The Heart of a Cyclist

Insights from Sports Cardiology

Michel Accad, MD

February 21, 2018

UCSF Mini Medical School

ATHLETIC HEART | SF
A SPORTS CARDIOLOGY CLINIC

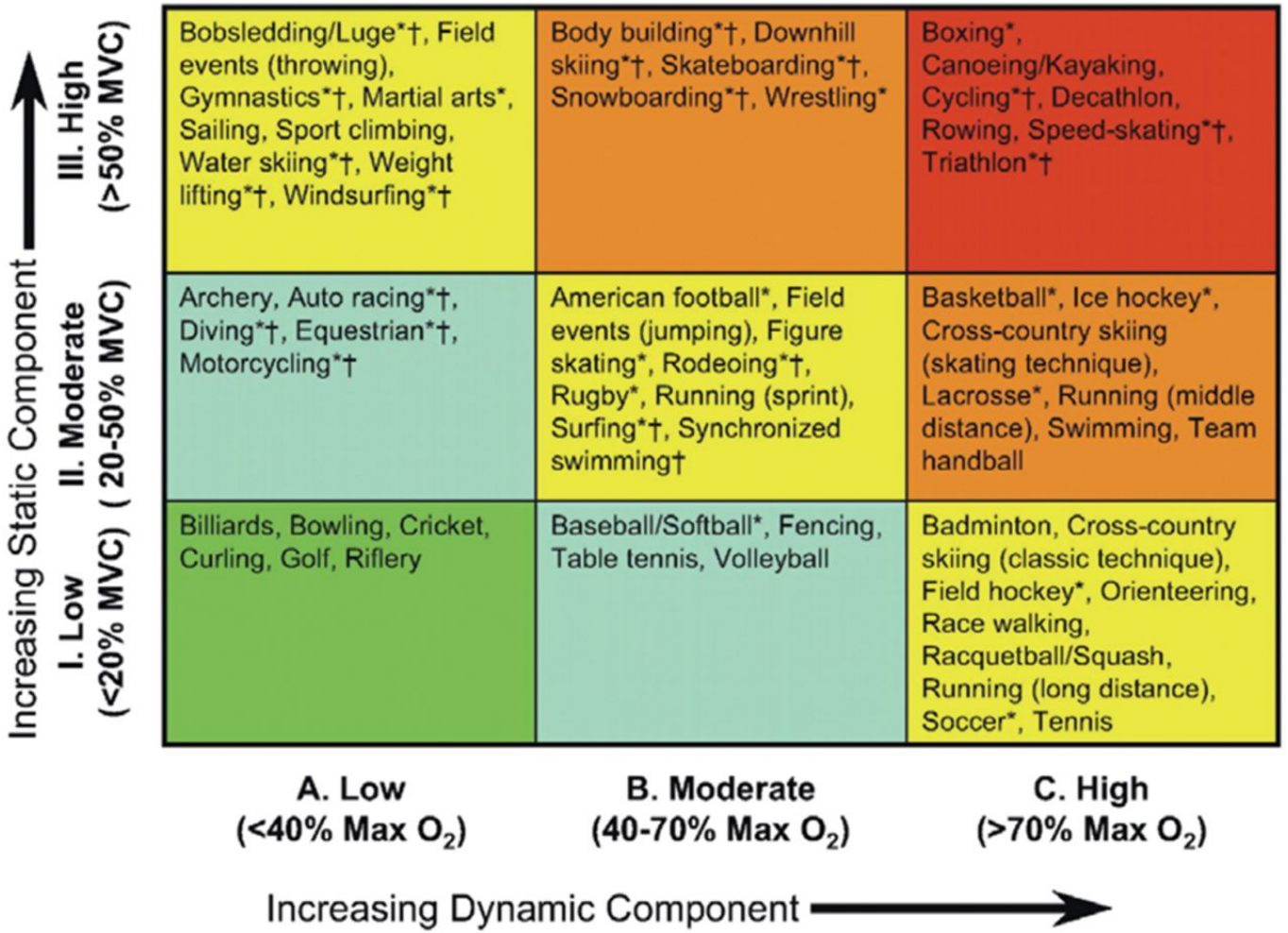
Lecture outline:

WARNING: Not a lecture about how to boost your performance!

- Preliminary comments
- Cardiac adaptations to regular, high-intensity cycling and endurance exercise
- Screening cyclists for occult heart disease: Controversies and reasonable solutions
- Trouble in paradise?.. Long term effects of high-intensity cycling and endurance exercise

Preliminary remarks

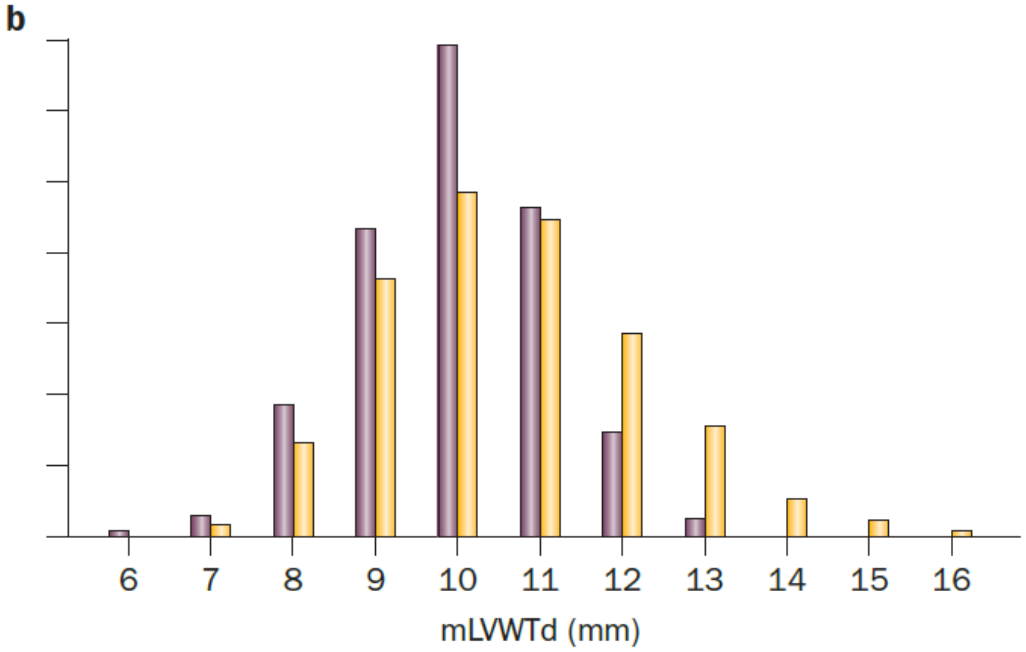
Cycling versus other exercises



Cycling vs other endurance sports

- Cannot make clear distinctions between cycling and other endurance sports
  - Variabilities between types of cycling and types of other sports;
  - Individual variabilities in exercise form;
  - Variabilities in testing conditions
- Similar cardiac adaptations observed
- Similar potential cardiac complications observed

