DEFIBRILLAZIONE EXTRATORACICA E ATTIVITÀ SPORTIVA: SICUREZZA, PERFORMANCE E RITORNO ALLA VITA ATTIVA

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Sport e ICD: una questione complessa? (1/2)

- In seguito a recenti casi di arresto cardiaco che hanno coinvolto atleti professionisti i quali, fortunatamente rianimati, sono stati sottoposti ad impianto di defibrillatore cardiaco impiantabile (ICD), molto si è dibattuto sulla possibilità di ottenere un certificato di idoneità medico-sportiva agonistica in Italia

- Gli organi di stampa ma anche molti medici hanno diffuso l'errata informazione che in Italia giocare con un ICD sia vietato


MÆHLE
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Sport e ICD: una questione complessa? (2/2)

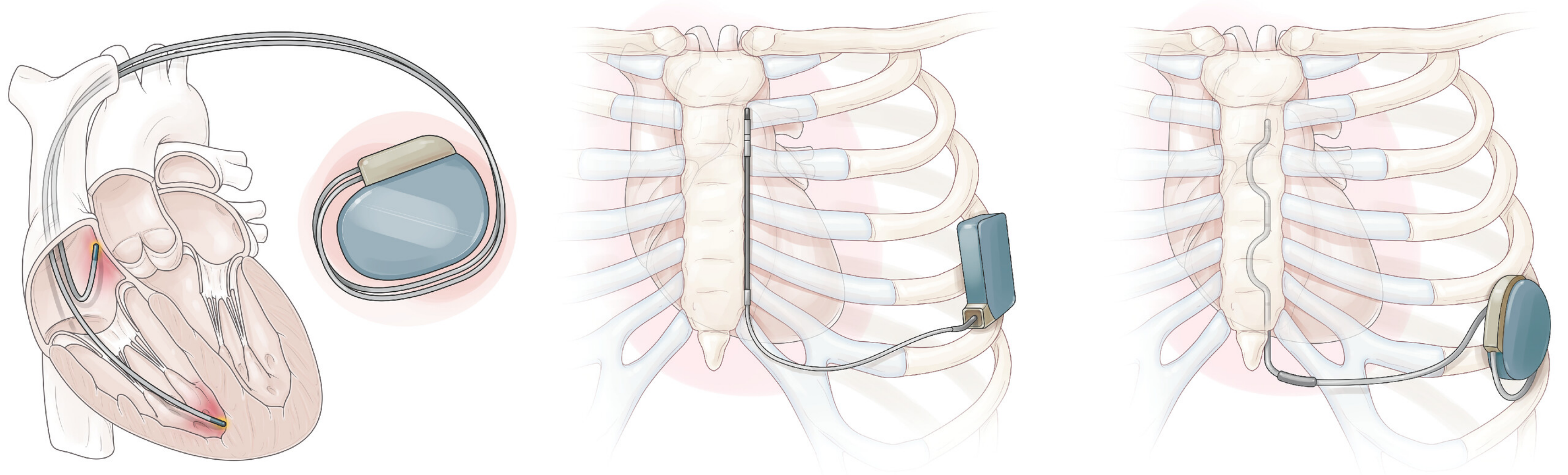
- In realtà, ciò non corrisponde al vero: la possibilità di giocare con l'ICD non solo è prevista dalle attuali linee guida italiane (COCIS 2023), ma anche dalla precedente edizione del 2017
- Il giudizio di idoneità non si basa sul dispositivo, ma sul tipo di disciplina e soprattutto sulla cardiopatia che ha portato all'impianto

Sports in patients implanted with ICDs

RISKS RELATED TO SPORTS IN ICD PATIENTS

1. Device-related Risks
2. Disease-related risks
3. Syncope-related

Pros and cons of the various ICD types



Conventional Transvenous ICD

Pros:
- Longer duration of use
- Supported by the strongest evidence
- Capable of bradycardia, antitachycardia, and, in some, biventricular pacing
- Longest battery life

Cons:
- Higher risk of infection
- Higher risk of lead-related complications

Subcutaneous ICD

Pros:
- Lower risk of infection
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Cons:
- Largest size
- Shorter battery life
- Not capable of bradycardia, antitachycardia, or biventricular pacing

Extravascular ICD

Pros:
- Lower risk of lead-related complications
- Capable of bradycardia and antitachycardia pacing

Cons:
- No clinical practice data (not FDA-approved for clinical use in the United States)
- Higher risk of inappropriate shocks
- Logistic difficulties in aligning electrophysiologist's availability with thoracic surgeon’s availability

Al-Khatib SM. N Engl J Med 2024;390(5):442-454

The ICD sport registry

- Multinational, prospective, observational registry

- Patients with ICDs who were 10 to 60 years of age and participating in organized sports, involving regular practice and regularly scheduled competition with static and dynamic components greater than those traditionally classified as IA (more vigorous than golf or bowling), were eligible to participate

- Patients were enrolled starting December 2006 by participating sites (41 North American, 18 European; n=211 patients; see the online-only Data Supplement for a list of sites) or by contacting the central site (Yale) directly (self-enrollment; North America only; n=161).

- Patients were contacted by phone to obtain information on sports participation, and medical records were obtained for clinical information

Lampert R, et al. Circulation. 2013;127(20):2021-30.

Registry Endpoint

- **The primary predetermined end point:** a serious adverse event during or up to 2 hours after sports defined as (1) tachyarrhythmic death or externally resuscitated tachyarrhythmia caused by shock failure, incessant ventricular arrhythmia, or postshock pulseless electric activity or (2) severe injury, defined as requiring hospitalization, resulting from shock or syncopal arrhythmia.

- **Secondary end points:** (1) numbers of appropriate (for ventricular tachyarrhythmia) and inappropriate shock episodes (both defined as a device-counted episode); (2) multiple shocks within 1 appropriate shock episode (ie, failure of first maximum-energy shock or recurrent arrhythmia); (3) moderate injury (requiring emergency room visit) associated with a shock; (4) ICD lead/system damage, including definite lead malfunction, defined as change in pacing function with documented noise on electrogram or visible lead abnormality, or probable malfunction, change in pacing function only.

Lampert R, et al. Circulation. 2013;127(20):2021-30.

Demographics

	Entire Cohort (n=372)	Competitive Subgroup (Varsity/Junior Varsity/Traveling Teams; n=60)
Age, n (%)		
10–19 y	89 (24)	55 (92)
20–29 y	70 (19)	5 (8)*
30–39 y	66 (18)	
40–49 y	72 (19)	
50–60 y	75 (20)	
Male, n (%)	249 (67)	33 (55)
Race, n (%)		
White	349 (94)	56 (93)
Black	12 (3)	3 (5)
Other/unknown	11 (3)	1 (2)
Cardiac diagnosis, n (%)		
Long-QT syndrome	73 (20)	28 (47)
Hypertrophic CM	65 (17)	13 (22)
Arrhythmogenic right ventricular dysplasia	53 (14)	3 (5)
Coronary artery disease	41 (11)	0
Idiopathic VT/VF (normal heart)	40 (11)	2 (3)
Dilated cardiomyopathy	31 (8)	0
Congenital heart disease	30 (8)	6 (10)
Catecholaminergic polymorphic VT	10 (3)	3 (5)
Brugada syndrome	7 (2)	1 (2)
Valvular heart disease	6 (2)	0
Left ventricular noncompaction	5 (1)	1 (2)
None, family history	5 (1)	1 (2)
Other	6 (2)	2 (4)

	Entire Cohort (n=372)	Competitive Subgroup (Varsity/Junior Varsity/Traveling Teams; n=60)
ICD indication		
Ventricular fibrillation/cardiac arrest, n (%)	102 (27)	15 (25)
Sustained VT, n (%)	53 (14)	1 (2)
Syncope, n (%)	99 (27)	25 (42)
Prophylactic–CAD/CM, n (%)†	32 (9)	0
Prophylactic–other, n (%)	65 (17)	17 (29)
Positive electrophysiology study, n (%)	21 (6)	2 (3)
Time since initial ICD implantation, mo	27 (12–59)	16 (8–28)
ICD rate cutoff, bpm‡	200 (188–215)	217 (210–222)
Primary prevention, bpm	201 (188–219)	
Secondary prevention, bpm	200 (187–210)	
Ejection fraction, %	60 (50–66)	67 (60–72)
Taking β-blocking agents, n (%)	229 (62)	40 (67)

CAD indicates coronary artery disease; CM, cardiomyopathy; ICD, implantable cardioverter-defibrillator; VF, ventricular fibrillation; and VT, ventricular tachycardia. Values are either number (percent) or median (interquartile range) as appropriate.

*All ≤ 21 years of age.

†As defined by the Sudden Cardiac Death in Heart Failure Trial,[5] Multicenter Unsustained Tachycardia Trial,[6] or Multicenter Automatic Defibrillator Implantation Trial II.[7]

‡Lowest zone with treatment programmed, secondary prevention, VT or VF, primary prevention, other diagnoses.

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Primary endpoint

There were no occurrences of the primary end point (tachyarrhythmic death or externally resuscitated tachyarrhythmia during or after sports participation or severe injury resulting from arrhythmia-related syncope or shock during sports)

The 95% confidence interval for the occurrence of an adverse event at 1 year, based on the 315 participants followed up for at least 1 year, was 0% to 1.2%; for 2 years, based on the 243 participants followed up for at least 2 years, the 95% confidence interval was 0% to 1.5%

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ICD shocks

Table 3. Number of Shock Events and of Individuals Receiving Shocks, Total Cohort

Rhythm	Competition Related, n*	Physical Activity Related, n†	Other, n	Total, n (%)
Ventricular tachycardia	22/16	14/11	11/8	47/35 (9)
Ventricular fibrillation	8/6	3/3	10/5	21/14 (4)
Sinus tachycardia	7/6	6/3	1/1	14/10 (3)
Atrial fibrillation	5/3	10/6	3/3	18/12 (3)
Other supraventricular tachycardia	2/2	2/2	0/0	4/4 (1)
Noise	0/0	2/2	6/5	8/7 (2)
T-wave oversensing	2/2	1/1	1/1	4/4 (1)
Other	3/2	1/1	1/1	5/4 (1)
Total, n (%)	49/36 (10)	39/29 (8)	33/23 (6)	121/77 (21)

Values refer to number of events/number of unique individuals. Percents refer to percent of the study population. Eighteen shocks did not have available implantable cardioverter-defibrillator–stored data, so the diagnosis is based on that of the treating physician. Of these, 4 were ventricular arrhythmia, 2 were supraventricular, 7 were noise, and 5 were other.

*Includes competition, postcompetition, or practice for competition.

†Includes physical activity and post–physical activity.

- **Overall, 77 individuals (21% of the study population)experienced 121 shock episodes.**
- **Forty-eight participants (13%) received at least 1 appropriate shock, and 40 (11%) received at least 1 inappropriate shock**

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ICD shocks

- **Statistically more individuals received shocks during either competition/practice or physical activity than during rest (16% versus 6%; P<0.0001)**
- Twenty-one individuals received appropriate shocks during competition/practice. Individuals **≥20 years of age** were more likely to receive appropriate shocks during competi-tion/practice. Those with **arrhythmogenic right ventricular dysplasia or idiopathic VF** were more likely than those with hypertrophic cardiomyopathy (P<0.05 for each) or with long-QT syndrome (P<0.05 and P=0.07, respectively) to receive appropriate shocks during competition/practice

Table 4. Bivariate Association of Clinical Characteristics and Appropriate Shocks During Sports

	Total, n	VT/VF Shock During Competition/Practice (n= 21), n (%)	*P* Value
Age, 10–19 y	89	1 (1)	0.03
20–60 y	283	20 (7)	
Competitive subgroup	60	1 (2)	0.22
Others	312	20 (6)	
Indication			
Secondary prevention	155	10 (6)	0.65
Primary prevention	217	11 (5)	
Cardiac diagnosis			
Idiopathic VT/VF (normal heart)	33	4 (12)	<0.01
CAD	39	3 (8)	
ARVD	53	8 (15)	
HCM	65	1 (2)	
LQTS	73	2 (3)	
Others	109	3 (3)	
Sex			
Female	123	10 (8)	0.16
Male	249	11 (4)	
β-Blocker			
Yes	229	14 (6)	1.00
No	115	7 (6)	

ARVD indicates arrhythmogenic right ventricular dysplasia; CAD, coronary artery disease; HCM, hypertrophic cardiomyopathy; LQTS, long-QT syndrome; VF, ventricular fibrillation; and VT, ventricular tachycardia.

