Recommendations for Sports Participation in Athletes with Known Cardiovascular Diseases

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Cardiology Update 2015

Davos (Switzerland), 8-12 February, 2015

Recommendations

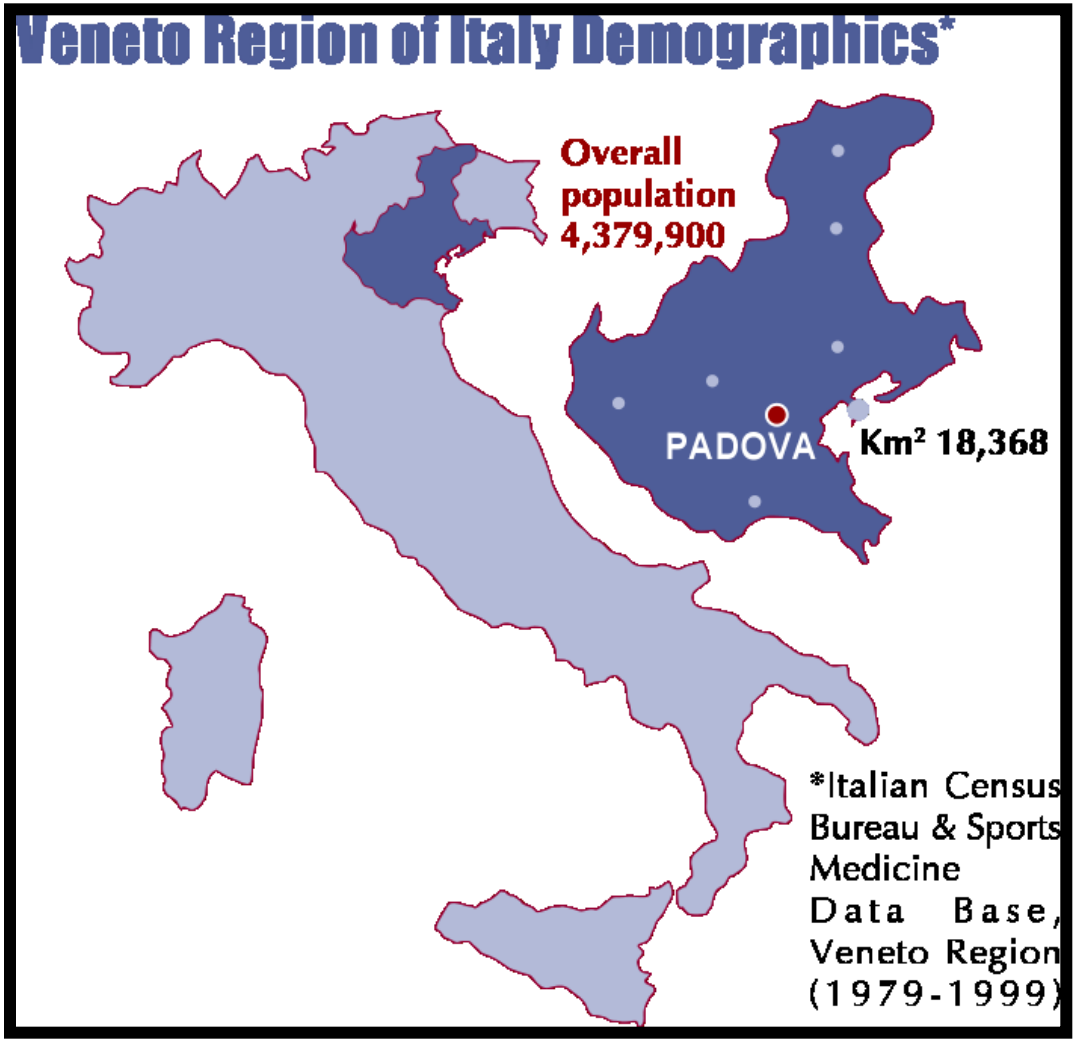
- Rationale for recommendation on sports eligibility/disqualification
- Bethesda and ESC documents
- Lessons from sport-related SCD studies
- Management of athletes with high risk conditions
- Bethesda *versus* ESC recommendations
- Future directions and conclusions

Cardiovascular risk of sport activity

Regular physical exercise is recommended by the medical community because it improves fitness and reduces cardiovascular morbidity and mortality.

On the other hand, vigorous exertion may acutely increase the risk of sudden arrhythmic death in susceptible individuals

Veneto Region of Italy Demographics*



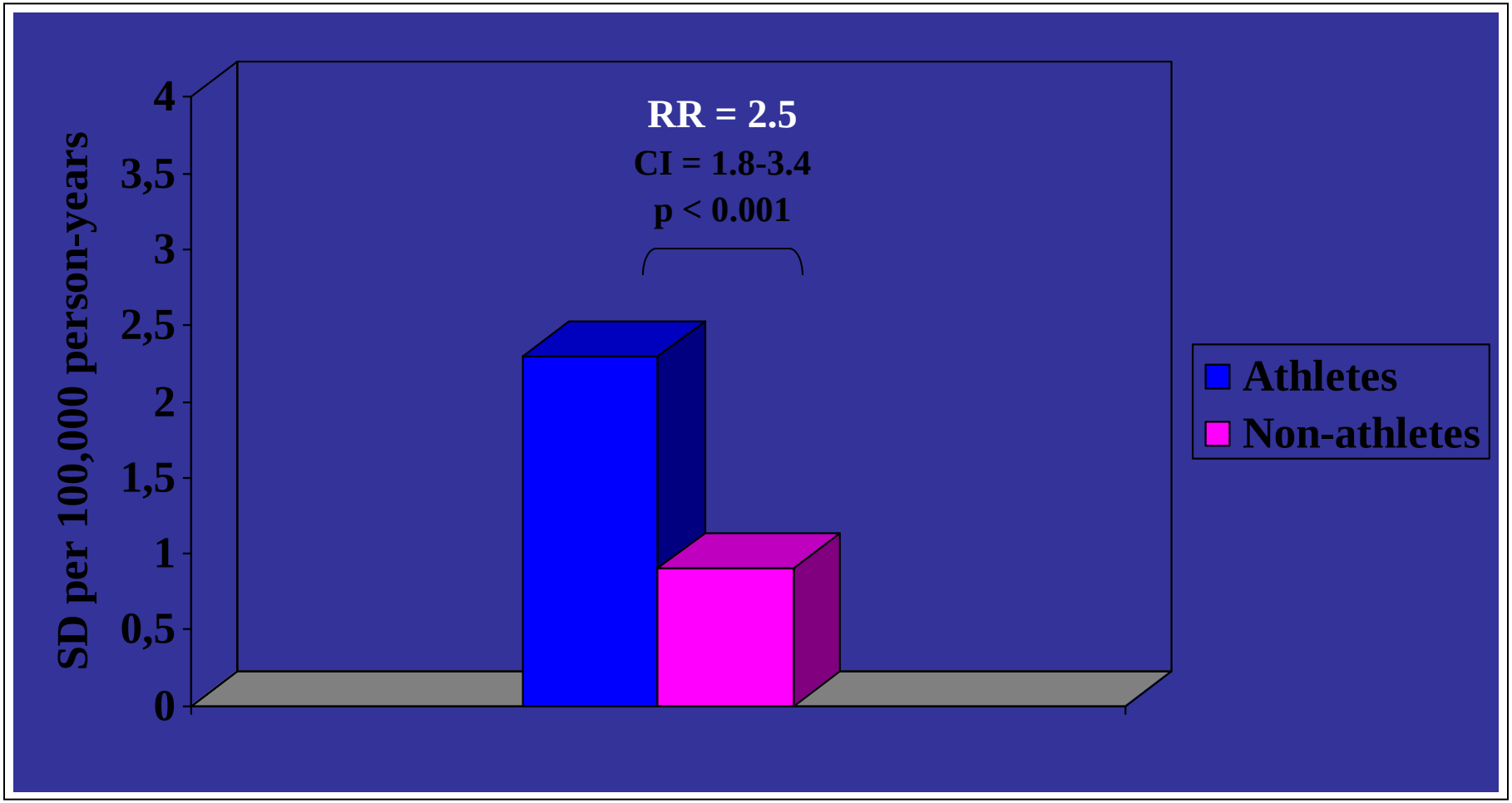
Overall population
4,379,900

Young population
(12-35 yrs)
1,386,650

Young athletes
112,790
(90,690 M; 22,100 F)

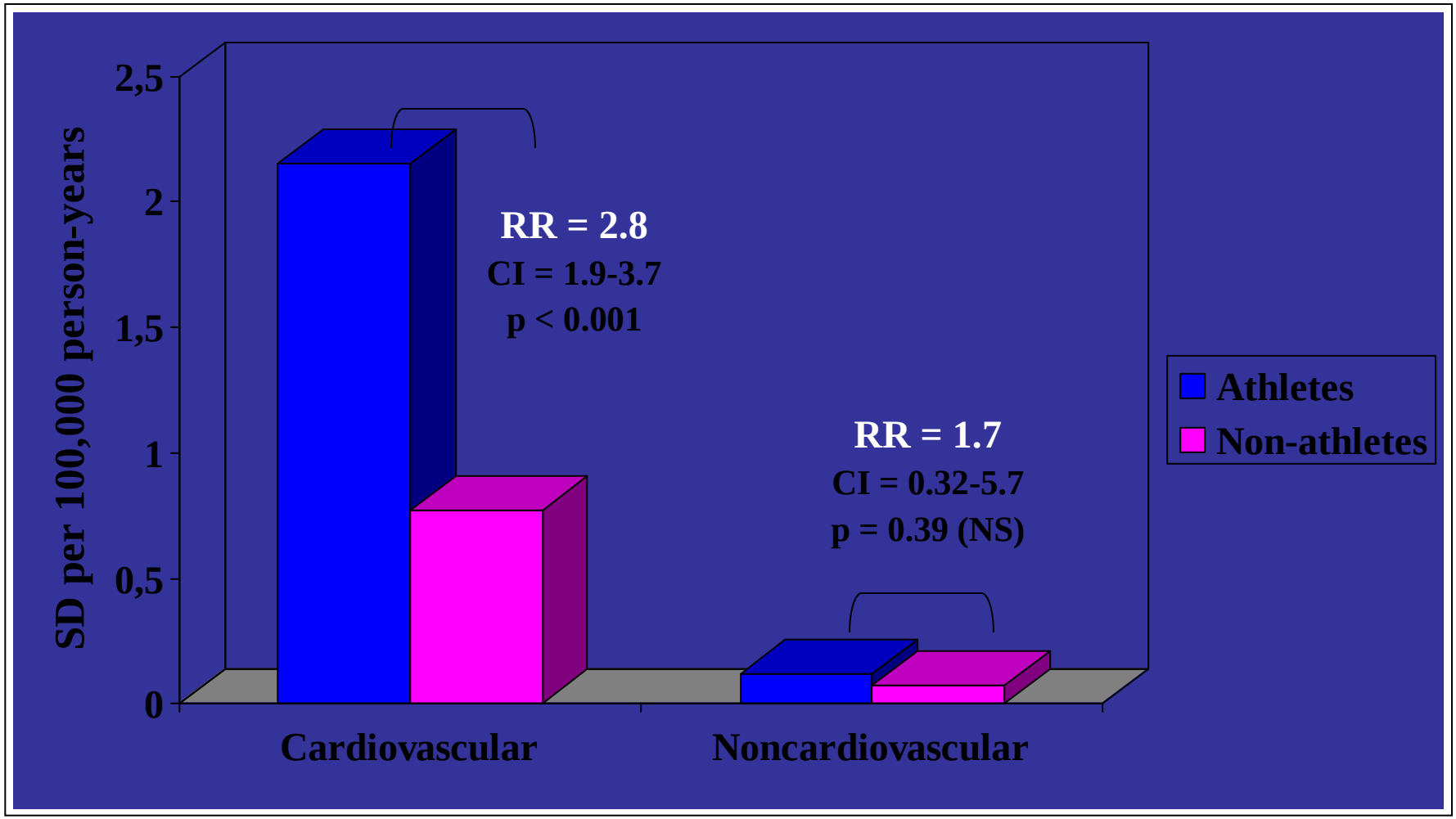
***Italian Census Bureau & Sports Medicine Data Base, Veneto Region (1979-1999)**