The nature of physiological distinctions…



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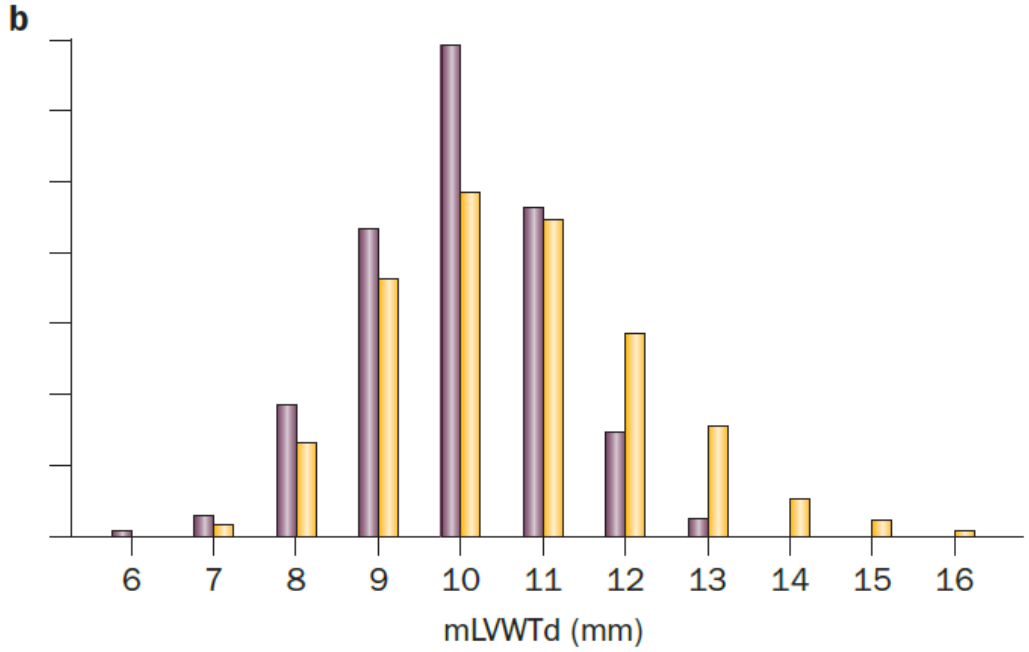


A lot of overlap!…

Cardiac adaptations: The cyclist’s heart

Cardiac adaptation: The cyclist's heart

- "Electrical" (ECG)
- Structural
- Functional
- Effect of sex, age, size, ethnicity

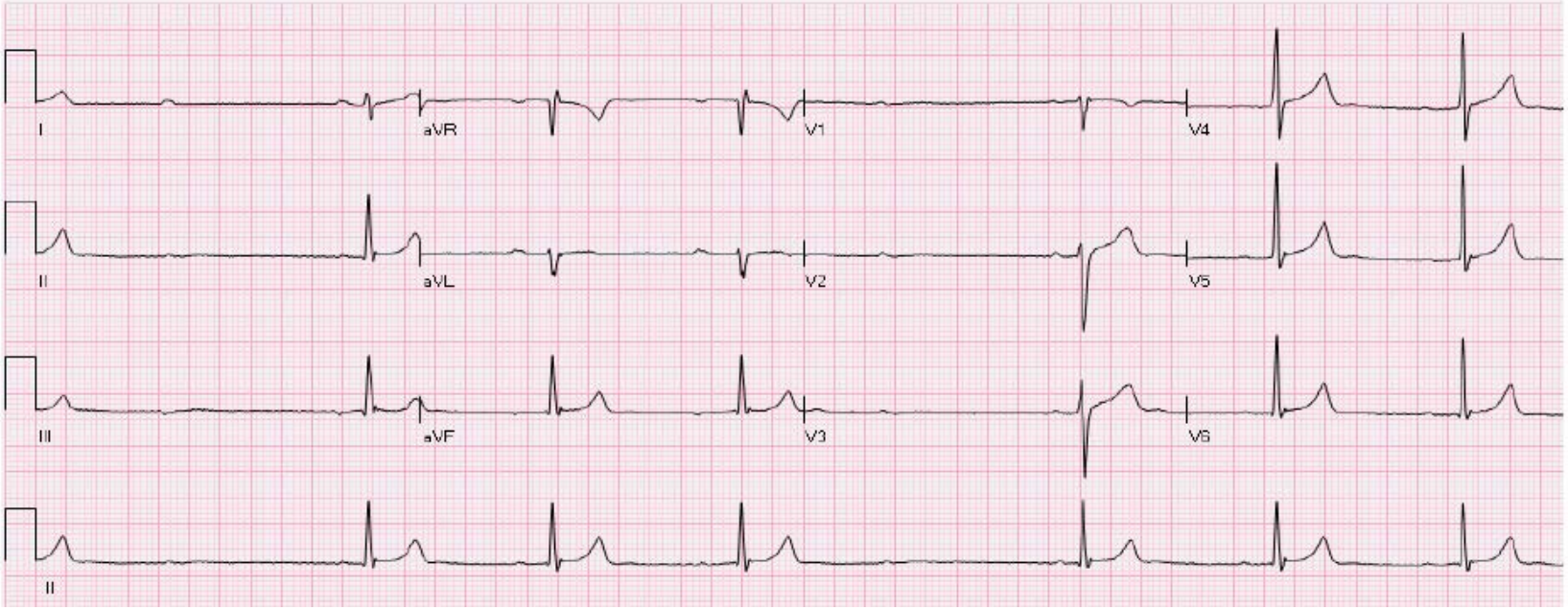
Cardiac adaptation: Electrical

- Sinus bradycardia
  - Slow resting pulse
  - Very common among well-trained athletes (80% versus 20%)
  - Can be accompanied by benign “heart block”
  - Cause unclear (cardiac changes versus autonomic nervous system changes)

