SPORTSCARDIOLOGYBC

Sports Cardiology BC:

Mission, Goals and Future Direction

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Phidippides (530 BC - 490 BC)

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Athenian herald: Professional-running courier

Ran 40km from Marathon to Athens to announce

Greek victory over Persia

'Nikomen' – We have won

Collapses and dies

Luc-Olivier Merson, 1869

Case

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- 44 y.o. male Caucasian marathon runner
- Cardiac RFs: nil
- PMH: nil
- Meds: nil
- Non-drinker, non-smoker, vegetarian; machinist
- No family history of cardiac disease
- Completed multiple marathons, including the Boston Marathon
- Runs a minimum of 50 miles per week for 5 years

Case: HPI

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- Running a marathon
- At mile 24 of 26, he suddenly collapses
- Found to be pulseless and apneic by a physician spectator; CPR initiated

- On arrival to hospital
  - Intubated, in ventricular fibrillation → cardioverted
  - 110/80, P = 100 irregular, T = 38.6
  - JVP not elevated, lungs clear, S4 noted
  - Cardiac markers, transaminases elevated
  - CXR: Normal
  - Swan-Ganz catheter inserted; PCWP = 6

Case (cont'd)

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- Stay complicated by significant ventricular ectopy requiring lidocaine and procainamide
- Suffered significant anoxic brain injury
- Died on Day 50 from *Pseudomonas* pneumonia
- Autopsy
  - Transmural myocardial infarction involving the anterior, septal, and lateral left ventricle
  - Left coronary artery system was large in diameter and was "widely patent" throughout its entirety
  - Right coronary artery had mild atherosclerosis

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'The unexpected demise of an athlete is always a tragic event, which has a tremendous impact on the media, because it strikes down apparently healthy individuals… everyone wonders what intervention might have prevented sudden death.'

Dr. Domenico Corrado, Cardiologist
University of Padua, Italy

Corrado, ESC, Paris 2011

Public Health Considerations

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- With the understood benefits of exercise, there has been a visible increase in participation in organized athletics and endurance sports and exercise in the aging population

- Paradoxically, exercise can acutely increase the risk of myocardial infarction, aortic dissection arrhythmias and sudden cardiac arrest and/or sudden cardiac death

Reasons CV Specialists See Athletes

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- Help create and implement cardiac policy.
- Perform and interpret CV screening tests.
- Make immediate participation and return-to-play decisions.
- Determine whether there is a CV cause of symptoms.

Lawless, JACC 2014 April 22; 63(15): 1461-72

Reasons CV Specialists See Athletes (cont.)

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- Evaluate finding(s) suggestive of underlying CV pathology during non-CV medical encounters or dedicated pre-participation CV screening
- Provide work-up and treatment after nonfatal sudden cardiac arrest
- Participation recommendation and exercise prescription with known or corrected CV disease
- Assist in transition from cardiac rehabilitation to higher level of exercise

Lawless, JACC 2014 April 22; 63(15): 1461-72

Important Questions

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- Does exercise increase the risk of SCD and what etiologies account for SCD in athletes?
- Can we prevent sudden cardiac death in athletes?
- What restrictions should be placed upon individuals with cardiovascular disease?
- What are appropriate exercise thresholds?

SCD and exercise: Mechanisms

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- Majority of deaths: Ventricular tachycardia (VT) or ventricular fibrillation (VF)
- Two mechanisms:
  - Prolonged physical training induces changes in cardiac structure (eg., chamber dilation and physiologic hypertrophy) that may create arrhythmic substrate
  - Immediate physiologic demands of intense athletics may trigger malignant arrhythmias and SCD in susceptible individuals with underlying cardiac abnormalities

Classification of SCD by age and etiology

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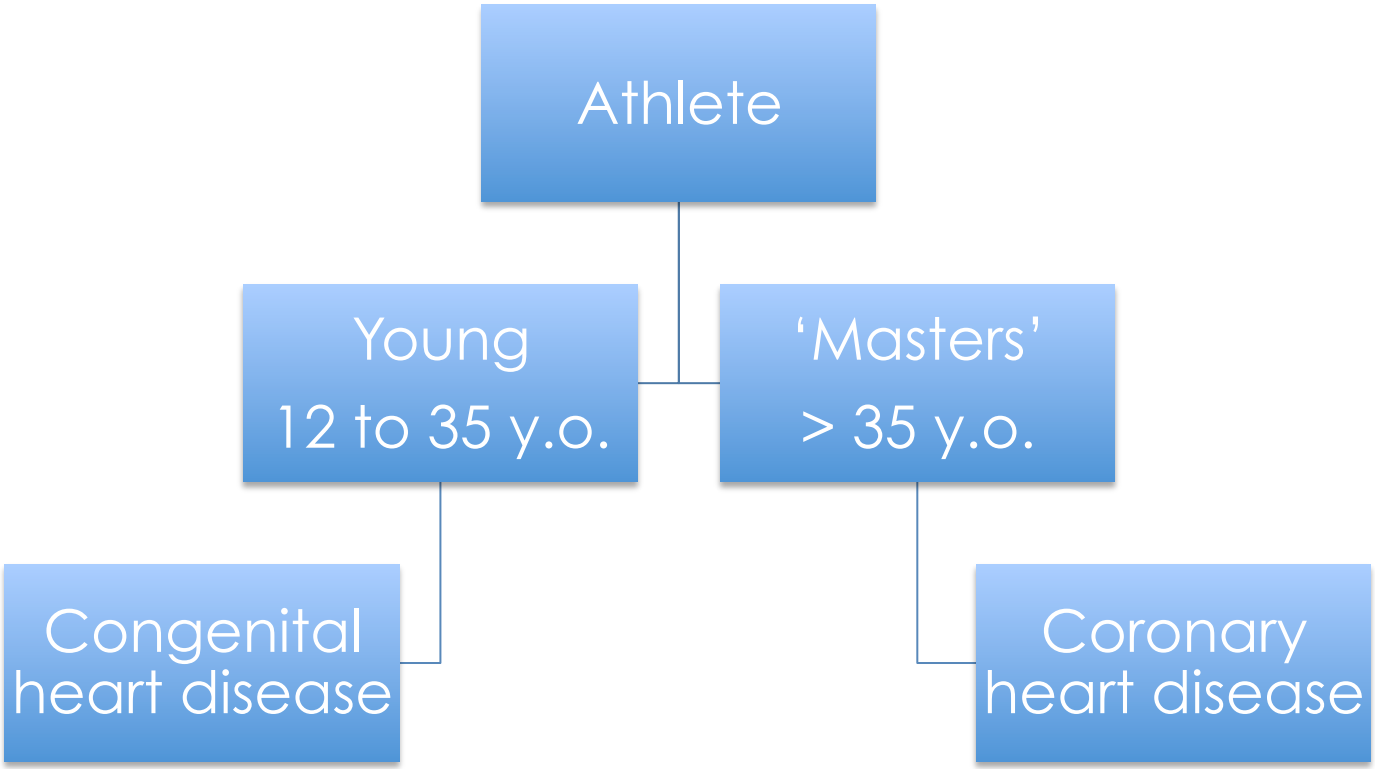

Incidence of SCD: Young Athlete

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- Accurate calculation requires a reliable number of SCDs (numerator) and an appropriately defined denominator (examples: participants, participant-years)
- Accurate reporting has been difficult due to the retrospective nature of most studies and underestimation due to reliance on media reports, insurance claims and other databases
- Differing rates have been reported due to varying methodologies for:
  - Case ascertainment
  - Data definition
  - Region studied

Reported Incidence Rates

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- Leading cause of mortality in young athletes on the playing field
- (SCD/#participants) have varied from as low as 1:300,000 athletes (Minnesota high school athletes) to as high as 1:9,000 (military recruits)
- (SCD/#participant-years): 1:917,000 participant-years (Minnesota high school athletes) → 1:3,000 participants-years (NCAA athletes)

NCAA SCD Incidence

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- "*Incidence, Etiology, and Comparative Frequency of Sudden Cardiac Death in NCAA Athletes: A Decade in Review*" – Harmon et al. 2015 Circulation AHA
- Database of all NCAA athletes developed (2003-2013)
- Cause of death adjudicated by expert panel
- 4,242,519 athlete-years (AY) (denominator), 514 total athlete deaths (numerator)

Results

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- SCD most common cause of medical death
- Incidence of SCD: **1:53,703 AY**

- Men vs. Women:
  - **1:37, 790 AY vs. 1:121,593 AY**
  - Incident rate ratio **= 3.22**

- Black vs. White (ethnicity):
  - **1:21,491 AY vs. 1:68,354**
  - Incident rate ratio **= 3.18**
  - ***no notable difference between black and white Division 1 basketball players**

Conclusions

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- Most common finding at autopsy after SCD was autopsy negative sudden unexplained death (AN-SUD)
- SCD rate in NCAA athletes is high
- Especially high in male and black athletes as well as basketball players
- Media reports only capture high profile cases and insurance claims cannot be considered reliable

Etiology of SCD in young athletes

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- Structural
  - Hypertrophic cardiomyopathy
  - Arrhythmogenic right ventricular cardiomyopathy or dysplasia
  - Premature coronary atherosclerosis
  - Congenital anomalies of coronary arteries
- Myocarditis
- Aortic rupture
- Valvular disease
- Pre-excitation syndromes and conduction diseases
- Ion channel diseases
  - Brugada
  - Long QT syndrome
  - Catecholaminergic Polymorphic Ventricular Tachycardia

Restriction from competitive sports: What do the experts agree upon?

