Effects of Physical Activity on the Heart

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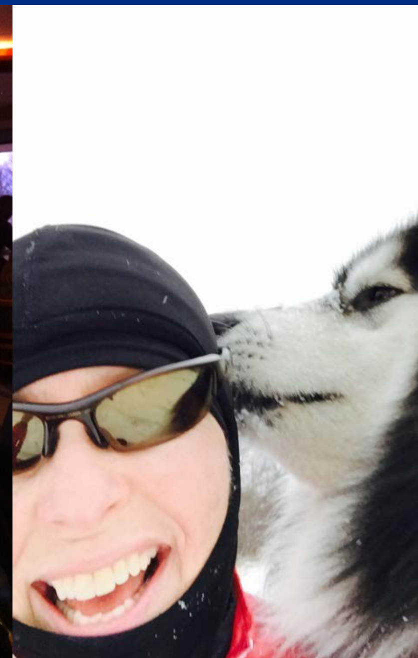
Disclosures






I love running!

Learning objectives

- Review the effects of physical activity on the heart and cardiovascular system
- Understand the current debate regarding “dose” of exercise
- Provide guidelines for current patient recommendations

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Question:

Do you try to exercise vigorously at least 3 days per week or accumulate at least 30 minutes of moderate physical activity per day?

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Does Exercise Prevent Cardiovascular Disease over a Lifetime in Healthy People?

→

Harriette Thompson; 92 yo female
completed San Diego Rock 'n Roll Marathon 2015
Time: 7:24:36

- This is principally an epidemiologic question
- Large, long-term randomized clinical trials are not feasible

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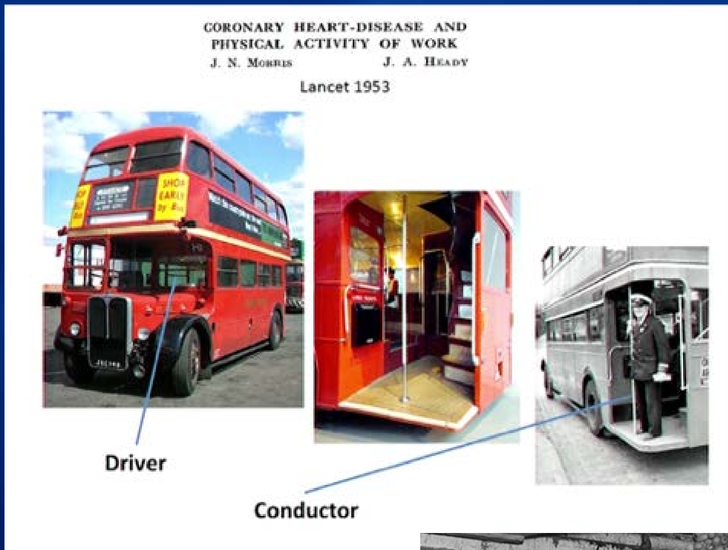
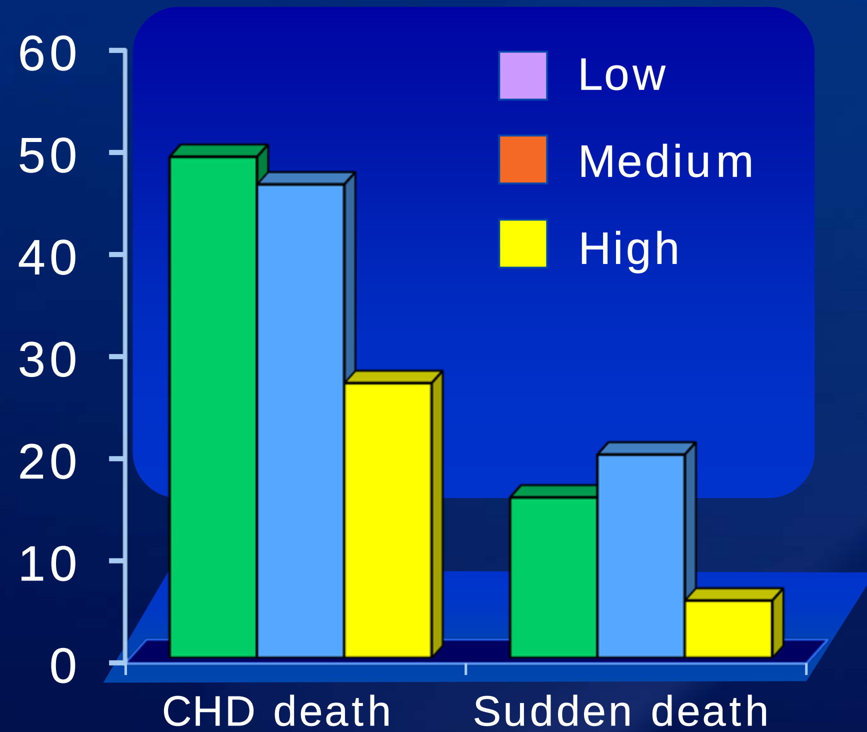
CHD and Physical Activity of Work