Sinus bradycardia

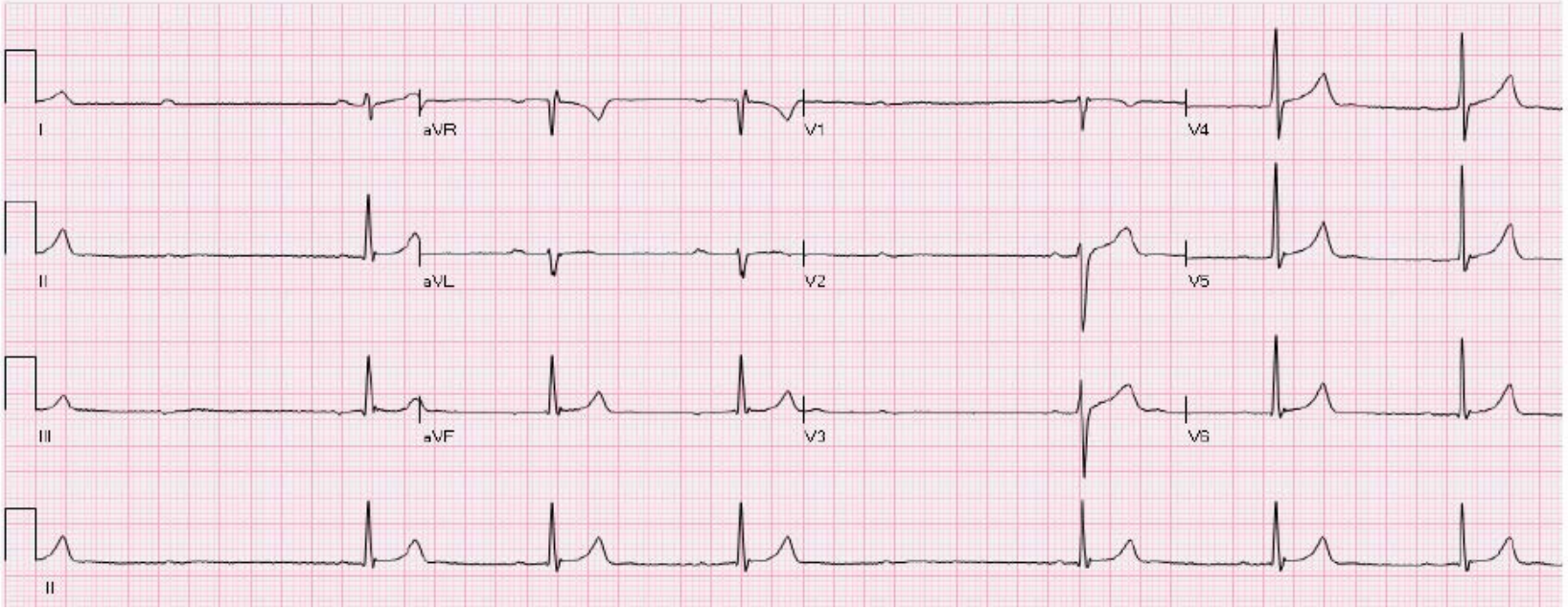
- No symptoms
- Goes away with exercise

Sinus bradycardia with AV block



Courtesy S. Sharma

Sinus bradycardia with AV block



- Asymptomatic
- Goes away with exercise

Courtesy S. Sharma

Cardiac adaptation: Electrical

- Respiratory sinus “arrhythmia”
  - More pronounced changed in pulse rate in response to respiration

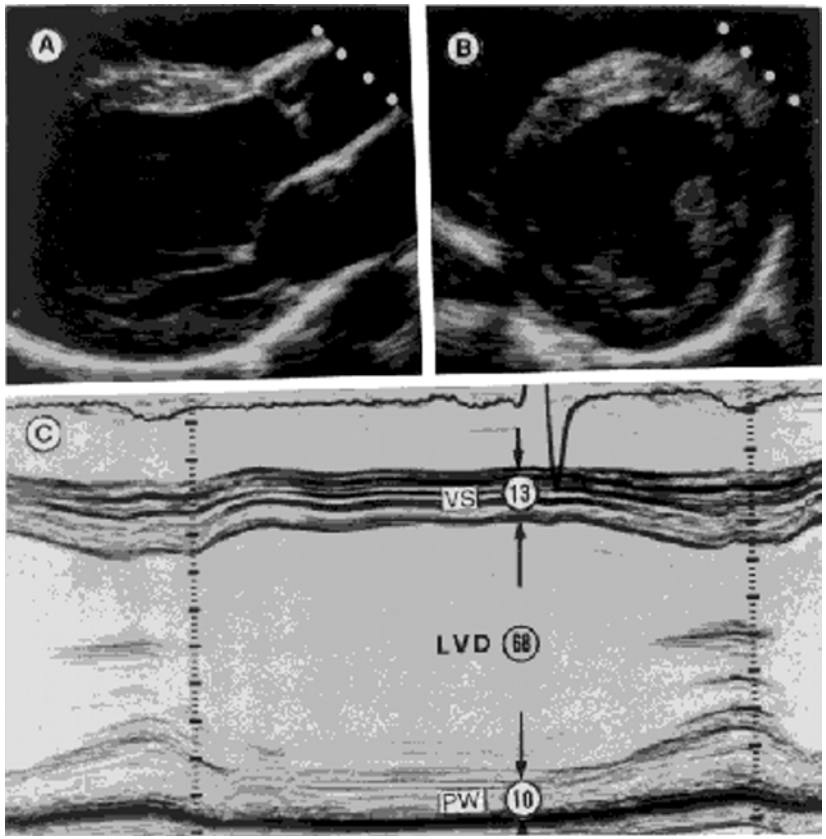
- Increased heart rate variability

Cardiac adaptation: Electrical

- Changes in configuration of ECG
  - Incomplete right bundle branch block
  - Repolarization changes:
    - “J-point” elevation
    - Tall T waves
    - Inverted or “abnormal” T waves
    - Other changes
  - ECG changes reflecting changes in cardiac structure
    - Left ventricular hypertrophy
    - Axis deviation

Cardiac adaptation: Structural

- Increased cavity sizes
  - Left ventricle
  - Right ventricle
  - Left atrium
  - Right atrium
- Increase left ventricular wall thickness



The cyclist's heart is the biggest!