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Multiple ICD shocks

Table 5. Events/Individuals Requiring >1 Shock for Termination to Sinus Rhythm

Sex	Age, y	Cardiac Diagnosis	Primary Sport	Activity	Activity Type	Shocks, n
M	28	Idiopathic VF	Ultimate Frisbee	Ultimate Frisbee	Competition	5
F	47	Idiopathic VF	Cycling	Cycling	Practice	4
M	44	CAD	Running	Running	Practice	2
M	50	CAD	Cycling	Cycling	Practice	6
M	57	CAD	Tennis, basketball	Walking	Physical Activity	6
F	16	CPVT	Lacrosse field hockey	Running	Post–physical activity	3
				Running	Post–physical activity	4
M	15	HCM	Baseball	Socializing	Other	2

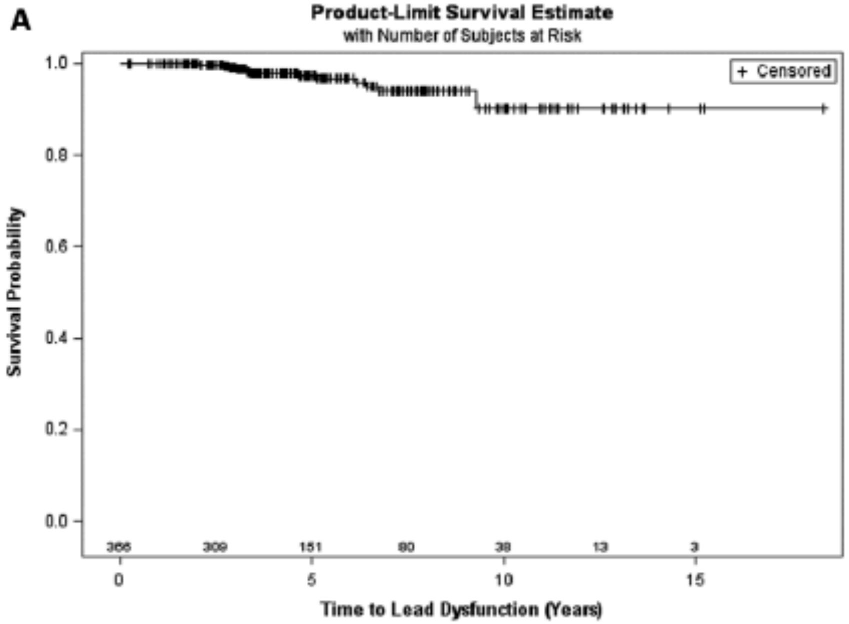
CAD indicates coronary artery disease; CPVT, catecholaminergic polymorphic ventricular tachycardia; HCM, hypertrophic cardiomyopathy; and VF, ventricular fibrillation.

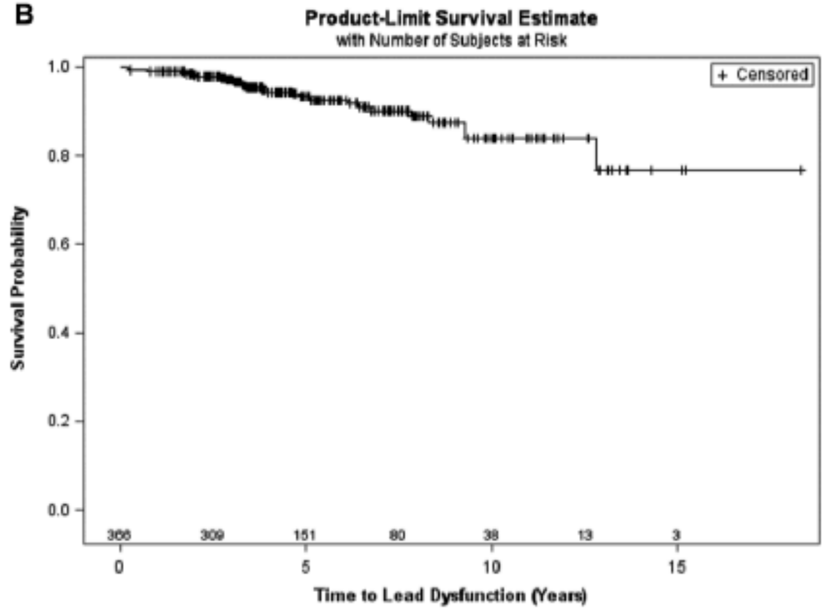
Among the 64 appropriate shock episodes, 8 episodes in 7 individuals (2% of study population) required >1 high-energy shock for arrhythmia termination (Table 5): 4 were related to competition/practice; 3 were related to other physical activity, and 1 occurred at rest.

Lampert R, et al. Circulation. 2013;127(20):2021-30.

System malfunction

Secondary End Point: System Malfunction
There were 13 definite and 14 possible lead malfunctions.
The estimated lead survival free of definite malfunction (from implantation date) was 97% at 5 years and 90% at 10 years; the rate of survival free of definite plus possible malfunction was 93% at 5 years and 84% at 10 years (Figure [A and B]).
There were no generator malfunctions.





Lampert R, et al. Circulation. 2013;127(20):2021-30.

Long-term FU data

- Among 440 participants, 393 in organized sports and 47 in high-risk sports, the most common diagnoses were long-QT syndrome (n=87, 20%), hypertrophic cardiomyopathy (n=75, 17%), and arrhythmogenic right ventricular cardiomyopathy (n=55, 13%). Of 201 subjects with a preimplantation history of ventricular fibrillation (VF) or tachycardia (VT), 61 (30%) had VT/VF during sports
- The most common organized sports were running, basketball, and soccer; the most common dangerous sport was skiing. Seventy-seven subjects (18%) engaged in varsity/junior varsity/ traveling team competition, (highly competitive subgroup). Seventy-two postcollege athletes (16%) participated at a national/international level
- **Median follow-up was 44 months** (interquartile range, 30–48 months), totaling 1446 person-years
- **no tachyarrhythmic deaths or externally resuscitated tachyarrhythmias during or after sports participation or injury resulting from arrhythmia-related syncope or shock during sports**

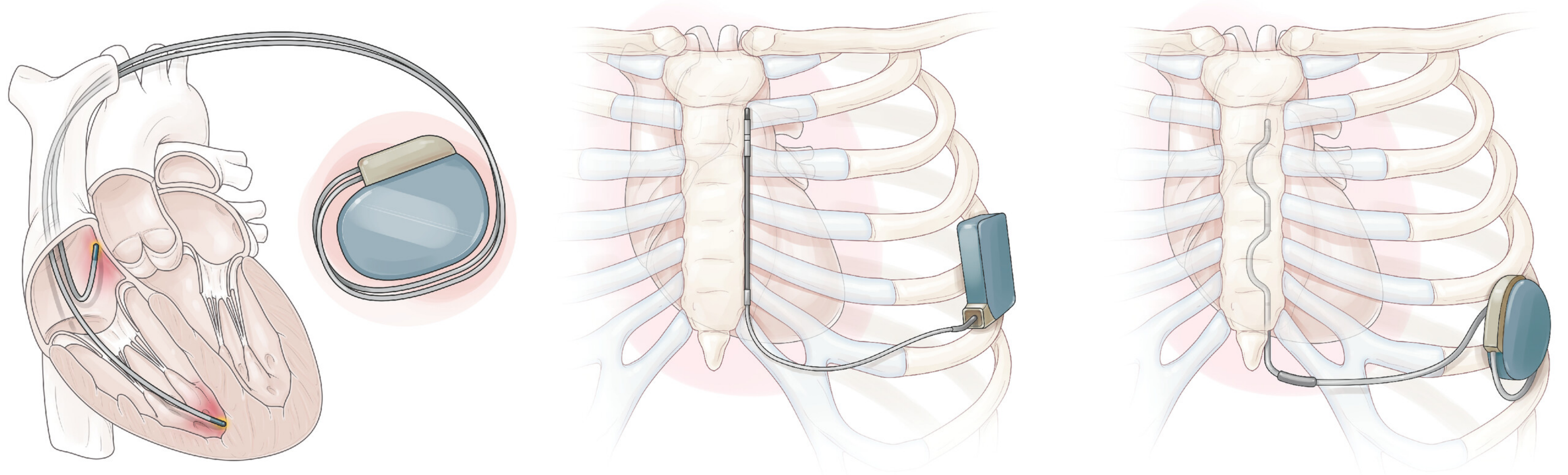
Lampert R, et al. Circulation 2017;135(23):2310-2312

Long-term FU data

- **Forty-six (10%) received appropriate shocks (for VT/VF) during competition or practice**, a rate of 3 per 100 person-years (identical to the initial report). More participants received shocks during competition/practice or physical activity than rest (20% versus 10%; $P<0.0001$)
- The only clinical or demographic **variable associated with receiving appropriate shocks during competition/practice was presence of arrhythmogenic right ventricular cardiomyopathy**
- Sixteen individuals (4% of total) received multiple appropriate shocks for VT/VF because of shock failure (n=2), immediate recurrence within a single device-defined episode (n=6), or electric storm (>1 device-defined episode within 24 hours, n=8). Eight occurred during competition/practice, 4 during other physical activity, and 4 at rest
- There were 31 definite and 13 possible lead malfunctions. **The estimated lead survival free of definite malfunction (from implantation date) was 95% at 5 years and 89% at 10 years and free of definite plus possible malfunction was 94% at 5 years and 85% at 10 years**. There were no generator malfunctions

Lampert R, et al. Circulation 2017;135(23):2310-2312

Pros and cons of the various ICD types



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Al-Khatib SM. N Engl J Med 2024;390(5):442-454

S-ICD and sports

Long-term performance of subcutaneous implantable defibrillators in athletes: A multicenter, real-world analysis of sport activities from the iSUSI registry

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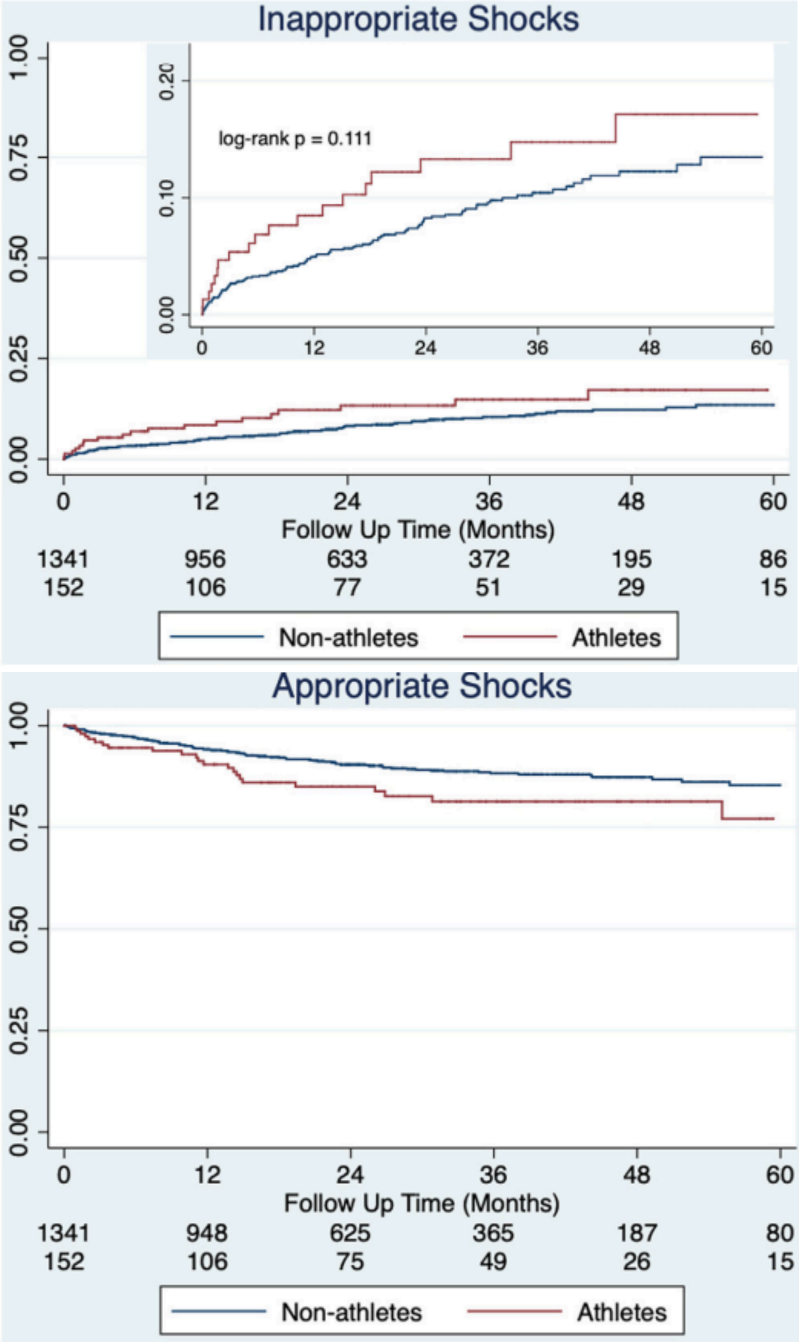
ABSTRACT

BACKGROUND No data regarding subcutaneous-implantable cardioverter defibrillator (S-ICD) technology in patients actively engaging in sports activities are available.

