figure. Annual Incidence Rates of Sudden Cardiovascular Death in Screened Competitive Athletes and Unscreened Nonathletes Aged 12 to 35 Years in the Veneto Region of Italy (1979-2004)



During the study period, the annual incidence of sudden cardiovascular death decreased by 89% in screened athletes (*P* for trend <.001). In contrast, the incidence rate of sudden cardiovascular death did not demonstrate consistent changes over time in unscreened nonathletes.

Corado et al. Trends in Sudden Cardiovascular Death in Young Competitive Athletes After Implementation of a Pre-participation Screening. JAMA 2006.

Introduction

To ECG or not to ECG ?

CONTROVERSIES IN CARDIOVASCULAR MEDICINE

Should an electrocardiogram be included in routine preparticipation screening of young athletes?

An Electrocardiogram Should Not Be Included in Routine Preparticipation Screening of Young Athletes

Bernard R. Chaitman, MD, FACC

Bethesda Conference #36 and the European Society of Cardiology Consensus Recommendations Revisited

A Comparison of U.S. and European Criteria for Eligibility and Disqualification of Competitive Athletes With Cardiovascular Abnormalities

Antonio Pelliccia, MD,* Douglas P. Zipes, MD,† Barry J. Maron, MD‡

Rome, Italy; Indianapolis, Indiana; and Minneapolis, Minnesota

"…The 2 consensus documents emanate from largely different cultural, social, and legal backgrounds existing in the U.S. and Europe…"

Pelliccia et al. JACC 2008
Chaitman et al. circulation 2007; lancet 2008.

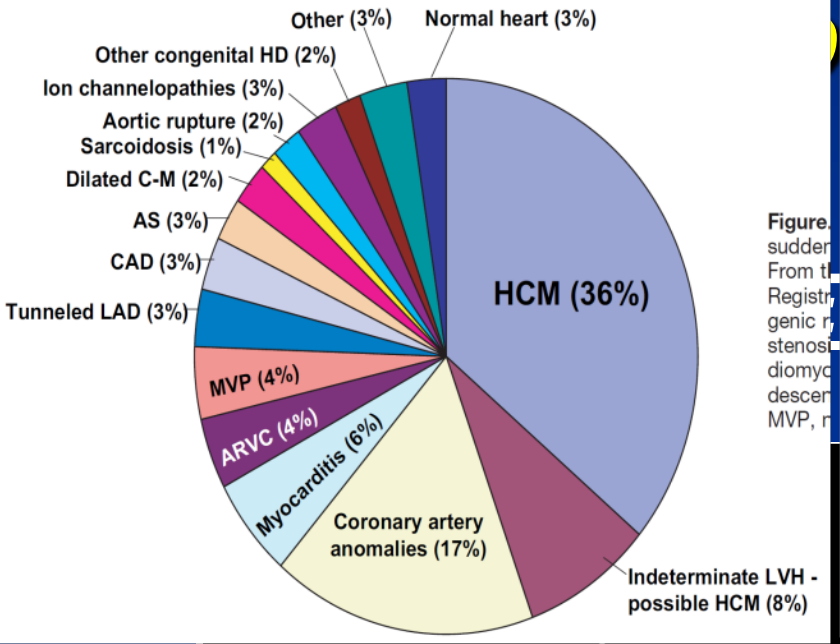
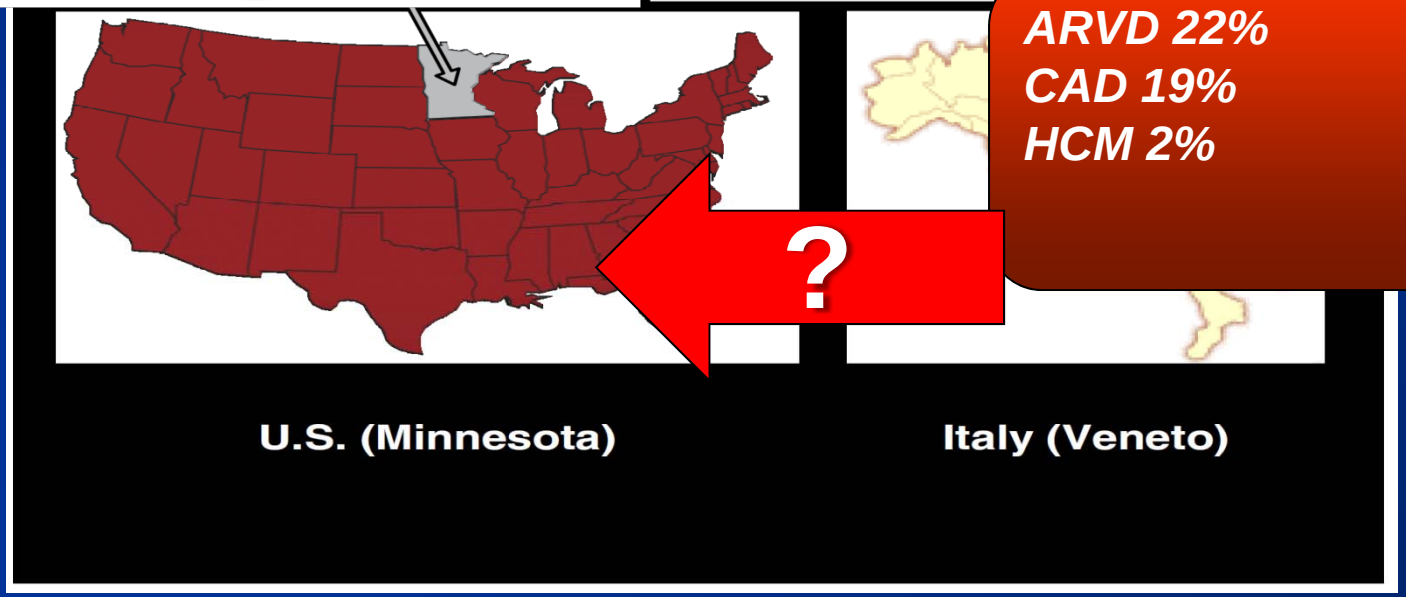