Physical Activity at Work and CHD Deaths in 6,451 Longshoremen



Paffenbarger RS et al. *N Engl J Med.* 1975;292:545-550.

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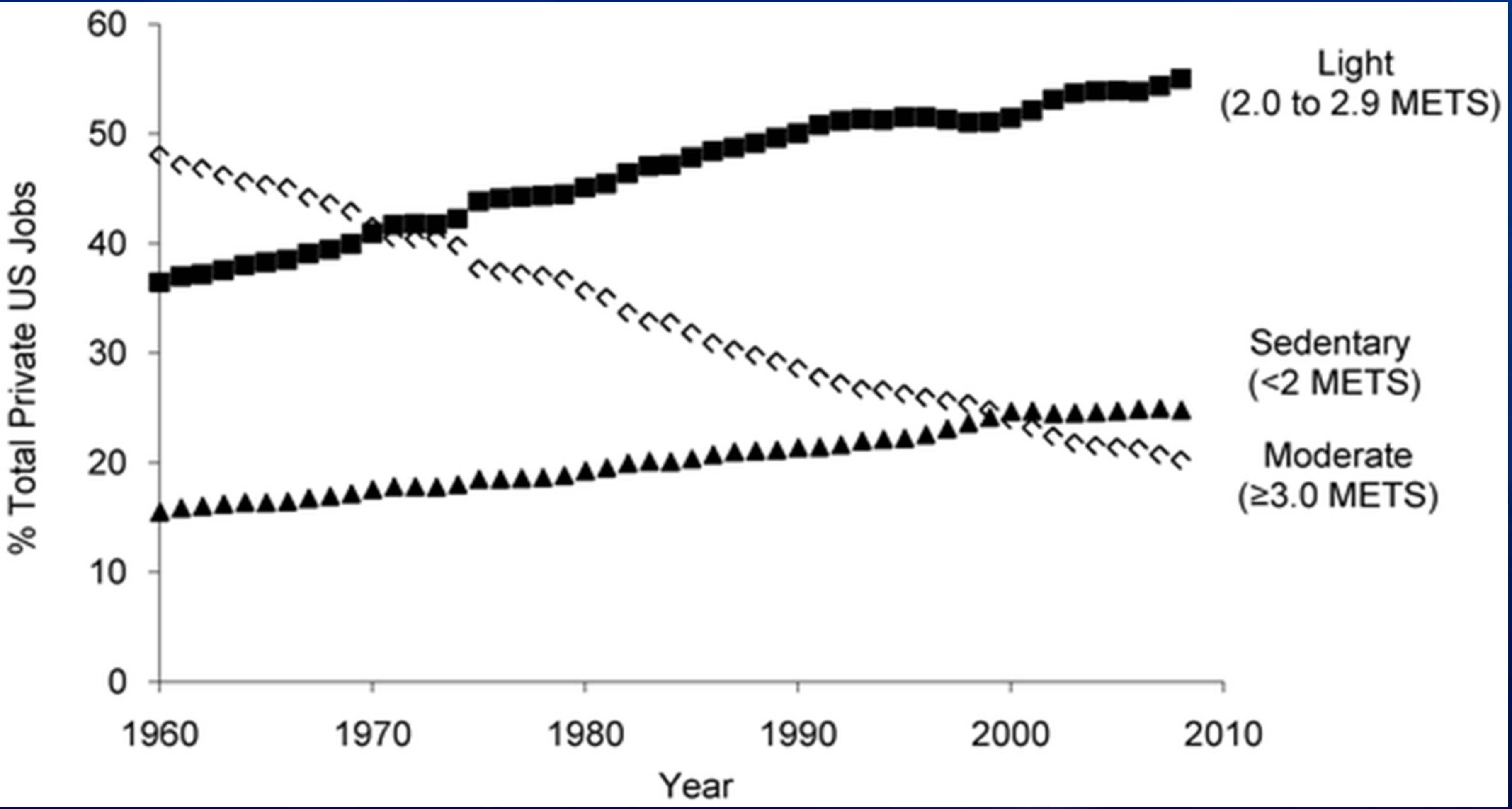
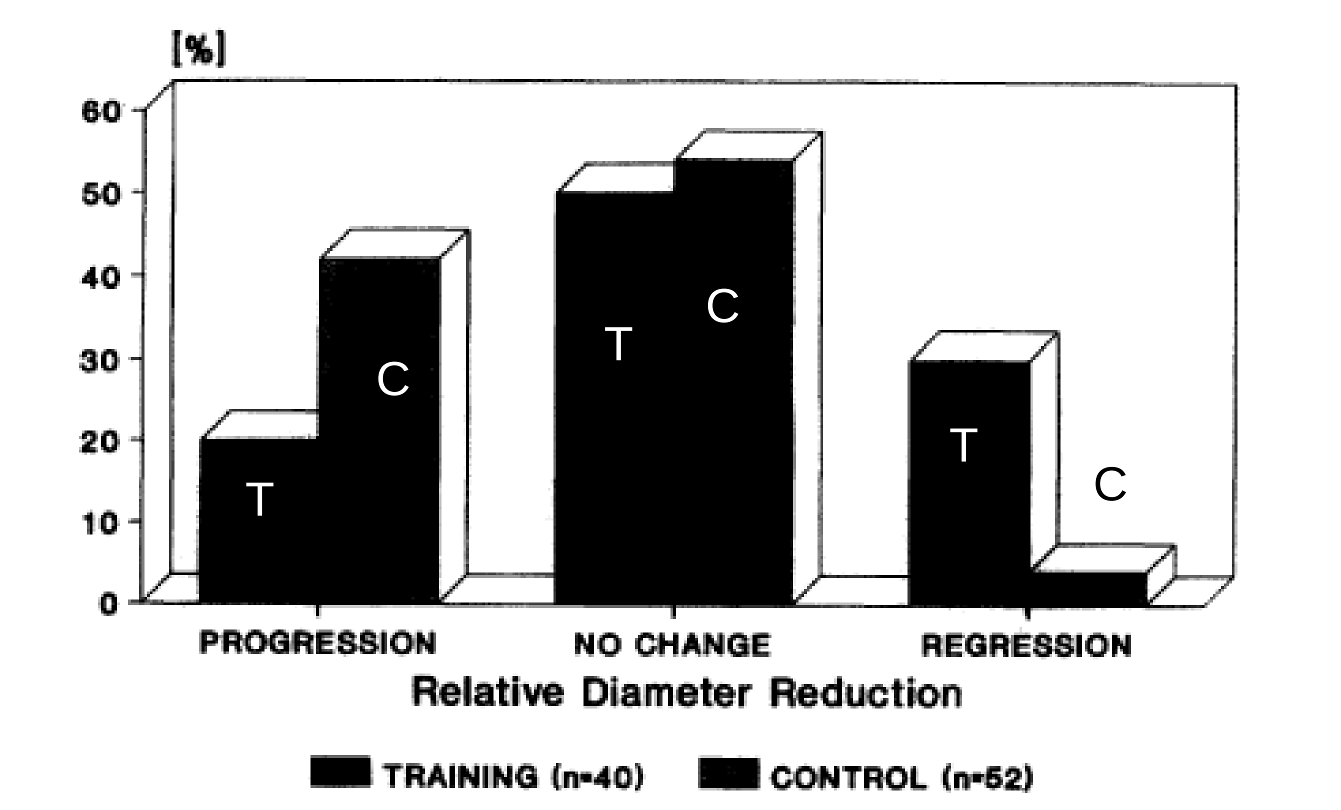
Occupational Activity 1960-2010



