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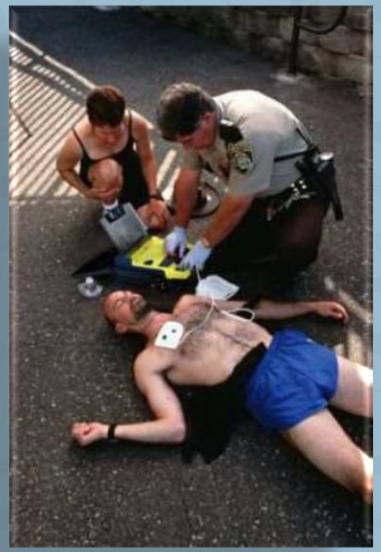


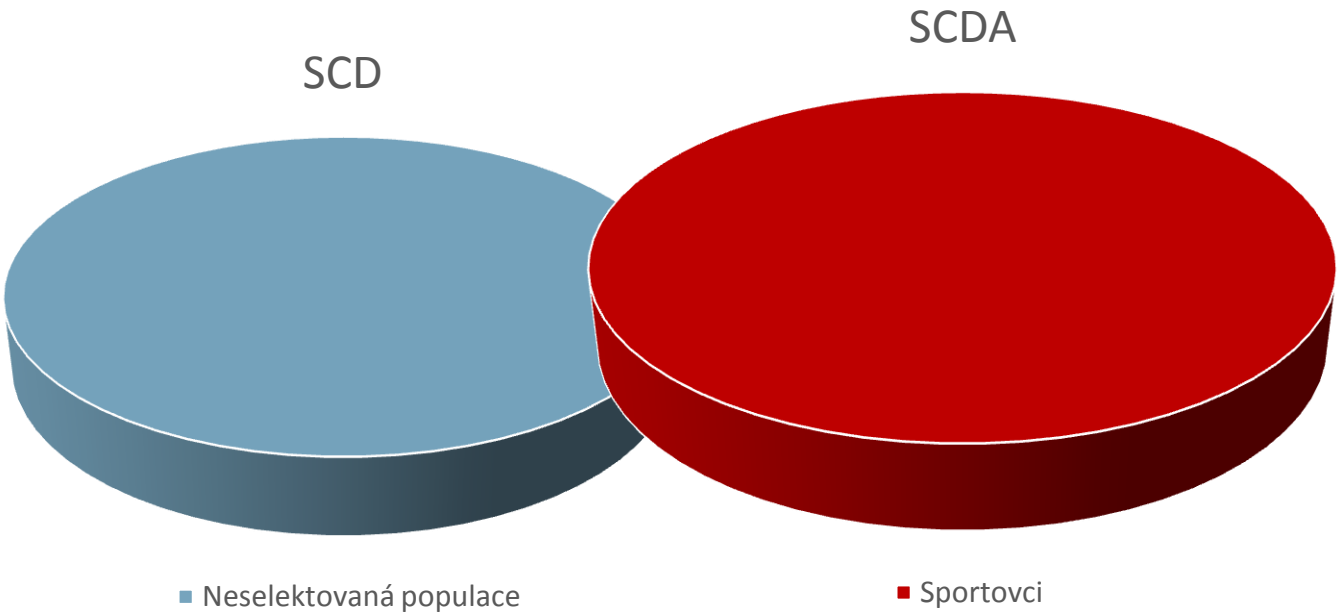
Riziko náhlé smrti u sportovců

Miloš Táborský

České kardiologické dny 2017

Praha, 20.11.2017

Náhlá smrt v běžné populaci x u sportovců

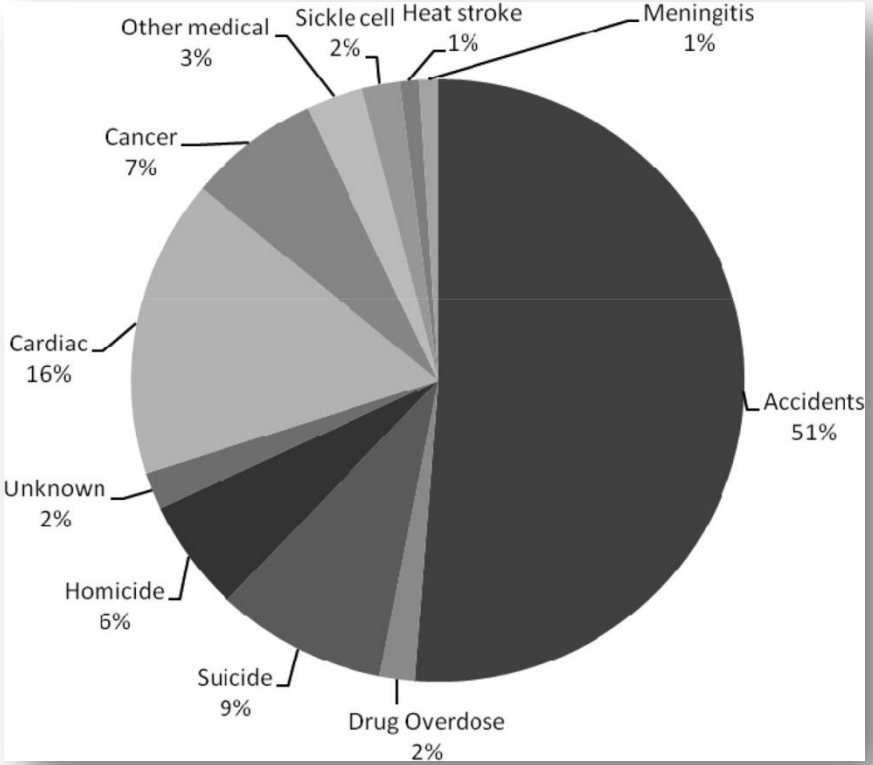


Incidence of SCD in young athletes

- Athletes appear at **excessive risk of SCD compared with similaraged non-athletes.**
- The annual incidence of SCD in young athletes (<35 years) is estimated to range from **0.7 to 3.0 per 100 000** athletes.
- In older athletes the incidence is higher and is expected to increase with age.
- The intensity of the activity and the age of the athlete are core risk factors.

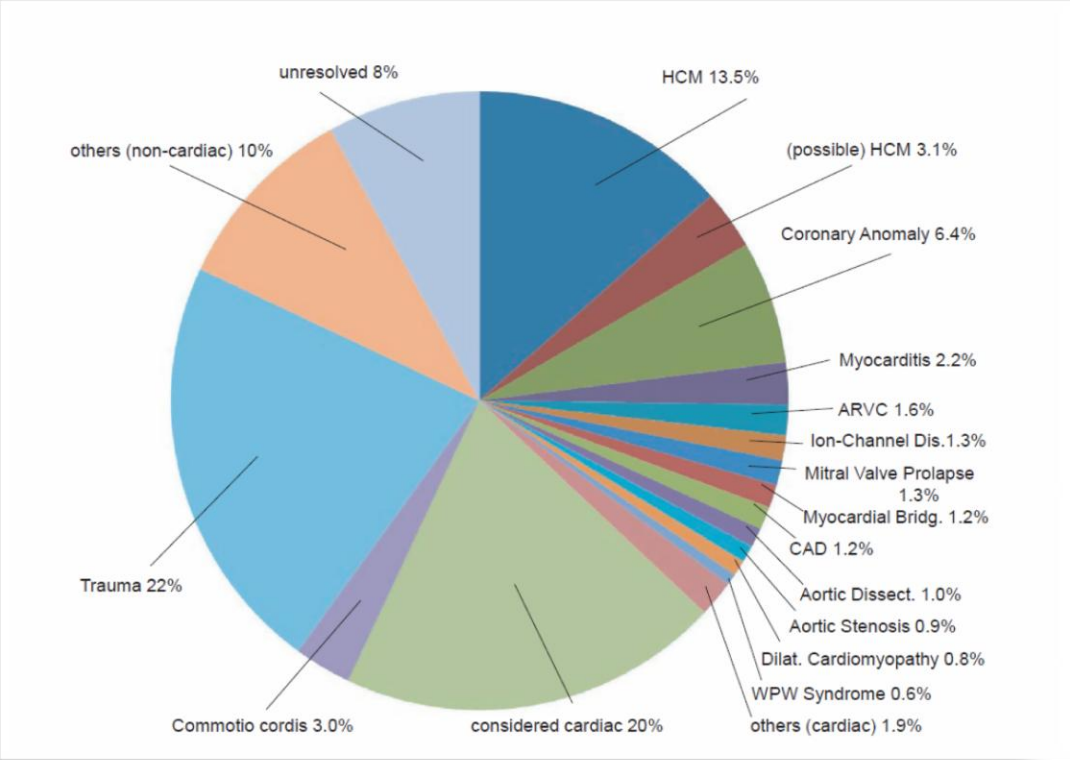
Corrado D, Basso C, Rizzoli G, Schiavon M, Thiene G. Does sports activity enhance the risk of sudden death in adolescents and young adults? J Am Coll Cardiol 2003;42:1959–1963.