Relative risk of SD
Young athletes vs non-athletes
(Veneto region of Italy; 1979-1999)



Corrado et al. J Am Coll Cardiol 2003; 42:1959-63

Relative risk of sport-related SD by cardiovascular and noncardiovascular diseases



Corrado et al. J Am Coll Cardiol 2003; 42:1959-63

Cardiovascular causes of sudden death associated with sports

Adults (age > 35 years):

Atherosclerotic coronary artery disease

Young competitive athletes (age ≤35 years):

Hypertrophic cardiomyopathy
Arrhythmogenic right ventricular cardiomyopathy
Congenital anomalies of coronary arteries
Myocarditis
Aortic rupture
Valvular disease
Preexcitation syndromes and conduction diseases
Ion channel diseases
Congenital heart disease, operated or unoperated

Rationale

- Proper management of athletes with at-risk cardiovascular disorders offers the possibility of preventing SCD and disease progression
- Lifestyle modification with restriction of competitive sports activity
- Clinical intervention with antiarrhythmic drugs, beta-blockers, catheter ablation and ICD therapy

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Bethesda Conferences #16th, 26th, 36th

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36TH BETHESDA CONFERENCE

Introduction: Eligibility Recommendations for Competitive Athletes With Cardiovascular Abnormalities—General Considerations

Barry J. Maron, MD, FACC, *Co-Chair*
Douglas P. Zipes, MD, MACC, *Co-Chair*

European Heart Journal (2005) **26**, 1422–1445
doi:10.1093/eurheartj/ehi325

ESC Report

Recommendations for competitive sports participation in athletes with cardiovascular disease

A consensus document from the Study Group of Sports Cardiology of the Working Group of Cardiac Rehabilitation and Exercise Physiology and the Working Group of Myocardial and Pericardial Diseases of the European Society of Cardiology

Antonio Pelliccia[1*], Robert Fagard[2], Hans Halvor Bjørnstad[3], Aris Anastassakis[4], Eloisa Arbustini[5], Deodato Assanelli[6], Alessandro Biffi[1], Mats Borjesson[7], François Carrè[8], Domenico Corrado[9], Pietro Delise[10], Uwe Dorwarth[11], Asle Hirth[3], Hein Heidbuchel[12], Ellen Hoffmann[11], Klaus P. Mellwig[13], Nicole Panhuyzen-Goedkoop[14], Angela Pisani[5], Erik E. Solberg[15], Frank van-Buuren[13], and Luc Vanhees[2]

Bethesda and ESC recommentations

- Expert consensus recommendations
- Competitive athlete with an identified cardiovascular abnormality
- Framework on which to base eligibility/disqualification decisions
- Nature and severity of the disease
- Type and level of sports activity (training and competition)

Table 32.1 Classification of sports

	A. Low dynamic	B. Moderate dynamic	C. High dynamic
I. Low static	Archering Bowling Cricket Golf Riflery	Baseball* Table tennis Tennis (doubles) Volleyball	Badminton Cross-country skiing (classic) Running (marathon) Walking
II. Moderate static	Auto racing*† Diving† Equestrian*† Gymnastics*† Karate/Judo*† Motorcycling*† Sailing	Fencing Field events (jumping) Figure skating* Lacrosse* Running (sprint)	Basketball* Biathlon Cross-country skiing (skating) Field hockey* Football* Ice hockey* Running (mid/long) Soccer* Squash* Swimming Team handball* Tennis (single)
III. High static	Bobsledding *† Field events (throwing) Luge*† Rock Climbing*† Waterskiing*† Weight lifting*† Windsurfing*†	Body building*† Downhill skiing*† Wrestling*	Boxing* Canoeing, kayaking Cycling*† Decathlon Rowing Speed skating

* Danger of bodily collision.† Increased risk if syncope occurs.

Modified with permission from Mitchell J, Haskell WL, Raven PB. Classification of Sports. *J Am Coll Cardiol* 1994; **24**: 864–6.

Bethesda and ESC recommendations

- Bethesda Conference and the ESC documents cannot be viewed as guidelines mandating specific behavior but only as expert panel recommendations
- Specific recommendations based on available (few) scientific data and the personal experience of the panel participants
- Recommendations viewed as the prudent consensus opinions of experts in the field rather than evidence-based medicine
- Documents from different cultural, social, and legal backgrounds (U.S.A. and Europe) present different approaches to disqualification decisions

Recommendations

- Rationale for recommendation on sports eligibility/disqualification
- Bethesda and ESC documents
- Lessons from sport-related SCD studies
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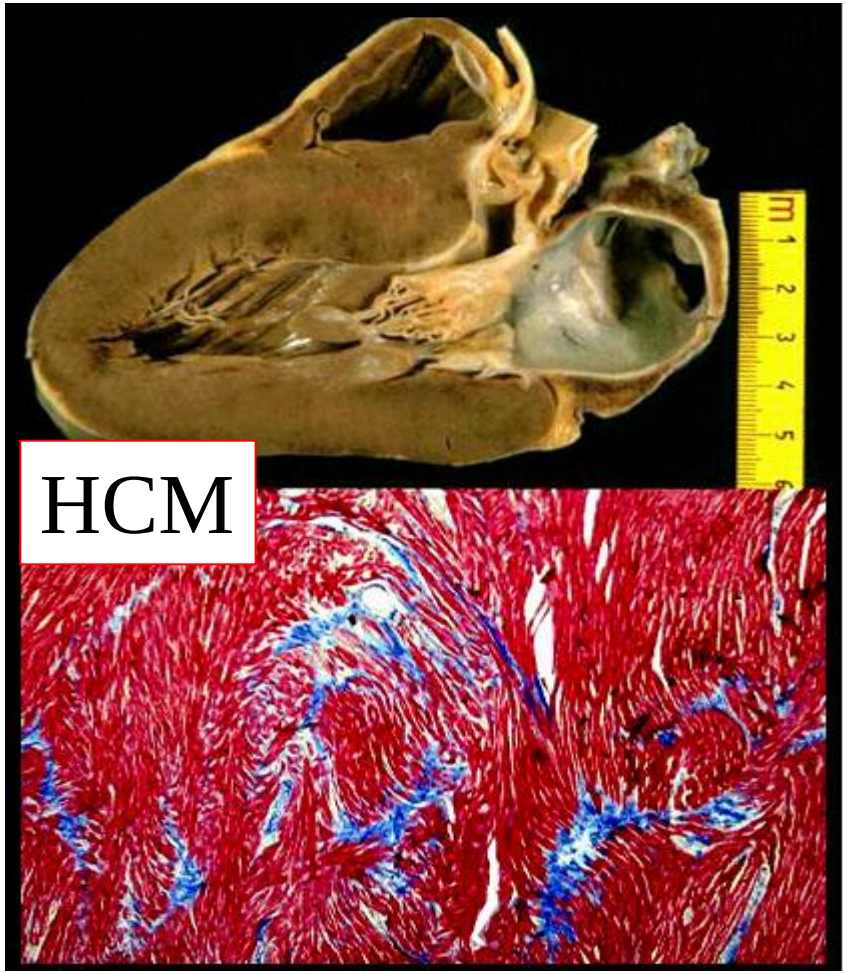
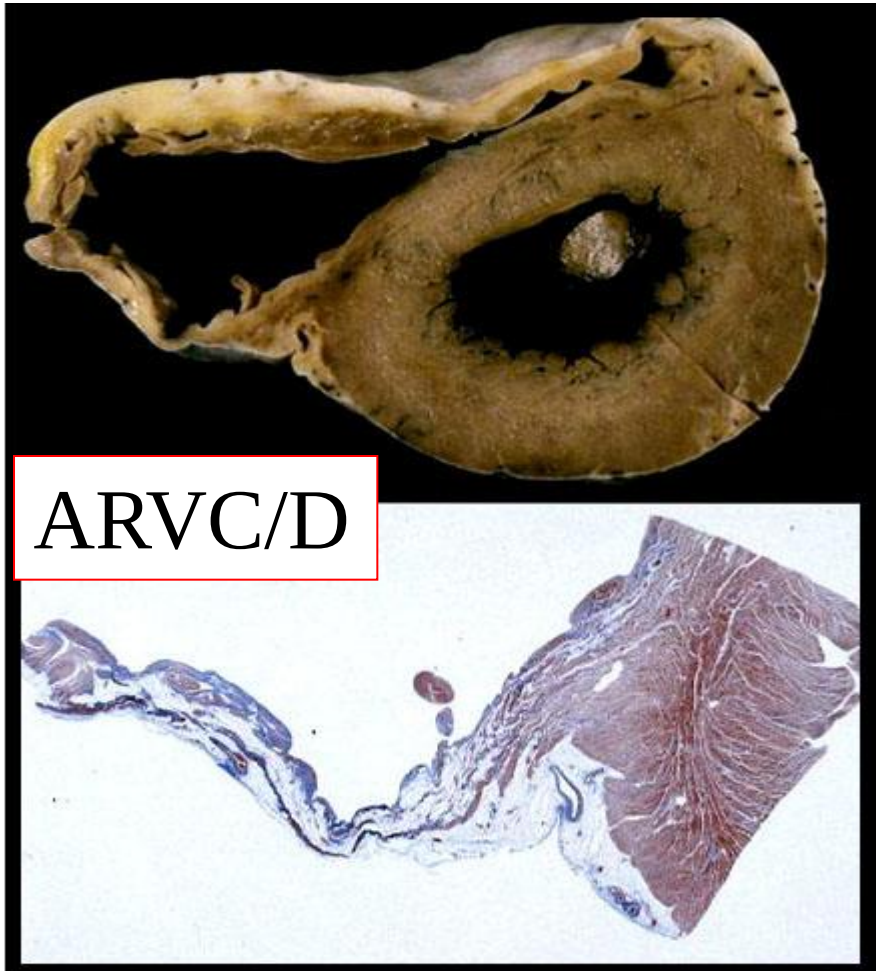
- Bethesda *versus* ESC recommendations
- Future directions and conclusions

