Sports Cardiology

Recommendations for Sports Participation in Athletes with Known Cardiovascular Diseases

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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)

RR = 2.5
CI = 1.8-3.4
p < 0.001

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

Cardiovascular

Athletes: RR = 2.8, CI = 1.9-3.7, p < 0.001

Non-athletes: RR = 1.7, CI = 0.32-5.7, p = 0.39 (NS)

Noncardiovascular

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
Recommendations

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• Management of athletes with high risk conditions
• Bethesda versus ESC recommendations
• Future directions and conclusions
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
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 Pelliccia¹*, Robert Fagard², Hans Halvor Bjørnstad³, Aris Anastassakis⁴, Eloisa Arbustini⁵, Deodato Assanelli⁶, Alessandro Biffi¹, Mats Borjesson⁷, François Carrè⁸, Domenico Corrado⁹, Pietro Delise¹⁰, Uwe Dorwarth¹¹, Asle Hirth³, Hein Heidbuchel¹², Ellen Hoffmann¹¹, Klaus P. Mellwig¹³, Nicole Panhuyzen-Goedkoop¹⁴, Angela Pisani⁵, Erik E. Solberg¹⁵, Frank van-Buuren¹³, and Luc Vanhees²
Bethesda and ESC recommendations

• 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>
<thead>
<tr>
<th></th>
<th>A. Low dynamic</th>
<th>B. Moderate dynamic</th>
<th>C. High dynamic</th>
</tr>
</thead>
</table>
| **I. Low static** | Archering  
Bowling  
Cricket  
Golf  
Rifley                             | 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.

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
• Management of athletes with high risk conditions
• Bethesda versus ESC recommendations
• Future directions and conclusions
**Athlete Subgroups**

<table>
<thead>
<tr>
<th>Age</th>
<th>Young Athletes (≤35 yrs)</th>
<th>Older athletes (&gt;35 yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sports</td>
<td>A variety of sports (ball games)</td>
<td>Jogging and running</td>
</tr>
<tr>
<td>Level</td>
<td>Competitive activity</td>
<td>Leisure sports activity</td>
</tr>
<tr>
<td>Pathology</td>
<td>Large spectrum of cardiac disease (inherited arrhythmogenic disorders)</td>
<td>Atherosclerotic coronary artery disease</td>
</tr>
<tr>
<td>Clinical history</td>
<td>Unsuspected heart disease (up to 75%)</td>
<td>Known coronary artery disease (up to 80%)</td>
</tr>
</tbody>
</table>
Leading causes of sudden cardiovascular death in young competitive athletes

HCM

ARVC/D

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)

P for trend <0.001

Corrado et al JAMA 2006;296:1593-1601
Mortality trend for sudden death from Cardiomyopathies