Obecné příčiny úmrtí u atletů v USA: 2004 -2008



Harmon KG. Circulation. 2011;123:1594-1600.

Příčiny náhlé srdeční smrti v souboru 1866 atletů



Maron BJ et al. Circulation 2009;119;1085-92.

Data o incidenci NSS u atletů a adolescentů

Study population	Ref.	Study design and reporting system	Incidence (person-years)
US Military (age 18–35)	Eckart *et al.*[21]	Retrospective, mandatory	1:9000
Italian Athletes (age 12–35)	Corrado *et al.*[10]	Prospective, mandatory	1:25,000
US Adolescents (age 12–19)	Atkins *et al.*[20]	Prospective, EMS	1:27,000
US Children (age 10–14)	Chugh *et al.*[22]	Prospective, EMS/ Hospitals	1:58,000
US Athletes (age 12–35)	Maron *et al.*[19]	Retrospective, public media reports	1:160,000

EMS = emergency medical service
Corrado D. European Heart Journal (2011) 32, 934–944
doi:10.1093/eurheartj/ehq482

Epidemiologie NSS u sportovců

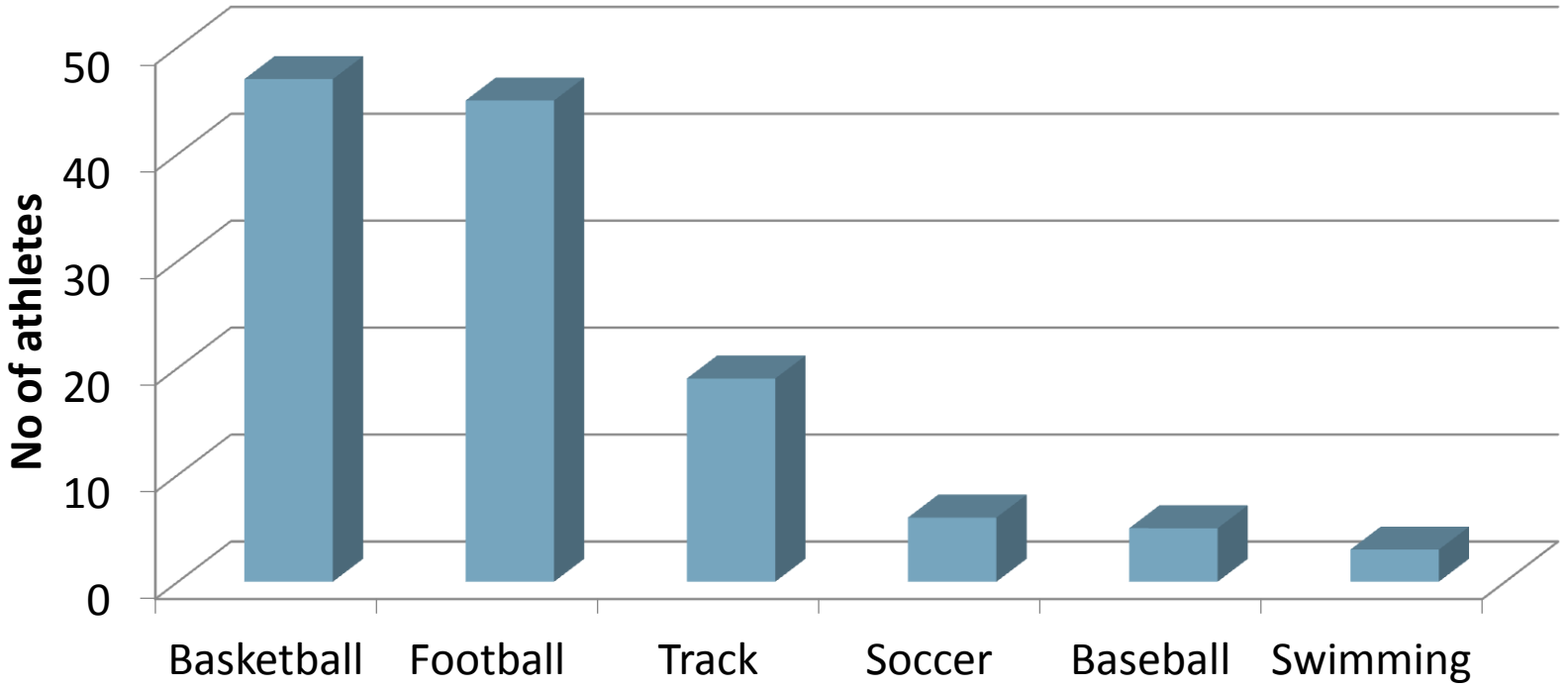
Table 1 Incidence studies in general populations of atheltes

Author	Year	Country	Study design	Case identification	Denominator	Exertional deaths of all?	SCD or SCA+SCD	Years studied	Population	Incidence	Number of years	Age range	Mean age	Number of cardiac deaths
Van Camp[21]	1996	USA	Retrospective cohort	National Center for Catastrophic Injury Research and media database	17 most popular sports, participants in NCAA, NFHS, NAIA, NAJC, added together, conversion factor to account multisport athletes used 'based on discussions with representatives from the national organisations'. 1.9 for high school and 1.2 for college	Exertional	SCD	1983–1993	College athletes and high school	1:300 000	10	17–24	17	100
Maron[26]	1996	USA	Retrospective cohort	US Registry for Sudden Death in Athletes	'Unavoidable selection bias and certainly significantly underestimate'	All	SCD	1985–1995	Athletes	_	10	12–40	17	134
Maron[25]	2003	USA	Retrospective cohort	US Registry for Sudden Death in Athletes	Not possible b/c of selection bias	All	SCD	1985–2000	Athletes	_	25	9–40	17	286
Corrado[22]	2003	Italy	Prospective cohort study	Mandatory death reporting	Registered Italian athletes	All	SCD	1979–1999	Athletes and young people	1:47 600 athlete 1:142 900 young people	20	12 –35	23	55
Maron[8]	2009	USA	Retrospective cohort	US Registry for Sudden Death in Athletes	Estimated 10.7 million athletes <39 participating in sports during 2000–2006 (method not described)	All	SCA+SCD	1980–2006	Athletes	1:163 934	27	8–39	18	690
Holst[6]	2010	Denmark	Retrospective cohort	Review of death certificates—then autopsies if available —15 sports related SCD (SrSCD)	Denmark population statistics	All and sports related	SCD	2000–2006	Athletes and young people	1:82 645 SrSCD 1:26 595 general pop	7	12 –35	26	15 SrSCD 470 SCD
Steinvil[23]	2011	Israel	Retrospective cohort	Retrospective review of two Israeli newspapers by two media researchers	45 000 registered competitive athletes in 2009, extrapolated the growth of the Israeli population age10–40 since 1985 based on that figure and allowed for a presumed doubling of the sporting population	All	SCD	1985— 19 971 998 —2009	Athletes	1st— 1:393 702nd— 1:37 593	24	12–44	24	24

SCA, sudden cardiac arrest; SCD, sudden cardiac death.