OBJECTIVE This study aims to compare S-ICD performance between athletes and nonathletes.

METHODS The primary outcome of the study was the comparison of overall device-related complications between athletes and nonathletes. Appropriate shocks, inappropriate shocks, and individual device-related complications were secondary outcomes.

RESULTS A total of 1493 patients were extracted from the International Subcutaneous Implantable Cardioverter Defibrillator Registry (iSUSI) registry, of whom 152 (10.2%) were athletes, mostly engaging in dynamic sports (54.2%). Brugada syndrome, myocarditis, and arrhythmogenic right ventricular cardiomyopathy (ARVC) were more common in athletes (11.2% vs 3.3%, *P* < .001; 19.1% vs 9.0%, *P* < .001; 8.6% vs 2.8%, *P* < .001, respectively). During a median follow-up time of 25.5 (12.0–41.2) months, athletes were more likely to experience appropriate shocks (yearly rate: 7.2 [4.9–10.7] % vs 4.3 [3.6–5.1] %, *P* = .028), occurring more frequently during exercise (3.9% vs 0.6%, *P* < .001). This finding lost significance when adjusting for confounders (adjusted hazard ratio [aHR] 1.440 [0.909–2.281], *P* = .120). No differences were found in overall device-related complications (yearly rate: 3.3% vs 3.4%, *P* = .448) and inappropriate shocks (yearly rate: 5.3% vs 3.7%, *P* = 0.111). Myopotential oversensing (4.0% vs 1.3%, *P* = .011) was more common in athletes, as were lead infections (3.3% vs 0.9%, *P* =.008), with the latter clustering in the early postimplantation period.



Gasperetti A, et al. Heart Rhythm 2025;22(7):1782-1789

S-ICD and sports

Table 3 Long-term outcomes

	Athletes (n = 152)	Nonathletes (n = 1341)	*P*
Follow-up time (months), median [IQR]	29.9 [12.6–46.3]	24.8 [12.0–40.7]	.082
Appropriate shocks, n (%)	25 (16.5)	124 (9.3)	**.005**
Occurring during exercise, n (%)	6 (3.9)	8 (0.6)	**< .001**
Patients with device-related complications, n (%)	25 (16.5)	186 (13.9)	.387
Inappropriate shocks, n (%)	19 (12.5)	113 (8.4)	.094
Occurring during exercise, n (%)	7 (4.6)	11 (0.7)	**< .001**
SVT/atrial fibrillation, n (%)	1 (0.7)	16 (1.2)	.471
T-waves oversensing, n (%)	7 (4.6)	47 (3.5)	.491
Myopotentials, n (%)	6 (4.0)	17 (1.3)	**.011**
Other, n (%)	5 (3.3)	33 (2.5)	.539
Lead displacement, n (%)	1 (0.7)	11 (0.8)	.831
Lead rupture, n (%)	0	9 (0.7)	.379
Lead infection, n (%)	5 (3.3)	12 (0.9)	**.008**
Pocket infection, n (%)	2 (1.3)	19 (1.4)	.637
Pocket hematoma, n (%)	2 (1.3)	43 (3.2)	.196
Ineffective shocks, n (%)	5 (1.3)	3 (0.8)	.725

Bold *P*-values are <.05.
IQR = interquartile range; SVT = supraventricular tachycardia.

Table 4 Long-term outcomes

	Leisure time (n = 29)	Competitive (n = 114)	Pro (n = 9)
Appropriate shocks, n (%)	6 (20.7)	17 (14.9)	2 (22.2)
Patients with device-related complications, n (%)	3 (10.3)	22 (19.3)	0
Inappropriate shocks, n (%)	3 (10.3)	16 (14.0)	0
SVT/atrial fibrillation, n (%)	0	1 (0.9)	0
T-waves oversensing, n (%)	1 (3.5)	6 (5.3)	0
Myopotentials, n (%)	2 (6.9)	4 (3.5)	0
Other, n (%)	0	5 (4.4)	0
Lead displacement, n (%)	0	1 (0.9)	0
Lead rupture, n (%)	0	0	0
Lead infection, n (%)	1 (3.5)	4 (3.5)	0
Pocket infection, n (%)	0	2 (1.8)	0
Pocket hematoma, n (%)	1 (3.5)	1 (0.9)	0
Ineffective shocks, n (%)	0	3 (2.6)	0

SVT = supraventricular tachycardia.

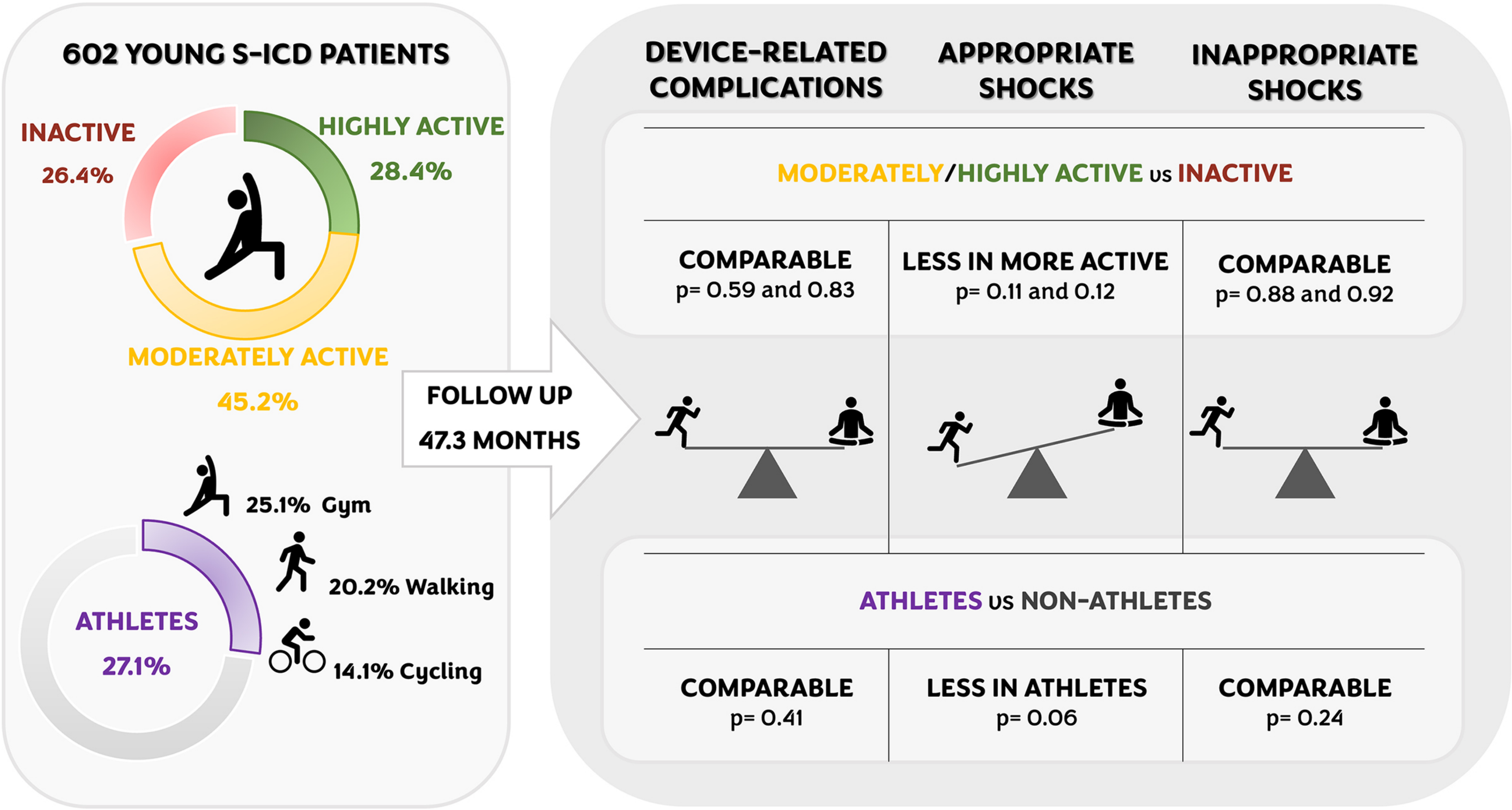
Gasperetti A, et al. Heart Rhythm 2025;22(7):1782-1789

The s-ICD in athletes

- Nessun decesso per cause aritmiche;
- 17% di incidenza di complicanze, specie shock inappropriati; nessun danno dell’elettrocatetere negli atleti; maggior rischio di infezioni negli atleti rispetto ai non atleti;
- 17% di incidenza di shock appropriati, con un tasso maggiore dimiopotenziali negli atleti rispetto ai non atleti;
- sport, substrato (specie la cardiopatia aritmogena del ventricolo destro) e BMI associati ad un maggior rischio di shock appropriati