Athlete Subgroups

Age	Young Athletes (≤35 yrs)	Older athletes (>35 yrs)
Sports	A variety of sports (ball games)	Jogging and running
Level	Competitive activity	Leisure sports activity
Pathology	Large spectrum of cardiac disease (inherited arrhythmogenic disorders)	Atherosclerotic coronary artery disease
Clinical history	Unsuspected heart disease (up to 75%)	Known coronary artery disease (up to 80%)

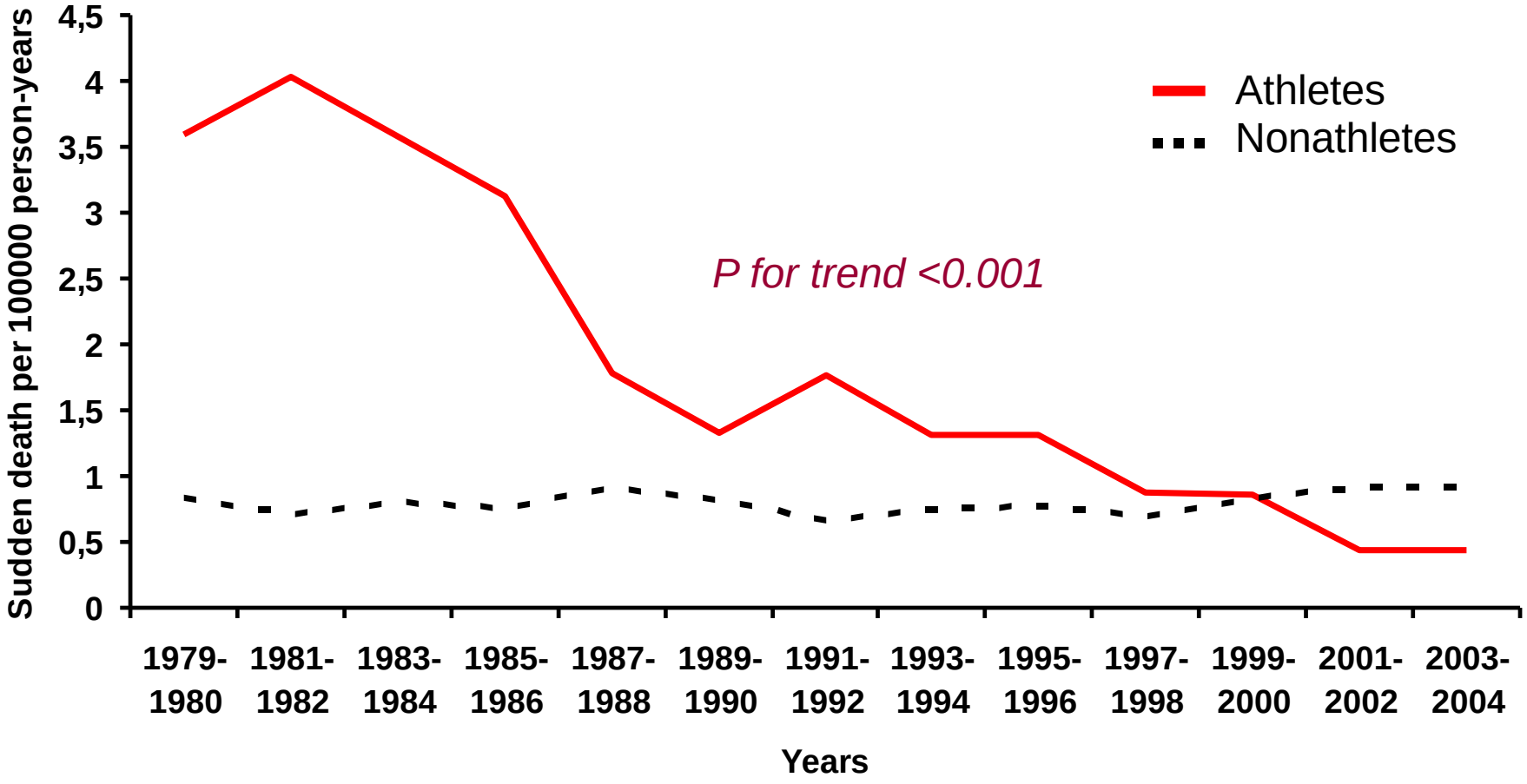
Leading causes of sudden cardiovascular death in young competitive athletes





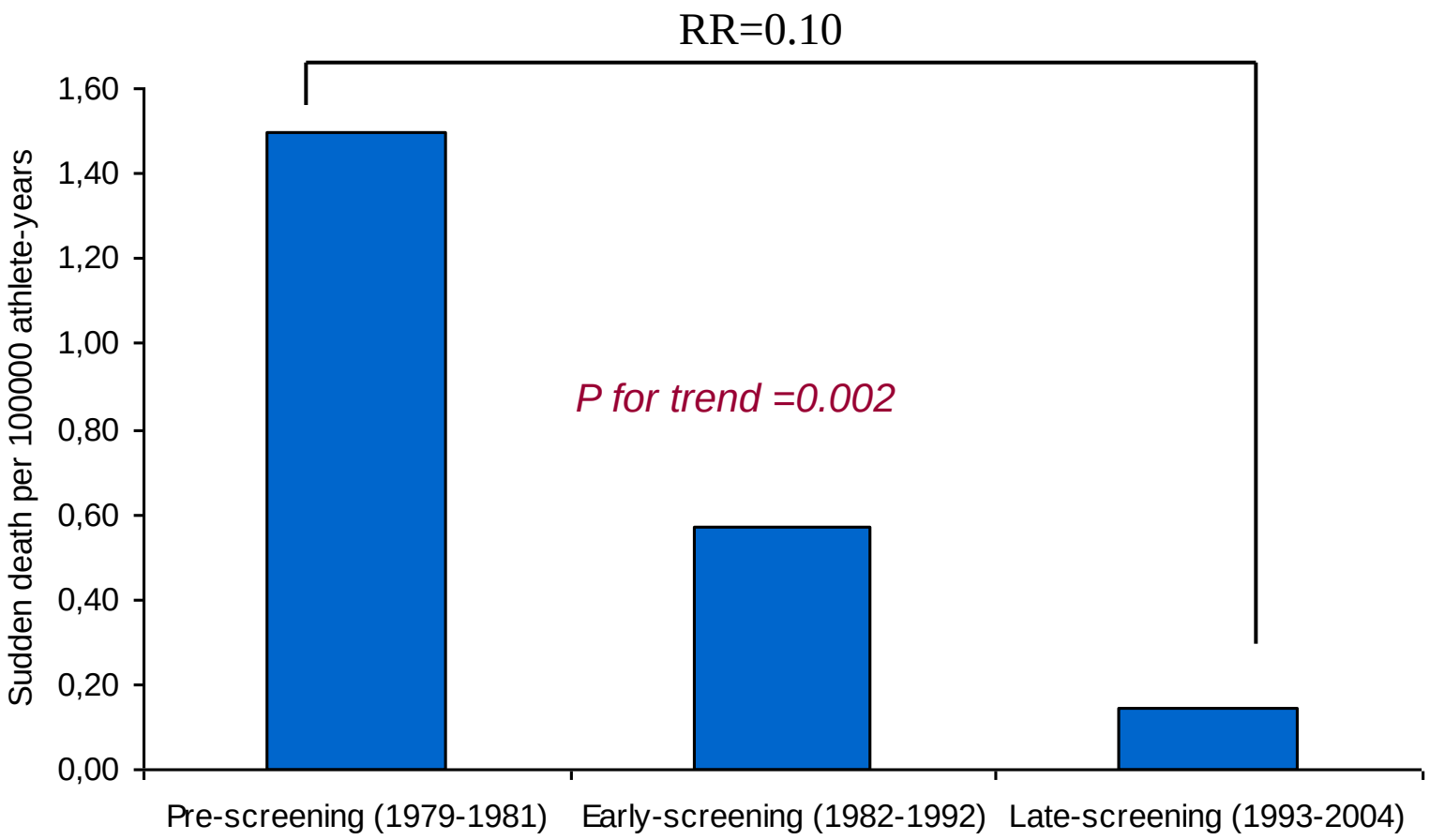
Corrado et al JAMA 2006;296:1593-1601

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)