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- Absolute restriction:
  - HCM
  - ARVC
  - Congenital coronary artery abnormalities (uncorrected)
- Partial restriction:
  - Myocarditis – for initial 6 months following diagnosis
  - MVP – class IA sports if
    - syncope/arrhythmia, family history of MVP/SCD, significant SVT or ventricular ectopy, moderate to severe MR, embolic event
  - LQTS – class IA sports
  - Brugada – class IA sports
  - CPVT – all have ICD, thus to class IA with minimal contact
- ICD: restrict to only recreational sports with no potential trauma allowed

Case for Screening

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- First symptom exhibited by 60% of SCD in young athlete victims in the US is cardiac arrest
- Widespread belief that screening of young should exist in some form - American Heart Association, International Olympic Committee, European Society of Cardiology
- Only Japan, Israel and Italy mandate athlete screening

Two approaches to screening: American vs. Italian

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AHA/ACC

- Cardiovascular screening q 2 to 4 years for high school/college athletes
- History and physical examination only

ESC/IOC/FIFA

- Systematic preparticipation screening of young competitive athletes
- History and physical examination, plus a 12-lead ECG

Canada……

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- No official recommendations exist
- BC has a very unique and ethnically diverse population
- Must develop a data set before any screening recommendations can be made

Sports Cardiology B.C. Young Athletes Study

- *"Prevalence of Cardiac Disease in British Columbia for Young Competitive Athletes – Sports Cardiology BC Heart Screening"*
- Determining prevalence in a subset of our population
- Using recommendations of AHA and ESC and compare and contrast efficiencies of screening methods
- To date >1200 participants

What is Excessive Endurance Exercise

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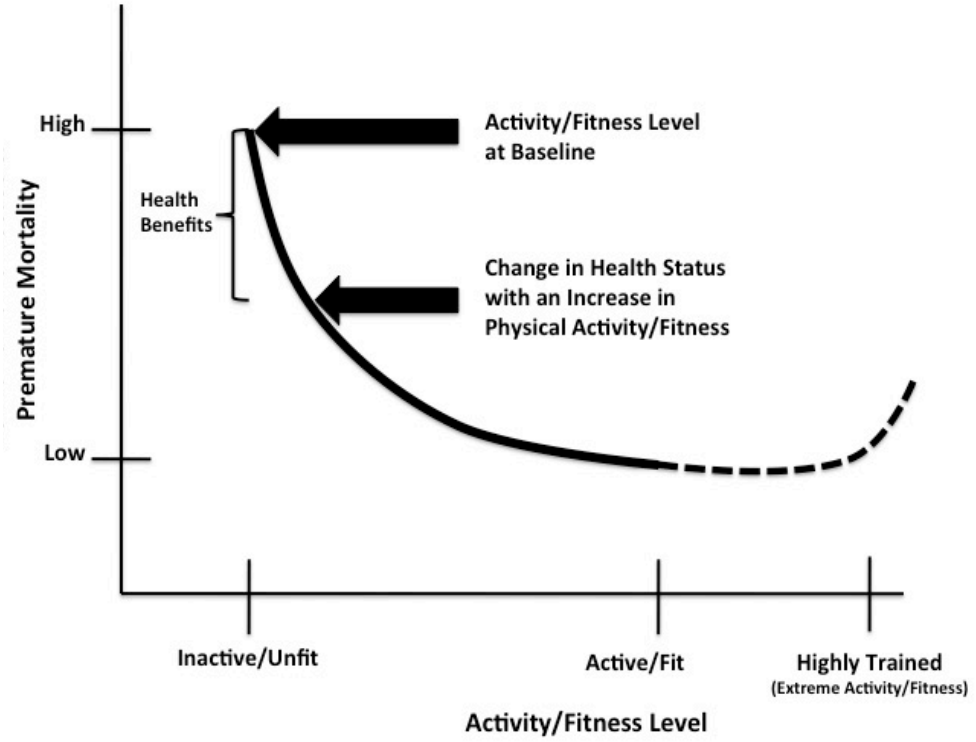
- Definitions vary in the literature
  - 1000kcal/wk is associated with 20-30% lower risk for premature all-cause mortality
- Greater benefits at higher volumes and intensities
- Many endurance athletes complete > 200 METs per week
- **~ 40 times greater than that needed for reduced cardiovascular mortality!**



Effective Pre-Participation Screening and Risk Stratification. In D. E. R. Warburton (Ed.), *Health-related Exercise Prescription for the Qualified Exercise Professional*

Proposed Pathogenesis of Cardiomyopathy in Endurance Athletes

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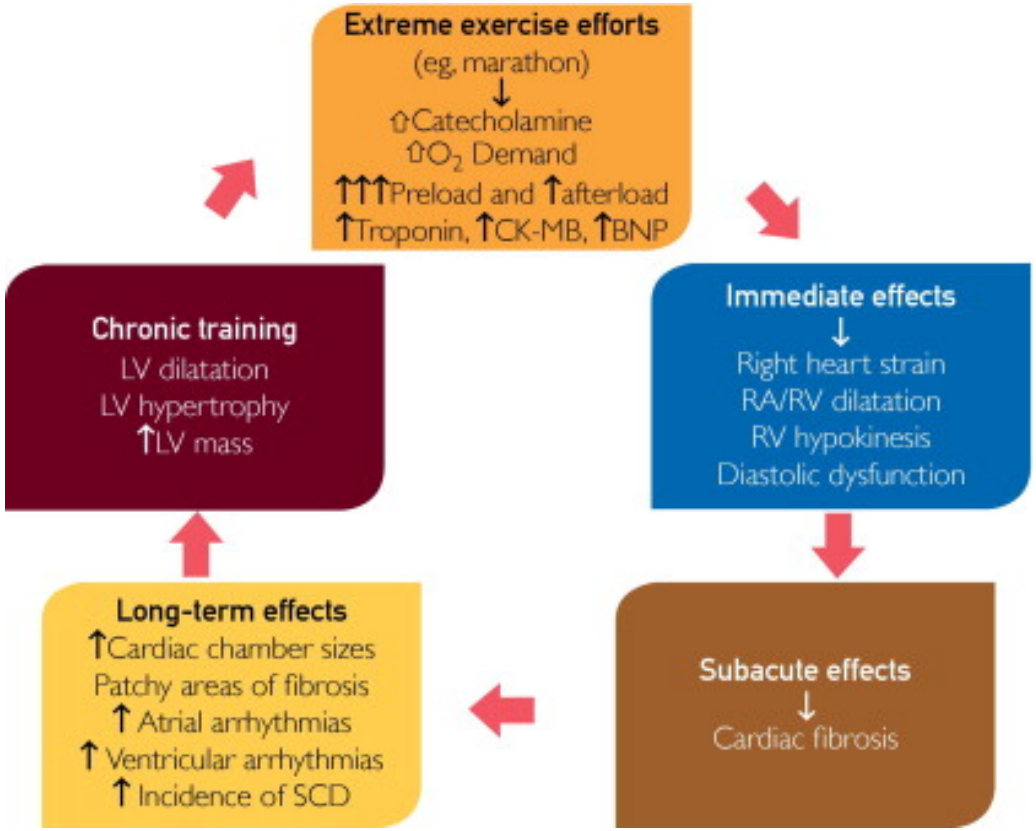

Mayo Clinic Proceedings, Volume 87, Issue 6, 2012, 587 - 595

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Athlete's Heart

- Increased cardiac mass
- Increased LV wall thickness
- Increased LV/RV diameters
- Enlarged LA dimensions
- Preserved cardiac function
- Reversible

European Heart Journal (2012) **33**, 998–1006
doi:10.1093/eurheartj/ehr397

CLINICAL RESEARCH
Exercise

Exercise-induced right ventricular dysfunction and structural remodelling in endurance athletes

André La Gerche[1,2*], Andrew T. Burns[3], Don J. Mooney[3], Warrick J. Inder[1], Andrew J. Taylor[4], Jan Bogaert[5], Andrew I. MacIsaac[3], Hein Heidbüchel[2], and David L. Prior[1,3]