Church et al PLOS1 2011

Effect of Exercise on Coronary Artery Disease Progression

- 113 patients with stable angina randomized
- 12 month training program versus usual care



Schuler G et al. *Circulation* 1992:86:1-11

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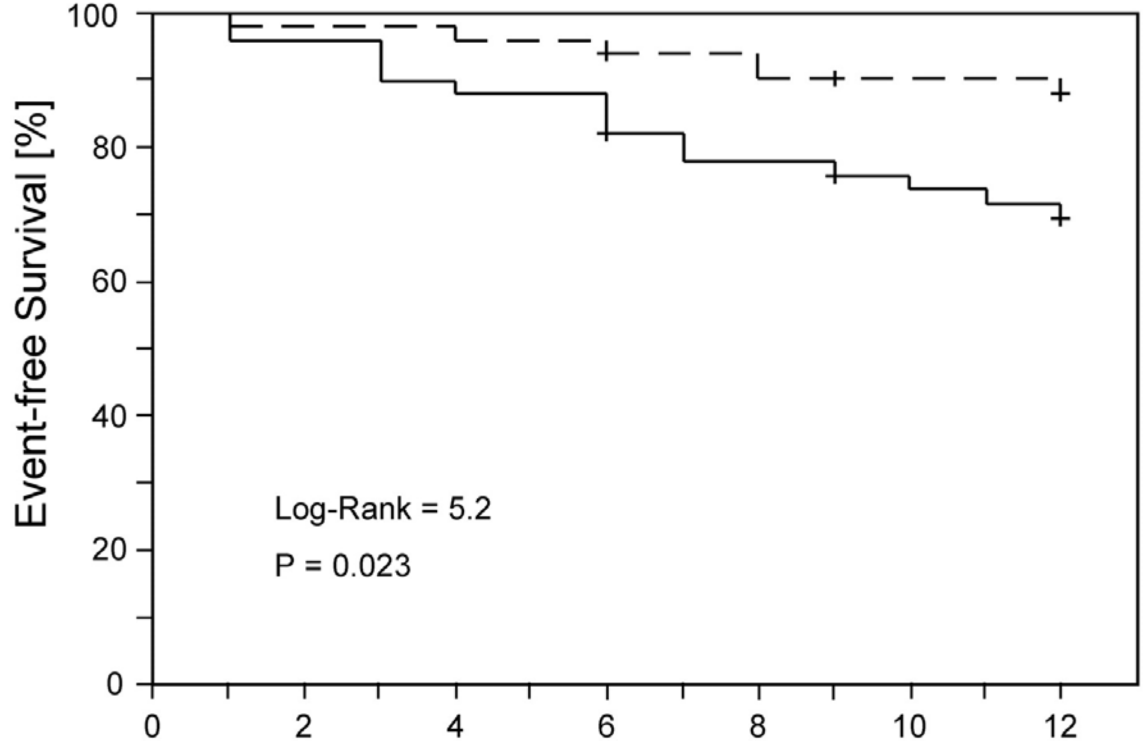
Exercise Training vs. PCI



Patients at Risk	0	6	12
PTCA/Stent Group	50	41	35
Exercise Training Group	51	48	45

Follow up [Months]