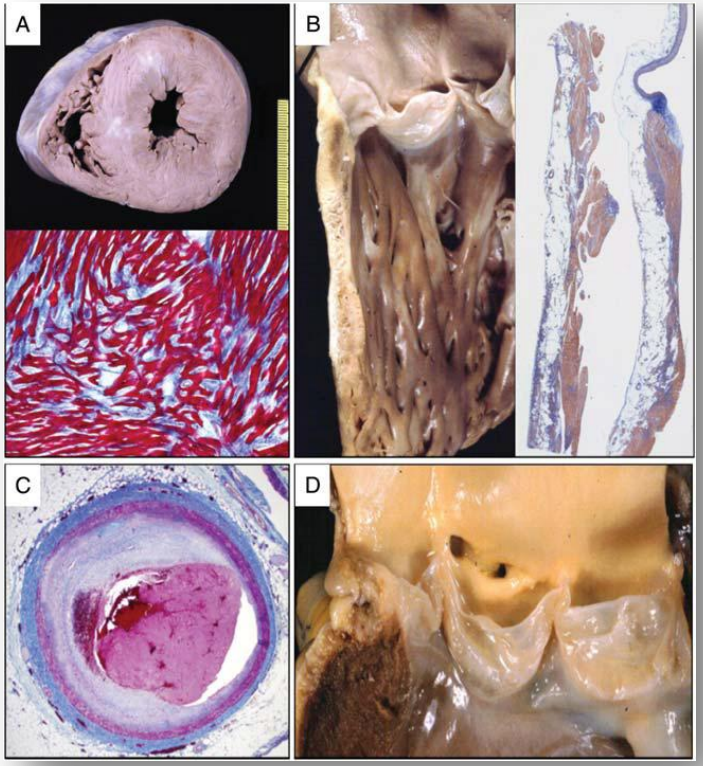
Harmon KG, et al. Br J Sports Med 2014;48:1185–1192. doi:10.1136/bjsports-2014-093872

Rizika NSS u různých sportovních odvětví



Maron BJ et al, JAMA 1996 ; 276 : 199 – 203.

Hlavní příčiny úmrtí u mladých kompetetivních atletů

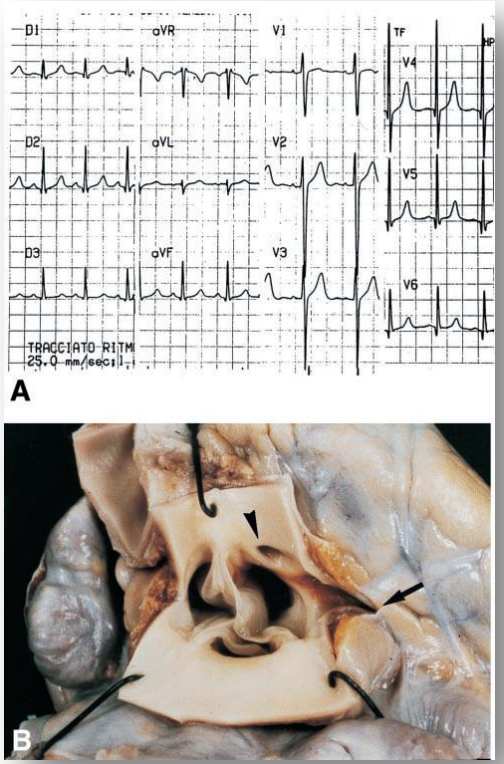


1. HCM 36 %
2. ARVC 4 %
3. Ateroskleróza 20 %
4. Vrozené anomálie koronárních tepen 17 %
5. Myokarditis 6 %
6. Geneticky podmín. arytmie 17 %

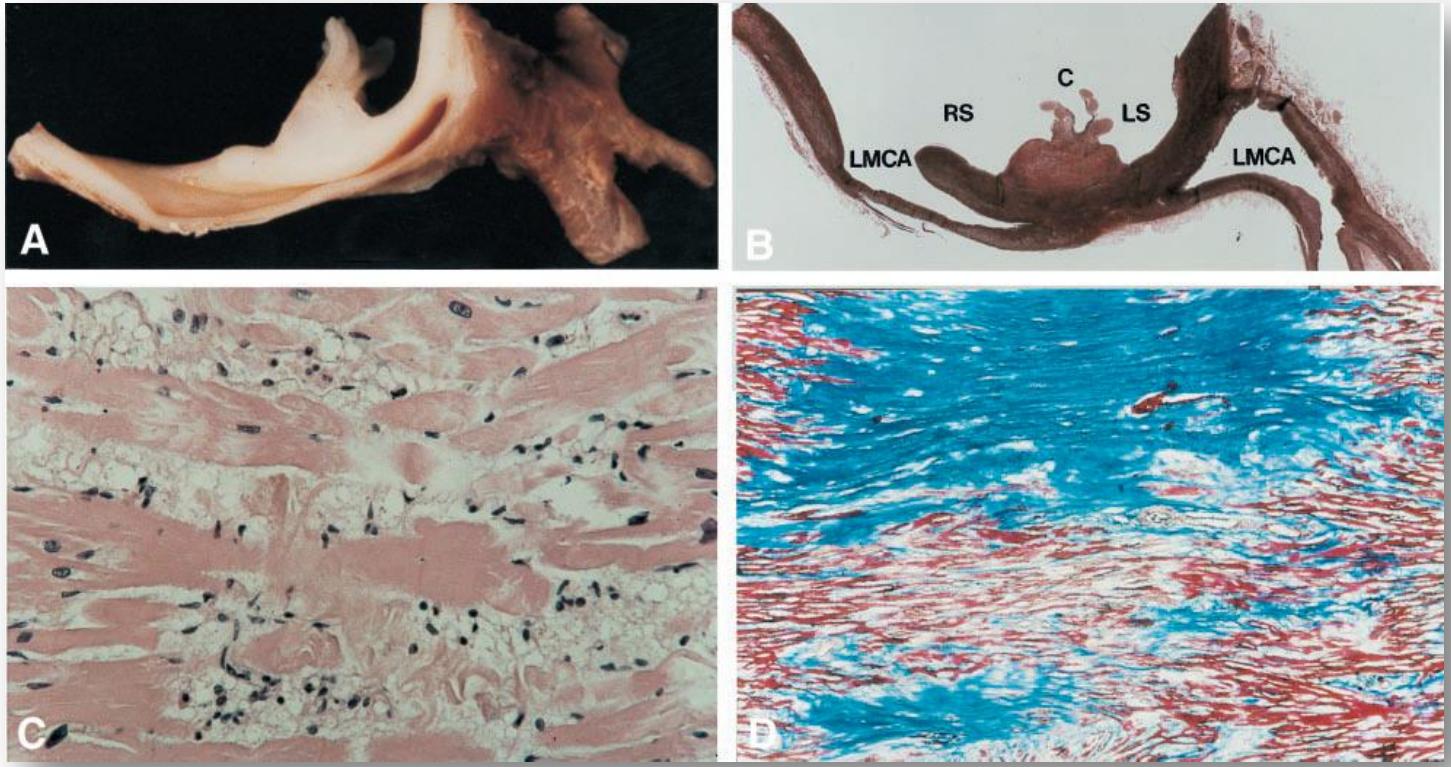
US National Registry of Sudden Death in Athletes.
Harmon KG, Drezner JA, Wilson MG, Sharma S. Incidence of sudden cardiac death in athletes: a state-of-the-art review. Heart 2014;100:1227–1234.