Spirito et al.
Am J Cardiol 1994; 74 : 802-806

TABLE II Calculated Effects of Type of Sport on Left Ventricular Internal Diastolic Cavity Dimension (LVIDd) and Wall Thickness in 947 Athletes

Sport	Impact on LVIDd (mm)	Sport	Impact on Wall Thickness (mm)
1) Endurance cycling	5.91	Rowing	2.13
2) Cross-country skiing	5.41	Endurance cycling	2.02
3) Swimming	4.90	Swimming	1.71
4) Pentathlon	4.35	Canoeing	1.70
5) Canoeing	4.23	Long-distance track	1.49
6) Sprint cycling	3.97	Water polo	1.38
7) Rowing	3.87	Sprint cycling	1.35
8) Long-distance track	3.47	Weightlifting	1.23
9) Soccer	3.11	Wrestling/judo	1.21
10) Team handball	2.87	Tennis	1.00
11) Tennis	2.69	Pentathlon	0.98
12) Roller hockey	2.41	Cross-country skiing	0.98
13) Boxing	2.25	Boxing	0.94
14) Alpine skiing	2.13	Roller skating	0.88
15) Fencing	2.09	Soccer	0.76
16) Taekwondo	2.07	Roller hockey	0.69
17) Water polo	2.02	Fencing	0.63
18) Diving	1.70	Sprint track	0.54
19) Roller skating	1.68	Volleyball	0.39
20) Volleyball	1.43	Diving	0.38
21) Bobsledding	1.35	Alpine skiing	0.29
22) Weightlifting	1.32	Field weight events	0.25
23) Wrestling/judo	1.25	Taekwondo	0.23
24) Equestrian	0.43	Team handball	0.19
25) Field weight events	0.18	Equestrian	0.13
26) Yachting	0.10	Bobsledding	0.07
27) Sprint track	0.00	Yachting	0.00

Cardiac adaptation: Functional

- Enhanced “relaxation” (diastolic filling)
- Higher stroke volume (volume of blood ejected during heart beat)
- Higher peak oxygen consumption

Cardiac adaptation: effect of sex

- Less data regarding female than male athletes (in part because increase in sports participation among female relatively recent)
- Compared to male athletes
  - Female athletes exhibit less absolute increases in cardiac size and wall thickness.
  - Female athletes exhibit less overlap with pathologic cardiac dimension
  - Rate of sudden death during exercise less for females (10:1)

Cardiac adaptation: effect of ethnicity

- Black athletes (African-American, Afro-Caribbean) exhibit
  - More pronounced ECG changes: repolarization abnormalities, T wave changes
  - A propensity for greater increase in wall thickness
  - No appreciable difference in LV cavity size, but larger average RV cavity size compared to white athletes
- Screening ECG interpretation criteria specific for black athletes have been proposed

Should cyclists (athletes) be screened for occult heart disease?

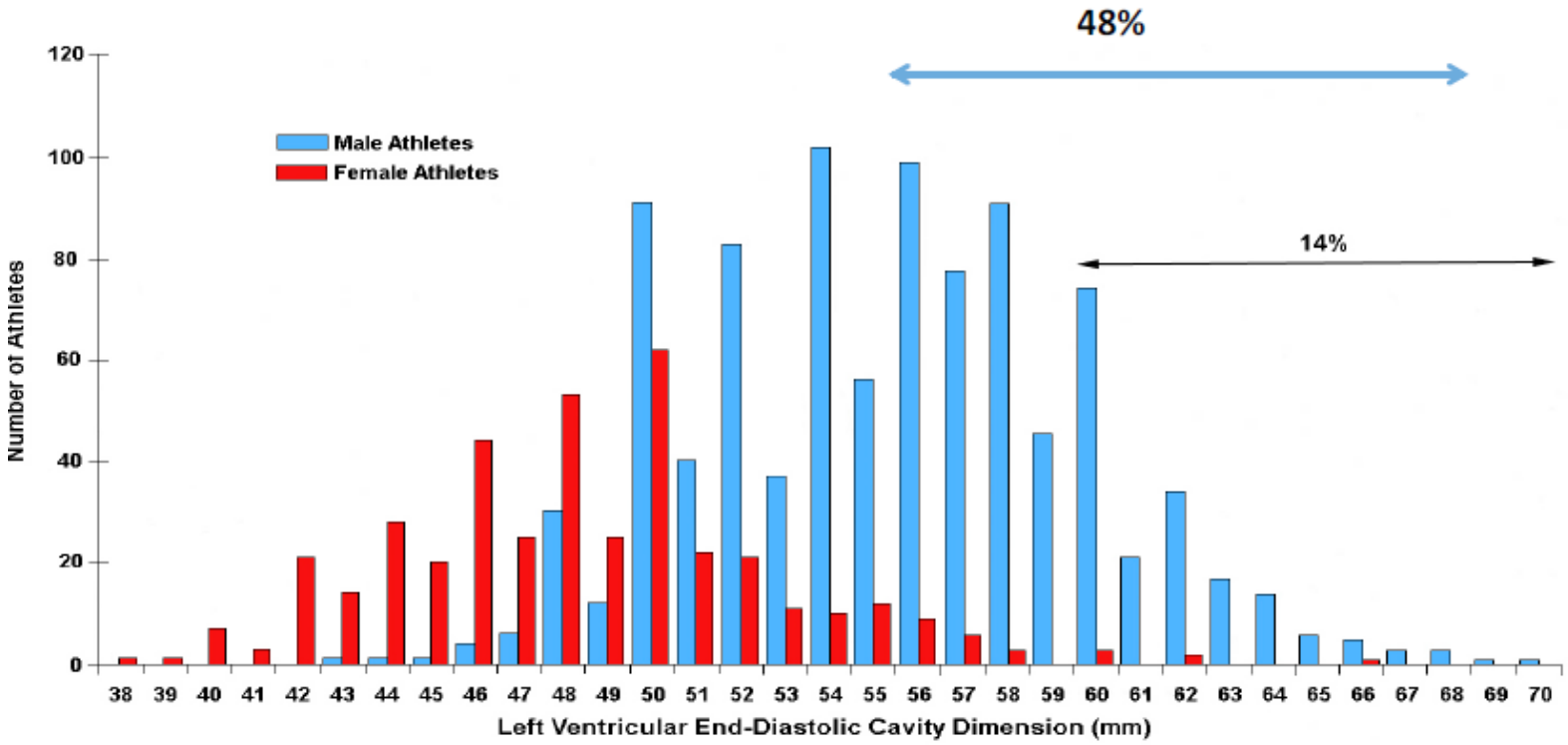
Screening rationale

- PRO:
  - Sudden cardiac arrest is frequently fatal, with high cost to victims, families, communities
  - Most conditions leading to cardiac arrest are potentially detectable
- CON:
  - Absolute numbers are extremely small
  - Screening tests not perfect
  - Screening policy is ethically problematic