[1]University of Melbourne Department of Medicine, St Vincent's Hospital, 29 Regent Street, Fitzroy VIC 3065, Australia; [2]Department of Cardiovascular Medicine, University Hospitals Leuven, Herestraat 49, 3000 Leuven, Belgium; [3]Cardiology Department, St Vincent's Hospital, 41 Victoria Parade, Fitzroy VIC 3065, Australia; [4]Alfred Hospital and Baker IDI Heart and Diabetes Institute, Commercial Road, Melbourne VIC 3004, Australia; and [5]Radiology Department, Medical Imaging Research Center, University Hospitals Leuven, Herestraat 49, 3000 Leuven, Belgium

- 40 athletes
- 1 of 4 events (Marathon, Endurance Triathlon, Alpine Cycling Race, Ultra-Triathlon)
- Well trained (> 10 hours of intense training)
- No cardiac symptoms
- No cardiac risk factors
- No resting or inducible structural or electrophysiological abnormalities during stress or echo

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Endpoints

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- 3 time points
  - 2-3 weeks prior to the race (baseline)
  - Immediately post-race (post-race)
  - 6-11 days post race (delayed)
- Measurements

Timepoint	cMRI	BNP/TnI	TTE
Baseline	✔	✔	✔
Post-Race		✔	✔
Delayed			✔

La Gerche A, et al. Eur J Journal 2012;33:998-1006.

Baseline Characteristics

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	Overall	Marathon run	Endurance triathlon[a]	Alpine cycling	Ultra triathlon[a]	P-value
Number of athletes	40	7	11	9	13	
Race distance (km)						
Race completion time	2 h 59 min ± 30 min		5 h 24 min ± 25 min	8 h 5 min ± 42 min	10 h 52 min ± 1 h 16 min	
Ambient temperature (°C)						
Age (years)	37 ± 8	38 ± 3	33 ± 7	44 ± 9	34 ± 8	0.014
Male (%)	90	86	91	78	100	0.378
BMI (kg/m^2)	23.6 ± 1.9	22.3 ± 1.6	24.0 ± 2.1	23.9 ± 2.1	23.5 ± 1.3	0.306
% of predicted VO_2max	146 ± 18	142 ± 8	141 ± 20	154 ± 20	148 ± 18	0.36
Training (years)	10 ± 9	13 ± 8	6 ± 5	12 ± 14	11 ± 9	0.277
Training (h/we	16.3 ± 5.1	14 ± 6	14 ± 3	13 ± 4	21 ± 5	01

La Gerche A, et al. Eur J Journal 2012;33:998-1006.

Effect of Prolonged Exercise on LV/RV Volumes

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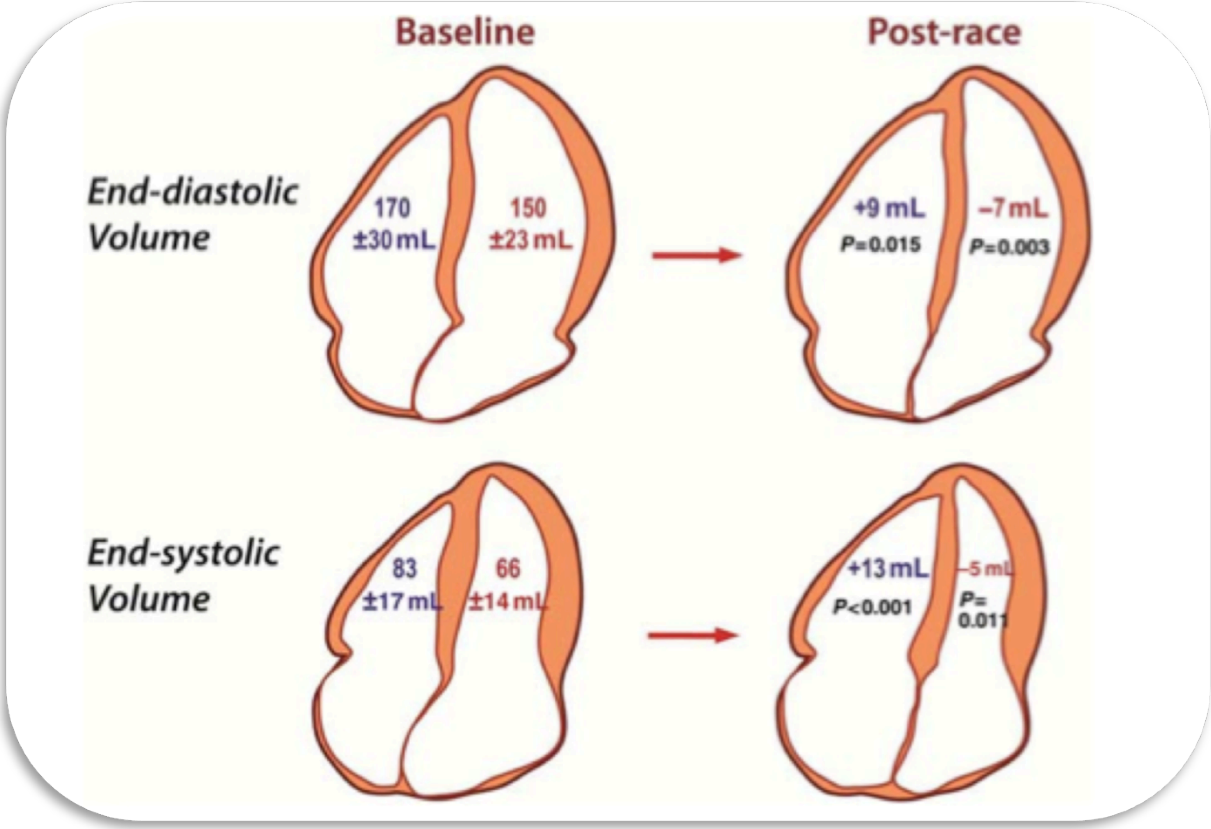

La Gerche A, et al. Eur J Journal 2012;33:998-1006.

Effect of Race Duration

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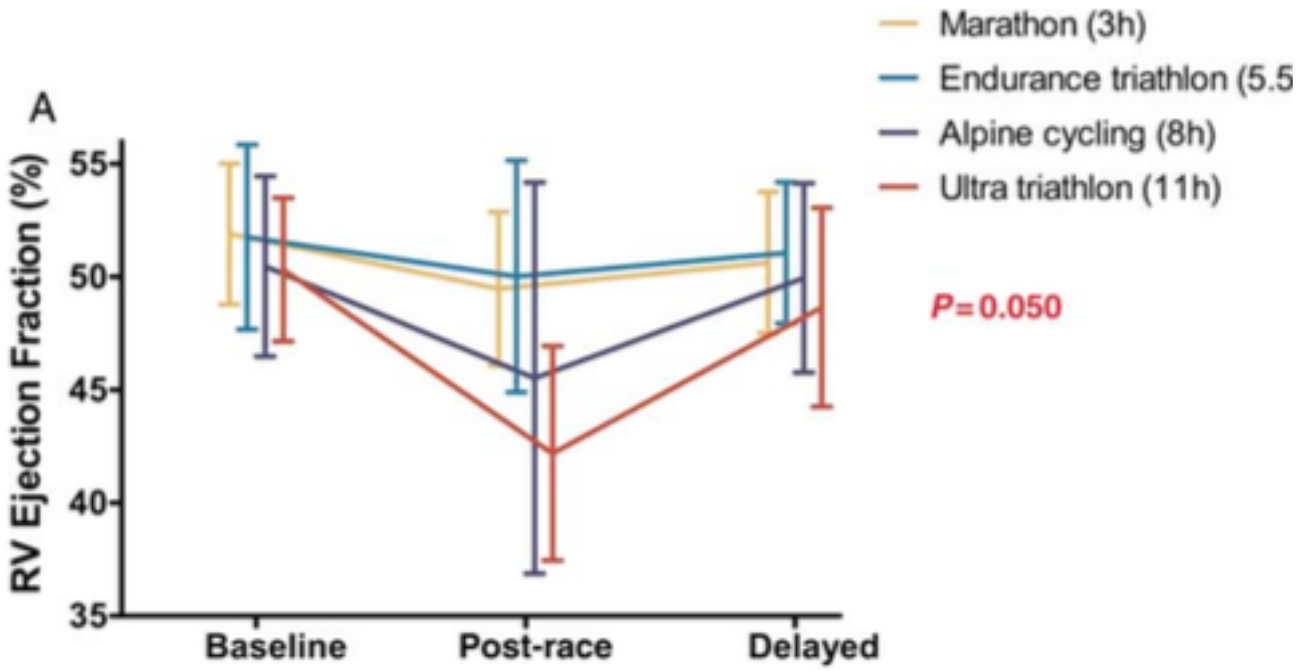

La Gerche A, et al. Eur J Journal 2012;33:998-1006.