Figure. sudden From th Registr genic r stenosi diomyo descen MVP, r

Table 2 Causes of sudden deaths in athletes and non-athletes (aged ≤35 years) in the Veneto region of Italy from 1979 to 1996

	Athletes ($n = 49$) n (%)	Non-athletes ($n = 220$) n (%)	Total ($n = 269$) n(%)
Arrhythmogenic RV cardiomyopathy	11 (22.4)	18 (8.2)*	29 (10.8)
Atherosclerotic coronary artery disease	9 (18.5)	36 (16.4)	45 (16.7)
Anomalous origin of coronary artery	6 (12.2)	1 (0.4)**	7 (2.6)
Conduction system pathology	4 (8.2)	20 (9)	24 (8.9)
Mitral valve prolapse	5 (10.2)	21 (9.5)	26 (9.7)
HCM	1 (2)	16 (7.3)	17 (6.3)
Myocarditis	3 (6.1)	19 (8.6)	22 (8.2)
Myocardial bridge	2 (4)	5 (2.3)	7 (2.6)
Pulmonary thrombo-embolism	1 (2)	3 (1.4)	4 (1.5)
Dissecting aortic aneurysm	1 (2)	11 (5)	12 (4.5)
Dilated cardiomyopathy	1 (2)	9 (4.1)	10 (3.7)
Other	5 (10.2)	61 (27.7)	66 (24.5)

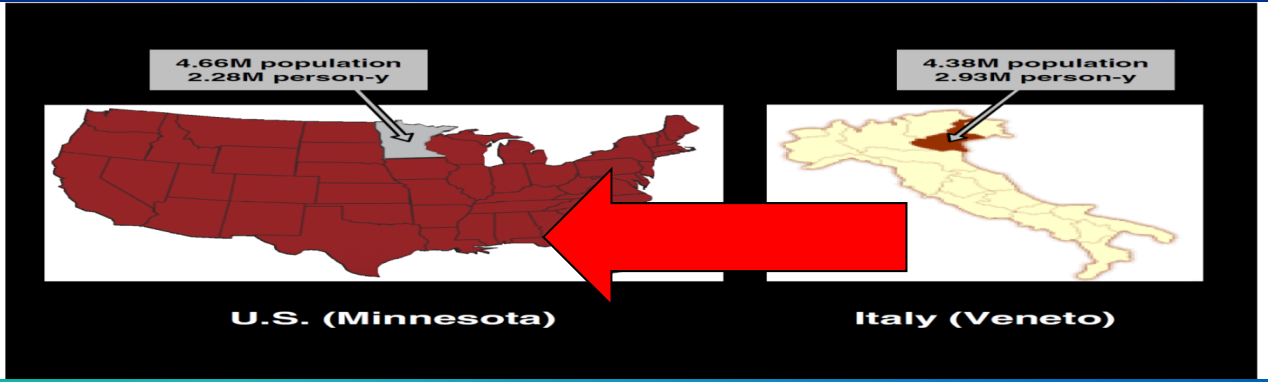
ARVD 22%
CAD 19%
HCM 2%



Maron et al. Comparison of U.S. and Italian Experiences With Sudden Cardiac Deaths in Young Competitive Athletes and Implications for Preparticipation Screening Strategies. Am j Cardiology 2009.