Gasperetti A, et al. Heart Rhythm 2025;22(7):1782-1789

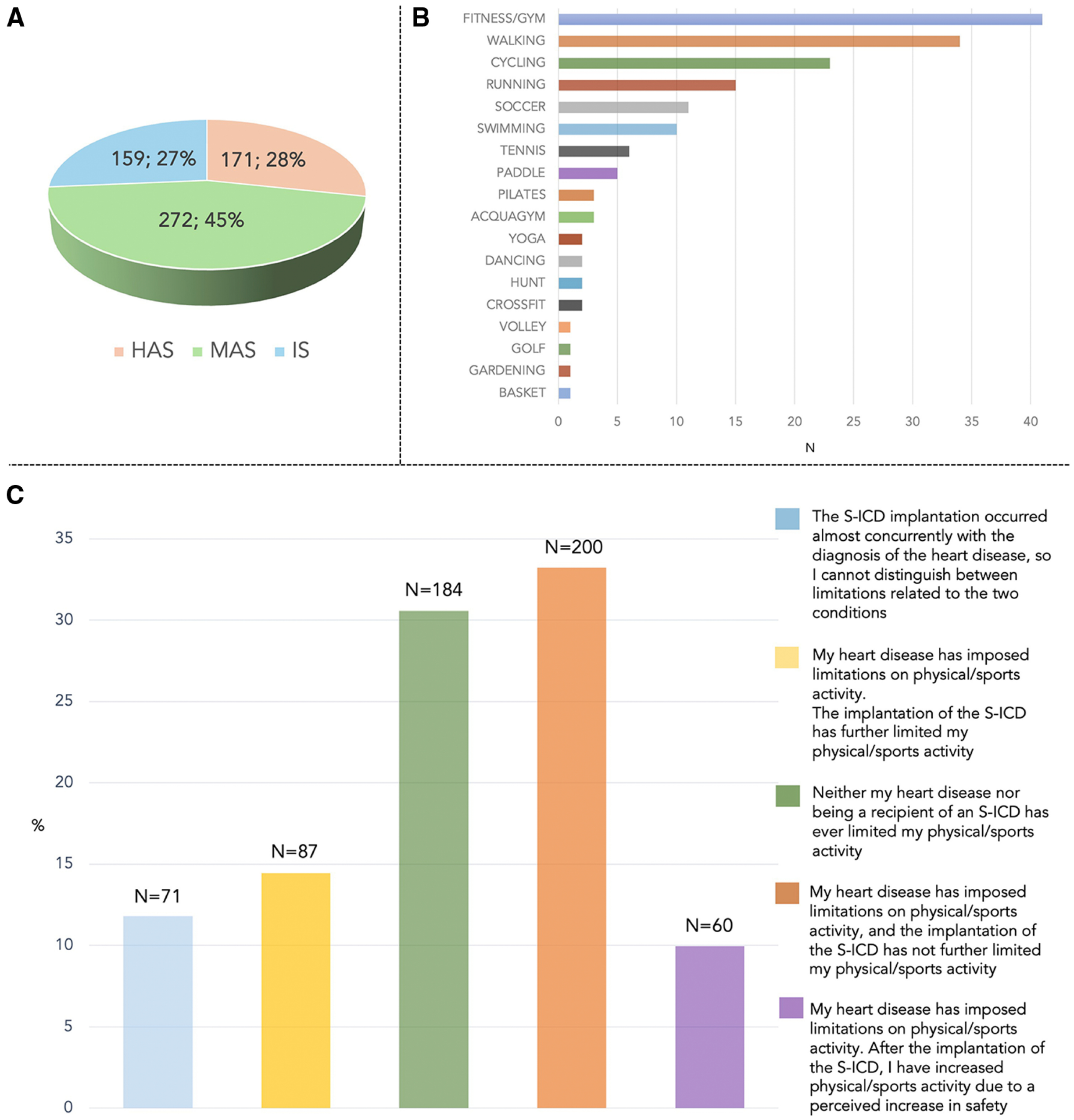
The s-ICD in sports – the Italian multicenter experience



Francia P, et al. Circ Arrhythm Electrophysiol 2025;18(3):e013365

The s-ICD in sports – the Italian multicenter experience

We enrolled 602 S-ICD recipients (77% men; age, 46±14 years). Common diagnoses included hypertrophic cardiomyopathy (24%), ischemic heart disease (20%), idiopathic dilated cardiomyopathy (17%), channelopathies (14%), and ARVC (10%)



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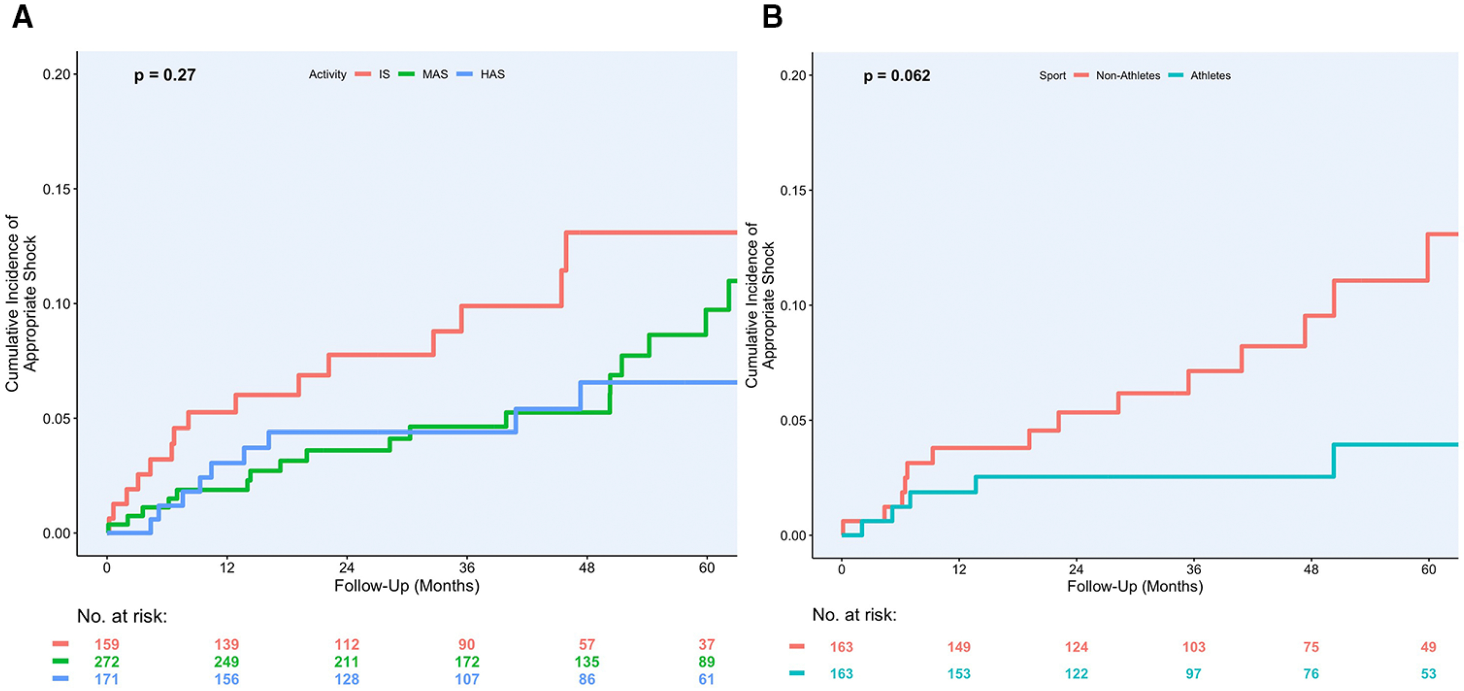

- During follow-up (47.3 [interquartile range, 27.0–67.6] months), 23 (3.8%) patients reached the primary end point. Of these, 1 patient – ARVC, inactive during the event - had externally resuscitated tachyarrhythmia due to multiple shock failures, 2 had at least 1 shock failure, and 20 had lead- or device-related complications requiring reintervention
- In multivariate Cox regression, after adjusting for age, sex, CAD, and EF, moderately active (HR, 0.58 [95% CI, 0.29–1.16]; P=0.12) and highly active subjects (HR, 0.51 [95% CI, 0.22–1.15]; P=0.11) showed a nonsignificant lower risk of appropriate shocks compared with inactive subjects
- The single heart disease that was associated with a significant risk of appropriate shocks was ARVC (HR, 2.36 [95% CI, 1.13–4.92]; P=0.02)

Francia P, et al. Circ Arrhythm Electrophysiol 2025;18(3):e01

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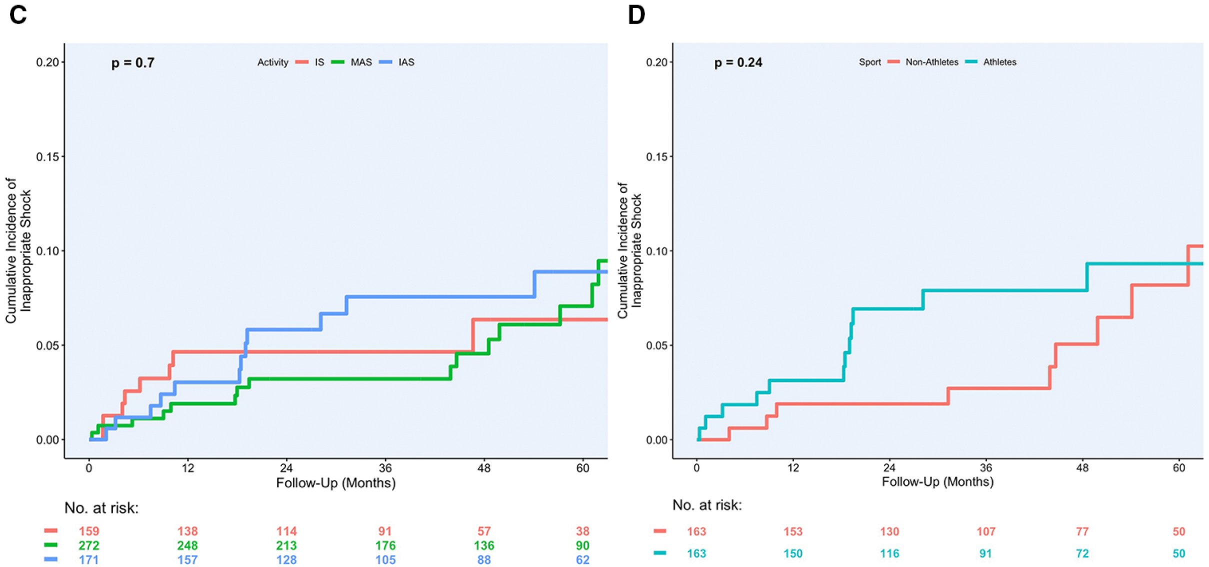

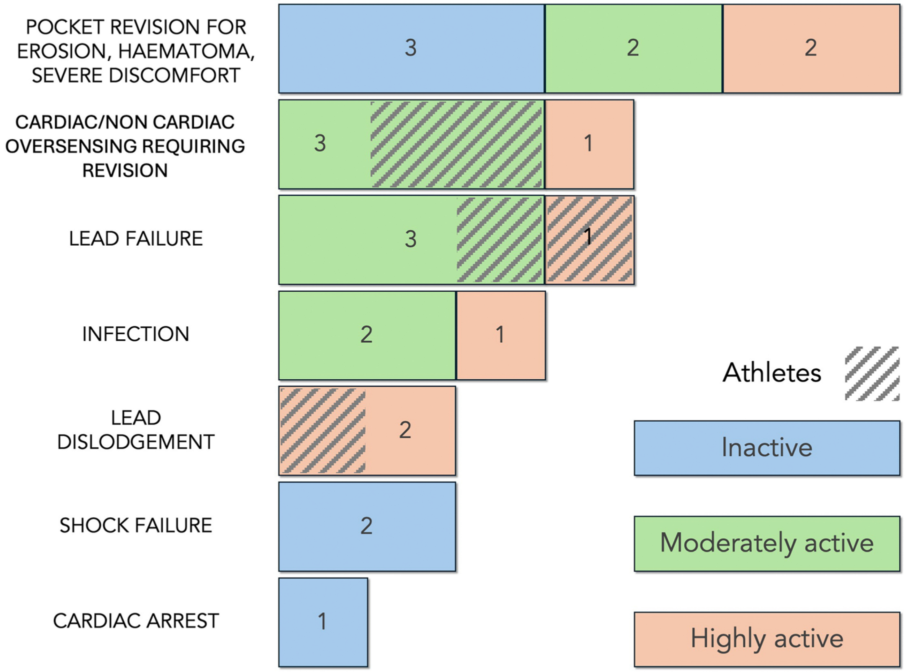

- In multivariate Cox regression after adjusting for age, sex, CAD, EF, and history of atrial fibrillation, moderately active (HR, 1.04 [95% CI, 0.45–2.43]; *P*=0.92) and highly active subjects (HR, 1.07 [95% CI, 0.44–2.61]; *P*=0.88) had similar risk of inappropriate shocks as compared with inactive subjects.

- 7 lead related complications (n=6 dislodgements and n=4 oversensing requiring revision) which all occurred in moderately-highly active subjects (n=5 recreational athletes)

Francia P, et al. Circ Arrhythm Electrophysiol 2025;18(3):e01

Hitting a new PR: Extravascular ICD implant in a professional powerlifter

Check for updates

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Introduction

Implantable cardiac defibrillators (ICDs) reduce the risk of sudden cardiac death in high-risk populations[1], but traditional transvenous devices carry additional risks for certain patients.[2] These risks can include venous obstruction, lead failure, and/or infection (eg, pocket infection, bacteremia, and endocarditis) that might require lead extraction and another implant procedure.[3] Competitive and recreational athletes face additional risks with transvenous devices given their higher-level activity and associated risk for lead injury or dislodgement.[4] Although subcutaneous ICD (S-ICD) can be an alternative, these devices cannot deliver antitachycardia pacing (ATP), and about 10% of patients fail the screening test and are not candidates for the device.[5,6] A newer alternative is the extravascular ICD (EV-ICD), which is designed for use in the substernal space and can deliver both ATP and defibrillation.[7,8] We describe a case of implant of the extravascular ICD as secondary prevention in a professional powerlifter after patient-centered shared decision-making.