Cardiac Fibrosis

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	DGE (n = 5)	No DGE (n = 35)	P-value
Age (years)	43 ± 13	35 ± 8	0.057
Training (years)	20 ± 16	8 ± 6	0.043
Predicted VO2 Max for age (%)	162 ± 26	144 ± 16	0.036
RVEF (%)	47.1 ± 5.9	51.1 ± 3.7	0.042
LVEF (%)	56.5 ± 6.8	59.8 ± 5.6	0.242

La Gerche A, et al. Eur J Journal 2012;33:998-1006.

Study Conclusions

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- Intense endurance exercise -> acute reduction in RV function
  - Increases with race duration
  - Correlates with increases in biomarkers
- Preserved LV function
- Focal DGE and RV remodeling -> more prevalent with longer history of sport

La Gerche A, et al. Eur J Journal 2012;33:998-1006.

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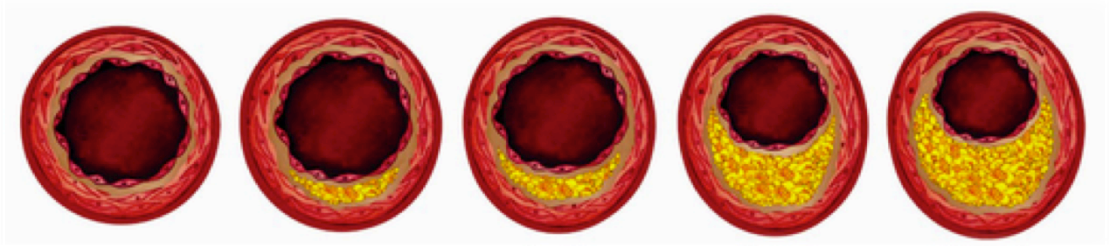
Atherosclerosis



Increased Coronary Artery Plaque Volume Among Male Marathon Runners

by Robert S. Schwartz, MD, Stacia Merkel Kraus, MPH, Jonathan G. Schwartz, MD, Kelly K. Wickstrom, BS, Gretchen Peichel, RN, Ross F. Garberich, MS, John R. Lesser, MD, Stephen N. Oesterle, MD, Thomas Knickelbine, MD, Kevin M. Harris, MD, Sue Duval, PhD, William O. Roberts, MD & James H. O'Keefe, MD

- Long term marathon running presumed to protect against CAD
- Schwartz et al. 2014
  - Single center observational study
  - Assessment of CAD by CCTA
  - 50 males who completed at least one marathon yearly for 25 consecutive years
  - 23 sedentary males (CCTA for clinical indications)

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Schwartz RS et al. Mo Medicine 2014;111:85-90.

Total Plaque Comparison

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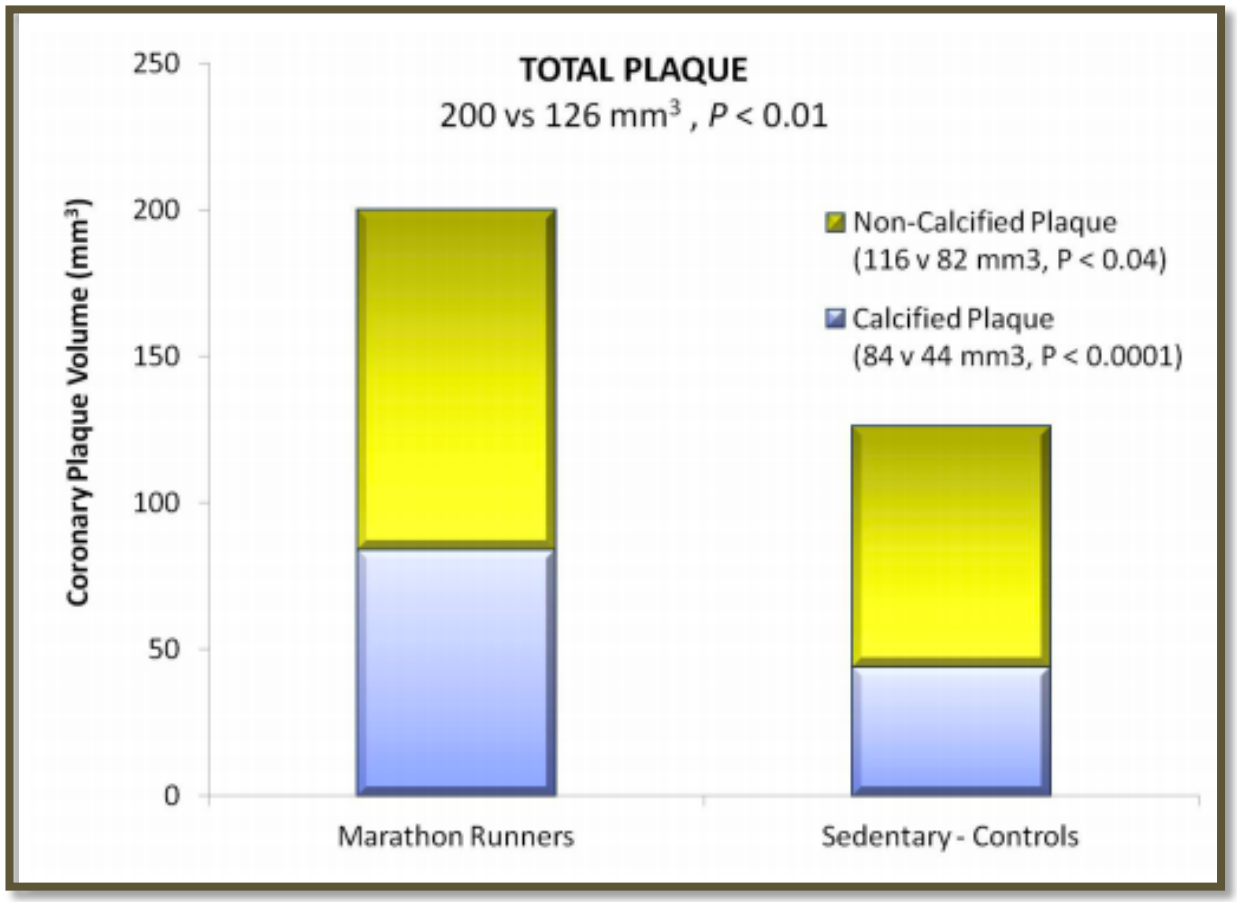
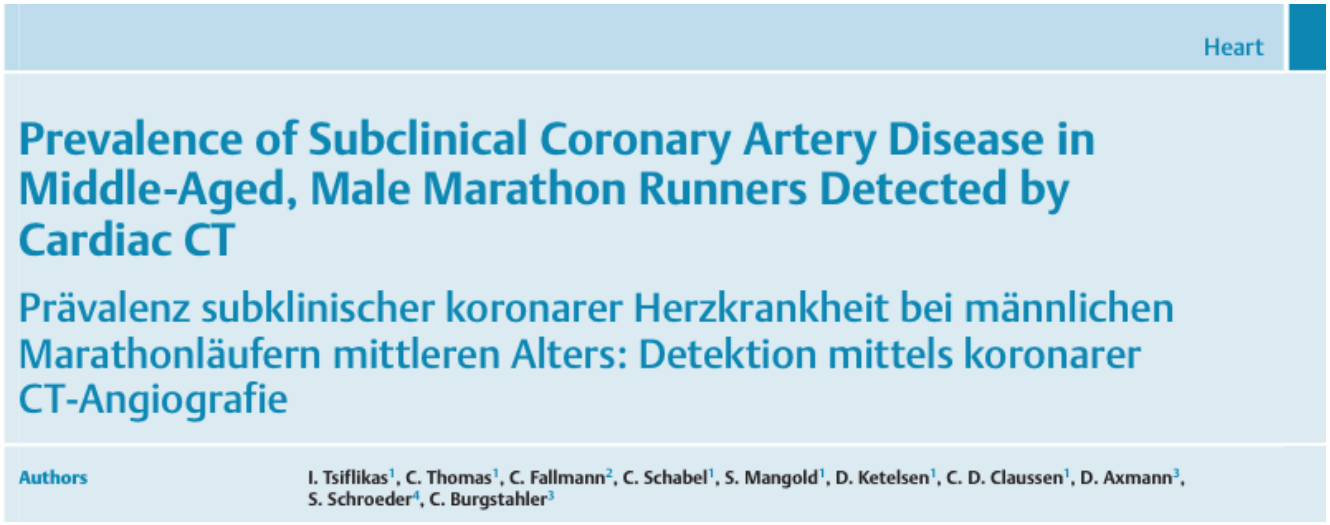


Schwartz RS et al. Mo Medicine 2014;111:85-90.