Heart diseases putting athletes at risk of sudden cardiac arrest

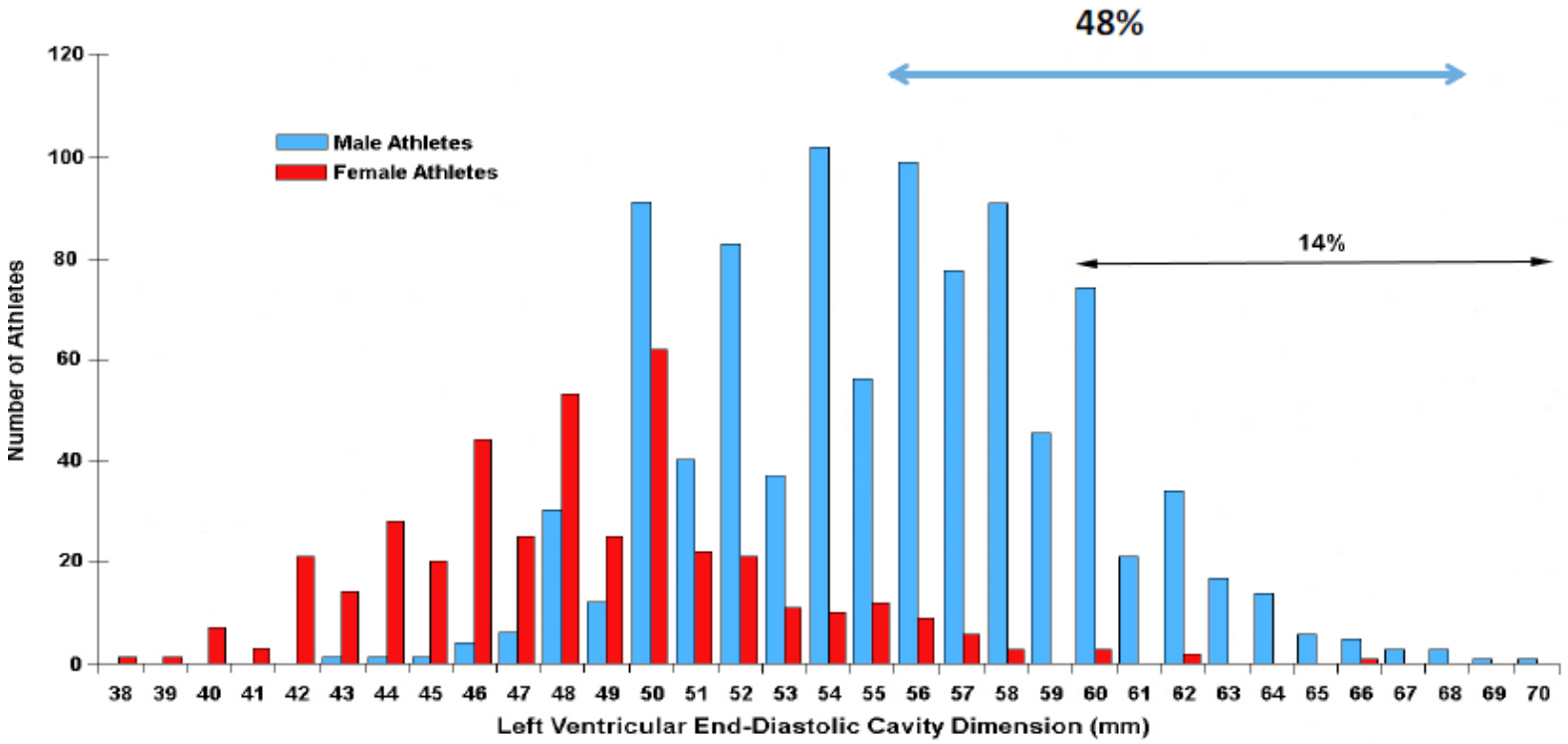
- Congenital
  - Hypertrophic cardiomyopathy
  - Other cardiomyopathies
  - Electrical disorders
    - Wolff-Parkinson-White
    - “Channelopathies”
  - Coronary anomalies
  - Connective tissue disorders
  - Heart valve disorders
  - Other
- Acquired
  - Coronary atherosclerosis
  - Cardiomyopathies
  - Hypertensive heart disease

Technical issues: Differentiating the athlete's heart from the abnormal heart



Pelliccia A et al. Ann Int Med. 1999; 130: 23-31
Slide courtesy S. Sharma, MD

Technical issues: Differentiating the athlete's heart from the abnormal heart



There is overlap between normal "athlete's heart" measurements and abnormal hearts

Clinical issue: Not all abnormal hearts will kill you

Clinical issue: Not all abnormal hearts will kill you

Eddy Merckx “The Cannibal” (b. 1945)

Clinical issue: Not all abnormal hearts will kill you

- “Merckx' cardiogram was “alarming” and at first Lavezzaro [cardiologist] thought it was from someone who had suffered a heart attack”
- Merckx: “On my father's side there are many heart problems. He and several uncles died young.”

But sudden cardiac death does happen…

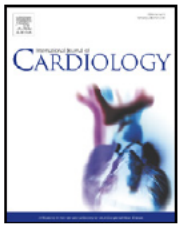
…rarely…

International Journal of Cardiology 223 (2016) 222–223

Contents lists available at ScienceDirect

International Journal of Cardiology

journal homepage: www.elsevier.com/locate/ijcard



Correspondence

Incidence of sudden cardiac death in professional cycling
Sudden cardiac death and exercise

Alejandro Santos-Lozano [a,b], Fabian Sanchis-Gomar [a,*], Nuria Garatachea [a,c,d], Ángel Arrarás-Flores [b], Helios Pareja-Galeano [a,f], Carmen Fiuza-Luces [a], Michael J. Joyner [e], Alejandro Lucia [a,f]

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[b] GIDFYS, Department of Health Sciences, European University Miguel de Cervantes, Valladolid, Spain
[c] Departamento de Fisiatría y Enfermería, Facultad de Ciencias de la Salud y del Deporte, GENUD (Growth, Exercise, Nutrition and Development) research group, Instituto Agroalimentario de Aragón –IA2– (Universidad de Zaragoza-CITA), Zaragoza, Spain
[d] Instituto Investigación Sanitaria Aragón (IIS Aragón) y Centro Investigación Biomédica en Red Fisiopatología de la Obesidad y Nutrición (CIBERObn), Spain
[e] Department of Anesthesiology, Mayo Clinic, Rochester, MN, USA
[f] European University, Madrid, Spain

…rarely…

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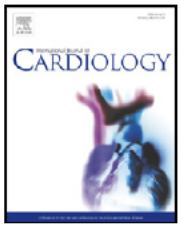