Case report

KEY TEACHING POINTS

- For athletes in whom transvenous-implantable cardiac defibrillators (ICDs) and subcutaneous-ICD devices are not suitable options, the extravascular-ICD is an important alternative that can support shared decision-making around optimizing safety for return to play.
- Recent society recommendations for athletes with arrhythmias emphasize an individualized and collaborative approach to facilitate continued participation in competitive sports even for those who require a cardiac implantable electronic device.
- High-intensity resistance exercises are not routinely recommended for those with severe cardiomyopathy, although studies have shown a benefit from moderate-intensity exercises which can improve left ventricular ejection fraction and maximal oxygen consumption.

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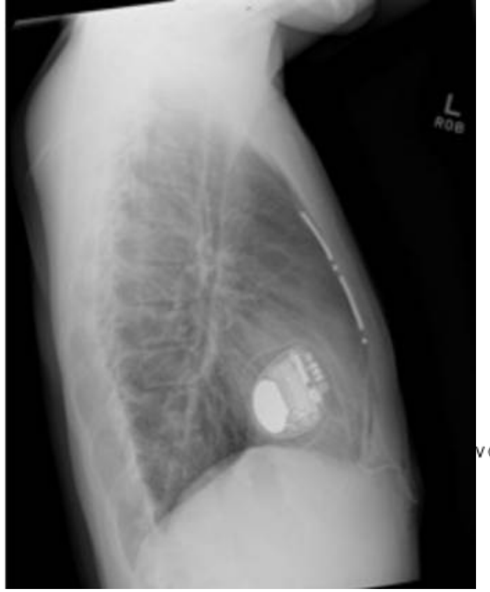

VOL. 29, 2024

RHYTHM DISORDERS AND ELECTROPHYSIOLOGY

CASE REPORT: CLINICAL CASE

Rapid Return to Play After Extravascular Implantable Cardioverter-Defibrillator Implantation in a Competitive Runner

Dustin Nash, MD,[a] Johannes C. von Alvensleben, MD,[a] Matthew Zipse, MD[b]

ABSTRACT

We present a case of long QT syndrome type 2 in a competitive runner who underwent implantation of a primary prevention extravascular implantable cardioverter defibrillator with a rapid return to partial activity within 2 weeks and a return to full activity within 4 weeks of implantation without affecting wound healing or device function. (JACC Case Rep. 2024;29:102490)

Sports in patients implanted with ICDs

RISKS RELATED TO SPORTS IN ICD PATIENTS

1. Device-related Risks
2. Disease-related risks
3. Syncope-related

	Gene mutation	RV HF	VAs	Fibrosis or fibrofatty replacement	ID alterations
Kirchhof et al n=19	JUP +/-	● ● ●	● ●		
Cruz et al n=10	PKP2 (c.2203C>T)	● ● ●			● ● ●
Moncayo Arlandi et al n=8	PKP2-Ser329	● ●			● ● ●
Van Opbergen et al n=8	PKP2 KO		● ●		
Lyon et al n=6	DSP KO	● ● ●	● ● ●	● ● ●	● ● ●
Martherus et al n=21	DSP^{R2834H}	●		● ●	● ● ●
Chelko et al n=52	Dsg2	● ● ●	● ● ●	● ● ●	● ● ●
Benito et al n=12	Healthy	● ●	● ●	●	

● = unit of measure for the observed deleterious effect, the number of dots reflects the magnitude of the impact.

Dei LL, Han J, et al. J Am Heart Assoc. 2025;14(12):e039125

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

Endurance athletics were sports with a high dynamic demand (>70% maximum O_2), as defined by the 36th Bethesda Conference Classification of Sports (Task Force 8), done for at least 50 h/year at vigorous intensity

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

Baltimore, Maryland

Objectives This study sought to determine how exercise influences penetrance of arrhythmogenic right ventricular dysplasia/cardiomyopathy (ARVD/C) among patients with desmosomal mutations.

Background Although animal models and anecdotal evidence suggest that exercise is a risk factor for ARVD/C, there have been no systematic human studies.

Methods Eighty-seven carriers (46 male; mean age, 44 ± 18 years) were interviewed about regular physical activity from 10 years of age. The relationship of exercise with sustained ventricular arrhythmia (ventricular tachycardia/ventricular fibrillation [VT/VF]), stage C heart failure (HF), and meeting diagnostic criteria for ARVD/C (2010 Revised Task Force Criteria [TFC]) was studied.

Results Symptoms developed in endurance athletes (N = 56) at a younger age (30.1 ± 13.0 years vs. 40.6 ± 21.1 years, $p = 0.05$); they were more likely to meet TFC at last follow-up (82% vs. 35%, $p < 0.001$) and have a lower lifetime survival free of VT/VF ($p = 0.013$) and HF ($p = 0.004$). Compared with those who did the least exercise per year (lowest quartile) before presentation, those in the second (odds ratio [OR]: 6.64, $p = 0.013$), third (OR: 16.7, $p = 0.001$), and top (OR: 25.3, $p < 0.0001$) quartiles were increasingly likely to meet TFC. Among 61 individuals who did not present with VT/VF, the 13 subjects experiencing a first VT/VF event over a mean follow-up of 8.4 ± 6.7 years were all endurance athletes ($p = 0.002$). Survival from a first VT/VF event was lowest among those who exercised most (top quartile) both before ($p = 0.036$) and after ($p = 0.005$) clinical presentation. Among individuals in the top quartile, a reduction in exercise decreased VT/VF risk ($p = 0.04$).

Conclusions Endurance exercise and frequent exercise increase the risk of VT/VF, HF, and ARVD/C in desmosomal mutation carriers. These findings support exercise restriction for these patients. (J Am Coll Cardiol 2013;62:1290–7)

The final study population included 87 individuals (46male) from 51 families with a single copy of a pathogenicARVD/C-associated desmosomal mutation (76 PKP2,7 DSG2, 3 DSP, 1 DSC2)

James CA, et al. J Am Coll Cardiol 2013;62(14):1290-1297

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, Brittney Murray, MS,
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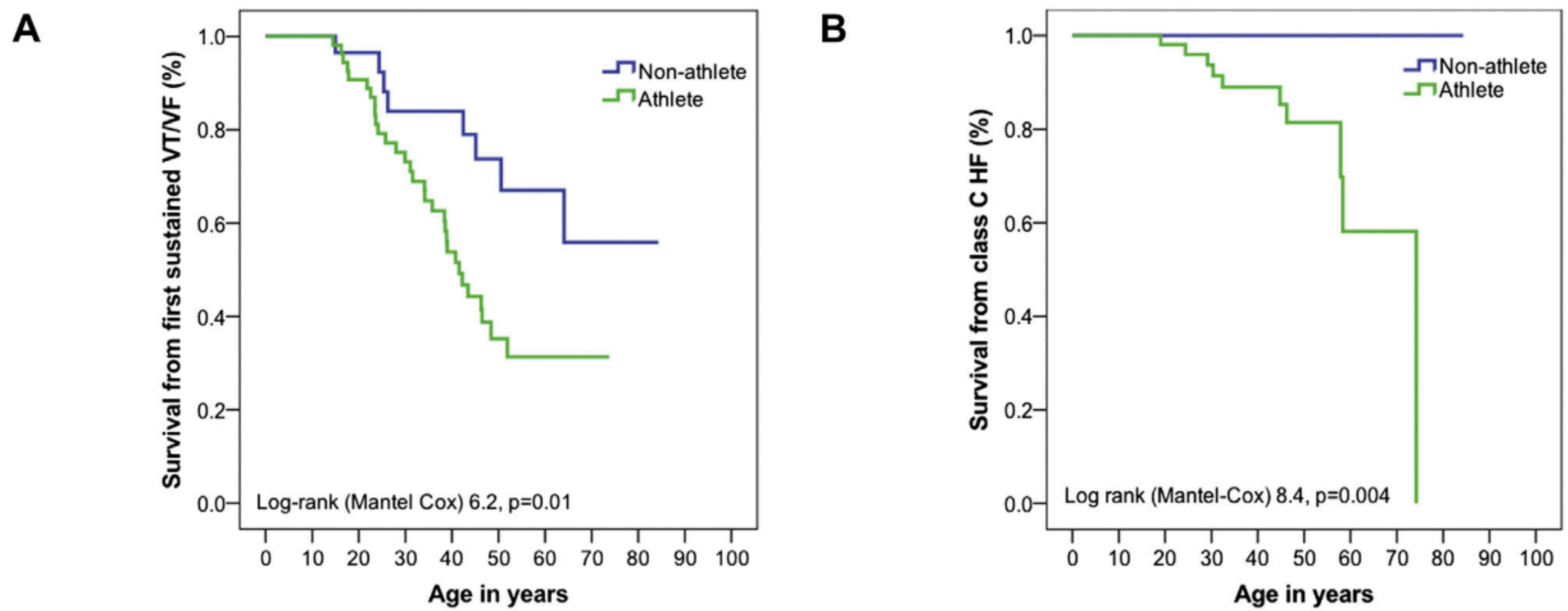

A — Numbers at risk

	0	10	20	30	40	50	60	70	80	90	100
Non-athlete	31	31	24	20	18	11	9	3	1	0	0
Athlete	56	56	49	36	24	9	3	2	0	0	0

B — Numbers at risk

	0	10	20	30	40	50	60	70	80	90	100
Non-athlete	31	31	24	22	18	11	9	4	1	0	0
Athlete	56	56	50	41	32	14	4	2	0	0	0

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

Cumulative lifetime survival free of sustained ventricular arrhythmias **(A)** and stage C heart failure **(B)** stratified by participation in endurance athletics. Event-free survival from sustained arrhythmias and stage C heart failure is significantly lower among endurance athletes. HF = heart failure; VT/VF = ventricular tachycardia/ventricular fibrillation (sustained ventricular arrhythmia).

James CA, et al. J Am Coll Cardiol 2013;62(14):1290-1297

Exercise and arrhythmic risk in *TMEM43* p.S358L arrhythmogenic right ventricular cardiomyopathy

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BACKGROUND High-level exercise has been associated with a malignant phenotype in desmosomal and genotype-negative forms of arrhythmogenic right ventricular cardiomyopathy (ARVC). This is the first study to examine this issue with ARVC secondary to the *TMEM43* p.S358L mutation.

OBJECTIVE The purpose of this study was to evaluate the impact of exercise on arrhythmic risk and cardiac death in *TMEM43* p.S358L ARVC.

METHODS Individuals with the *TMEM43* p.S358L mutation enrolled in a prospective registry who had **received** a primary prevention implantable cardioverter-defibrillator (ICD) were invited to complete the modified Paffenbarger Physical Activity Questionnaire to assess their physical activity in the year before their ICD implantation. Time-to-event analyses using unadjusted and adjusted Cox proportional hazards models evaluated associations between physical activity and first appropriate ICD discharge secondary to malignant ventricular arrhythmia or cardiac death.

RESULTS In 80 subjects with the *TMEM43* p.S358L mutation, exercise ≥9.0 metabolic equivalent of task (MET)-hours/day (high level) in the year before ICD implantation was associated with an adjusted 9.1-fold increased hazard of first appropriate ICD discharge (there were no deaths) relative to physical activity <9.0 MET-hours/day (moderate level) (95% confidence interval [CI] 3.3–24.6 MET-hours/day; $P < .001$). The median age from birth to first appropriate ICD discharge was 58.5 years (95% CI 56.5–60.5 years) vs 35.8 years (95% CI 28.2–43.4 years) ($P < .001$) in subjects in moderate- and high-level exercise groups, respectively.

CONCLUSION Exercise ≥9.0 MET-hours/day is associated with an increased risk of malignant ventricular arrhythmias in the *TMEM43* p.S358L subtype of ARVC. Extrapolating these data, we suggest molecular testing be offered in early childhood to inform exercise choices reflective of the genotype.