Heart

Prevalence of Subclinical Coronary Artery Disease in Middle-Aged, Male Marathon Runners Detected by Cardiac CT

Prävalenz subklinischer koronarer Herzkrankheit bei männlichen Marathonläufern mittleren Alters: Detektion mittels koronarer CT-Angiografie

Authors I. Tsiflikas[1], C. Thomas[1], C. Fallmann[2], C. Schabel[1], S. Mangold[1], D. Ketelsen[1], C. D. Claussen[1], D. Axmann[3], S. Schroeder[4], C. Burgstahler[3]

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- 50 male marathon runners (mean age: 52.7, range 45 -67 years)
- Marathons completed: 1-72, median 7, mean 13.8
  - Representative of real life (persons with no or minimal long distance running experience constitute a large portion of marathon participants)
- Personal minimum time: 2:33 - 4:30hr

Pre-Participation Screen

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- Physical exam
- Rest ECG
- Cardiovascular Risk Profile (TC, LDL, HDL, TRIGS, FG)
- Color Doppler Echo
- Treadmill stress test (evaluation of VO2max)
- Training experience, weekly training volume
- Coronary Dual Source CT Angiography (DSCTA) including calcium scoring

Tsifilikas et al. 2015. RoFo

Distribution of Agaston Score within the study population

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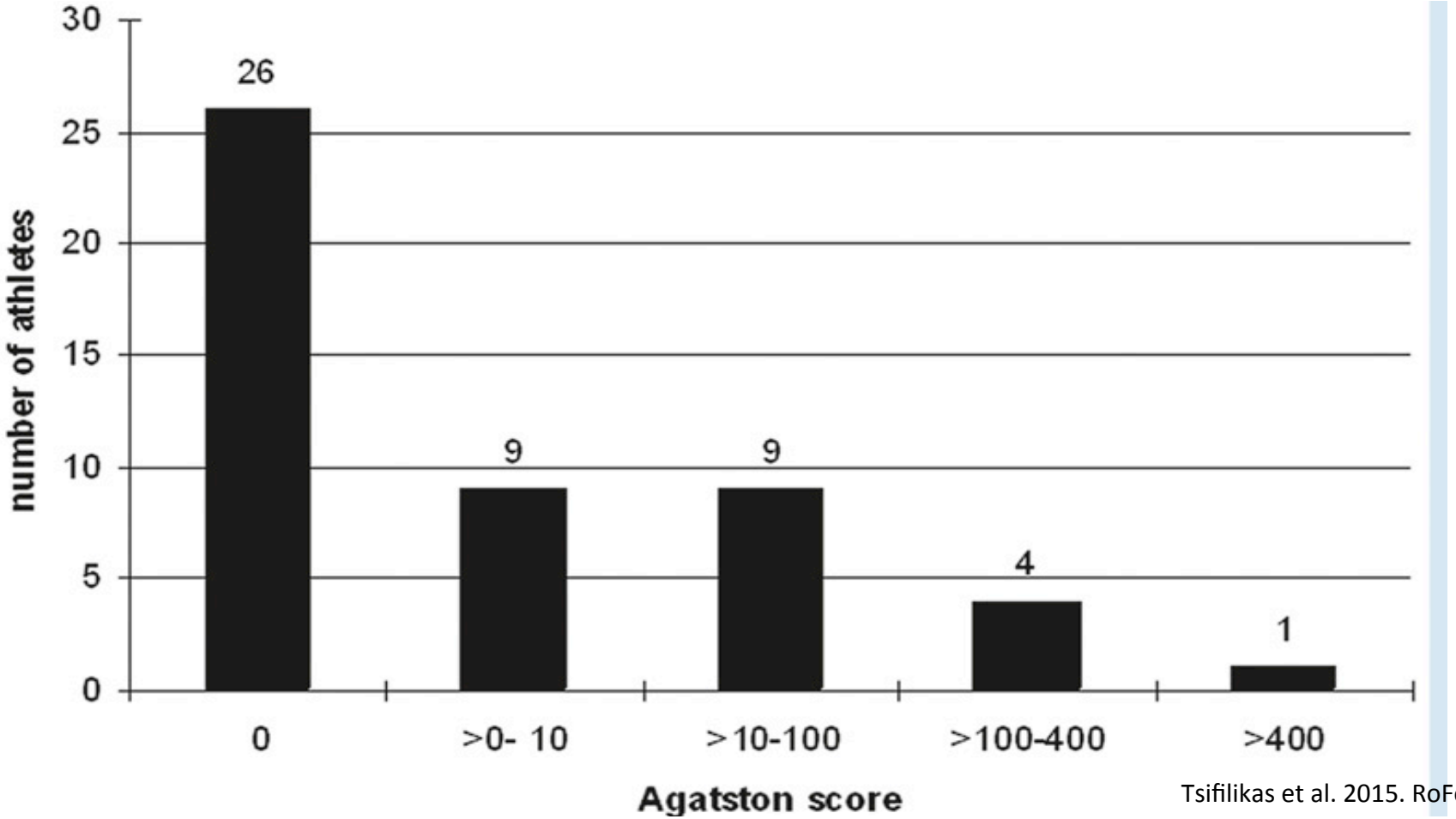

Tsifilikas et al. 2015. RoFo

Risk Factors and their association between coronary calcification and the degree of coronary artery disease

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risk factor	coronary atherosclerosis Pearson's Chi²	odds ratio [95 % CI]	degree of CAD - Pearson's Chi²
family risk	**0.0019**	**6.60 [1.92 – 22.62]**	**0.02**
hypertension	0.5713	1.71 [0.26 – 11.26]	0.55
former smoking	0.2715	1.94 [0.60 – 6.34]	0.46
hypercholesterolemia	0.0861	–	0.44

Tsifilikas et al. 2015. RoFo

Results

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- 50% of male marathon runners had mild-moderate CAD despite favorable risk profile
- One had significant CAD
  - Reported atypical chest pain
- 24% of the participants plaque were located in the proximal coronary artery system
- Exercise stress test failed to detect those with CAD
- Traditional risk factors did not differ between those with and without CAD
- Age and family history were the only risk factors that predicted risk

Tsifilikas et al. 2015. RoFo

Potential Explanations

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- Jim Fixx dilemma
  - Excessive exercise versus previous bad habits
- Metabolic and mechanical stresses
  - Potentially lead to accelerated atherosclerosis from oxidative stress
- Increased sustained levels of catecholamines
- Belief that exercise trumps a bad diet and smoking

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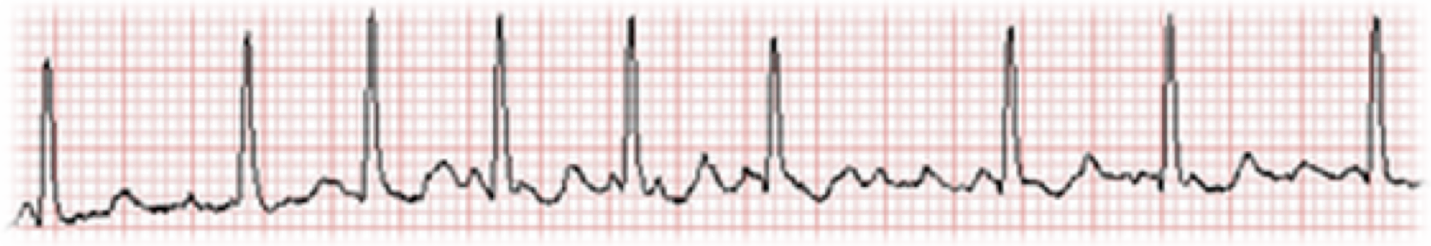
Atrial Fibrillation



AF Risk in Endurance Sport

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- Karjalainen et al. 1998
  - OR 5.5 for AF associated with vigorous exercise in middle-aged endurance cross-country runners
- Elousa et al. 2006
  - 3 times higher prevalence of lone AF
  - 5 times higher prevalence of vagal AF
  - Threshold limit of 1,500 lifetime hours of intense endurance practice needed for this to hold true
- Abdulla J. and Nielsen JR. 2009
  - Meta-analysis
  - 655 athletes versus 895 controls
  - AFIB 23% in athletes vs. 12.5% in non-athletes
  - Mean age 51 +/-9, 93% men, P=0.0001

Elousa R et al. Int J Cardiol 2006;108:332-337
Karjalainen J et al. BMJ 1998;316:1784-1785.
Abdulla J. and Nielsen JR. Europace 2011; 11:1156-1159

AF Risk In Endurance Sport

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- Studies with longer follow-up revealed an even higher prevalence
  - Incidence of AF increases with age in athletes
- Grimsmo et al. 2010
  - 12.8% of lone AF after 28-30 years of follow-up in endurance competitive cross-country skiers
- Baldesberger et al. 2008
  - 10% prevalence (vs 0%) in former professional cyclists (mean age 66 ± 7 years) vs male golfers

Baldesberger S et al. Eur Heart J 2008.