RR=0.10

P for trend =0.002

Corrado et al JAMA 2006;296:1593-1601
## Athlete Subgroups

<table>
<thead>
<tr>
<th></th>
<th>Young Athletes ($\leq 35$ yrs)</th>
<th>Older athletes ($&gt;35$ yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sports</strong></td>
<td>A variety of sports (ball games)</td>
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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.
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<table>
<thead>
<tr>
<th>Lesion</th>
<th>Evaluation</th>
<th>Criteria for eligibility</th>
<th>Recommendations</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCM</td>
<td>History, PE, ECG, Echo</td>
<td>Definite diagnosis of HCM</td>
<td>No competitive sports</td>
<td>—</td>
</tr>
<tr>
<td>HCM with low risk profile</td>
<td>History, PE, ECG, Echo, ET, 24-hour Holter</td>
<td>No SD in the relatives, no symptoms; mild LVH, Normal BP response to exercise; no ventricular arrhythmias</td>
<td>Low dynamic, low static sports (IA)</td>
<td>Yearly</td>
</tr>
<tr>
<td>ARVC</td>
<td>History, PE, ECG, Echo (CE-CMR)</td>
<td>Definite diagnosis of ARVC</td>
<td>No competitive sports</td>
<td>—</td>
</tr>
<tr>
<td>DCM</td>
<td>History, PE, ECG, Echo</td>
<td>Definite diagnosis of DCM</td>
<td>No competitive sports</td>
<td>—</td>
</tr>
<tr>
<td>DCM with low risk profile</td>
<td>History, PE, ECG, Echo, ET, Holter</td>
<td>No SD in the relatives, no symptoms; mildly depressed EF (≥40%), normal BP response to exercise; no complex ventricular arrhythmias</td>
<td>Low–moderate dynamic and low static sports (IA, IB)</td>
<td>Yearly</td>
</tr>
<tr>
<td>Long QT syndrome</td>
<td>History, ECG, (ET, Holter, genetic testing)</td>
<td>Definite diagnosis of Long QT syndrome</td>
<td>No competitive sports</td>
<td>—</td>
</tr>
<tr>
<td>Short QT syndrome</td>
<td>History, ECG, (Holter, genetic testing)</td>
<td>Definite diagnosis of Short QT syndrome</td>
<td>No competitive sports</td>
<td>—</td>
</tr>
<tr>
<td>Brugada syndrome</td>
<td>History, ECG, Echo, provocative test</td>
<td>Definite diagnosis of Brugada syndrome</td>
<td>No competitive sports</td>
<td>—</td>
</tr>
<tr>
<td>Catecholaminergic Polymorphic VT</td>
<td>History, ECG, ET (genetic testing)</td>
<td>Definite diagnosis of Catecholaminergic Polymorphic VT</td>
<td>No competitive sports</td>
<td>—</td>
</tr>
<tr>
<td>Lenègre disease</td>
<td>History, ECG, ET (genetic testing)</td>
<td>Definite diagnosis of Lenègre disease</td>
<td>No competitive sports</td>
<td>—</td>
</tr>
</tbody>
</table>

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.