Anomálie koronárních tepen

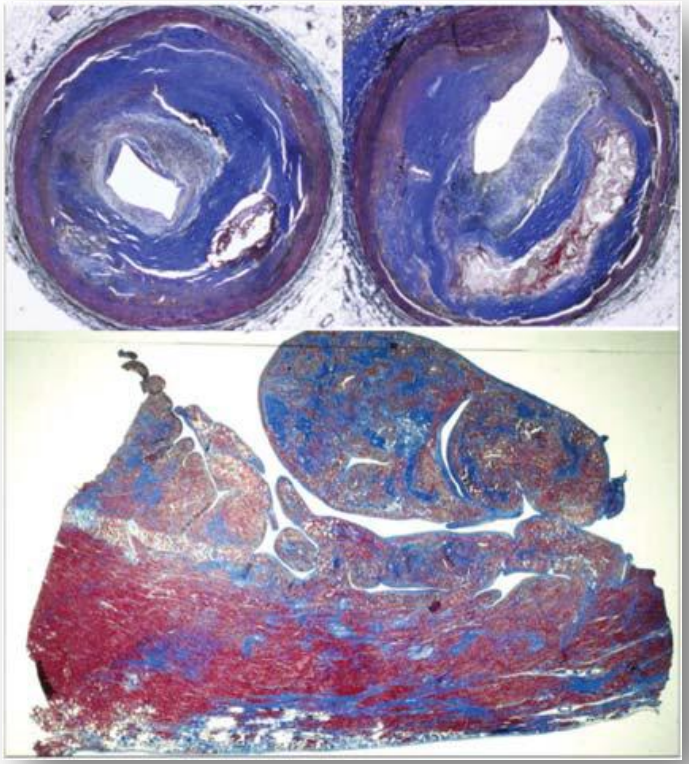
- 15 letý hráč fotbalu, 1 rok před NSS synkopa, nevyšetřen
- EKG 1 M před úmrtím v rámci preparticipačního srreeningu



Abnormální LMCA jako příčina NSS



NSS u 38 letého zcela asymptomatického atleta



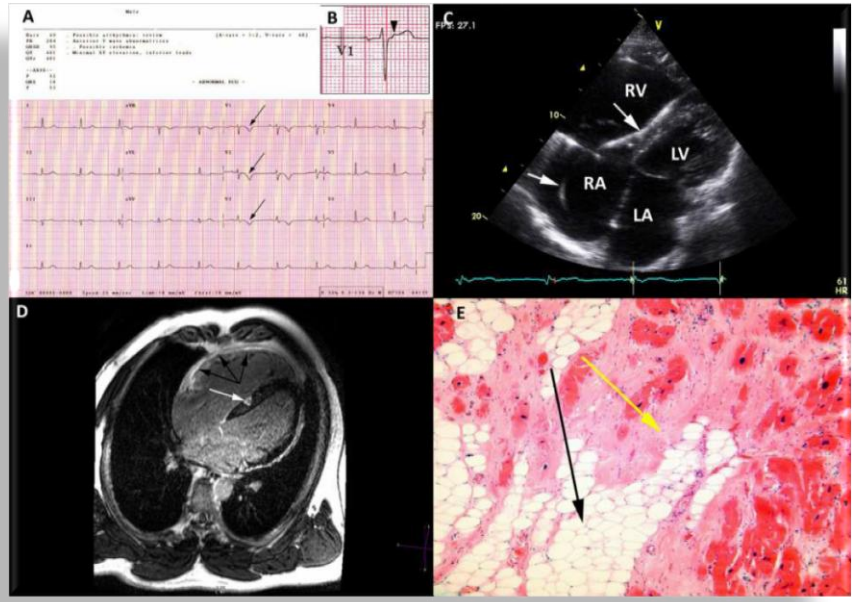
Prevalence ICHS u atletů s NSS

Ref.	Population	Prevalence (%)
Fuller *et al.*[26]	5617 high school athletes (USA)	0.4
Corrado *et al.*[12]	42,386 athletes age 12–35 (Italy)	0.2
Wilson *et al.*[27]	2720 athletes and children age 10–17 (UK)	0.3
Bessem *et al.*[28]	428 athletes age 12–35 (Netherlands)	0.7
Baggish *et al.*[31]	510 collegiate athletes (USA)	0.6

Corrado D. European Heart Journal (2011) 32, 934–944
doi:10.1093/eurheartj/ehq482

Trigry NSS u sportovců:

1. Dehydratace
2. Iontová dysbalance
3. Adrenergní zátěž
4. Změny acidobazické rovnováhy
5. Zvýšení natriuretických peptidů a troponinu u maratonských běžců
6. Subklinická zánětlivá odpověď ve fázi zotavení - zvýšené koncentrace C-reaktivního proteinu a IL 1



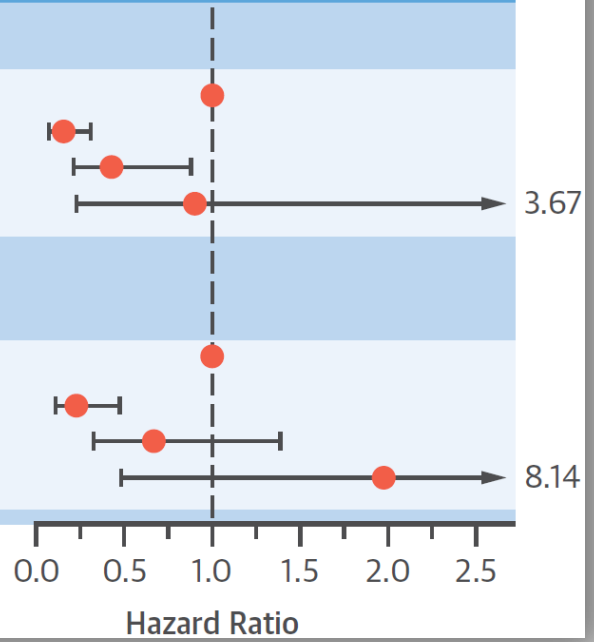
Sportovní srdce a fibrilace síní

- U atletů dochází ke zvětšení objemu síní.
- Mírná dilatace levé síně je zpravidla benigní, avšak dilatace většího stupně může predisponovat ke vzniku fibrilace síní.
- Mírná zátěž u jedinců středního a vyššího věku riziko fibrilace snižuje.
- **Vysoká zátěž a dlouhodobý sklon k bradykardii mohou být ve srovnání s obecnou populací spojeny v průměru až s 3-10 x vyšším rizikem.**

Mozaffarian D. Circulation 2008;118:800–807.
Grundvold I. Circ Arrhythm Electrophysiol 2013;6:726–731.