Grimsmo J et al. Eur J Cardiovasc Prev Rehabil 2010.

Factors Influencing Development of AF

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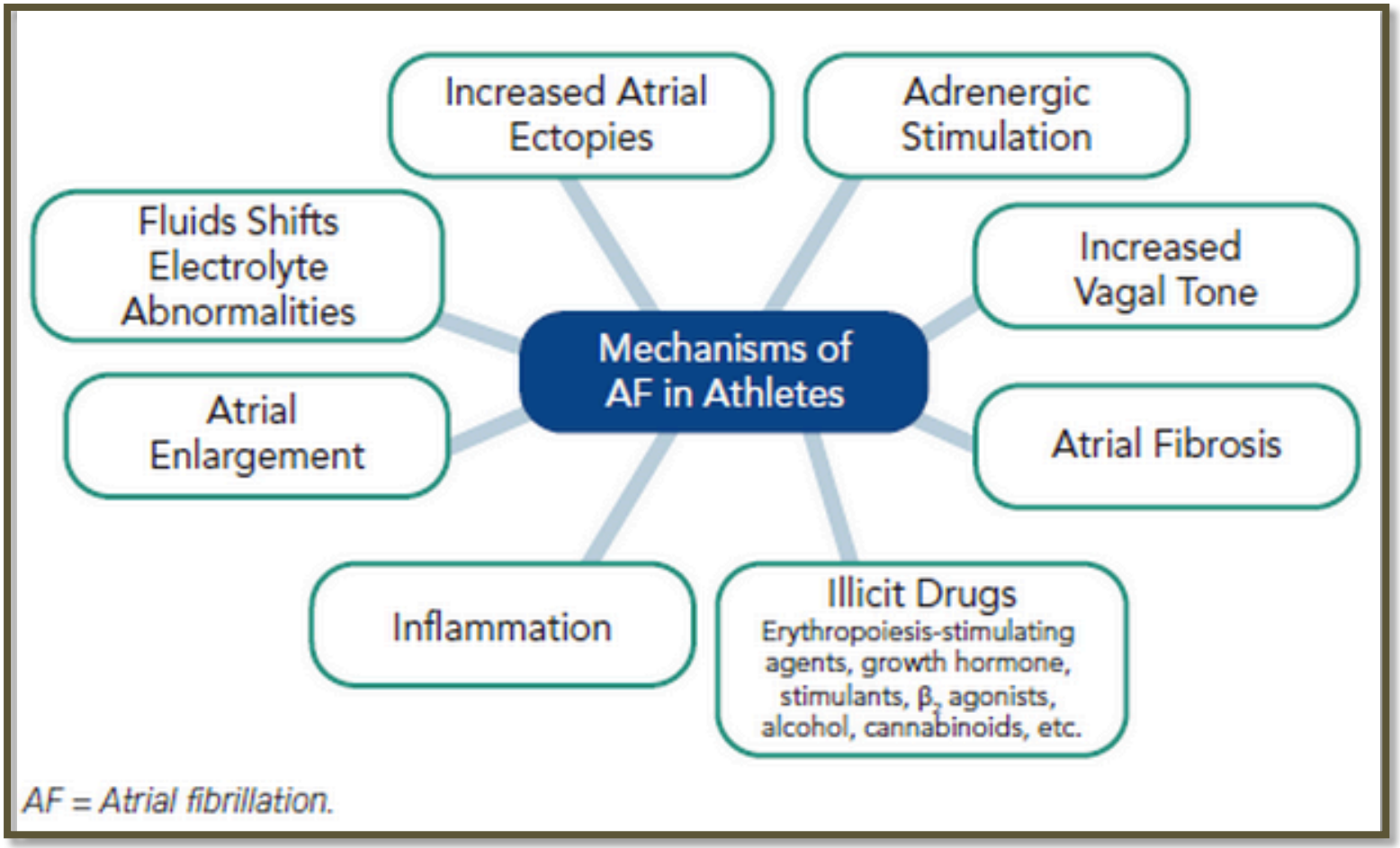

Fragakis N, et al. Arrhythmia & Electrophysiology Review 2014;3(1):15–9.

AF Summary

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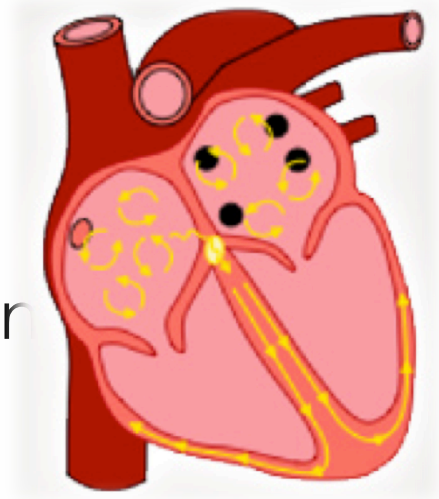
- Theoretical mechanism
  - Volume overload -> LA/RA stretch -> excessive oxidative stress -> myocardial damage -> scattered fibrosis and remodelling -> AF substrate
- Increased risk of AF in extreme endurance athletes
  - Multifactorial
  - Heightened vagal tone
  - Possible relation to atrial dilation
- Years of endurance training may be r
  before development of AF



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Effects of Frequency, Intensity, and Duration on Mortality

Frequency: Increased physical activity reduces risk of MI and SCD

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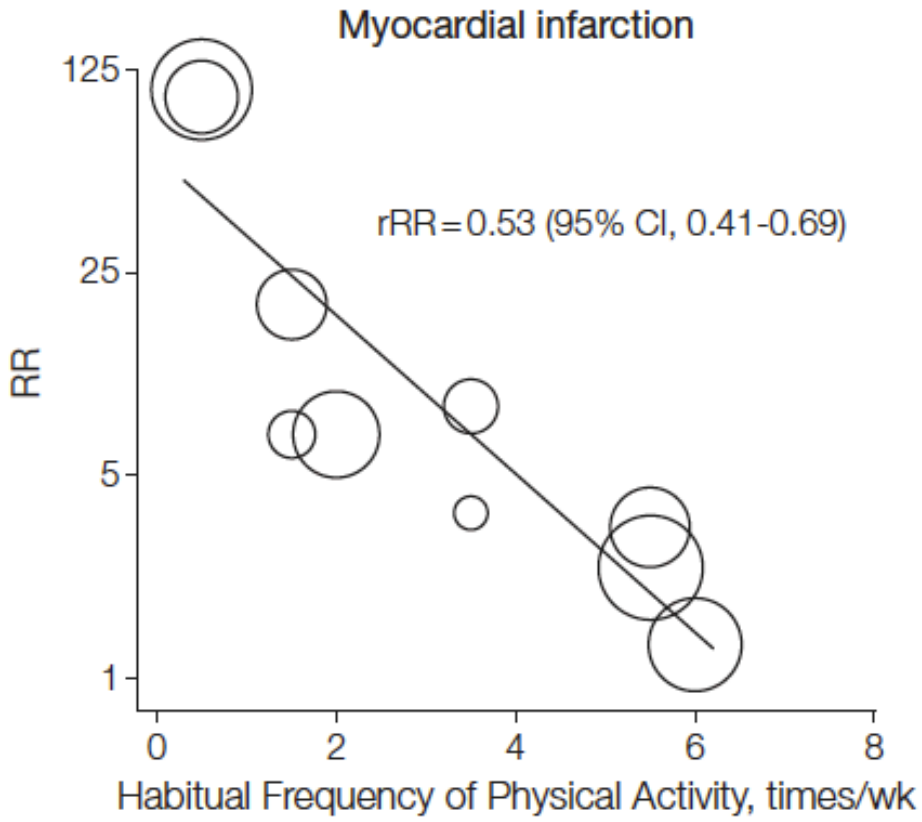