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Incidence of sudden cardiac death in professional cycling
Sudden cardiac death and exercise

“SCD appears to be a very rare phenomenon in professional cycling with a lower incidence compared with other sports and athletic cohorts e.g., all sports combined”

- 6/98 documented deaths were cardiac
- 0.007/100,000 participant-years in TdF

…rarely but…

- Non-race sudden cardiac death not counted
- Non-professional sudden cardiac death rarely attract media attention
- Professional cyclists are thoroughly screened (e.g., Eddy Merckx, 1968)
- “Acceptable risk” or “rare” is a personal judgment, and not rationally related to any specific rate or threshold of sudden cardiac death incidence

Screening versus evaluation

Screening

- Mass event
- Public health approach
- Compulsory/routine
- Relies on “screening test” → False +, -
- Ethical issues (“Who?”)
- Focused on decreasing rates

Evaluation

- Individual attention
- Clinical approach
- Voluntary
- May involve multiple tests from the get-go
- Open to anyone
- Focused on individual need/value/risk tolerance

Trouble in paradise?

Is too much exercise bad for you?

Are elite cyclists at greater risk of heart problems?

by Dr Andre La Gerche

January 11, 2017
Photography by Daniel Simms & Matt de Neef

It seems an almost regular occurrence in cycling that a rider is forced to retire as a result of heart issues. The past year has provided several such examples: Australian veteran Michael Rogers called timed on his career in April 2016 following the discovery of a previously unknown arrhythmia; Johan Vansummeren retired two months later due to a heart anomaly; and then, just two weeks ago, Gianni Meersman was forced off the bike due to a cardiac arrhythmia.

The good

European Heart Journal (2013) **34**, 3145–3150
doi:10.1093/eurheartj/eht347

FASTTRACK CLINICAL RESEARCH
Sports cardiology

Mortality of French participants in the Tour de France (1947–2012)

Eloi Marijon[1,2,3,4]*, Muriel Tafflet[1,2,5], Juliana Antero-Jacquemin[1,5], Nour El Helou[1,5,6], Geoffroy Berthelot[1,5], David S. Celermajer[7], Wulfran Bougouin[1,2,4], Nicolas Combes[8], Olivier Hermine[1,9,12,13], Jean-Philippe Empana[1,2], Grégoire Rey[10], Jean-François Toussaint[1,5,11†], and Xavier Jouven[1,2,3,4†]

[1]Paris Descartes University, Paris, France; [2]Paris Cardiovascular Research Center (PARCC), INSERM UMRS-970, Paris, France; [3]Cardiology Department, Georges Pompidou European Hospital and Assistance Publique–Hôpitaux de Paris (AP-HP), Paris, France; [4]Sudden Death Expertise Center, Paris, France; [5]Institut de Recherche BioMédicale et d'Épidémiologie du Sport (IRMES), Paris, France; [6]St Joseph University, Beirut, Lebanon; [7]University of Sydney, Sydney, Australia; [8]Clinique Pasteur, Toulouse, France; [9]Service d'hématologie Adultes, CNRS-UMR 8147, Hôpital Necker-Enfants-Malades, Paris, France; [10]CépiDc INSERM, Paris, France; [11]CIMS, Hôtel-Dieu, AP-HP, Paris, France; [12]Imagine, Institut des Maladies Génétiques, Paris, France; and [13]Laboratory of Excellence GR-EX, Paris, France

Received 4 July 2013; revised 19 July 2013; accepted 6 August 2013; online publish-ahead-of-print 3 September 2013

See page 3106 for the editorial comment on this article (doi:10.1093/eurheartj/eht373)

The good

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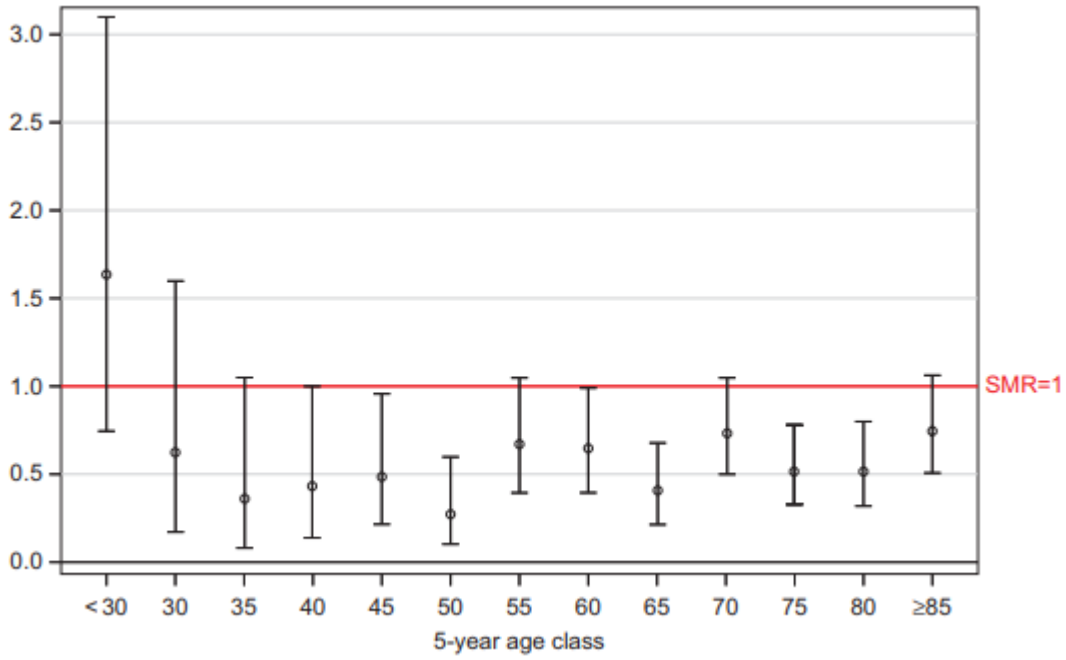
"Compared with the general population, we observed a 41% lower mortality in French cyclists"