Dávka sportovního zatížení jedince: Více nemusí být nutně lépe …

DOSE OF JOGGING	NO. OF PARTICIPANTS	ALL-CAUSE MORTALITY DEATHS
Adjusted for age and sex		
Sedentary nonjogger (reference)	413	128
Light jogger	576	7
Moderate jogger	262	8
Strenuous jogger	40	2
Adjusted for age, sex, smoking, alcohol intake, education, and diabetes		
Sedentary nonjogger (reference)	394	120
Light jogger	570	7
Moderate jogger	252	8
Strenuous jogger	36	2



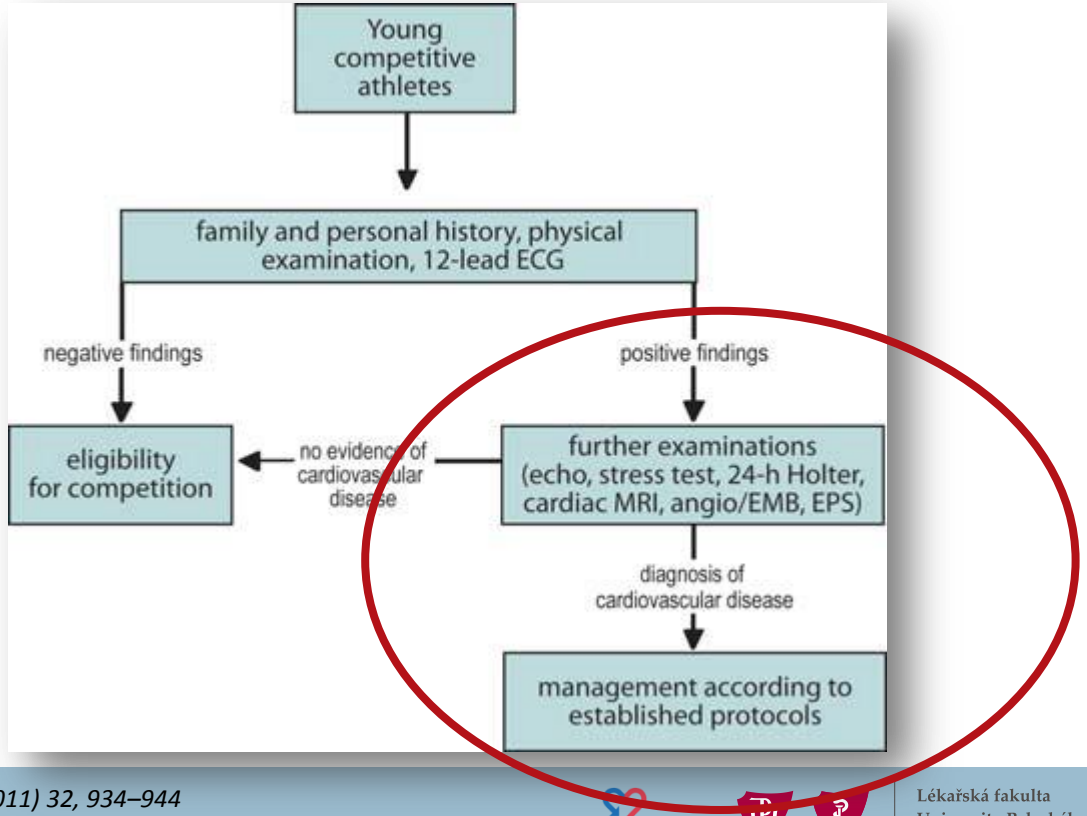
The Copenhagen City Heart Study
Schnohr, P. et al. J Am Coll Cardiol. 2015; 65(5):411-9.

Cardiac screening should be adapted to the age of the athlete to account for age-specific risk factors

In young athletes (≤35 years of age), screening should focus on inheritable cardiomyopathies , channelopathies and anatomical abnormalities

In older athletes, CAD is the most common cause of SCD and screening should also be targeted to detect signs of ischaemia.

Jak skutečně efektivní je preparticipační screening ?



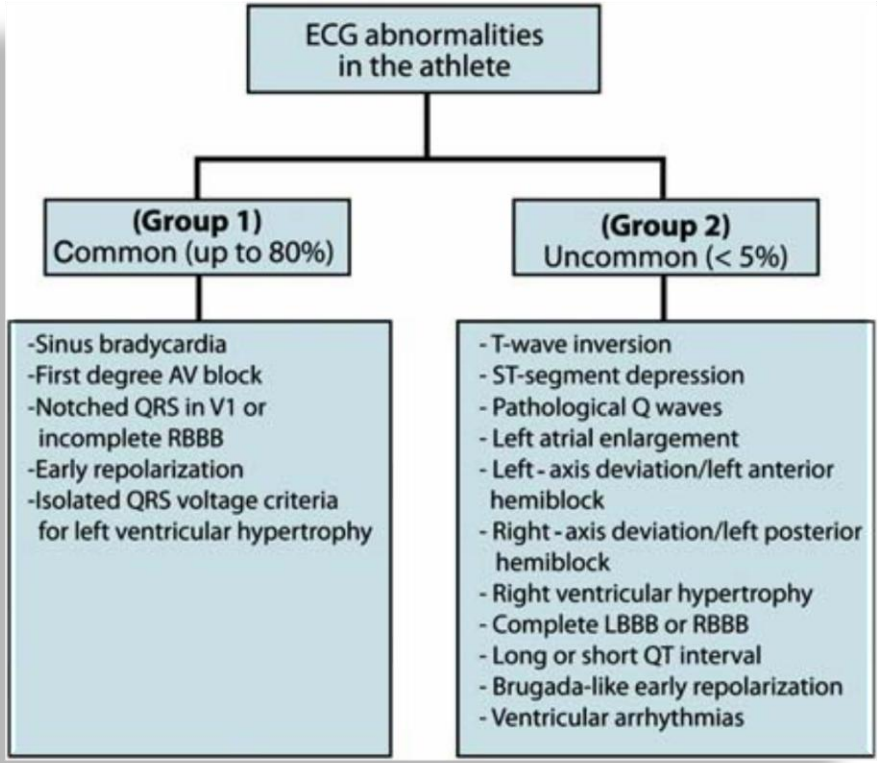
Corrado D. European Heart Journal (2011) 32, 934–944
doi:10.1093/eurheartj/ehq482

EKG změny KV onemocnění jako příčiny NSS detekovatelné v rámci preparticipačního screeningu

Disease	QTc interval	P-wave	PR interval	QRS complex	ST interval	T-wave	Arrhythmias
Hypertrophic cardiomyopathy	Normal	(left atrial enlargement)	Normal	Increased voltages in mid-left precordial leads; abnormal 'q' waves in inferior and/or lateral leads; (LAD, LBBB); (delta wave)	Down-sloping (up-sloping)	Inverted in mid-left-precordial leads; (giant and negative in the 'apical' variant)	(atrial fibrillation); (PVB); (VT)
Arrhythmogenic right ventricular cardiomyopathy/ dysplasia	Normal	Normal	Normal	Prolonged >110 ms in right precordial leads; epsilon wave in right precordial leads; reduced voltages ≤0.5 mV in frontal leads; (RBBB)	(up-sloping in right precordial leads)	Inverted in right precordial leads	PVB with a LBBB pattern; (VT with a LBBB pattern)
Dilated cardiomyopathy	Normal	(left atrial enlargement)	(prolonged ≥0.21 s)	LBBB	Down-sloping (up-sloping)	Inverted in inferior and/or lateral leads	PVB; (VT)
Myocarditis	(prolonged)	Normal	Prolonged ≥0.21 s	(abnormal 'q' waves)	Down- or up-sloping	Inverted in ≥2 leads	(atrial arrhythmias); (PVB); (2nd or 3rd degree AV block); (VT)
Long QT syndrome	Prolonged >440 ms in males; >460 ms in females	Normal	Normal	Normal	Normal	Bifid or biphasic in all leads	(PVB); (torsade de pointes)
Brugada syndrome	Normal		Prolonged ≥0.21 s	S1S2S3 pattern; (RBBB/LAD)	Up-sloping 'coved-type' in right precordial leads	Inverted in right precordial leads	(polymorphic VT); (atrial fibrillation) (sinus bradycardia)
Lenègre disease	Normal	Normal	Prolonged ≥0.21 s	RBBB; RBBB/LAD; LBBB	Normal	Secondary changes	(2nd or 3rd degree AV block)
Short QT syndrome	Shortened <300 ms	Normal	Normal	Normal	Normal	Normal	Atrial fibrillation (polymorphic VT)
Preexcitation syndrome (WPW)	Normal	Normal	Shortened <0.12 s	Delta wave	Secondary changes	Secondary changes	Supraventricular tachycardia; (atrial fibrillation)
Coronary artery diseases	(prolonged)	Normal	Normal	(abnormal 'q' waves)	(down- or up-sloping)	Inverted in ≥2 leads	PVB; (VT)