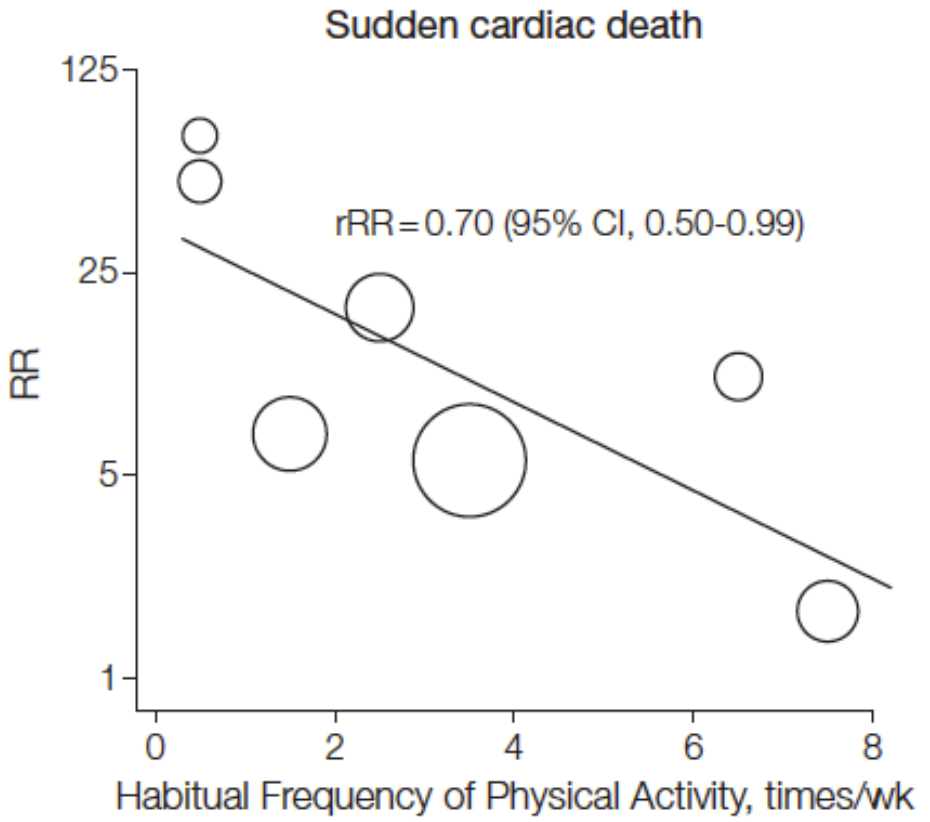

Dahabreh, JAMA. 2011 Mar 23;305(12):1225-33.

Frequency of Exercise on the Risk of Sudden Death and non sudden death during Vigorous Exertion

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Frequency of Vigorous Exercise	Sudden Death (N=109)	Nonsudden Death (N=146)
	relative risk (95% CI)	
<1 time/wk	1.0	1.0
1 time/wk	1.68 (0.98–2.87)	0.61 (0.37–1.02)
2–4 times/wk	1.13 (0.69–1.88)	0.59 (0.40–0.88)
≥5 times/wk	1.36 (0.76–2.43)	0.61 (0.37–1.02)
P for trend	0.63	0.03

Albert CM et al. N Engl J Med 2000;343:1355-1361

Jogging and Mortality

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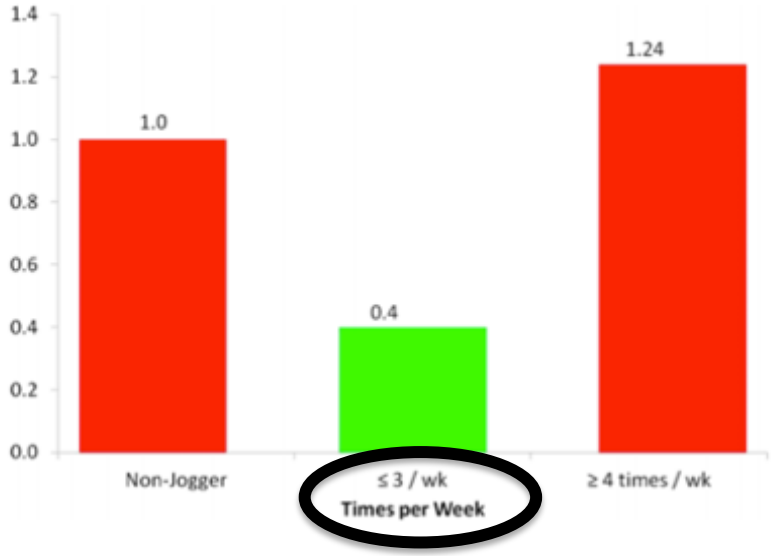

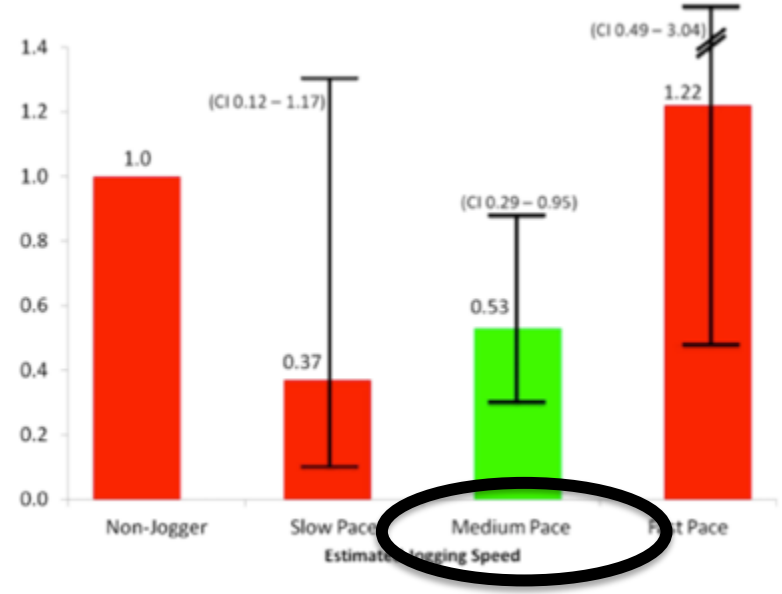

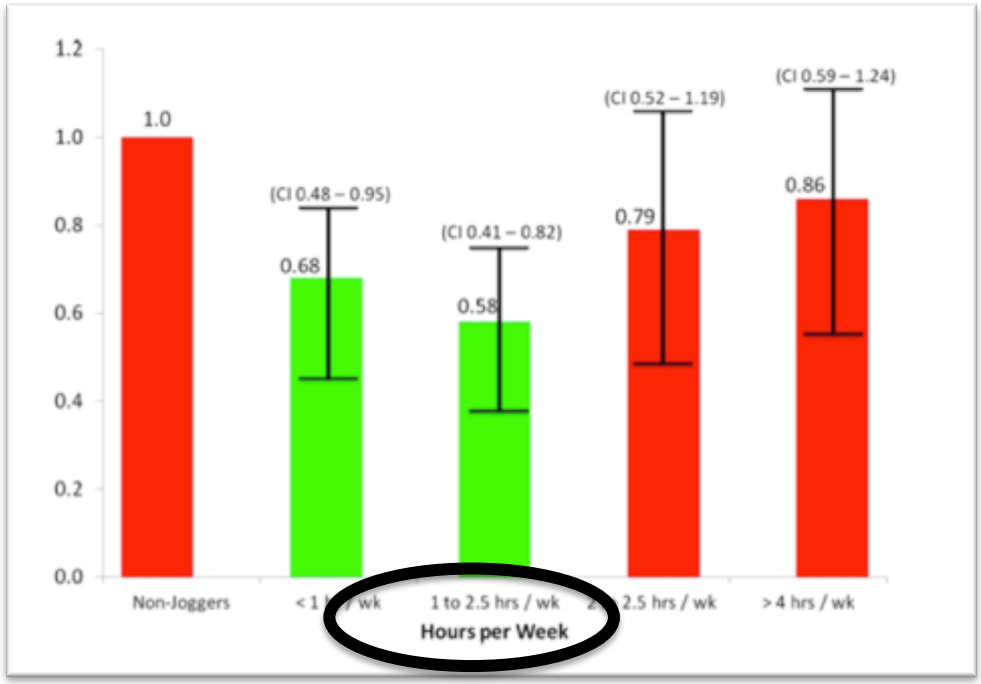

O'Keefe JH, et al. Heart 2013;99:588-590.

Schnohr P, et al. Am J Epidemiol 2013;177:683-689.

Screening in Masters Athletes

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- Recommendations vary across agencies and countries
- Family history and personal symptoms questionnaire and physical examination (i.e. AHA 14-element)
    - Specific to the Masters athlete?
- Cardiovascular risk score (i.e. SCORE, FRS)

– Resting ECG and stress testing?

– Other imaging modalities?