The good

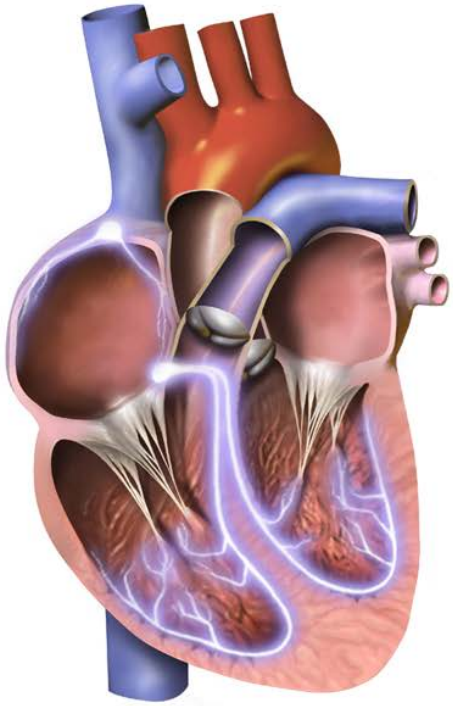

3.0
2.5
2.0
1.5
1.0
0.5
0.0
SMR=1
< 30
30
35
40
45
50
55
60
65
70
75
80
≥85
5-year age class

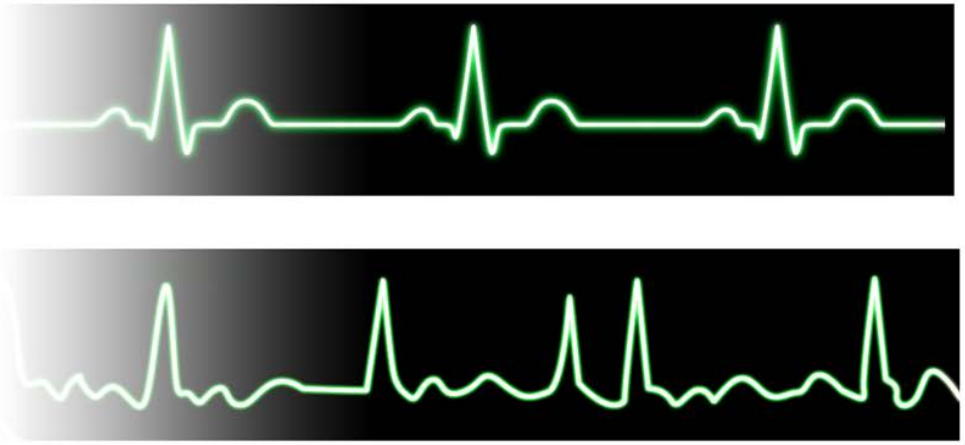
The good

Table I **Standardized mortality ratio by causes of death**

	Expected Death	Observed Death	SMR	95% CI
Infectious diseases	5.44	4	0.74	(0.20–1.88)
Neoplasms	106.01	59	0.56	(0.42–0.72)
Endocrine and nutritional diseases	6.90	4	0.58	(0.16–1.48)
Mental disorders	6.61	3	0.45	(0.09–1.33)
Nervous system diseases	9.05	4	0.44	(0.12–1.13)
Cardiovascular diseases	78.87	53	0.67	(0.50–0.88)
Respiratory system diseases	17.87	5	0.28	(0.09–0.65)
Digestive system diseases	18.21	4	0.22	(0.06–0.56)
Musculoskeletal diseases	1.11	1	0.90	(0.02–5.02)
Genitourinary system diseases	3.66	2	0.55	(0.07–1.98)
Ill-defined conditions	14.03	8	0.57	(0.25–1.12)
External causes	27.29	29	1.06	(0.71–1.53)

The bad





Atrial Fibrillation

Graphic courtesy BruceBlaus via Wikimedia

The bad

European Heart Journal (2008) **29**, 71–78
doi:10.1093/eurheartj/ehm555

CLINICAL RESEARCH
Arrhythmia/electrophysiology

Sinus node disease and arrhythmias in the long-term follow-up of former professional cyclists

Sylvette Baldesberger[1], Urs Bauersfeld[2], Reto Candinas[1], Burkhardt Seifert[3], Michel Zuber[4], Manfred Ritter[5], Rolf Jenni[6], Erwin Oechslin[6], Pia Luthi[1], Christop Scharf[1], Bernhard Marti[7], and Christine H. Attenhofer Jost[1]*

[1]Cardiovascular Center Zurich, Klinik Im Park, Seestr. 220, 8027 Zurich, Switzerland; [2]Division of Cardiology, University Children's Hospital, Zurich, Switzerland; [3]Department of Biostatistics University of Zurich, Zurich, Switzerland; [4]Outpatient Clinic Othmarsingen, Zurich, Switzerland; [5]HerzZentrum Hirslanden, Zurich, Switzerland; [6]Division of Cardiology, University Hospital Zurich, Zurich, Switzerland; [7]Institute of Sports Science Magglingen, Zurich, Switzerland

Received 6 February 2007; revised 16 October 2007; accepted 5 November 2007; Online publish-ahead-of-print 7 December 2007

The bad

- Atrial fibrillation:
  - More than 5 times more common among veteran endurance athletes than in the general, healthy but less active population
  - 5-8% of long-term endurance athletes go on to developing atrial fibrillation
  - Atrial fibrillation impacts ability to pursue high level endurance activities and interferes with quality of life.

The bad

- Atrial fibrillation
  - Predictors of AF:
    - Male, low resting heart rate, tall stature, large left atrium
    - Other factors: Inflammation?.. Atrial fibrosis?... Stimulants?...

    →Difficult to predict/anticipate

    → Seems to respond well to standard treatment for AF, including ablation.

The ugly

EDITORIAL

Coronary Artery Calcification Among Endurance Athletes

"Hearts of Stone"

EDITORIAL

Articles, see p 126 and p 138

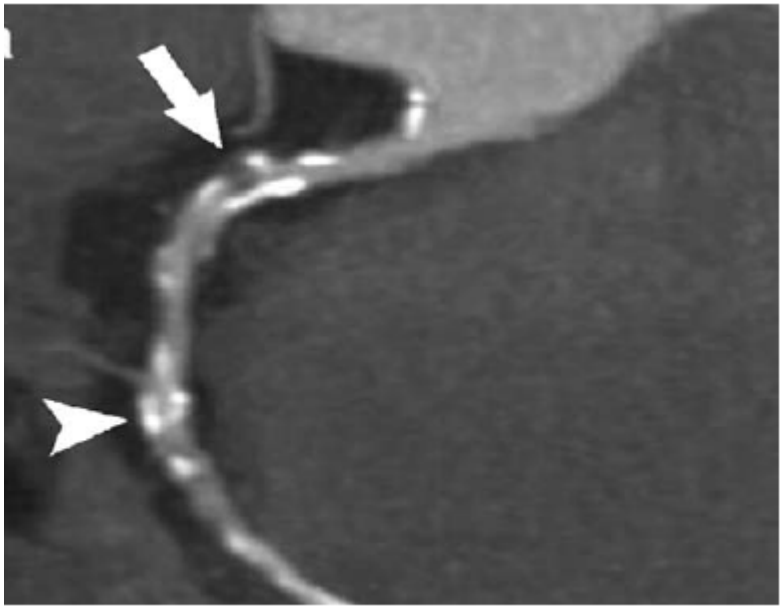
Aaron L. Baggish, MD
Benjamin D. Levine, MD