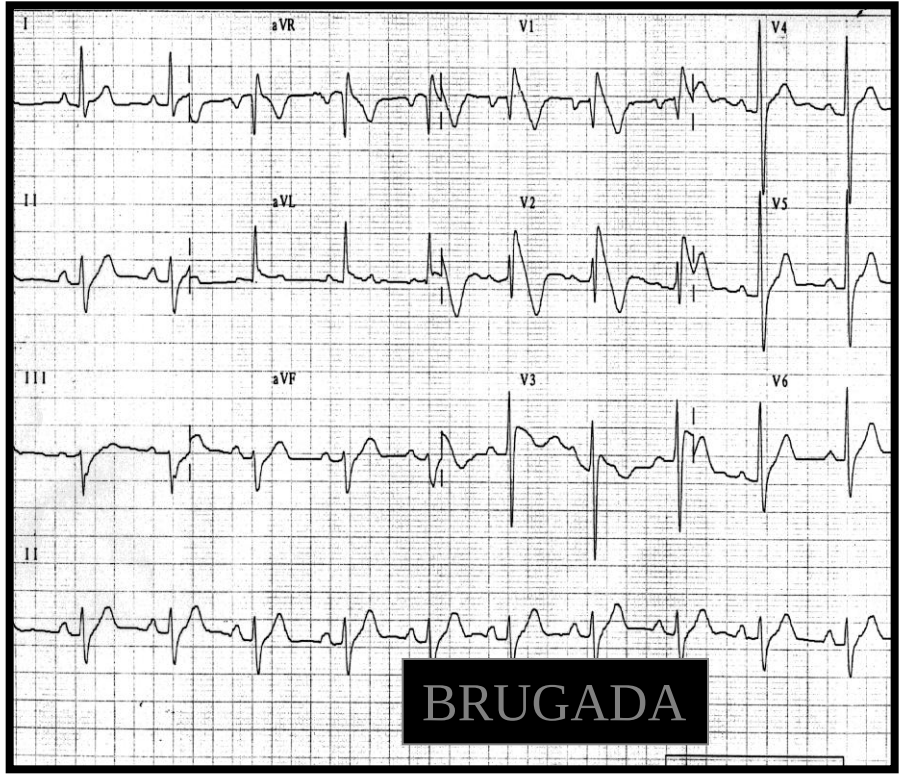


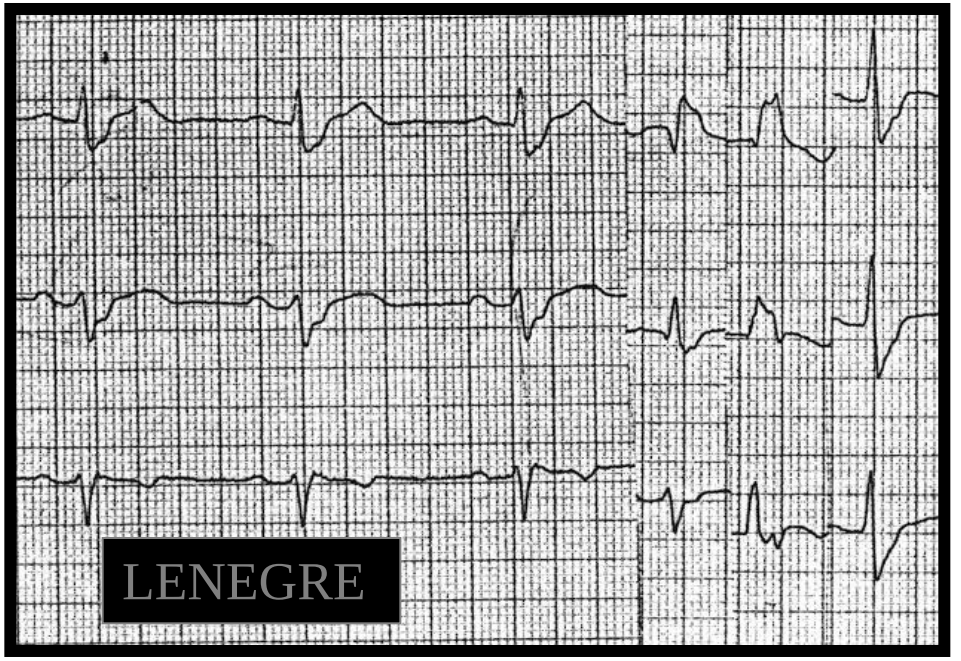
Corrado et al JAMA 2006;296:1593-1601

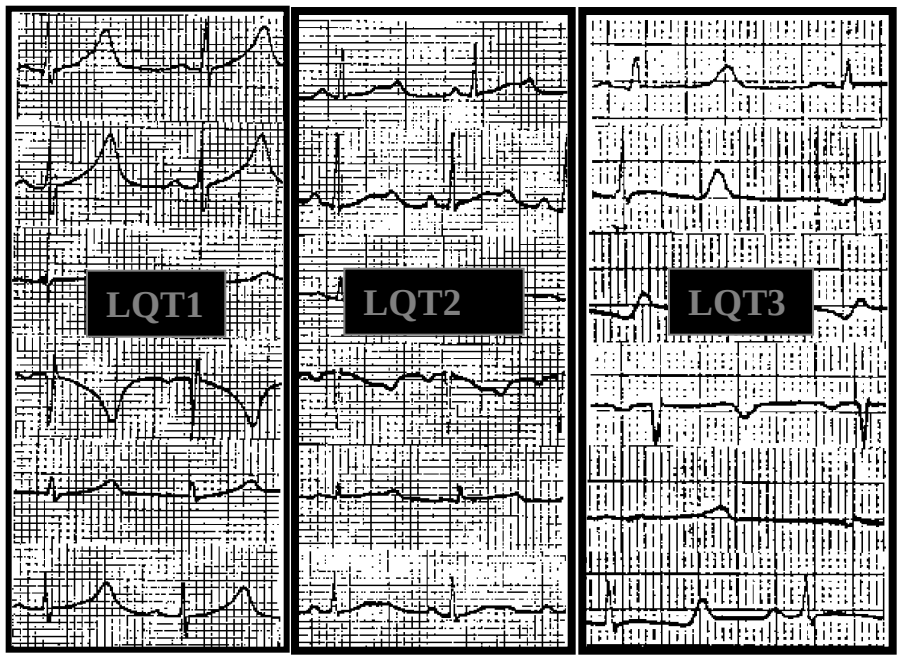
Mortality trend for sudden death from Cardiomyopathies

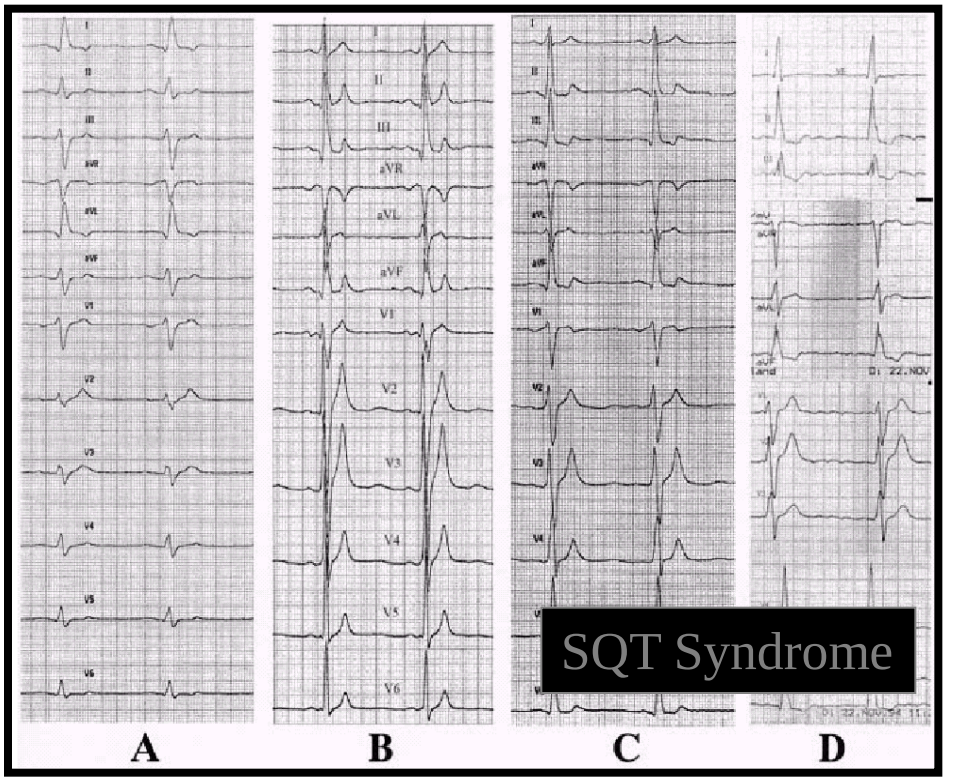


Corrado et al JAMA 2006;296:1593-1601


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
BRUGADA


LENEGRE


LQT1
LQT2
LQT3


SQT Syndrome
A
B
C
D

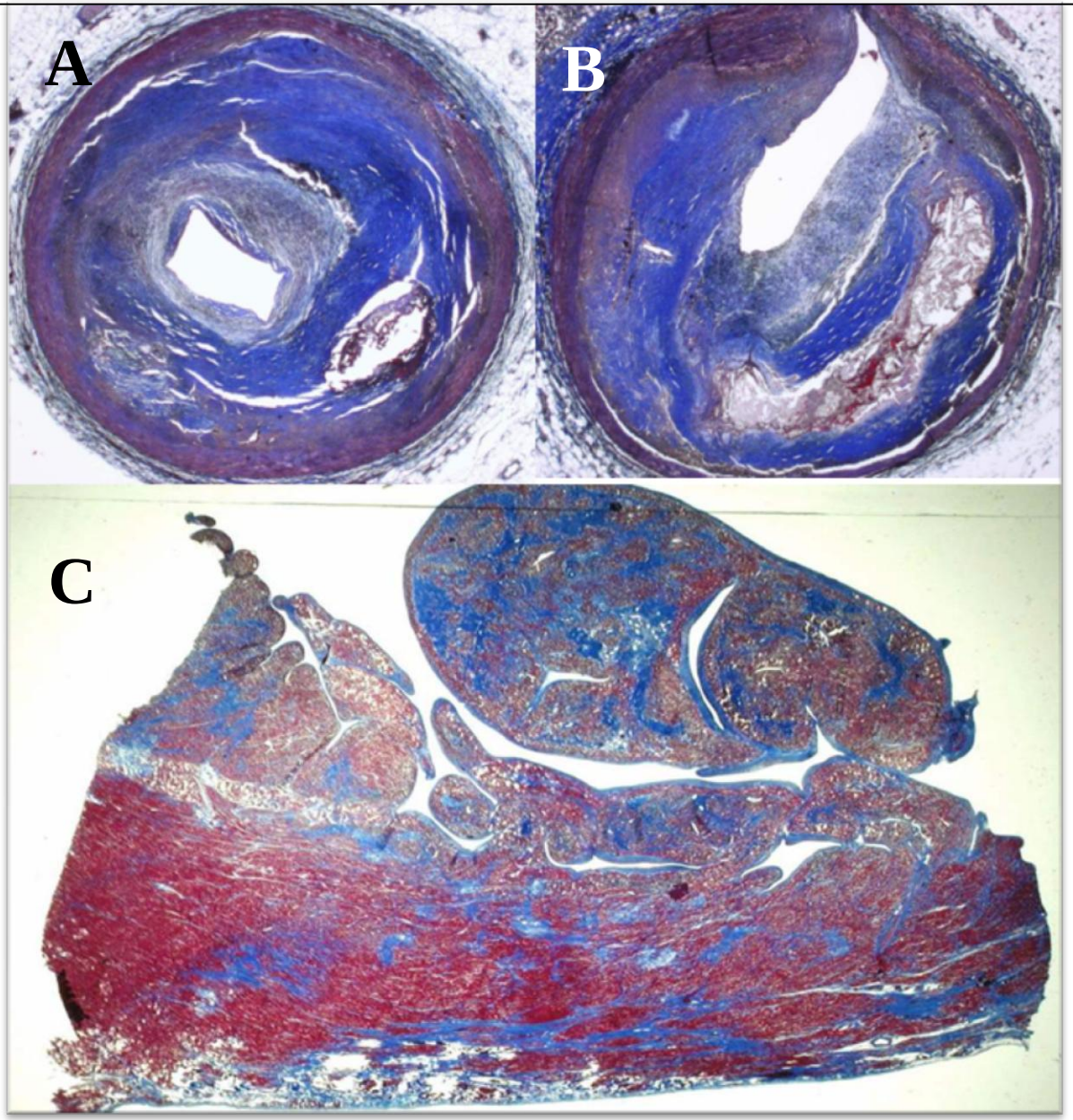
Athlete Subgroups

Age	Young Athletes (≤35 yrs)	Older athletes (>35 yrs)
Sports	A variety of sports (ball games)	Jogging and running
Level	Competitive activity	Leisure sports activity
Pathology	Large spectrum of cardiac disease (inherited arrhythmogenic disorders)	Atherosclerotic coronary artery disease
Clinical history	Unsuspected heart disease (up to 75%)	Known coronary artery disease (up to 80%)