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Current Recommendations for Physical Activity Clearance:		
Self and Health-Care Professional Administered Questionnaires 1. Physical Activity Readiness Questionnaire for Everyone (PAR-Q+) 2. Electronic Physical Activity Readiness Medical Examination (ePAR-Q+) 3. AHA/ACSM Health/Fitness Facility Pre-participation Screening Questionnaire		
Recommended Pre-Participation Screening for Athletes:		
	EACPR – Individual Approach	**AHA – Selective Approach**
Eligibility for pre-participation screening	○ All adult/senior non-professional engaged in vigorous activity ○ Individuals engaged in moderate activity + positive assessment of risk using SCORE	○ All Masters athletes (> 40 yrs)
Pre-Participation Screen	○ History ○ Physical Examination ○ Risk SCORE ○ Rest ECG	○ History ○ Physical Examination ○ Rest ECG
Criteria for Max Exercise Test	○ Abnormal Pre-Participation Screen: ○ Presence of alarming symptoms ○ Abnormal physical examination ○ High risk SCORE profile ○ Abnormal rest ECG	○ Symptoms suggestive of coronary disease ○ Moderate to high cardiovascular risk profile (i.e. Men >40 yrs, women >50yrs + ≥ 1 risk factor) ○ All athletes ≥ 65 yr

Debates in Screening: Imaging Modalities

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For/Against	Echo	CCT/CACS	CMR
Arguments For	• Accessible • No direct adverse effects • Detects disorders not seen on ECG (coronary anomalies, aortic dilation, BAV, MVP, some cardiomyopathies) • Risk stratify for AFIB? • Identify subclinical CVD?	• Highly sensitive test for CAD (>50% stenosis) • Can detect mild to moderate disease in active individuals • Prognostic value over routine risk factors **- does this alter treatment decision making?**	• Most comprehensive • Can distinguish between athlete's heart and other cardiomyopathies • Detect myocardial fibrosis - concern in lifelong endurance athletes?
Arguments Against	• Does not detect disease beyond ECG, physical, questionnaire in Masters athlete (Aagaard et al. 2013)	• Radiation exposure (1.26 mSv for CCT, 0.30mSv for CACS) • **Reduction in morbidity and mortality?**	• Expensive • Limited availability • Low pre-test probability in athletic population

Sports Cardiology BC Research Study: Cardiovascular Screening and Risk Assessment in Masters Athletes

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Primary Objective:

- Prevent adverse cardiac events and sudden cardiac death in sport in the Masters athlete

Outcomes:

- Prevalence of cardiovascular disease (i.e. CAD)
- Prevalence of risk factors (i.e. hypertension, dyslipidemia)
- Prevalence of atrial fibrillation in the masters athlete and its association with intensity of sport and volume of physical activity

– Compare and contrast efficiencies of different screening tests used (questionnaire, physical exam, 12-lead ECG)

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N = 800+ Recreationally Competitive and High Performance Masters Athletes

Initial Screen:

History and Personal Symptoms Questionnaire, Physical Exam, Framingham Risk Score, Resting 12-lead ECG

- Negative
  - No Further Testing → Follow-Up (5 Years): ECG, FRS, Questionnaire
- Positive
  - Exercise Treadmill Test
    - Negative: Follow-Up (5 years): ECG, FRS, Questionnaire
    - Positive
      - Further Examinations (i.e. echo, 24 h holter, CMR, CCT/CACS)
        - No Cardiovascular Disease
          - Follow-Up (5 years): ECG, FRS, Questionnaire
        - Cardiovascular disease→ Clinical Care
        - Other → Clinical Care

Sports Cardiology BC

- Multidisciplinary medical team approach
- Goals of the program are outlined by the 4 pillars:
  - **Research, Clinical Assessment, Education and Advocacy**

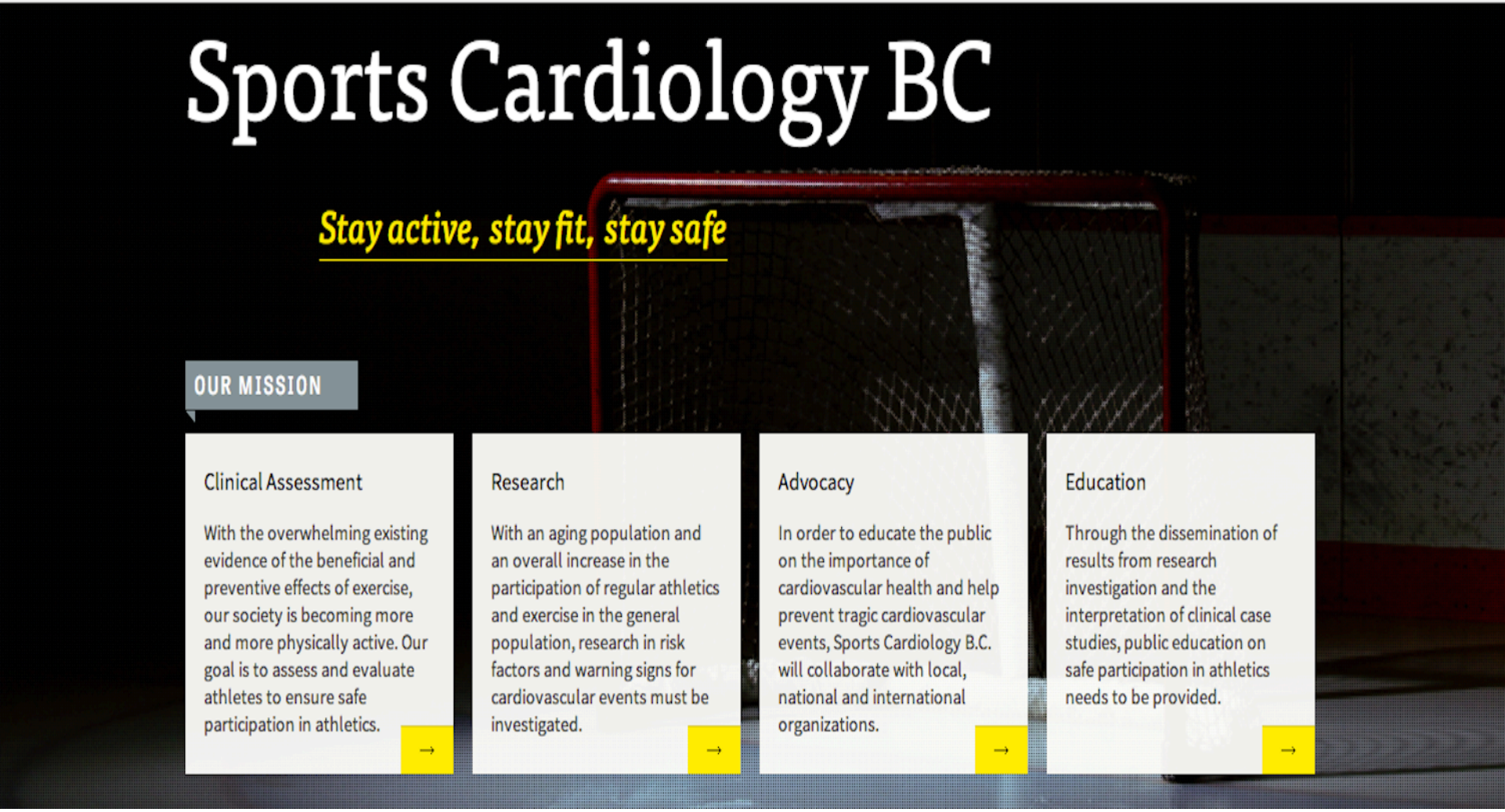
- Clinical focus: Risk assessment and guidance in athletes with cardiac abnormalities, with a focus on Master's athletes with CHD

- Resource for medical community to educate and provide local perspective on controversial topics

- Research: Detection, prevention and treatment of cardiovascular disease, registry formation, risk factor and disease prevalence

Sports Cardiology BC

Stay active, stay fit, stay safe



OUR MISSION

Clinical Assessment

With the overwhelming existing evidence of the beneficial and preventive effects of exercise, our society is becoming more and more physically active. Our goal is to assess and evaluate athletes to ensure safe participation in athletics.

→

Research

With an aging population and an overall increase in the participation of regular athletics and exercise in the general population, research in risk factors and warning signs for cardiovascular events must be investigated.

→

Advocacy

In order to educate the public on the importance of cardiovascular health and help prevent tragic cardiovascular events, Sports Cardiology B.C. will collaborate with local, national and international organizations.

→

Education

Through the dissemination of results from research investigation and the interpretation of clinical case studies, public education on safe participation in athletics needs to be provided.

→

Team

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- Dr. Saul Isserow
- Dr. Brett Heilbron
- Dr. Andrew Krahn
- Dr. Shub Sanatani
- Dr. Jack Taunton
- Dr. Darren Warburton
- Dr. Kam Shojania
- Dr. James McKinney
- Dr. Hamed Nazzari
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- Dr. Rick Leather
- Dr. Kevin Pistawka
- Dr. Mike Wilkinson
- Dr. Janet McKeown
- Dr. Rich Vandegriend
- Dr. Michael Luong
- Dr. Christopher Fordyce
- Mr. Faisal Aziz

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Questions?

www.sportscardiologybc.org