Study Objective

Evaluate a 20 Y projection model for a US ECG based screening program derived From Italian experience and ESC guidelines



How many lives would be saved?

How much will it cost?

What will be the cost to save one life?

Methods

Data collection

- Italian ECG based screening experience
- US number of athletes to be screened
- Establishing a cost-projection model
- US costs of exams and procedures

Methods

Italian ECG based screening experience

42,386 athletes screened yearly for 20Y

ECG abnormalities	Qualified	Disqualified	Total
	3,035	879	3,914

~2% disqualified after 20Y screening

Methods

✔ US number of athletes to be screened

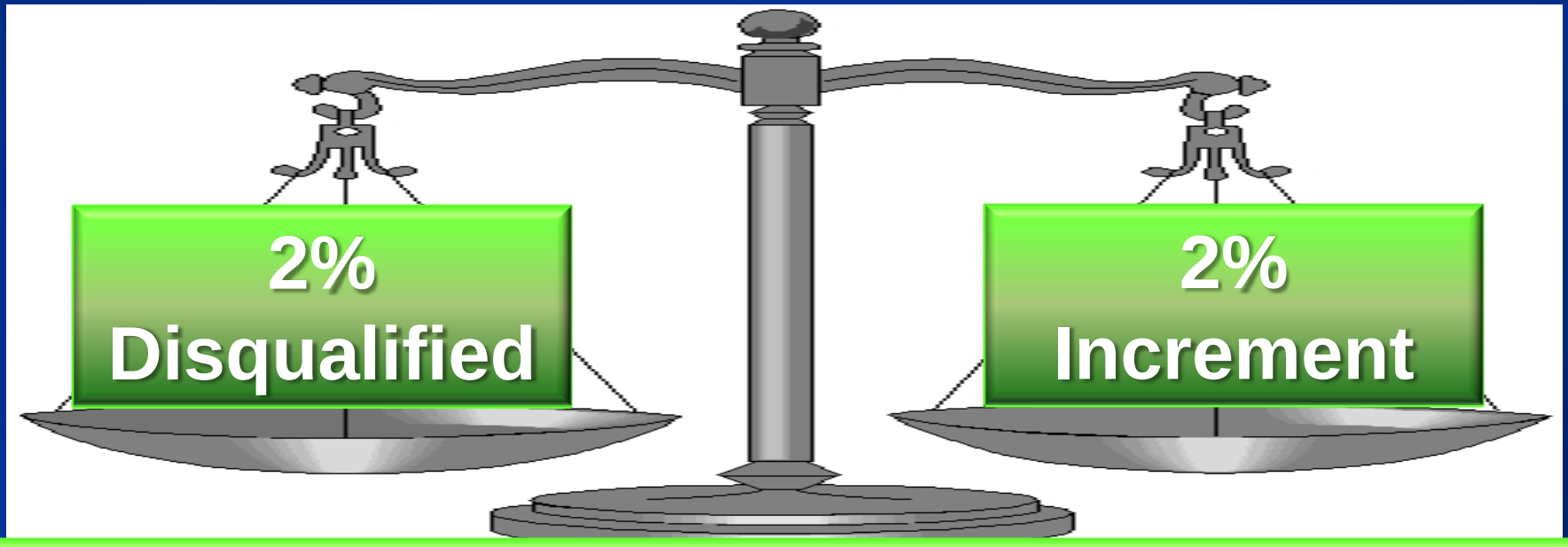
National Federation of State High School Associations	National College Athletic Association
http://www.nfhs.org/	http://www.ncaa.org/

Methods

✔ *Cost projection model*

Start screening in 2013 for 20 Y

2013 total athletes to screen: 8.5 million



20Y screening X 8.5 million = 170 million

Methods

US costs of exams and procedures

Procedure	HCPCS code	Lowest price	Highest price	OPPS	Minimum copayment	Min price	Max price
History and exam	G0402	130	*219*	94	0	224	313
Electrocardiogram	93005	7	*15*	27	5	39	47
Echocardiogram	93303	57	*293*	581	116	754	990
Exercise test	93017	35	*76*	178	36	249	290
Holter	93225	20	*43*	65	13	98	121
Cardiac MRI	75561	113	*799*	535	107	755	1441
Catheterization	93452	211	*1226*	2720	544	3,475	4,490
EPS	93620	605	*670*	3730	746	5,081	5,146
						3,104	3,692
				*Averaged price for MRI/Cath/EPS**			

All prices are in U.S. dollars.
CMS = Centers for Medicare and Medicaid Services
HCPCS = Healthcare Common Procedure Coding System
OPPS = Outpatient Prospective Payment System
Centers for Medicare and Medicaid Services. http://www.cms.gov/apps/physician-fee-schedule

Results

How much will it cost?