Sudden death of a 47-year old marathon runner

Obstructive atherosclerotic coronary artery disease of both left (anterior descending branch) and right coronary arteries (A,B)

C) Histology of the myocardium shows replacement type fibrosis due to previous myocardial infarction.



Recommendations

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Table 32.5 Recommendation for competitive sport participation in athletes with inherited cardiomyopathies (including channelopathies)

Lesion	Evaluation	Criteria for eligibility	Recommendations	Follow-up
HCM	History, PE, ECG, Echo	Definite diagnosis of HCM	No competitive sports	—
HCM with low risk profile	History, PE, ECG, Echo, ET, 24-hour Holter	No SD in the relatives, no symptoms; mild LVH, Normal BP response to exercise; no ventricular arrhythmias	Low dynamic, low static sports (IA)	Yearly
ARVC	History, PE, ECG, Echo (CE-CMR)	Definite diagnosis of ARVC	No competitive sports	—
DCM	History, PE, ECG, Echo	Definite diagnosis of DCM	No competitive sports	—
DCM with low risk profile	History, PE, ECG, Echo, ET, Holter	No SD in the relatives, no symptoms; mildly depressed EF (≥40%), normal BP response to exercise; no complex ventricular arrhythmias	Low–moderate dynamic and low static sports (IA, IB)	Yearly
Long QT syndrome	History, ECG, (ET, Holter, genetic testing)	Definite diagnosis of Long QT syndrome	No competitive sports	—
Short QT syndrome	History, ECG, (Holter, genetic testing)	Definite diagnosis of Short QT syndrome	No competitive sports	—
Brugada syndrome	History, ECG, Echo, provocative test	Definite diagnosis of Brugada syndrome	No competitive sports	—
Catecholaminergic Polymorphic VT	History, ECG, ET (genetic testing)	Definite diagnosis of Catecholaminergic Polymorphic VT	No competitive sports	—
Lenègre disease	History, ECG, ET (genetic testing)	Definite diagnosis of Lenègre disease	No competitive sports	—
Healthy gene carriers	Disease-specific clinical assessment	No symptoms, no phenotype, no ventricular arrhythmias	Only recreational, non-competitive sport activities	Yearly

ARVC, arrhythmogenic right ventricular cardiomyopathy/dysplasia; BP, blood pressure; DCM, dilated cardiomyopathy; HCM, hypertrophic cardiomyopathy; Echo, echocardiography; EF, ejection fraction; ET, exercise testing; Holter, 24-hour ECG monitoring; LV, left ventricular; LVH, left ventricular hypertrophy; PE physical examination; SD, sudden death; Sport type (see ➔ Table 32.1); VT, ventricular tachycardia.

Modified with permission from Pelliccia A, Fagard R, Bjornstad HH, *et al.* Recommendations for competitive sports participation in athletes with cardiovascular disease: a consensus document from the Study Group of Sports Cardiology of the Working Group of Cardiac Rehabilitation and Exercise Physiology and the Working Group of Myocardial and Pericardial Diseases of the European Society of Cardiology. *Eur Heart J* 2005; **26**: 1422–45.

Table 32.7 Recommendation for competitive sport participation in athletes with rhythm and conduction abnormalities (II—ventricular tachyarrhythmias and electrical devices)

Lesion	Evaluation	Criteria for eligibility	Recommendations	Follow-up
Premature ventricular beats	History, ECG, Echo (ET, Holter, in selected cases invasive tests)	In the absence of: cardiac disease or arrhythmogenic condition†, family history of SD, symptoms (syncope), relation with exercise, frequent and/or polymorphic PVBs and/or frequent couplets with short RR interval	All sports	Yearly
Non-sustained VT	History, ECG, Echo (ET, Holter, in selected cases invasive tests)	In the absence of: cardiac disease or arrhythmogenic† condition, family history of SD, relation with exercise, multiple episodes of NSVT with short RR interval	All sports	Every 3 months
Slow VT, fascicular VT, RVOT VT	History, ECG, Echo, ET, Holter (in selected cases EP study)	In the absence of: cardiac disease or arrhythmogenic† condition, family history of SD, symptoms (syncope)	All sports, except those with increased risk*	Every 3 months
Syncope	History, ECG, Echo, ET, Holter; Tilting Test	(a) Neurocardiogenic (b) Arrhythmic or primary cardiac	(a) All sports (except those with increased risk*) (b) See specific cause	Yearly
Pacemaker	ECG, Echo, ET, Holter	Normal heart rate increase during exercise, no significant arrhythmias, normal cardiac function	Low–moderate dynamic and low static sports (I, II A), except those with risk of bodily collision	Yearly
ICD	ECG, Echo, ET, Holter	No malignant VTs; normal cardiac function; at least 6 months after the implantation or the last appropriate intervention	Low–moderate dynamic and low static sports (I, II A), except those with risk of bodily collision	Yearly

Table 8 Recommendations for competitive sport participation in athletes with IHD

Lesion	Evaluation	Criteria for eligibility	Recommendations	Follow-up
Athletes with definite diagnosis of IHD and high probability of cardiac events	History, ECG, ET, Echo, coronary-angiography		No competitive sports allowed	
Athletes with definite diagnosis of IHD and low probability of cardiac events	History, ECG, ET, Echo, coronary-angiography	No exercise induced ischaemia, no symptoms or major arrhythmias, not significant (<50%) coronary lesions, EF >50%	Only low-moderate dynamic and low static sports (I A,B)	Yearly
Athletes without evidence of IHD but with high risk profile (>5% global SCORE)	History, ECG, ET	If positive provocative ECGs, further testing are needed (stress echo, scintigraphy, and/or coronary angiography) to confirm IHD. If positive, consider as athletes with diagnosis of IHD	Only low-moderate dynamic and low static sports (I A,B)	Yearly
		If negative provocative ECGs	Individual based decision; avoid high static sports (IIIA–C)	Yearly
Athletes without evidence of IHD and low risk profile	History, ECG, ET optional	Negative ECG	All competitive sports	Every 1–3 years

ECG, 12-lead electrocardiogram; ET, exercise testing or other provocative testing; sport type, see *Table 1*.

Athlete disqualification

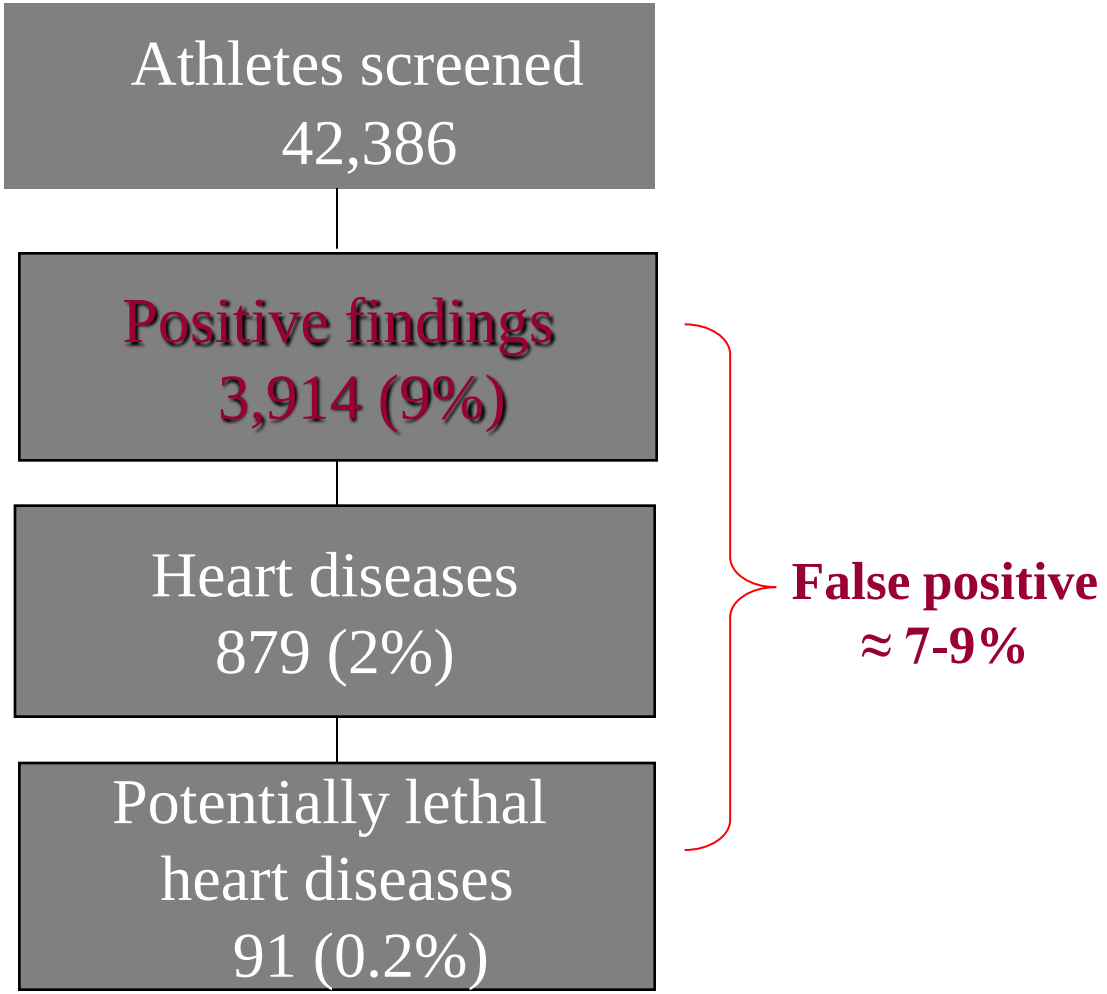
- Risk of SCD associated with competitive sports in the setting of life-threatening cardiovascular disease is a controllable factor
- The devastating impact of even infrequent fatal events in the athletic population justifies appropriate restriction from competition
- Athlete disqualification may be associated with an important individual cost in terms of health, contentment, and even future opportunity for professional sports