Less common or uncommon ECG findings are reported in brackets; coronary artery diseases, either premature coronary atherosclerosis or congenital coronary anomalies; QTc, QT interval corrected for heart rate by Bazett's formula; LBBB, left bundle branch block; RBBB, right bundle branch block; LAD,. left-axis deviation of 2308 or more; PVB, either single or coupled premature ventricular beats; VT , either non-sustained or sustained ventricular tachycardia. Adapted from Corrado et al.
Corrado D. European Heart Journal (2011) 32, 934–944 doi:10.1093/eurheartj/ehq482

Klasifikace EKG abnormalit u atletů



Delise P. Recommendations for interpretation of 12-lead electrocardiogram in the athlete. Eur Heart J 2010;31:243–259.

Nutnost standardizované interpretace EKG u atletů: Seattle Criteria

Box 1 Normal ECG findings in athletes

1. Sinus bradycardia (≥ 30 bpm)
2. Sinus arrhythmia
3. Ectopic atrial rhythm
4. Junctional escape rhythm
5. 1° AV block (PR interval > 200 ms)
6. Mobitz Type I (Wenckebach) 2° AV block
7. Incomplete RBBB
8. Isolated QRS voltage criteria for LVH
   - *Except*: QRS voltage criteria for LVH occurring with any non-voltage criteria for LVH such as left atrial enlargement, left axis deviation, ST segment depression, T-wave inversion or pathological Q waves
9. Early repolarisation (ST elevation, J-point elevation, J-waves or terminal QRS slurring)
10. Convex ('domed') ST segment elevation combined with T-wave inversion in leads V1–V4 in black/African athletes

These common training-related ECG alterations are physiological adaptations to regular exercise, considered normal variants in athletes and do not require further evaluation in asymptomatic athletes.

AV, atrioventricular; bpm, beats per minute; LVH, left ventricular hypertrophy; ms, milliseconds; RBBB, right bundle branch block.

Table 1 Abnormal ECG findings in athletes

Abnormal ECG finding	Definition
T-wave inversion	>1 mm in depth in two or more leads V2–V6, II and aVF, or I and aVL (excludes III, aVR and V1)
ST segment depression	≥0.5 mm in depth in two or more leads
Pathologic Q waves	>3 mm in depth or >40 ms in duration in two or more leads (except for III and aVR)
Complete left bundle branch block	QRS ≥120 ms, predominantly negative QRS complex in lead V1 (QS or rS), and upright monophasic R wave in leads I and V6
Intraventricular conduction delay	Any QRS duration ≥140 ms
Left axis deviation	−30° to −90°
Left atrial enlargement	Prolonged P wave duration of >120 ms in leads I or II with negative portion of the P wave ≥1 mm in depth and ≥40 ms in duration in lead V1
Right ventricular hypertrophy pattern	R–V1+S–V5>10.5 mm *AND* right axis deviation >120°
Ventricular pre-excitation	PR interval <120 ms with a delta wave (slurred upstroke in the QRS complex) and wide QRS (>120 ms)
Long QT interval*	QTc≥470 ms (male) QTc≥480 ms (female) QTc≥500 ms (marked QT prolongation)
Short QT interval*	QTc≤320 ms
Brugada-like ECG pattern	High take-off and downsloping ST segment elevation followed by a negative T wave in ≥2 leads in V1–V3
Profound sinus bradycardia	<30 BPM or sinus pauses ≥ 3 s
Atrial tachyarrhythmias	Supraventricular tachycardia, atrial-fibrillation, atrial-flutter
Premature ventricular contractions	≥2 PVCs per 10 s tracing
Ventricular arrhythmias	Couplets, triplets and non-sustained ventricular tachycardia

Note: These ECG findings are unrelated to regular training or expected physiological adaptation to exercise, may suggest the presence of pathological cardiovascular disease, and require further diagnostic evaluation.
*The QT interval corrected for heart rate is ideally measured with heart rates of 60–90 bpm. Consider repeating the ECG after mild aerobic activity for borderline or abnormal QTc values with a heart rate <50 bpm.

Drezner JA, Ackerman MJ, Anderson J, et al. Electrocardiographic interpretation in athletes: the 'Seattle criteria'. Br J Sports Med 2013;47:122–124.

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Co říkají guidelines ESC k prevenci NSS u sportovců ?

Doporučení ESC pro prevenci NSS u sportovců

Recommendations	Class	Level
Careful history taking to uncover underlying cardiovascular disease, rhythm disorder, syncopal episodes or family history of SCD is recommended in athletes.	I	C
Upon identification of ECG abnormalities suggestive of structural heart disease, echocardiography and/or CMR imaging is recommended.	I	C
Physical examination and resting 12-lead ECG should be considered for pre-participation screening in younger athletes.	IIa	C
Middle-aged individuals engaging in high-intensity exercise should be screened with history, physical examination, SCORE and resting ECG.	IIa	C
Staff at sporting facilities should be trained in cardiopulmonary resuscitation and on the appropriate use of automatic external defibrillators.	IIa	C

CMR = cardiac magnetic resonance; ECG = electrocardiogram; SCD = sudden cardiac death; SCORE = Systematic Coronary Risk Evaluation.

Indications for autopsy and molecular autopsy in sudden death victims

Recommendations	Class	Level
An autopsy is recommended to investigate the causes of sudden death and to define whether SCD is secondary to arrhythmic or non-arrhythmic mechanisms (e.g. rupture of an aortic aneurysm).	I	C
Whenever an autopsy is performed, a standard histological examination of the heart is recommended and it should include mapped labelled blocks of myocardium from representative transverse slices of both ventricles.	I	C
The analysis of blood and other adequately collected body fluids for toxicology and molecular pathology is recommended in all victims of unexplained sudden death.	I	C

Priori SG. European Heart Journal (2015) 36, 2793–2867.
doi:10.1093/eurheartj/ehv316

AHA/ACC Scientific Statement

Eligibility and Disqualification Recommendations for Competitive Athletes With Cardiovascular Abnormalities: Preamble, Principles, and General Considerations

A Scientific Statement From the American Heart Association and American College of Cardiology

Barry J. Maron, MD, FACC, Co-Chair; Douglas P. Zipes, MD, FAHA, MACC, Co-Chair; Richard J. Kovacs, MD, FAHA, FACC, Co-Chair; on behalf of the American Heart Association Electrocardiography and Arrhythmias Committee of the Council on Clinical Cardiology, Council on Cardiovascular Disease in the Young, Council on Cardiovascular and Stroke Nursing, Council on Functional Genomics and Translational Biology, and the American College of Cardiology

This document addresses medical issues related to trained athletes with cardiovascular abnormalities. The objective is to present, in a readily useable format, consensus recommendations and guidelines principally addressing criteria for eligibility and disqualification from organized competitive sports for the purpose of ensuring the health and safety of young athletes. Recognizing certain medical risks imposed on athletes with cardiovascular disease, it is our aspiration that the recommendations that constitute this document will serve as a useful guide to the practicing community for clinical decision making. The ultimate goal is prevention of sudden death in the young, although it is also important not to unfairly or unnecessarily remove people from a healthy athletic lifestyle or competitive sports (that may be physiologically and psychologically intertwined with good quality of life and medical well-being) because of fear of litigation. It is our goal that the recommendations in this document, together with sound clinical judgment, will lead to a healthier, safer playing field for young competitive athletes.