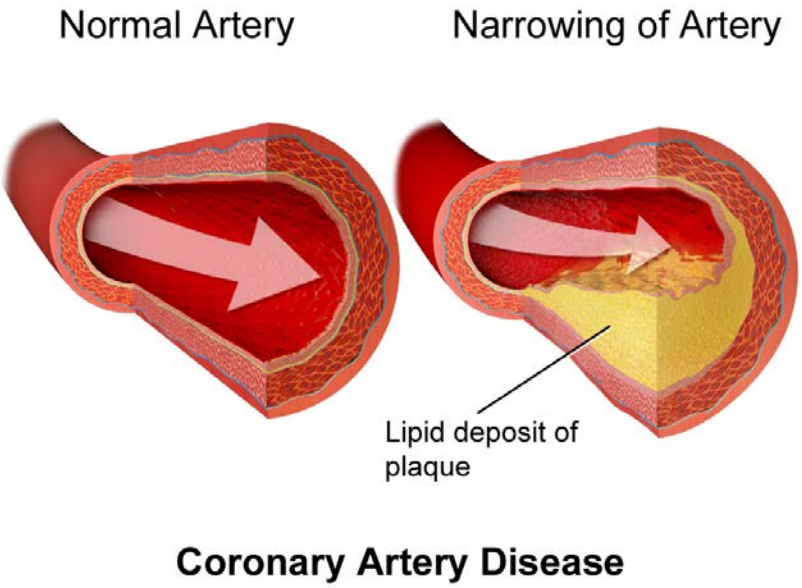
…cause you'll never break, never break, never break, this heart of stone.
—Mick Jagger and Keith Richards, The Rolling Stones, *Heart of Stone*, 1964

Routine moderate-intensity exercise reduces incident cardiovascular disease and increases longevity. The complex mechanisms by which exercise promotes favorable cardiovascular health outcomes include attenuation of traditional atherosclerotic risk factors including dyslipidemia, hypertension, central adiposity, and glucose intolerance. As such, current physical activity guidelines

Circulation. 2017;136:149–151

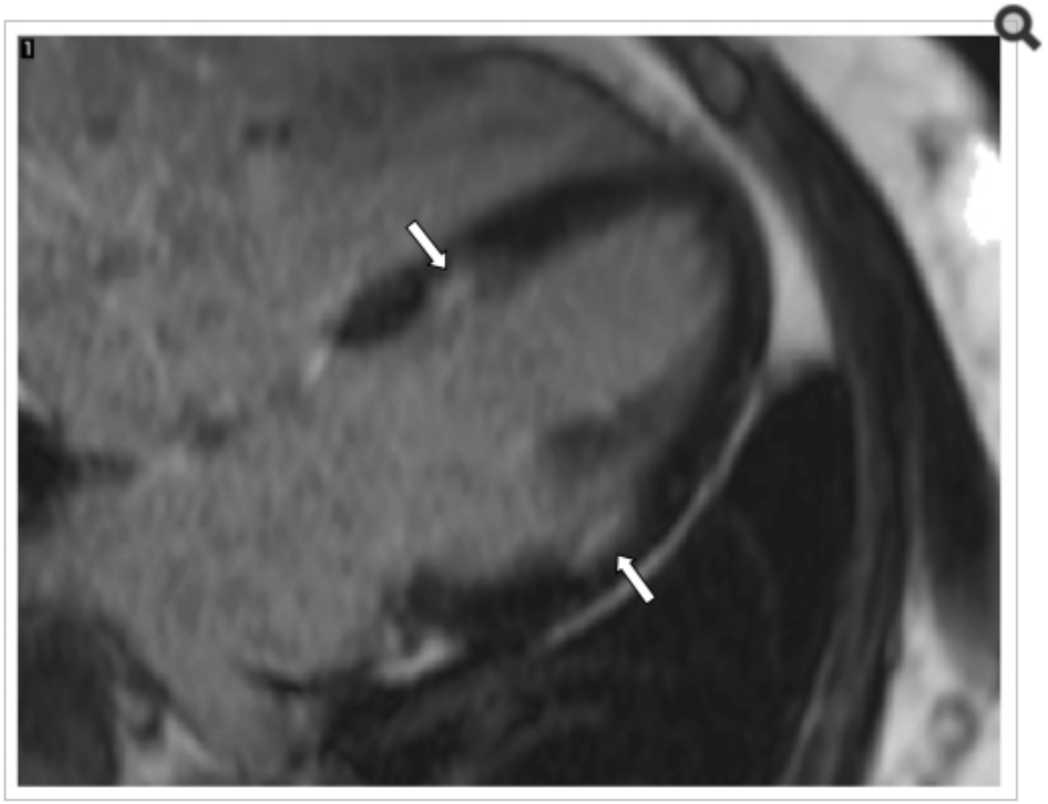
The ugly





Asymptomatic coronary calcifications detected by CT

The ugly



Asymptomatic myocardial fibrosis (scar) detected by MRI

Wilson M. et al. *Journal of Applied Physiology*. 2011;110(6):1622-1626.

The ugly

- Middle-aged, Master's level male endurance athletes
  - Have more coronary calcifications, more plaques, and more bulky plaques than healthy, more sedentary controls.
  - Have more evidence of scar in the heart muscle that may indicate prior (silent) heart attacks (14% vs 0%)
- There is a positive relationship between the lifelong "volume of exercise" and the amount of coronary calcification in middle-aged men.

The good + the bad + the ugly

- No firm conclusion can be drawn regarding the overall impact of lifelong high-intensity endurance training, except for a higher risk of atrial fibrillation.
- A subset of men seem to be prone to coronary calcifications, plaques, and heart scars. Significance uncertain…
- That subset may (or may not) be identified through periodic testing.

Conclusions

- Long term endurance exercises leads to specific cardiac adaptations (“Athletes Heart)
- Features of the athlete’s heart overlap with those of the abnormal heart
- Screening is tricky and best left as a personal decision. ***Most beneficial if paired with commitment to healthy living***
- A few clouds on the horizon but generally bright skies for the amateur and professional cyclist.

Thank you!