KEYWORDS Arrhythmogenic right ventricular dysplasia/cardiomyopathy; Exercise; *TMEM43*; Cardiomyopathy; Ventricular arrhythmias; Implantable cardioverter-defibrillator

(Heart Rhythm 2020;17:1159–1166)

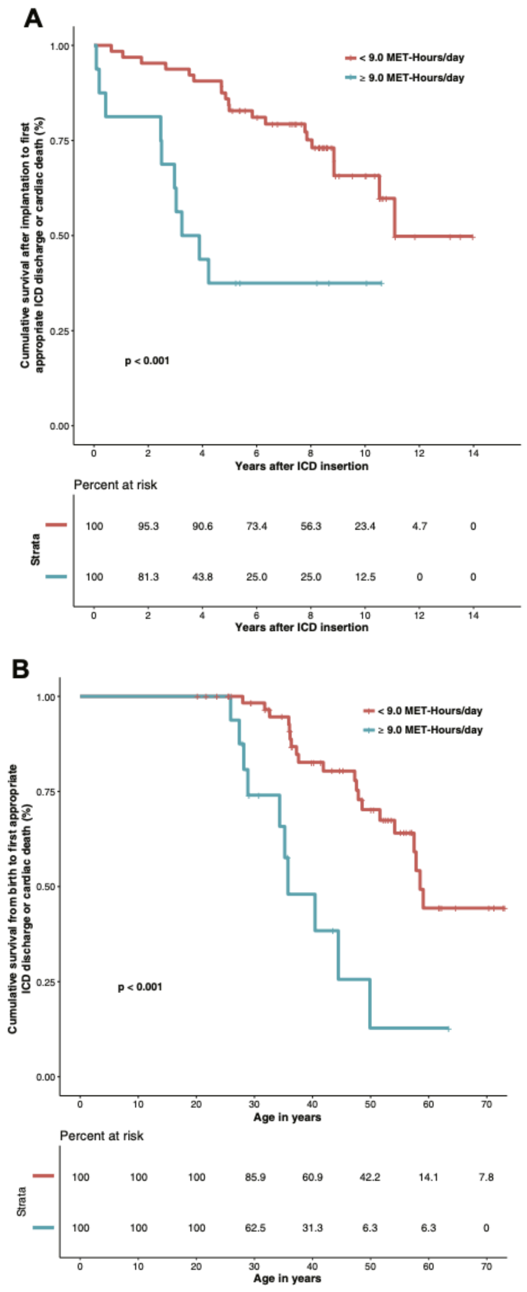
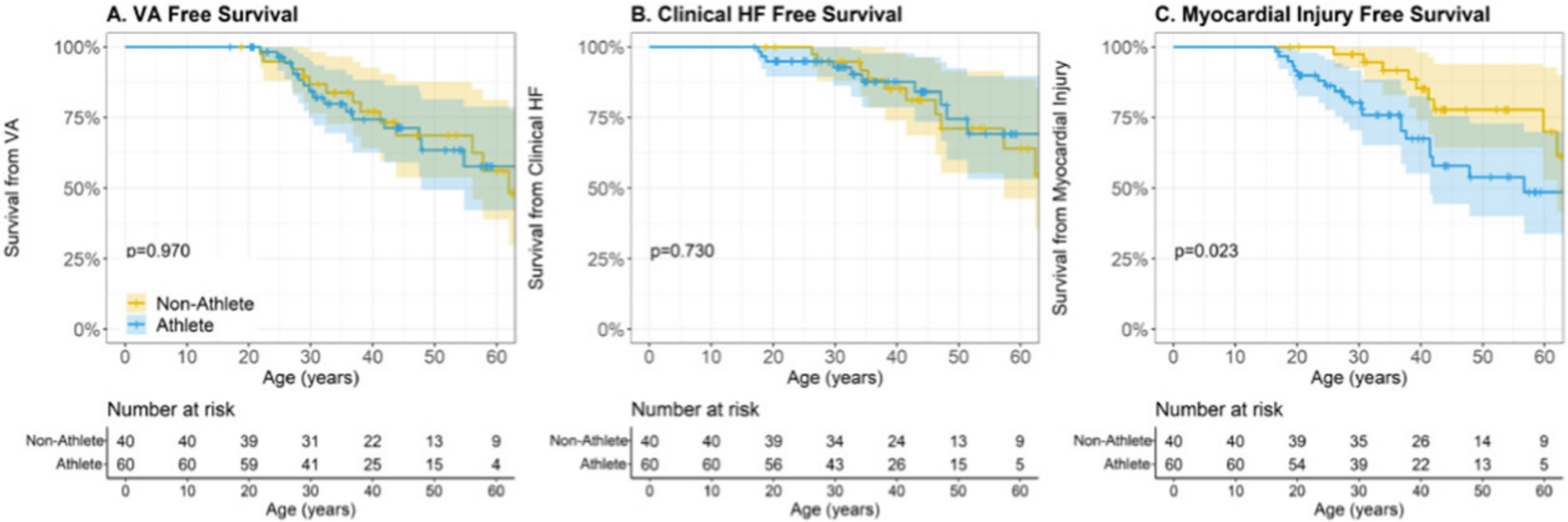


Figure 3 Kaplan-Meier survival curves comparing low and high levels of physical activity. **A:** Cumulative time to event after implantation to first appropriate ICD discharge or cardiac death. **B:** Cumulative survival from birth to first appropriate ICD discharge or cardiac death. ICD = implantable cardioverter-defibrillator; MET = metabolic equivalent of task.

Endurance Exercise Promotes Episodes of Myocardial Injury in Individuals with a Pathogenic Desmoplakin (DSP) Variant

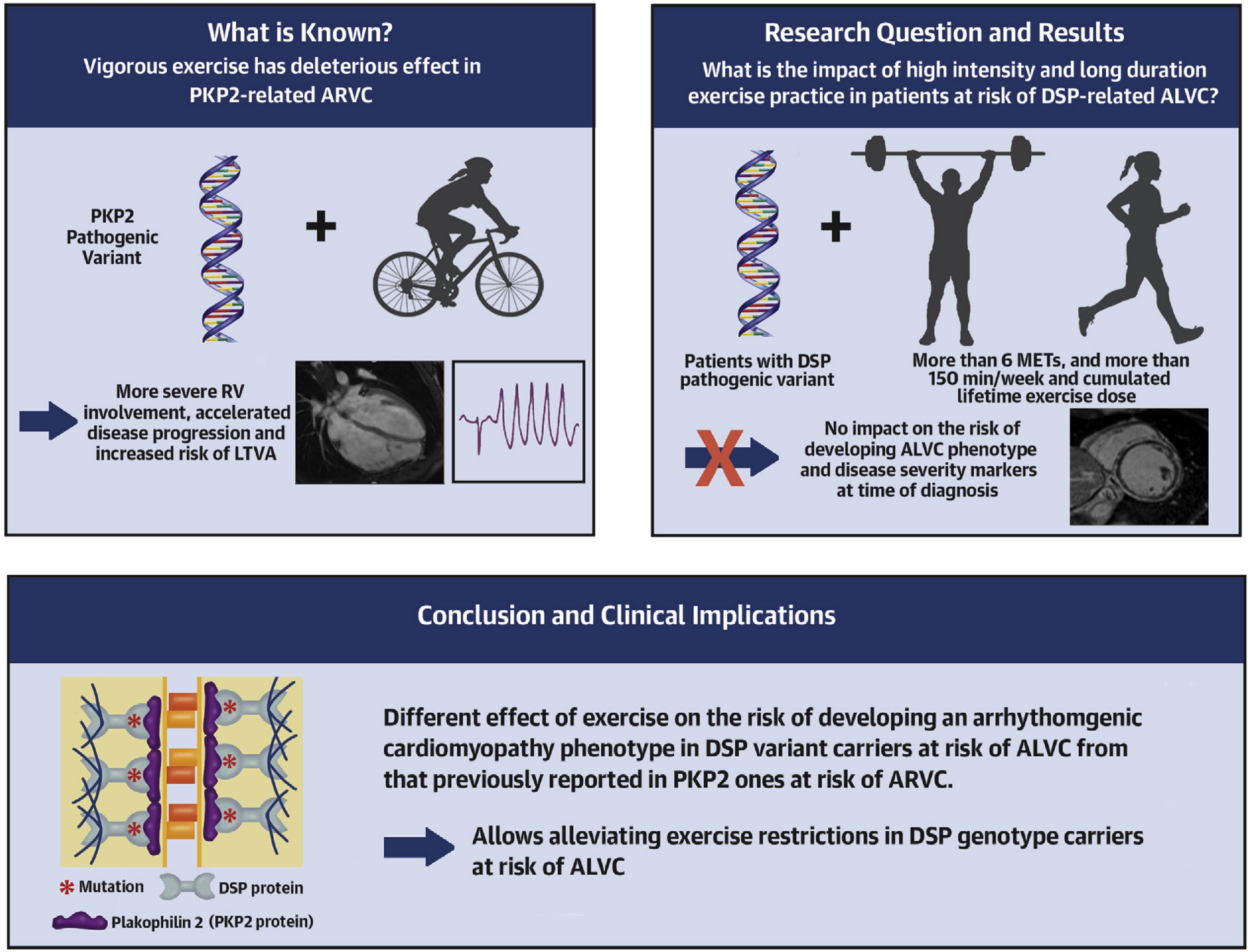
- Participants with a pathogenic or likely pathogenic desmoplakin variant
- N=100, 66% female, average age 36 ± 15 years
- 73% with phenotypic expression at presentation

- Physical exercise data were collected by telephone interview from age 10
- Exercise dose was quantified in metabolic equivalent hours per week (METhr/wk)
- Participants were classified as athletes or non-athletes based on an exercise dose >24 METhr/wk

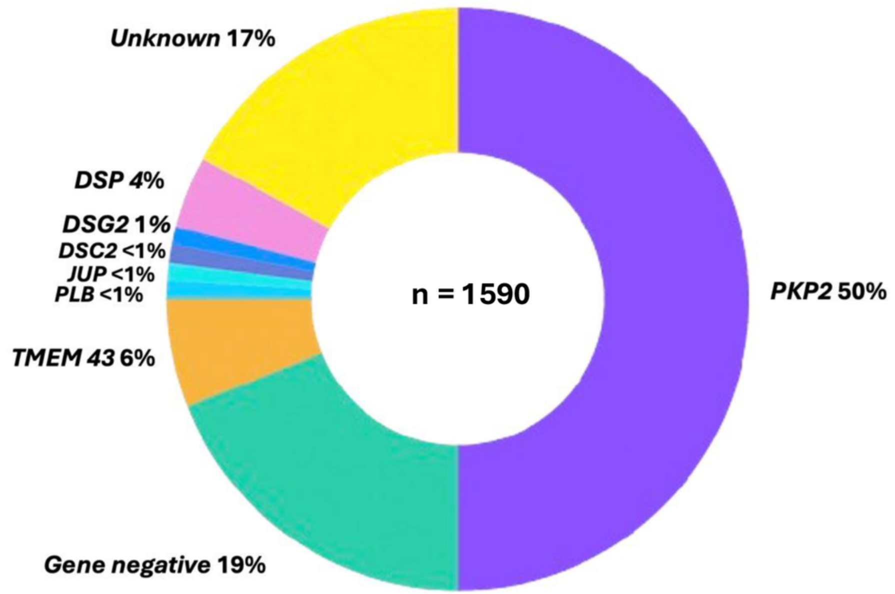


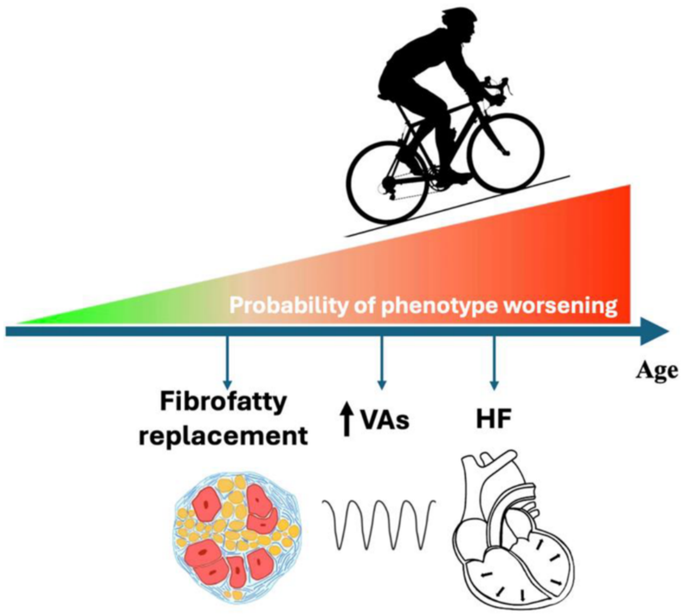
VA=Sustained ventricular arrhythmia, HF=Heart failure