170 million screening events

100%	HX+Exam+ECG
9.2%	Echo
3.1%	ETT
1.2%	Holter
0.2%	Cath/EPS/MRI

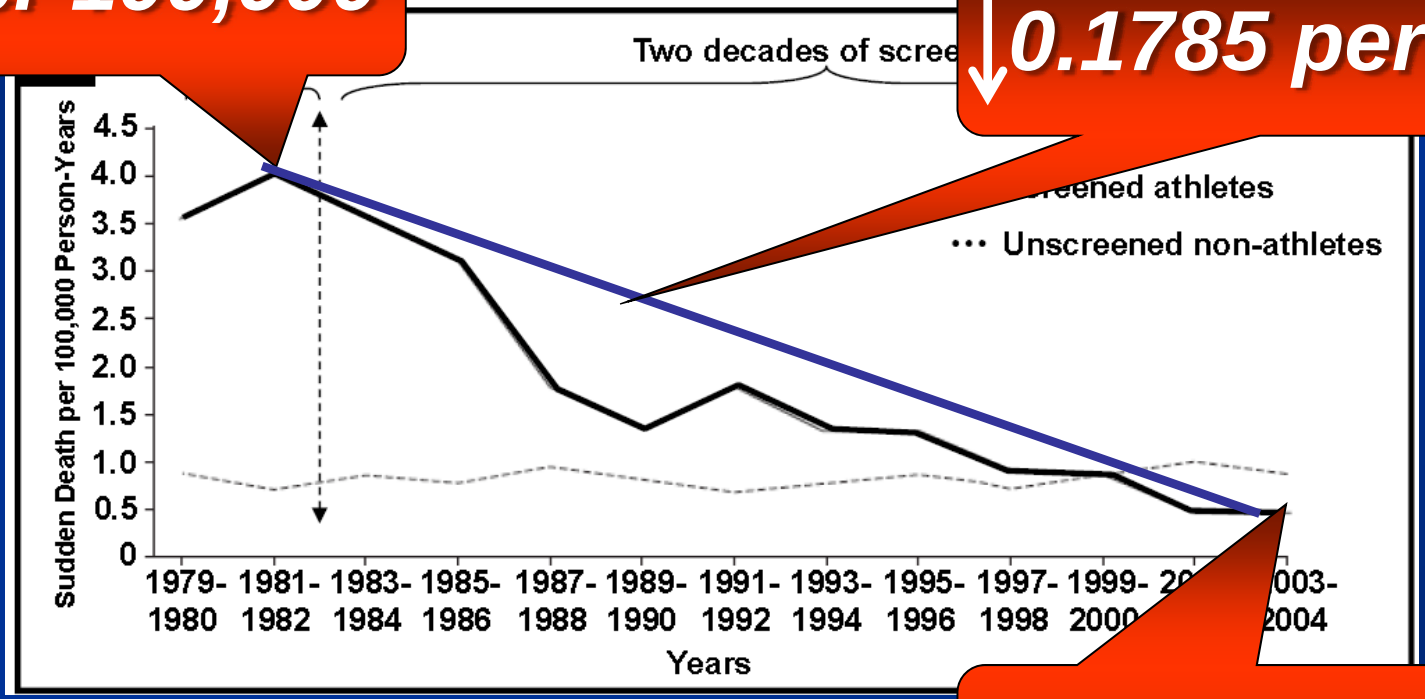
Min price	Max price
51 Billion US$	69 Billion US$

Results

How many lives would be saved?