Cardiovascular conditions causing disqualification from competitive sports in 879 athletes over 2 consecutive screening periods (1982-1992 and 1993-2004) at the Center for Sports Medicine in Padua, Italy

	NUMBER OF DISQUALIFIED ATHETES*			
CARDIOVASCULAR CAUSES OF DISQUALIFICATION	***Total Study Period (1982-2004) N=879 (%)***	***Early screening Period (1982-1992) N=455 (%)***	***Late screening Period (1993-2004) N=424 (%)***	**P-value**
Rhythm and conduction abnormalities	345 (39)	166 (36)	179 (42.2)	0.13
- ventricular arrhythmias	173 (19.6)	81 (18)	92 (21.6)	0.20
- supraventricular arrhythmias	73 (8.3)	39 (8.6)	34 (8.0)	0.56
- WPW Syndrome	55 (6.3)	29 (6.3)	26 (6.1)	0.88
- LBBB or RBBB & LAD	26 (3.0)	8 (1.7)	18 (4.2)	0.10
- second Degree AV Block	13 (1.5)	7 (1.5)	6 (1.4)	0.89
- long QT Syndrome	5 (0.6)	2 (0.4)	3 (0.7)	0.93
Systemic hypertension:	205 (23)	118 (25.9)	87 (20.5)	0.96
Valvular disease (including MVP):	184 (21)	106 (23.3)	78 (18.4)	0.09
Cardiomyopathies	60 (6.8)	20 (4.4)	40 (9.4)	0.005
- hypertrophic	30 (3.4)	14 (3.0)	16 (3.8)	0.50
- arrhythmogenic right ventricular	16 (1.8)	2 (0.4)	14 (3.3)	0.004
- dilated	14 (1.6)	4 (0.9)	10 (2.4)	0.21
Coronary artery disease	11 (1.3)	2 (0.4)	9 (2.1)	0.05
Other	74 (8.4)	43 (9.5)	31 (7.3)	0.42

Screening of young athletes for Cardiovascular diseases

(Center for Sports Medicine, Padua 1979-2004)



Corrado et al JAMA 2006; 296: 1593-1601

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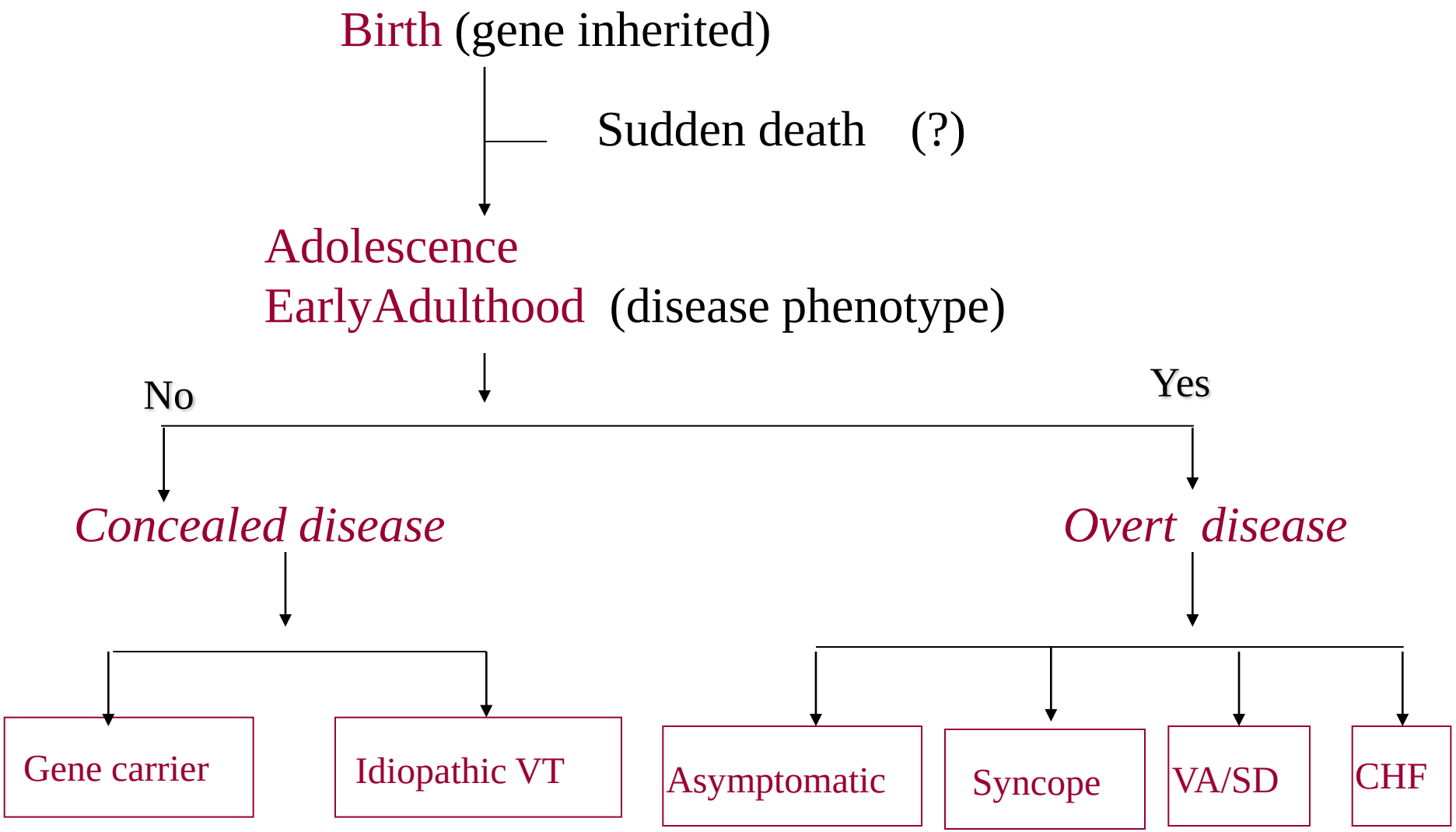
Table 1 Summary of Selected Differences Between BC#36 and ESC Recommendations for Competitive Athletes With Selected CV Abnormalities

	Clinical Criteria and Sports Permitted	
	BC#36	**ESC**
Gene carriers without phenotype (HCM, ARVC, DCM, ion channel diseases*)	All sports	Only recreational sports
LQTS	>0.47 s in male subjects, >0.48 s in female subjects	>0.44 s in male subjects, >0.46 s in female subjects
	Low-intensity competitive sports	Only recreational sports
Marfan syndrome	If aortic root <40 mm, no MR, no familial SD, then low-moderate intensity competitive sports permitted	Only recreational sports
Asymptomatic WPW	EPS not mandatory	EPS mandatory
	All competitive sports (restriction for sports in dangerous environment)†	All competitive sports (restriction for sports in dangerous environment)†
Premature ventricular complexes	All competitive sports, when no increase in PVCs or symptoms occur with exercise	All competitive sports, when no increase in PVCs, couplets, or symptoms occur with exercise
Nonsustained ventricular tachycardia	If no CV disease, all competitive sports	If no CV disease, all competitive sports
	If CV disease, only low-intensity competitive sports	If CV disease, only recreational sports

*Long-QT syndrome (LQTS), Brugada syndrome, catecholaminergic polymorphic ventricular tachycardia; †sports in dangerous environments are restricted, given the risk should impaired consciousness occur, such as motor sports, rock climbing, and downhill skiing.

ARVC = arrhythmogenic right ventricular cardiomyopathy; BC#36 = Bethesda Conference #36; CV = cardiovascular; DCM = dilated cardiomyopathy; EPS = electrophysiologic study; ESC = European Society of Cardiology; HCM = hypertrophic cardiomyopathy; MR = magnetic resonance; PVC = premature ventricular complex; SD = sudden death; WPW = Wolff-Parkinson-White syndrome.

Natural history of ARVC/D



Corrado & Thiene, Circulation 2006;113:1634-7

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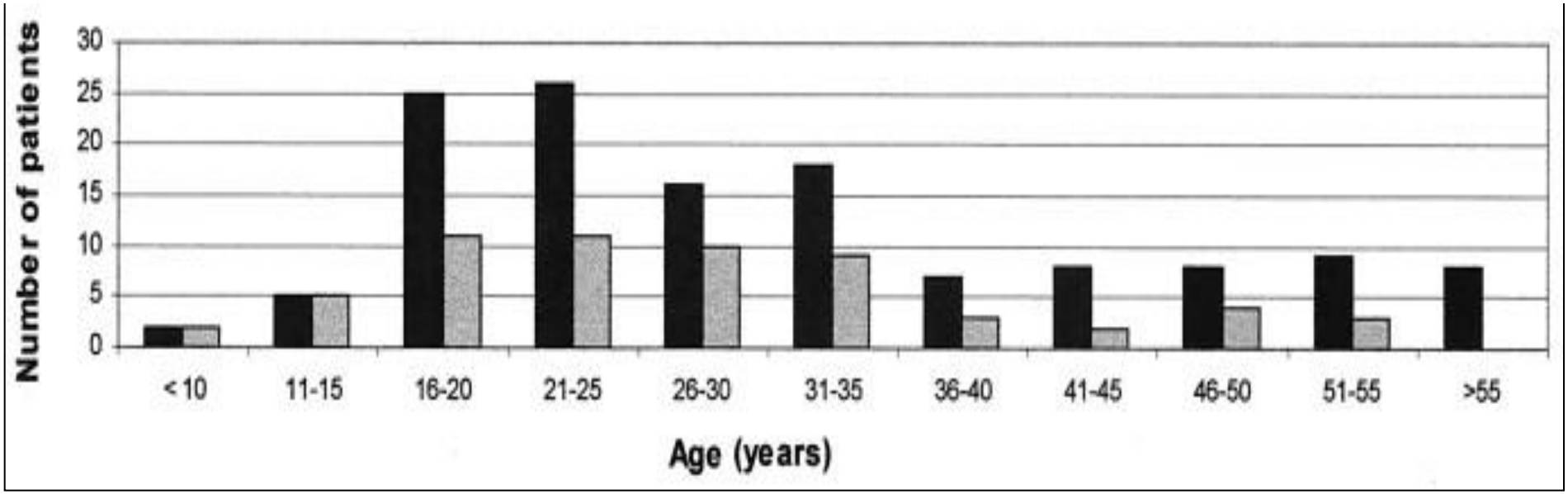
Electrophysiology