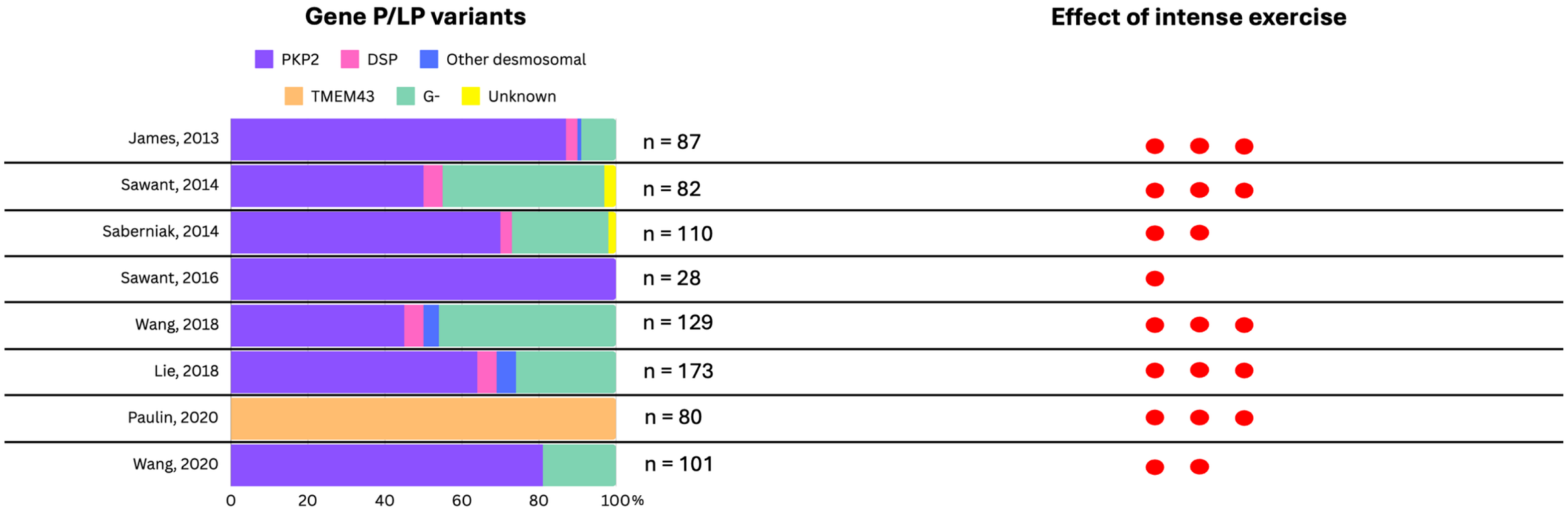
CENTRAL ILLUSTRATION: Impact of Prior Exercise Practice on Arrhythmogenic Left Ventricular Cardiomyopathy Features at Time of Diagnosis in Desmoplakin Gene Variant Carriers



Jean C, et al. JACC Clin Electrophysiol. 2025;11(9):1923-1932.







● = unit of measure for the observed deleterious effect, the number of dots reflects the magnitude of the impact.

Dei LL, Han J, et al. J Am Heart Assoc. 2025;14(12):e039125

ESC Guidelines on sports cardiology and exercise in patients with cardiovascular disease

Shared decision making should be considered during decisions relating to continuation of intensive or competitive sports participation in individuals with an ICD, taking into account the effect of sports on the underlying substrate, the fact that intensive sports will trigger more appropriate and inappropriate shocks, the psychological impact of shocks on the athlete/patient, and the potential risk for third parties.	IIa	C
An ICD is not recommended as a substitute for disease-related recommendations when these mandate sports restrictions.	III	C

Pelliccia A, et al. Eur Heart J. 2021;42(1):17-96

HRS expert consensus statement on arrhythmias in the athlete: Evaluation, treatment, and return to play

Recommendations for shared decision-making and clinical management determination

COR	LOE	Recommendations
1	C-LD	1. In athletes with arrhythmogenic conditions, determination of clinical treatment options should be made through shared decision-making, prioritizing preferences, values, and goals of the athlete.[53]
1	C-EO	2. In athletes with arrhythmogenic conditions, the fundamentals of shared decision-making should be grounded in core principles of knowledge, humility, respect and trust, teamwork with key stakeholders, and transparent communication.

2a	B-NR	4. In athletes with an ICD, return to play is reasonable, in the context of shared decision-making that includes underlying disease entity, clinical characteristics, and sport type.[192–194]
2a	B-NR	5. In athletes who have experienced SCA and are undergoing ICD implant, it is reasonable to consider sport type and disease entity in the decision regarding ICD type and location.[192,195]
2a	C-EO	6. For athletes undergoing ICD implantation who will be returning to play, a waiting period of 4-6 weeks after a new implant or 2 weeks after generator replacement is reasonable.

Lampert R, et al. Heart Rhythm 2024;21(10):e151-e252

Circulation

AHA/ACC SCIENTIFIC STATEMENT

Clinical Considerations for Competitive Sports Participation for Athletes With Cardiovascular Abnormalities: A Scientific Statement From the American Heart Association and American College of Cardiology

- Athletes with PKP2-mediated ACM should be advised that competitive endurance sports will likely increase their risk of VA, ICD shocks, and structural disease pro-gression
- These risks of higher-intensity competitive sports participation likely outweigh benefits
- In athletes with non-PKP2 genotype-positive ACM, or genotype-negative ACM, evidence for either increased SCA risk or disease acceleration with competitive sports participation is not established.
- Competitive sports participation can be considered in these individuals, butshould be carefully individualized given uncertainty andneed for more data

Circulation 2025

Circulation

AHA/ACC SCIENTIFIC STATEMENT

Clinical Considerations for Competitive Sports Participation for Athletes With Cardiovascular Abnormalities: A Scientific Statement From the American Heart Association and American College of Cardiology

Implantable cardioverter defibrillator
Specific clinical considerations
Competitive sports participation is reasonable for competitive athletes who have received an ICD for primary or secondary prevention with SDM, which takes into consideration the underlying diagnosis, comprehensive confirmation of rhythm stability, and the possibility of both appropriate and inappropriate device therapies.
For competitive athletes who receive a new ICD, competitive sports participation should be restricted for 4 to 8 wk (or 2 wk after generator replacement) as determined by sporting discipline to allow for postprocedural recovery.

Competitive sports participation for competitive athletes with an ICD who participate in collision or impact competitive sports (see Section I) can be considered with SDM that addresses the potential risk of ICD system damage or malfunction.

James CA, et al. J Am Coll Cardiol 2013;62(14):1290-1297

Decreto del Ministero della Sanità 18 febbraio 1982
Norme per la tutela sanitaria dell'attività sportiva agonistica
(Pubbl. sulla Gazzetta Ufficiale del 5 marzo 1982, n. 63)

Art. 1
Ai fini della tutela della salute, coloro che praticano attività sportiva agonistica devono sottoporsi previamente e periodicamente al controllo dell'idoneità specifica allo sport che intendono svolgere o svolgono.
La qualificazione agonistica a chi svolge attività sportiva è demandata alle federazioni Sportive Nazionali o agli enti sportivi riconosciuti.
Devono sottoporsi altresì ai controlli di cui sopra i partecipanti ai Giochi della Gioventù per accedere alle fasi
nazionali.

Original Contribution

FREE

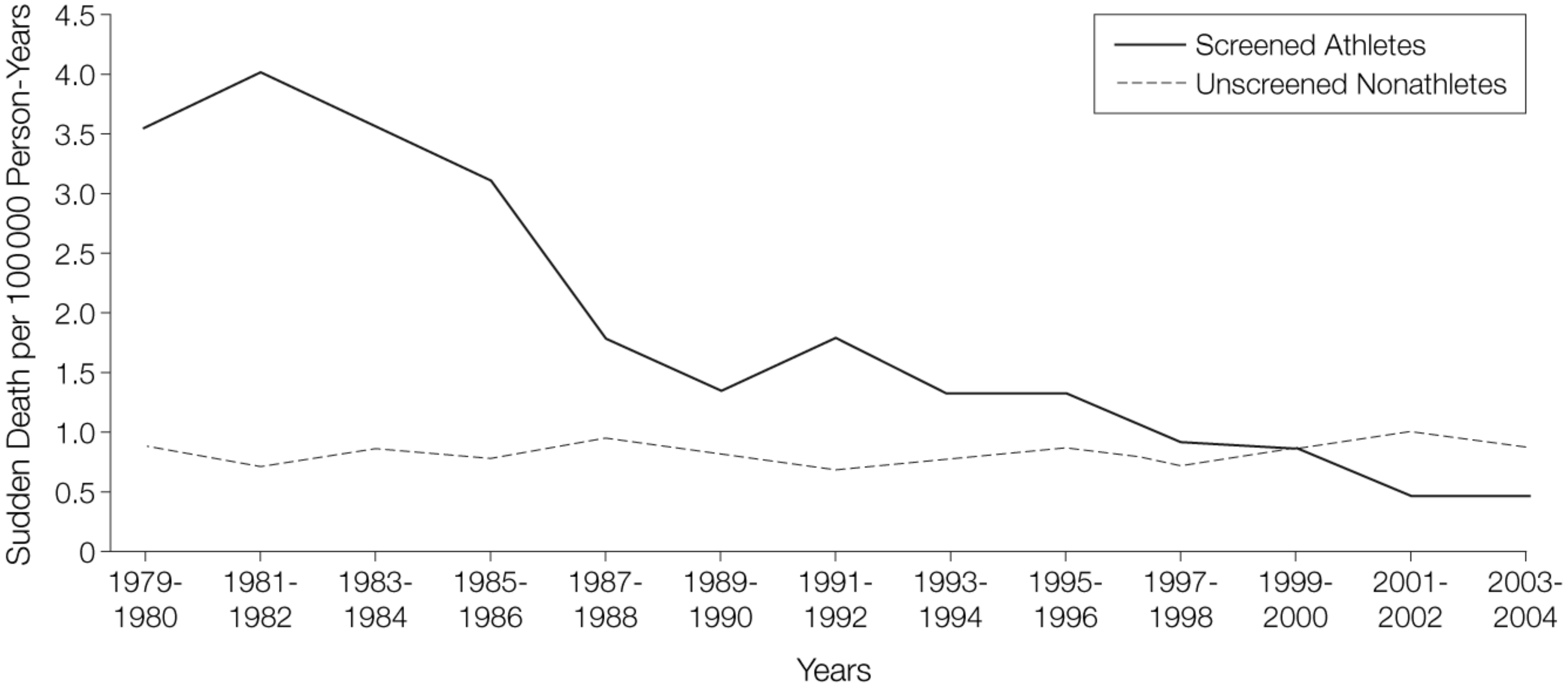
Cite Permissions Metrics

Trends in Sudden Cardiovascular Death in Young Competitive Athletes After Implementation of a Preparticipation Screening Program

JAMA
Published Online: October 4, 2006
2006;296;(13):1593-1601.
doi:10.1001/jama.296.13.1593

Domenico Corrado, MD, PhD; Cristina Basso, MD, PhD; Andrea Pavei, MD ; et al

Author Affiliations | Article Information



COCIS 2023
Protocolli Cardiologici per il Giudizio di Idoneità allo Sport Agonistico

Tabella 21 - Raccomandazioni per la concessione dell'idoneità agonistica nei soggetti con ICD.