4 per 100,000

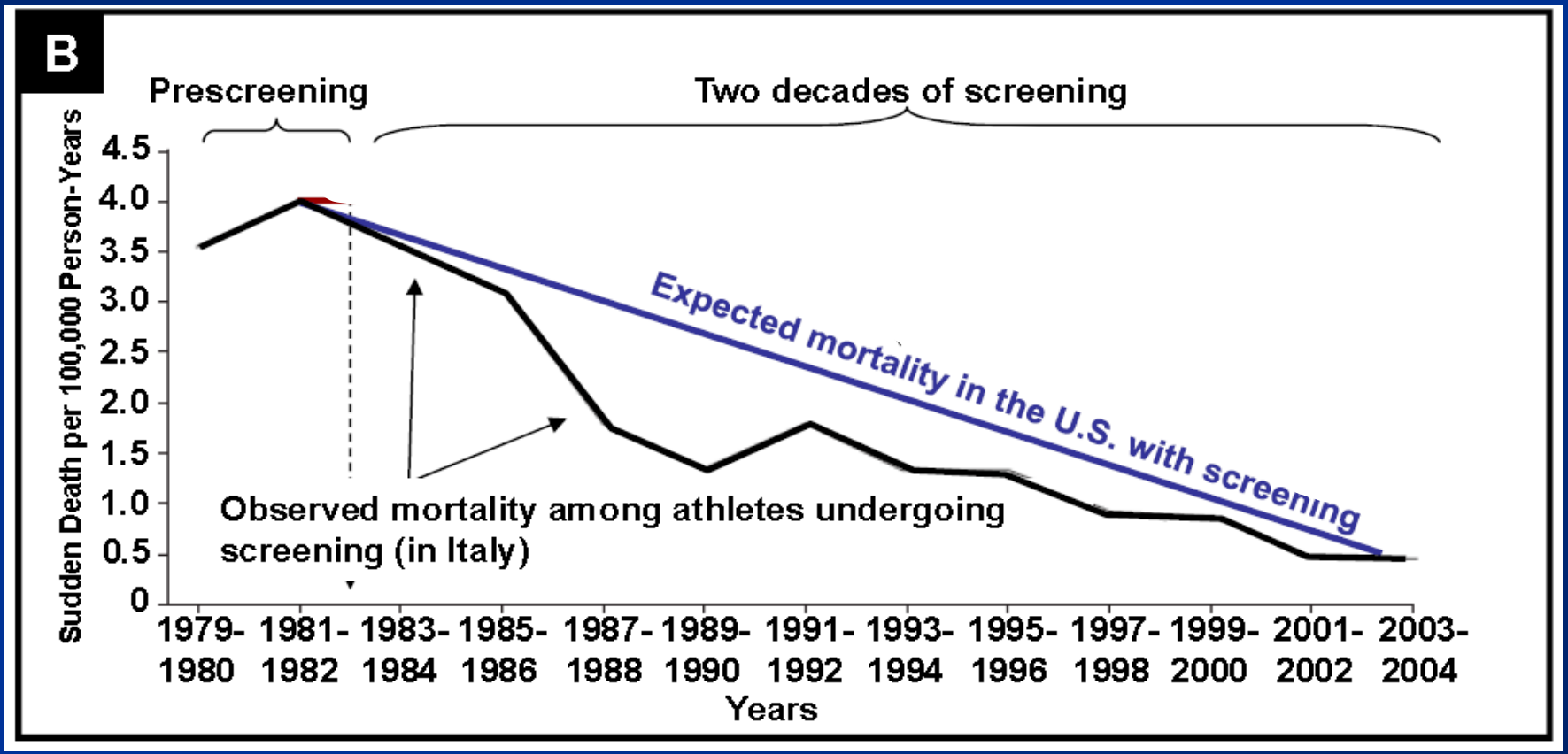
↓0.1785 per year



0.43 per 100,000

Results

How many lives would be saved?



How many lives would be saved?

Year of screening	Number of sudden deaths: Unscreened population	ECG-screened population	Lives saved by screening
	340	340	
	347	325	
	354	310	
	361	294	
	368	279	
	375	264	
	383	249	
	391	234	
	398	219	
	406	203	
	414	188	
	423	173	
	431	158	
	440	143	
	449	128	
	458	112	
	467	97	
	476	82	
	486	67	41
	495	52	444
	505	37	469
Total	8766	3954	4813

Unscreened:

- 2% yearly incline in athletes
- Constant SD rate of 4/100,000

Screened:

- Constant number of athletes
- 0.1785 per 100,000 SD reduction per year

How many lives would be saved?

Min price	Max price
51 Billion US$	69 Billion US$

Number of life saved = 4,813

Cost of one life saved

Min price	Max price
10.6 million US$	14.4 million US$

Summary

- **A 20 year ECG based pre-participation screening program in the US:**
  - **170,000,000 screening processes**
  - **At a of cost 51-69 billion us$**
  - **Will save 4,813 athlete lifes**
  - **At a cost per life saved of 10.6-14.4 mil us$**
  - **Will disqualify 3.4 million athletes**

Discussion

- **Model underestimation of cost**
  - **Repeat procedures for true positives**
  - **Lower baseline mortality rates in US**
- **Should public funds be spent on other validated modalities?**
  - **Use of AED's**
  - **Education**

Thank you