Historical Context

There have been 3 prior documents, all sponsored by the American College of Cardiology (ACC),[1–3] that addressed eligibility and disqualification criteria for competitive athletes with cardiovascular diseases: Bethesda Conferences 16 (1985), 26 (1994), and 36 (2005), published and used over a 30-year period. Each of the 3 initiatives (and the present American Heart Association (AHA)/ACC scientific statement) were driven by the tenet that young trained athletes with underlying cardiovascular abnormalities are likely at some increase in risk for sudden cardiac death (usually on the athletic field) compared to nonathletes or competitive athletes without cardiovascular disease.[4–8]

All 3 Bethesda Conferences and the present derived AHA/ACC document provide expert consensus recommendations. These insights use (1) the experience and expertise of the panelists (ie, individual and collective judgments, using the "art of medicine") and (2) available scientific evidence that estimates the medical risk in athletes with underlying acquired, genetic,

Maron BJ. Circulation. 2015;132:e256-e261. DOI: 10.1161/CIR.0000000000000236

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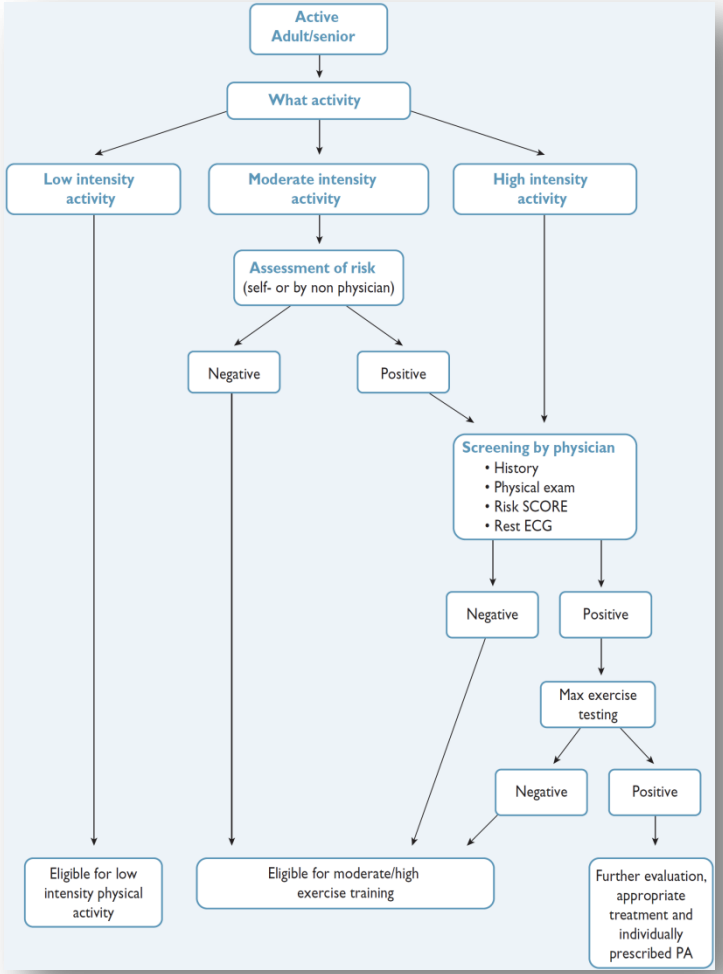
Recommendations for cardiovascular evaluation of middle-aged/senior active individuals engaged in leisure time sport activities



ECG = electrocardiogram; PA = physical activity; SCORE = systematic coronary risk evaluation

Borjesson M. Eur J Cardiovasc Prev Rehabil 2011;18:446–458.

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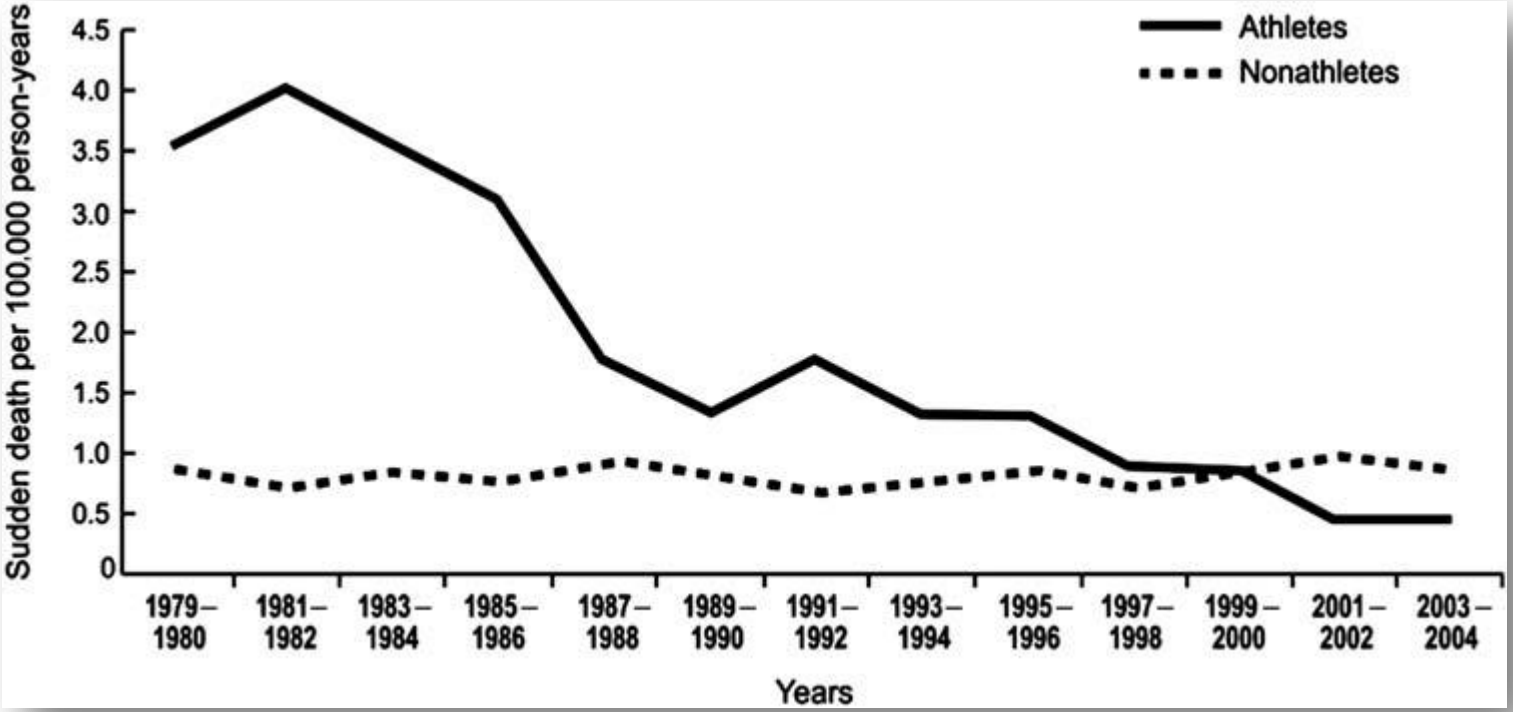
Efektivita správně provedených screeningových programů

Je italský model preparticipačního screeningu v regionu Veneto skutečně reprodukovatelný ?