	CLASSE	LDE
Nei soggetti sottoposti ad impianto ICD, l'idoneità può essere presa in considerazione qualora le due seguenti condizioni siano rispettate: • dopo almeno 3 mesi dall'impianto o dall'ultimo intervento dell'ICD con stimolazione anti-tachicardica o shock (sia esso appropriato o meno) e previa valutazione del rischio intrinseco e/o di contatto dello sport praticato; • in assenza di una cardiopatia incompatibile di per sé con lo sport o, comunque, di una cardiopatia che tenderebbe a peggiorare nel tempo per il carico emodinamico correlato (sport ad impegno cardiovascolare da medio a elevato, quali la maggioranza di quelli del Gruppo C e D). Il giudizio deve essere individualizzato e coinvolgere Centri Cardiologici ad elevata competenza in materia.	II	C
L'idoneità deve essere negata in presenza di cardiopatia incompatibile di per sé con lo sport o di cardiopatia che tenderebbe a peggiorare per il carico emodinamico correlato (ad esempio, i soggetti con cardiomiopatia aritmogena o cardiomiopatia ipertrofica che abbia richiesto l'ICD stesso in prevenzione primaria o secondaria, etc.) indipendentemente dal rischio aritmico e di intervento, appropriato e non, dell'ICD, e negli sport a rischio intrinseco.	III	B

Attività sportiva e defibrillatore impiantabile: quando è ancora possibile? Un documento della Società Italiana di Cardiologia dello Sport (SIC Sport)

Alessandro Zorzi[1,2], Simone Ungaro[1], Luigi Sciarra[3], Antonio Scarà[3,4], Paolo Compagnucci[5], Zefferino Palamà[6], Giampiero Patrizi[7], Antonio Dello Russo[5,8]

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[2]*Ospedale Riabilitativo di Alta Specializzazione (ORAS), Motta di Livenza (TV)*
[3]*Malattie dell'Apparato Cardiovascolare, Università degli Studi, L'Aquila*
[4]*Ospedale San Carlo di Nancy – Gruppo Villa Maria, Roma*
[5]*Clinica di Cardiologia e Aritmologia, Azienda Ospedaliero-Universitaria delle Marche, Ancona*
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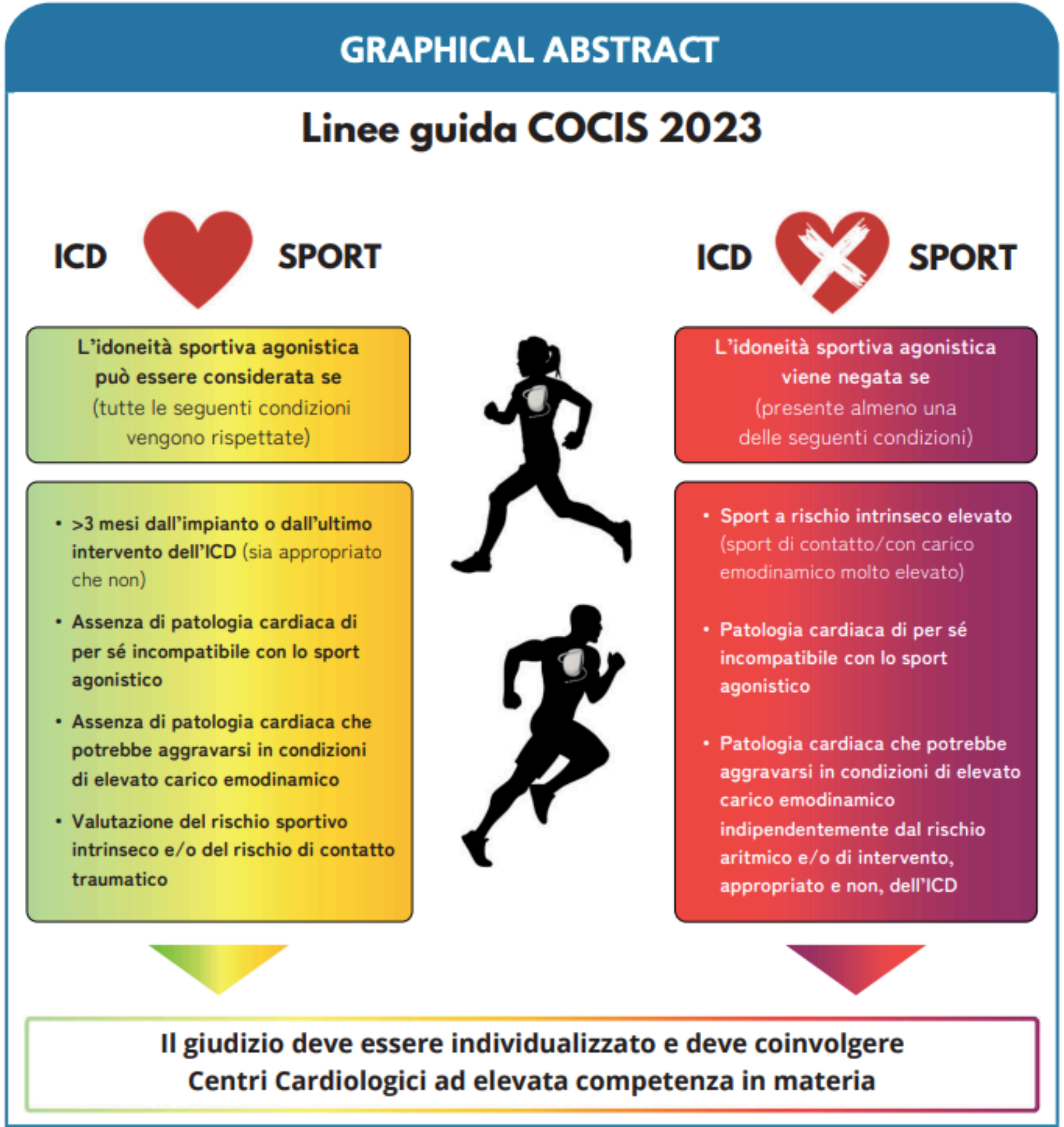
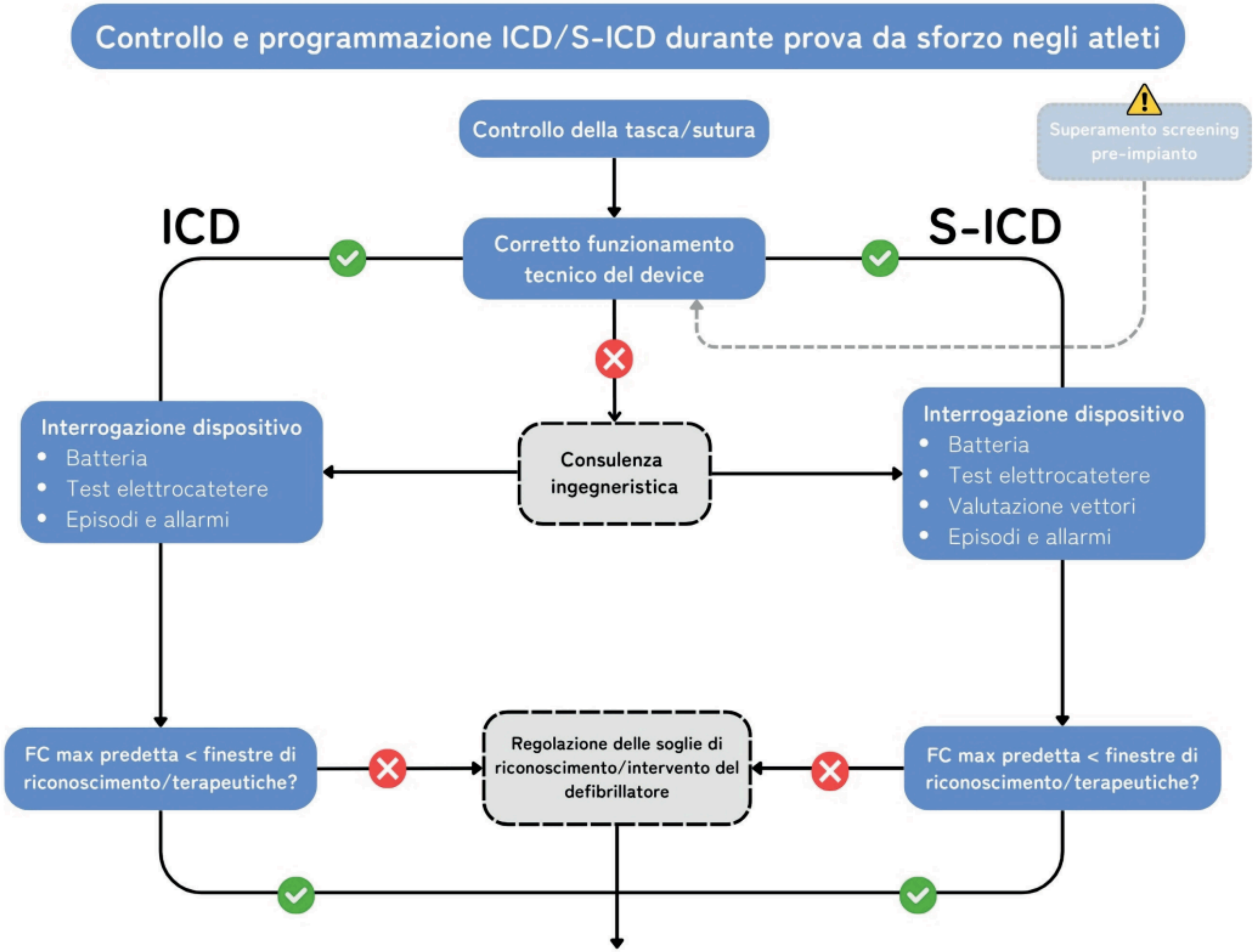
Zorzi et al. Giornale Italiano di Cardiologia, *2026*



Riassunto delle indicazioni delle linee guida italiane (COCIS 2023) sulla concessione, dal punto di vista cardiologico, dell'idoneità agonistica a soggetti portatori di defibrillatore cardiaco impiantabile (ICD).

Zorzi et al. Giornale Italiano di Cardiologia, *2026*



Zorzi et al. Giornale Italiano di Cardiologia, *2026*

Prova da sforzo

Prima della prova

- Registrazione continua e sincronizzazione ECG con EGM (ICD) e S-ECG (s-ICD)
- Eseguire un esercizio di breve durata senza carico per verificare adeguatezza dei segnali
- Garantire la presenza di un DAE
- Tenersi pronti a inibire terapie inappropriate

Durante la prova

- Monitoraggio continuo ECG + EGM/S-ECG
- Posizionare il paziente in posizione concorde a quella assunta durante sport
- Pronta e rapida interruzione se:
  - Tachicardia sostenuta > soglia di detezione
  - Segni clinici (ipotensione, sincope, dolore toracico)
- Osservazione risposta cronotropa e presenza di aritmie

Dopo la prova

- Re-analisi di sensing, soglie, comportamento aritmico
- Verifica comparsa di oversensing onde T/miopotenziali durante la prova (S-ICD)
- Valutazione della risposta funzionale e sicurezza dell'ICD durante lo sforzo
- Accurata documentazione dei risultati

Valutazione clinica finale

- Valutazione competenza cronotropa
- Valutazione idoneità all'attività sportiva agonistica/non-agonistica
- Follow-up programmato (favorire telemedicina)
- Eventuali modifiche di programmazione permanenti
- Limitare i rischi legati ai contatti/collisioni
- Evitare Shock inappropriati frequenza dipendenti

Garantire la sicurezza dell'atleta e di chi lo circonda

Zorzi et al. Giornale Italiano di Cardiologia, *2026*

Conclusions

- Contrary to what is often reported by the media, in Italy there is no absolute ban on competitive sports for individuals with an ICD: according to the 2023 COCIS guidelines, eligibility is determined not by the device itself, but by the underlying heart disease and the type of sport practiced
- the indication for ICD implantation must follow the same criteria used for the general population, without considering the desire to practice sports as a determining factor
- The s-ICD appears particularly suitable in the absence of pacing indications

Thank You!

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SCHEDULE

- ATHLETE'S HEART AND VENTRICULAR ARRHYTHMIAS
- **CASE #1**
- CASE #2

Diagnostic conclusion

- Genetic testing (NGS) is ongoing…