Clinical Profile and Long-term Follow-up of 37 Families With Arrhythmogenic Right Ventricular Cardiomyopathy

Andrea Nava, MD,* Barbara Bauce, MD,* Cristina Basso, MD, PHD,† Michela Muriago, MD,* Alessandra Rampazzo, BSC, PHD,‡ Carla Villanova, MD, PHD,* Luciano Daliento, MD, FACC,* Gianfranco Buja, MD,* Domenico Corrado, MD,* Gian Antonio Danieli, BSC,‡ Gaetano Thiene, MD†

Padua, Italy



Age of patients at time of ARVC diagnosis (black bars) and at time of onset of arrhythmias (gray bars)

Intercalated disc proteins crosstalk

- A series of recent studies (Delmar group) demonstrated interactions between PKP-2, Cx43, NaV1.5
- Disruption of these protein complexes by downregulation of PKP-2 in cultured neonatal rat cardiomyocytes led to reduction of Na+ channel current
- Ion Na+ channel function is disrupted in some forms of ARVC and may contribute to the disease arrhythmogenesis in the pre-histologic phase of the disease

Circulation Research
JOURNAL OF THE AMERICAN HEART ASSOCIATION

American Heart Association

Pediatr Cardiol (2012) 33:975–979
DOI 10.1007/s00246-012-0257-0

RILEY SYMPOSIUM

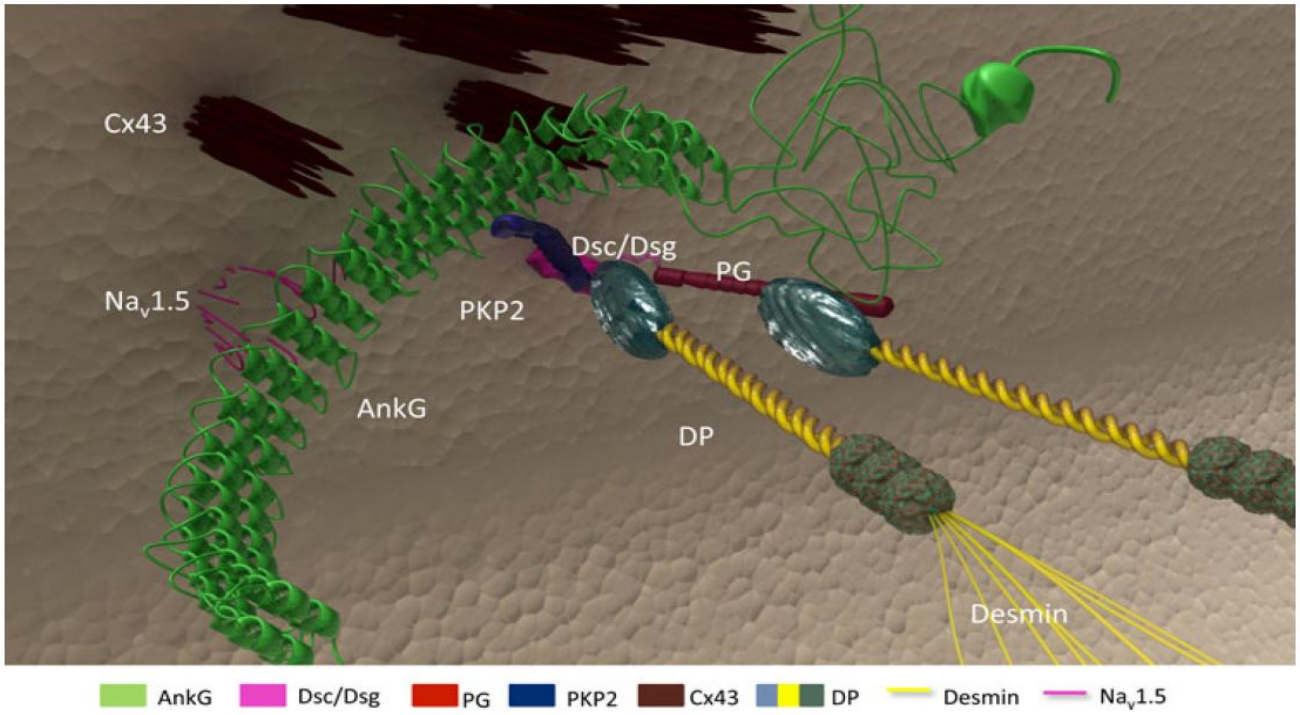
Loss of Plakophilin-2 Expression Leads to Decreased Sodium Current and Slower Conduction Velocity in Cultured Cardiac Myocytes

Priscila Y. Sato, Hassan Musa, Wanda Coombs, Guadalupe Guerrero-Serna, Gustavo A. Patiño, Steven M. Taffet, Lori L. Isom and Mario Delmar

Circ Res. 2009;105:523-526; originally published online August 6, 2009;

Desmosome–Ion Channel Interactions and Their Possible Role in Arrhythmogenic Cardiomyopathy

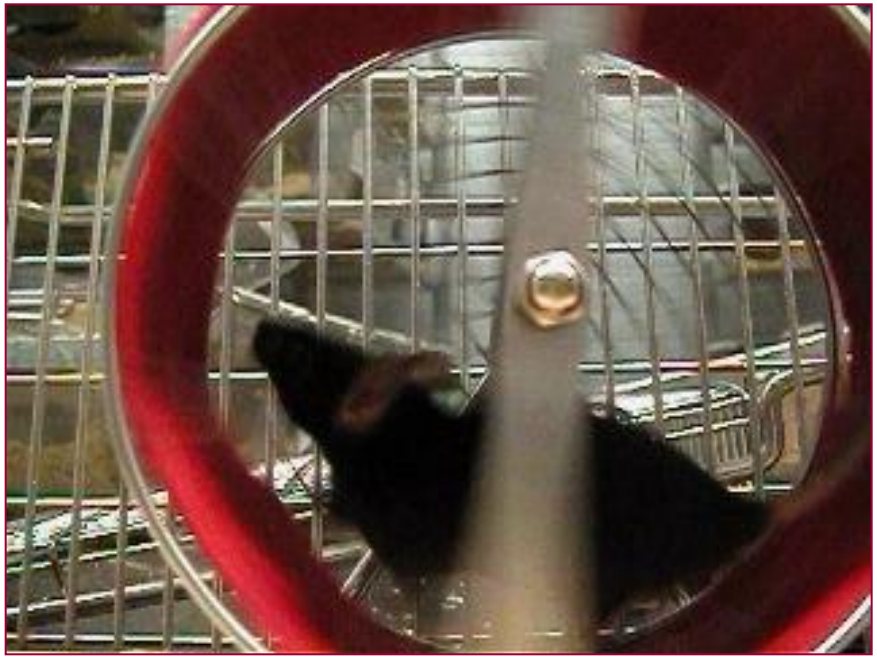
Mario Delmar



Desmosomes together with adherens junctions and gap junctions, connect cardiac myocytes end to end at the level of the intercalated discs (ID). Recent data support the concept of cross-regulation between structural and electrical components at the ID. Diagramatic representation of the interaction between desmosomes, gap junctions, and sodium channels at the ID.