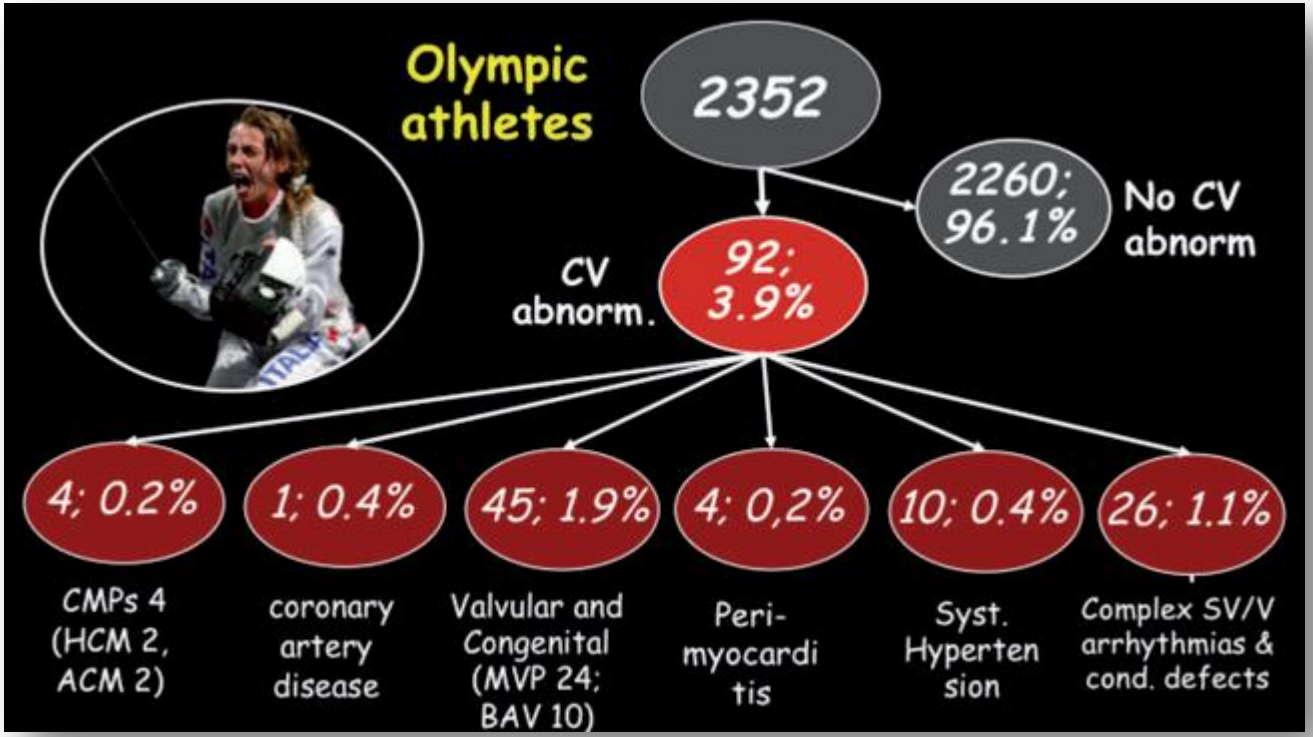
Corrado D, Basso C, Pavei A, Michieli P, Schiavon M, Thiene G. Trends in sudden cardiovascular death in young competitive athletes after implementation of a preparticipation screening program. JAMA 2006;296:1593–1601.

Ekonomická efektivita preventivních strategií

- 785 athletes ages 35–56 years engaged in high-intensity sport
- A new cardiovascular abnormality was established in **2.8%** of athletes and the **cost was $199 per athlete.**
- The authors concluded that the overall evaluation seems to be feasible with a reasonable cost

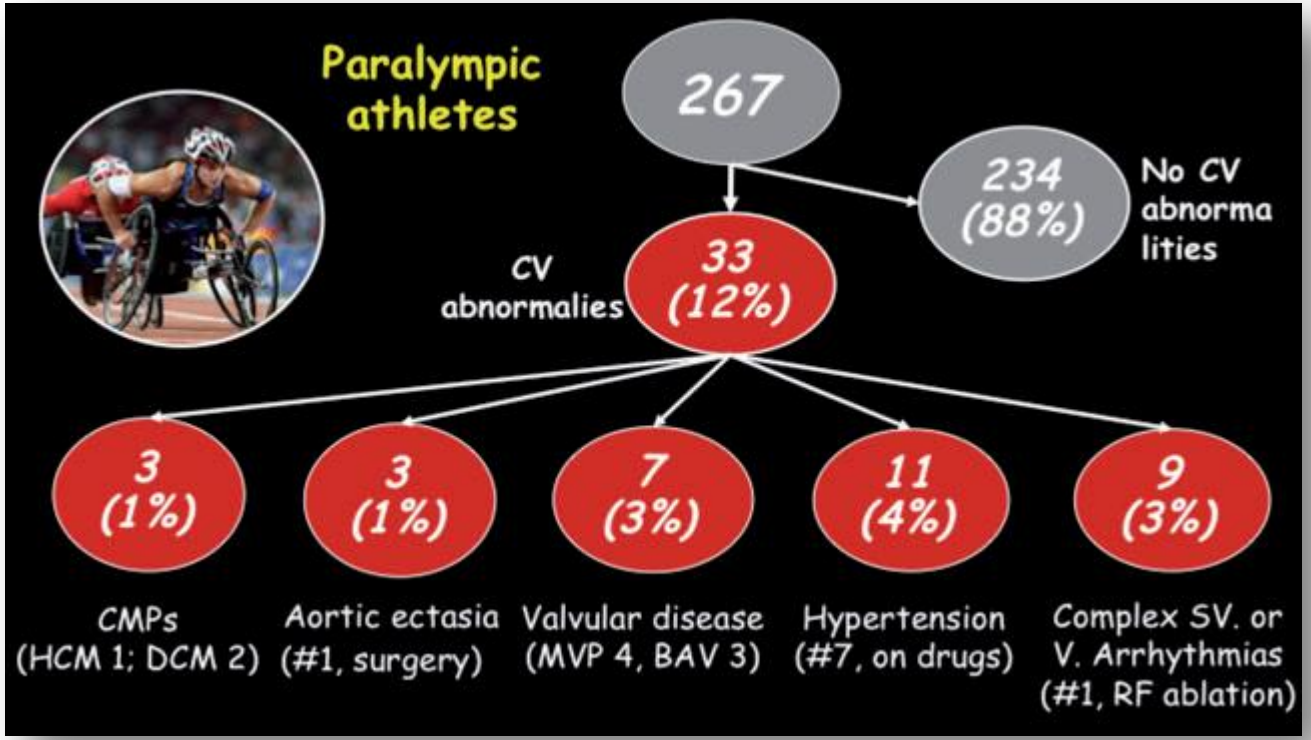
Menafoglio A. Cardiovascular evaluation of middle-aged individuals engaged in high-intensity sport activities: implications for workload, yield and economic costs. Br J Sports Med 2014 Nov 13. doi:10.1136/bjsports-2014-093857

Výsledky screeningu olympijských atletů v Itálii: 2009



Peliccia A. EHJ 2017. doi:10.1093/eurheartj/ehx349

Výsledky screeningu paralympijských atletů v Itálii: 2009



Peliccia A. EHJ 2017. doi:10.1093/eurheartj/ehx349

Take home message:

- Sudden cardiac death in young athletes is rare.
- Exercise is a trigger for SCD in predisposed athletes.
- Early diagnosis of cardiac pathology is challenging in some athletes.
- Pre-participation screening with ECG identifies athletes with CMP and OD
- Early CPR and AEDs save lives in sport.

Co je důležité pro běžnou praxi sportovních klubů pro prevenci náhlé smrti ?

1. Výuka trenérů, zaměstnanců a hráčů v KP resuscitaci

2. Umět pracovat s AED a aktivovat RZP

3. Screeningové programy, které budou správně interpretovat sportovní EKG a nebudou zbytečně traumatizovat sportovce/rodiče dětí

4. Nepodléhat komerčním programům s plošným echo screeningem a dalšími neindikovanými vyšetřeními

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