<table>
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<tr>
<th>Lesion</th>
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<th>Criteria for eligibility</th>
<th>Recommendations</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Premature ventricular beats</td>
<td>History, ECG, Echo (ET, Holter, in selected cases invasive tests)</td>
<td>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</td>
<td>All sports</td>
<td>Yearly</td>
</tr>
<tr>
<td>Non-sustained VT</td>
<td>History, ECG, Echo (ET, Holter, in selected cases invasive tests)</td>
<td>In the absence of: cardiac disease or arrhythmogenic† condition, family history of SD, relation with exercise, multiple episodes of NSVT with short RR interval</td>
<td>All sports, except those with increased risk*</td>
<td>Every 3 months</td>
</tr>
<tr>
<td>Slow VT, fascicular VT, RVOT VT</td>
<td>History, ECG, Echo, ET, Holter; Tilting Test</td>
<td>(a) Neurocardiogenic (b) Arrhythmic or primary cardiac</td>
<td>(a) All sports (except those with increased risk*) (b) See specific cause</td>
<td>Yearly</td>
</tr>
<tr>
<td>Pacemaker</td>
<td>ECG, Echo, ET, Holter</td>
<td>Normal heart rate increase during exercise, no significant arrhythmias, normal cardiac function</td>
<td>Low–moderate dynamic and low static sports (I, II A), except those with risk of bodily collision</td>
<td>Yearly</td>
</tr>
<tr>
<td>ICD</td>
<td>ECG, Echo, ET, Holter</td>
<td>No malignant VTs; normal cardiac function; at least 6 months after the implantation or the last appropriate intervention</td>
<td>Low–moderate dynamic and low static sports (I, II A), except those with risk of bodily collision</td>
<td>Yearly</td>
</tr>
<tr>
<td>Lesion</td>
<td>Evaluation</td>
<td>Criteria for eligibility</td>
<td>Recommendations</td>
<td>Follow-up</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>-------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------</td>
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<td>----------------</td>
</tr>
<tr>
<td>Athletes with definite diagnosis of IHD and high probability of cardiac events</td>
<td>History, ECG, ET, Echo, coronary-angiography</td>
<td>No exercise induced ischaemia, no symptoms or major arrhythmias, not significant (&lt;50%) coronary lesions, EF &gt; 50%</td>
<td>No competitive sports allowed</td>
<td></td>
</tr>
<tr>
<td>Athletes with definite diagnosis of IHD and low probability of cardiac events</td>
<td>History, ECG, ET, coronary-angiography</td>
<td>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</td>
<td>Only low-moderate dynamic and low static sports (I A,B)</td>
<td>Yearly</td>
</tr>
<tr>
<td>Athletes without evidence of IHD but with high risk profile (5% global SCORE)</td>
<td>History, ECG, ET</td>
<td>If negative provocative ECGs</td>
<td>Individual based decision; avoid high static sports (III A–C)</td>
<td>Yearly</td>
</tr>
<tr>
<td>Athletes without evidence of IHD and low risk profile</td>
<td>History, ECG, ET optional</td>
<td>Negative ECG</td>
<td>All competitive sports</td>
<td>Every 1–3 years</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhythm and conduction abnormalities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- ventricular arrhythmias</td>
<td>345 (39)</td>
<td>166 (36)</td>
<td>179 (42.2)</td>
<td>0.13</td>
</tr>
<tr>
<td>- supraventricular arrhythmias</td>
<td>73 (8.3)</td>
<td>39 (8.6)</td>
<td>34 (8.0)</td>
<td>0.56</td>
</tr>
<tr>
<td>- WPW Syndrome</td>
<td>55 (6.3)</td>
<td>29 (6.3)</td>
<td>26 (6.1)</td>
<td>0.88</td>
</tr>
<tr>
<td>- LBBB or RBBB &amp; LAD</td>
<td>26 (3.0)</td>
<td>8 (1.7)</td>
<td>18 (4.2)</td>
<td>0.10</td>
</tr>
<tr>
<td>- second Degree AV Block</td>
<td>13 (1.5)</td>
<td>7 (1.5)</td>
<td>6 (1.4)</td>
<td>0.89</td>
</tr>
<tr>
<td>- long QT Syndrome</td>
<td>5 (0.6)</td>
<td>2 (0.4)</td>
<td>3 (0.7)</td>
<td>0.93</td>
</tr>
<tr>
<td>Systemic hypertension:</td>
<td>205 (23)</td>
<td>118 (25.9)</td>
<td>87 (20.5)</td>
<td>0.96</td>
</tr>
<tr>
<td>Cardiomyopathies</td>
<td>60 (6.8)</td>
<td>20 (4.4)</td>
<td>40 (9.4)</td>
<td>0.005</td>
</tr>
<tr>
<td>- hypertrophic</td>
<td>30 (3.4)</td>
<td>14 (3.0)</td>
<td>16 (3.8)</td>
<td>0.50</td>
</tr>
<tr>
<td>- arrhythmogenic right ventricular</td>
<td>16 (1.8)</td>
<td>2 (0.4)</td>
<td>14 (3.3)</td>
<td>0.004</td>
</tr>
<tr>
<td>- dilated</td>
<td>14 (1.6)</td>
<td>4 (0.9)</td>
<td>10 (2.4)</td>
<td>0.21</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>11 (1.3)</td>
<td>2 (0.4)</td>
<td>9 (2.1)</td>
<td>0.05</td>
</tr>
<tr>
<td>Other</td>
<td>74 (8.4)</td>
<td>43 (9.5)</td>
<td>31 (7.3)</td>
<td>0.42</td>
</tr>
</tbody>
</table>
Screening of young athletes for cardiovascular diseases
(Center for Sports Medicine, Padua 1979-2004)

Athletes screened
42,386

Positive findings
3,914 (9%)

Heart diseases
879 (2%)

Potentially lethal heart diseases
91 (0.2%)

False positive
≈ 7-9%

Corrado et al JAMA 2006; 296: 1593-1601
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<table>
<thead>
<tr>
<th>Clinical Criteria and Sports Permitted</th>
<th>BC#36</th>
<th>ESC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gene carriers without phenotype</strong> (HCM, ARVC, DCM, ion channel diseases*)</td>
<td>All sports</td>
<td>Only recreational sports</td>
</tr>
<tr>
<td><strong>LQTS</strong></td>
<td>$&gt;0.47 \text{ s in male subjects}$, $&gt;0.48 \text{ s in female subjects}$</td>
<td>Low-intensity competitive sports</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$&gt;0.44 \text{ s in male subjects}$, $&gt;0.46 \text{ s in female subjects}$</td>
</tr>
<tr>
<td><strong>Marfan syndrome</strong></td>
<td>If aortic root $&lt;40 \text{ mm}$, no MR, no familial SD, then low-moderate intensity competitive sports permitted</td>
<td>Only recreational sports</td>
</tr>
<tr>
<td><strong>Asymptomatic WPW</strong></td>
<td>EPS not mandatory</td>
<td>All competitive sports (restriction for sports in dangerous environment)$\dagger$</td>
</tr>
<tr>
<td></td>
<td>All competitive sports, when no increase in PVCs or symptoms occur with exercise</td>
<td>EPS mandatory</td>
</tr>
<tr>
<td><strong>Premature ventricular complexes</strong></td>
<td>All competitive sports, when no increase in PVCs or symptoms occur with exercise</td>
<td>All competitive sports, when no increase in PVCs, couplets, or symptoms occur with exercise</td>
</tr>
<tr>
<td><strong>Nonsustained ventricular tachycardia</strong></td>
<td>If no CV disease, all competitive sports</td>
<td>If no CV disease, all competitive sports</td>
</tr>
<tr>
<td></td>
<td>If CV disease, only low-intensity competitive sports</td>
<td>If CV disease, only recreational sports</td>
</tr>
</tbody>
</table>