Impact of Exercise and Training

Plakoglobin deficient (- / +) mouse model

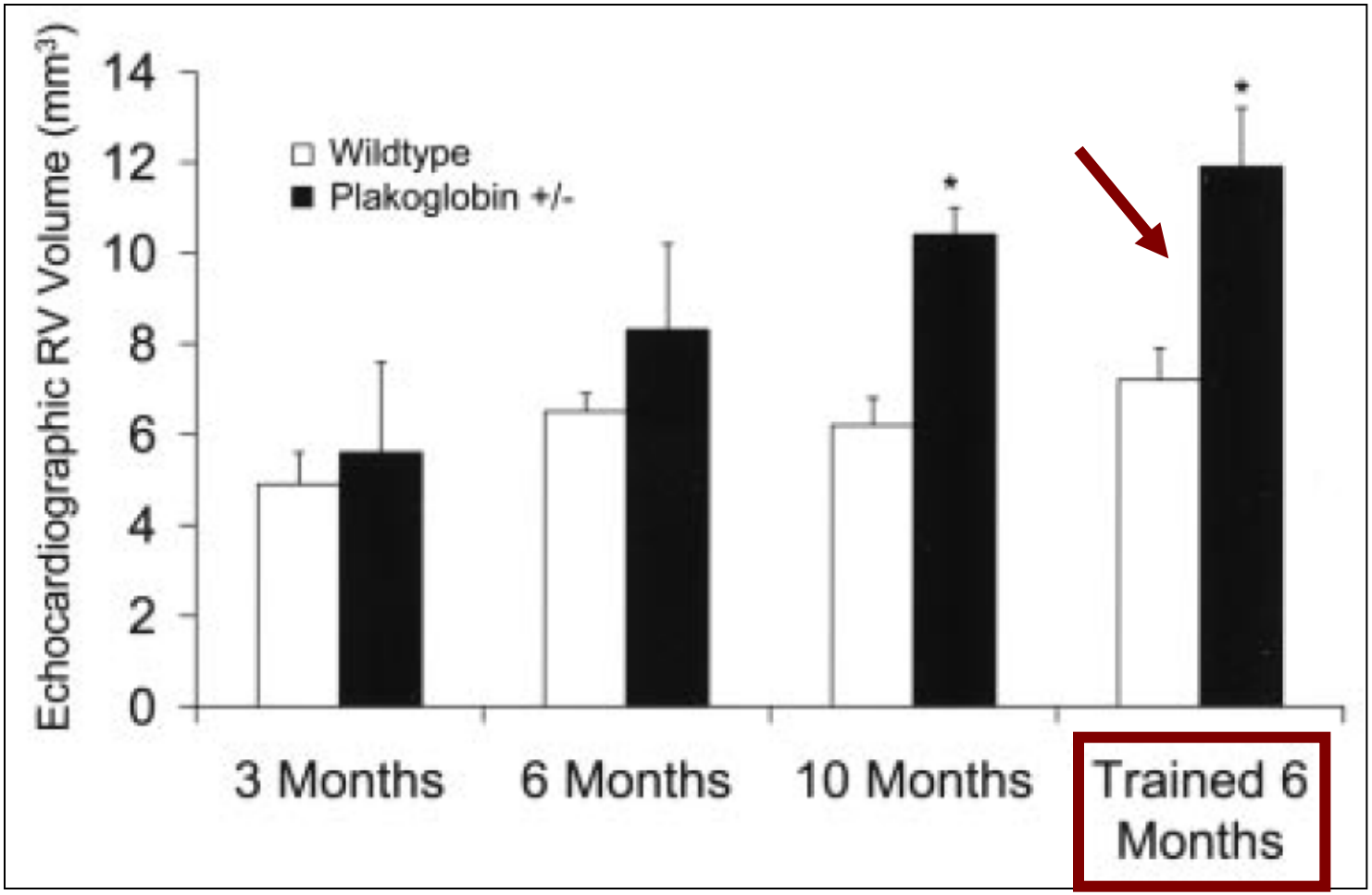


Treadmill - Training
139 ± 16 km distance / week

Swim - Training
10 – 90 min/ day

Kirchhof P, et al. Circulation. 2006. 114:1799-1806

Exercise accelerates RV enlargement



Echo measurements confirmed by MRI. No changes in LV or LA size or function

Kirchhof P, et al. Circulation. 2006. 114:1799-1806

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Exercise Increases Age-Related Penetrance and Arrhythmic Risk in Arrhythmogenic Right Ventricular Dysplasia/Cardiomyopathy–Associated Desmosomal Mutation Carriers

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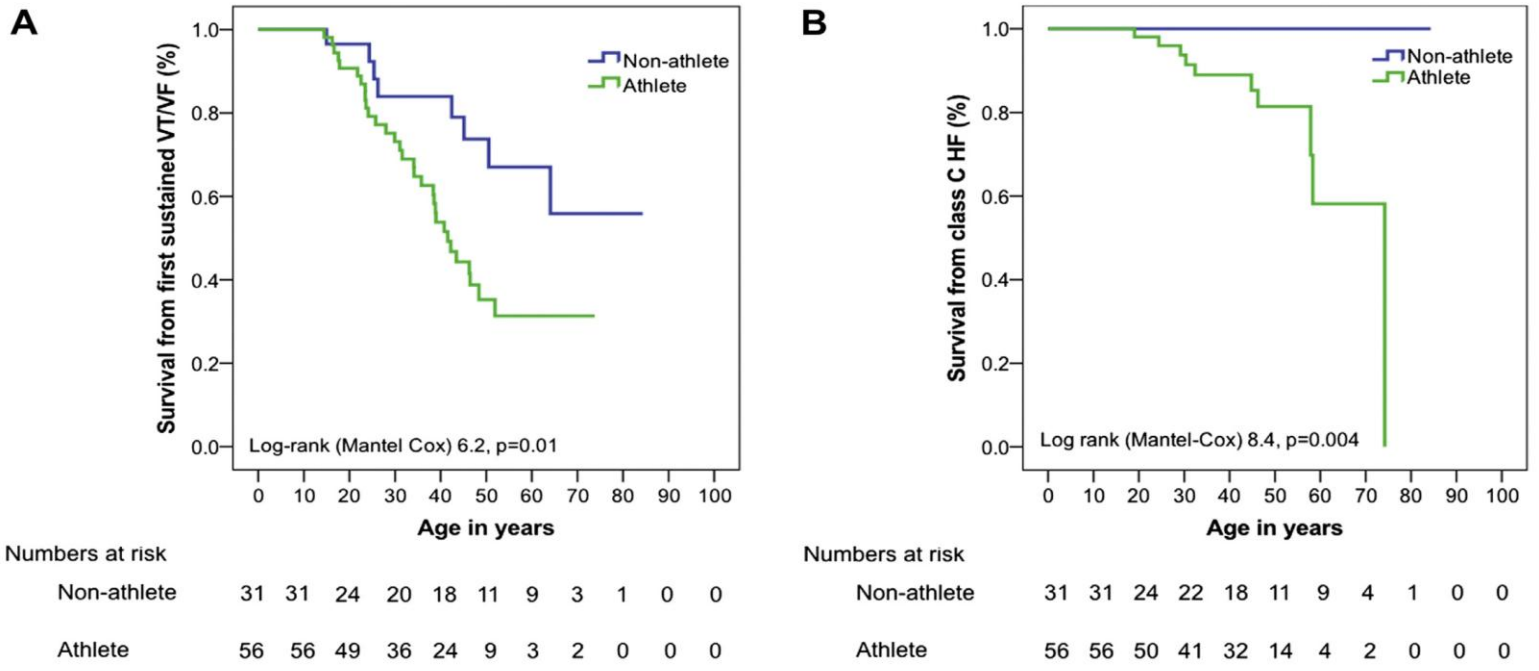

Figure 1 Cumulative Lifetime Survival Free from Sustained Ventricular Arrhythmia and Class C Heart Failure

Future directions and conclusions

- To provide evidence-based guidelines
- To address (CMR-related) emerging conditions (myocardial bridge, non-compact myocardium, epicardial LV scar)
- To extend recommendations to leisure-time sports activity
- To update recommendations in a collaborative fashion with the aim of creating a shared consensus document applicable to sports medicine worldwide
- To reduce the number of unnecessary disqualifications and to adapt (rather than restrict) sports activity in relation to specific cardiovascular risk

Cardiomyopathy

- Given the frequency of sudden death in young athletes with HCM and ARVC, the increased incidence of sudden death in affected athletes versus non-athletes, and the difficulty to accurately predict sudden death risk in a given individual, the available guidelines recommend that all athletes with probable or unequivocal clinical diagnosis of inherited cardiomyopathies (including cardiac ion channel diseases) should be excluded from most competitive sports, except possibly low-intensity activities such a bowling or golfing

How much is an athlete's life?

Atheletes screened	**1,000,000**
Estimate cost to initially screen all athletes (30∈)	**∈ 30,000,000**
Estimate cost to evaluate ~100,000 athletes with positive findings (60∈)	**∈ 6,000,000**
Total cost to of screening	**∈ 36,000,000**
N° of SDs in unscreened athletes (mortality 4/100000 athlete-years)	**40**
N° of SDs in screened athletes (mortality 0.4/100000 athlete-years)	**4**
Lives saved	**36**
Cost for a life saved	**∈ 1,000,000**
Cost for one year of life saved (YLS): 10 additional years of life	**∈ 100,000/YLS**
Cost for one year of life saved: 20 additional years of life	**∈ 50,000/YLS**
Cost for one year of life saved: 30 additional years of life	**∈ 33,000/YLS**

Table 1. Number and Annual Incidence Rates of Total and Cause-Specific Sudden Cardiovascular Death in Screened Athletes and Unscreened Nonathletes in Relation to 3 Screening Periods*

	Periods							
	Prescreening (1979-1981)		Early Screening (1982-1992)		Late Screening (1993-2004)			
	No. of Events	Incidence Rate (95% CI)	No. of Events	Incidence Rate (95% CI)	No. of Events	Incidence Rate (95% CI)	*P* for Trend	RR (95% CI)†
Total sudden deaths in athletes	14	4.19 (1.78-7.59)	29	2.35 (1.94-2.75)	12	0.87 (0.46-1.28)	.001	0.21 (0.09-0.48)
Cardiomyopathies	5	1.50 (0.21-2.78)	7	0.57 (0.26-0.87)	2	0.15 (0-0.36)	.002	0.10 (0.01-0.59)
Coronary artery disease	3	0.90 (0-3.12)	5	0.41 (0.09-0.72)	3	0.22 (0-0.47)	.08	0.24 (0.03-1.81)
Cardiac conduction disease	1	0.30 (0-1.56)	2	0.16 (0-0.40)	1	0.07 (0-0.23)	.29	0.24 (0.01-19.02)
Myocarditis	1	0.30 (0-1.56)	4	0.32 (0.02-0.63)	2	0.15 (0-0.36)	.40	0.48 (0.02-28.61)
Congenital coronary anomalies	1	0.30 (0-1.56)	4	0.32 (0.02-0.63)	2	0.15 (0-0.36)	.40	0.48 (0.02-28.61)
Mitral valve prolapse	1	0.30 (0-1.56)	4	0.32 (0.02-0.63)	1	0.07 (0-0.23)	.19	0.24 (0.01-19.02)
Other‡	2	0.60 (0-1.87)	3	0.24 (0-0.52)	1	0.07 (0-0.23)	.06	0.12 (0.01-2.33)
Total sudden death in nonathletes	29	0.77 (0.26-1.26)	110	0.79 (0.69-0.88)	126	0.81 (0.68-0.94)	.80	1.05 (0.69-1.64)
Cardiomyopathies	8	0.21 (0.10-0.33)	35	0.25 (0.17-0.33)	40	0.26 (0.19-0.33)	.76	1.21 (0.56-2.99)
Coronary artery disease	7	0.19 (0.07-0.30)	23	0.17 (0.12-0.22)	25	0.16 (0.12-0.21)	.81	0.87 (0.36-2.37)
Cardiac conduction disease	3	0.08 (0-0.28)	8	0.06 (0.02-0.10)	12	0.08 (0.03-0.13)	.66	0.97 (0.26-5.36)
Myocarditis	4	0.10 (0-0.34)	15	0.11 (0.06-0.16)	20	0.13 (0.08-0.18)	.58	1.21 (0.41-4.88)
Congenital coronary anomalies	2	0.05 (0-0.17)	5	0.04 (0.01-0.06)	7	0.05 (0.01-0.08)	.87	0.85 (0.16-8.37)
Mitral valve prolapse	2	0.05 (0-0.17)	9	0.06 (0.03-0.11)	8	0.05 (0.02-0.09)	.72	0.97 (0.19-9.38)
Other‡	3	0.08 (0-0.28)	15	0.11 (0.07-0.15)	14	0.09 (0.05-0.13)	.79	1.13 (0.32-6.15)

Abbreviations: CI, confidence interval; RR, relative risk.
*Incidence rates are shown as events per year per 100 000 athletes aged 12 to 35 years. Number of events represent the actual number of events.
†Reported for the rates of sudden cardiovascular deaths during the late screening period (1993-2004) using prescreening (1979-1981) rates as the baseline.
‡Includes myocardial bridge, aortic stenosis, aortic rupture, and pulmonary thromboembolism.

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