*Long-QT syndrome (LQTS), Brugada syndrome, catecholaminergic polymorphic ventricular tachycardia; $\dagger$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

Birth (gene inherited) → Sudden death (?)

Adolescence (disease phenotype)

Early Adulthood

No → Concealed disease

Gene carrier → Idiopathic VT

Yes → Overt disease

Asymptomatic → Syncope → VA/SD → CHF

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

Exercise accelerates RV enlargement

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

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

Cynthia A. James, ScM, PhD, Aditya Bhonsale, MD, Crystal Tichnell, MGC, Britney Murray, MS, Stuart D. Russell, MD, Harikrishna Tandri, MD, Ryan J. Tedford, MD, Daniel P. Judge, MD, Hugh Calkins, MD

Baltimore, Maryland

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 as bowling or golfing.
## How much is an athlete’s life?

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Athletes screened</td>
<td>1,000,000</td>
</tr>
<tr>
<td>Estimate cost to initially screen all athletes (30 €)</td>
<td>€ 30,000,000</td>
</tr>
<tr>
<td>Estimate cost to evaluate ~100,000 athletes with positive findings (60 €)</td>
<td>€ 6,000,000</td>
</tr>
<tr>
<td><strong>Total cost to of screening</strong></td>
<td>€ 36,000,000</td>
</tr>
<tr>
<td>N° of SDs in unscreened athletes (mortality 4/100000 athlete-years)</td>
<td>40</td>
</tr>
<tr>
<td>N° of SDs in screened athletes (mortality 0.4/100000 athlete-years)</td>
<td>4</td>
</tr>
<tr>
<td><strong>Lives saved</strong></td>
<td>36</td>
</tr>
<tr>
<td><strong>Cost for a life saved</strong></td>
<td>€ 1,000,000</td>
</tr>
<tr>
<td>Cost for one year of life saved (YLS): 10 additional years of life</td>
<td>€ 100,000/YLS</td>
</tr>
<tr>
<td>Cost for one year of life saved: 20 additional years of life</td>
<td>€ 50,000/YLS</td>
</tr>
<tr>
<td>Cost for one year of life saved: 30 additional years of life</td>
<td>€ 33,000/YLS</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td></td>
<td>No. of Events</td>
</tr>
<tr>
<td>Total sudden deaths in athletes</td>
<td>14</td>
</tr>
<tr>
<td>Cardiomyopathies</td>
<td>5</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>3</td>
</tr>
<tr>
<td>Cardiac conduction disease</td>
<td>1</td>
</tr>
<tr>
<td>Myocarditis</td>
<td>1</td>
</tr>
<tr>
<td>Congenital coronary anomalies</td>
<td>1</td>
</tr>
<tr>
<td>Mitral valve prolapse</td>
<td>1</td>
</tr>
<tr>
<td>Other†</td>
<td>2</td>
</tr>
<tr>
<td>Total sudden death in nonathletes</td>
<td>29</td>
</tr>
<tr>
<td>Cardiomyopathies</td>
<td>8</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>7</td>
</tr>
<tr>
<td>Cardiac conduction disease</td>
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</tr>
<tr>
<td>Myocarditis</td>
<td>4</td>
</tr>
<tr>
<td>Congenital coronary anomalies</td>
<td>2</td>
</tr>
<tr>
<td>Mitral valve prolapse</td>
<td>2</td>
</tr>
<tr>
<td>Other†</td>
<td>3</td>
</tr>
</tbody>
</table>

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.
‡Includes myocardial bridge, aortic stenosis, aortic rupture, and pulmonary thromboembolism.