American Heart Association

Rainer Hambrecht et al. Circulation. 2004;109:1371-1378

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Effect of Exercise on Coronary Artery Disease Progression

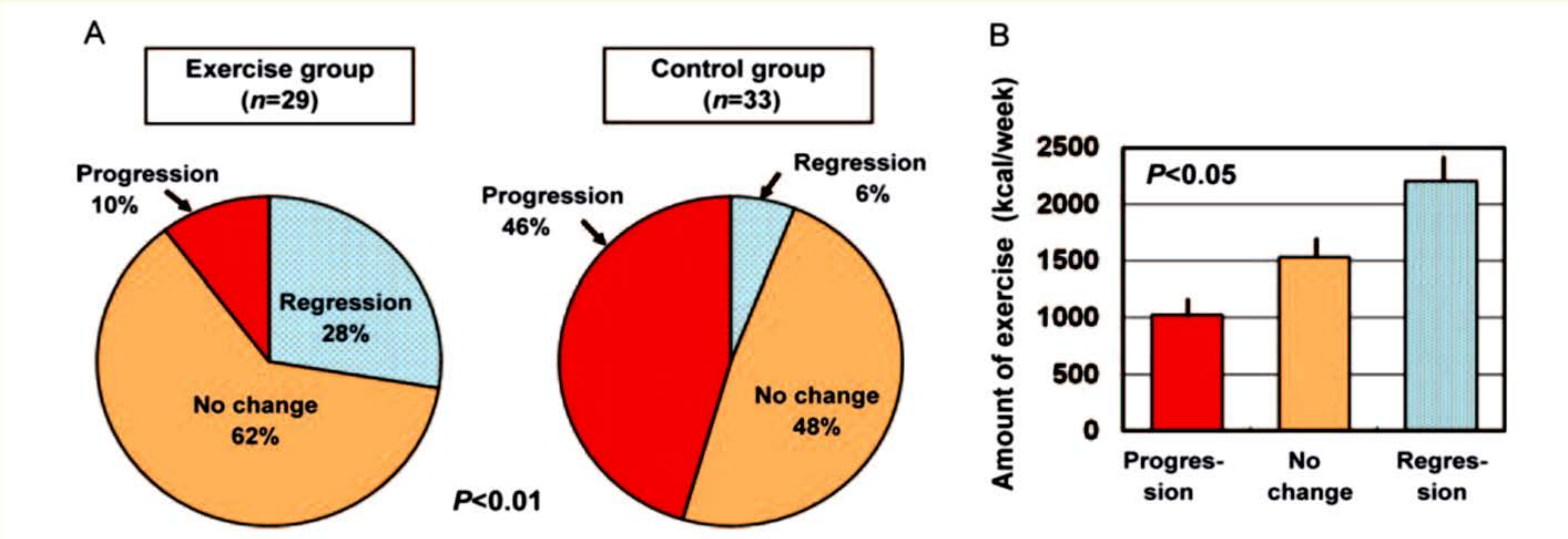

Figure 1 (*A*) Attenuation of progression of coronary atherosclerotic lesions by 12-month exercise training/physical activity in patients with coronary artery disease. (*B*) The relation between amount of exercise (expressed by energy expenditure) and changes in coronary lesions. Higher levels of exercise training/physical activity were associated with a halt of progression, or even regression, of coronary lesions. (Constructed according to data in Suaya *et al.*[30])

Schuler et al. doi:10.1093/eurheartj/eht111; April 7, 2013

Benefits of Physical Activity on Coronary Risk Factors

- Improved blood lipids
  - ↑ HDL-cholesterol
  - ↓ Triglycerides
  - ↓ Small, dense LDL-cholesterol
- Decreased blood pressure
  - ~ 4/4 mmHg in normotensive subjects
  - ~ 11/6 mmHg in hypertensive subjects
- Improved insulin resistance
- Reduced visceral adiposity
- Reduced hs-CRP

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Comparison of Coronary Arteries in Runners versus Inactive Men

- 11 inactive male volunteers
- 11 male ultradistance runners

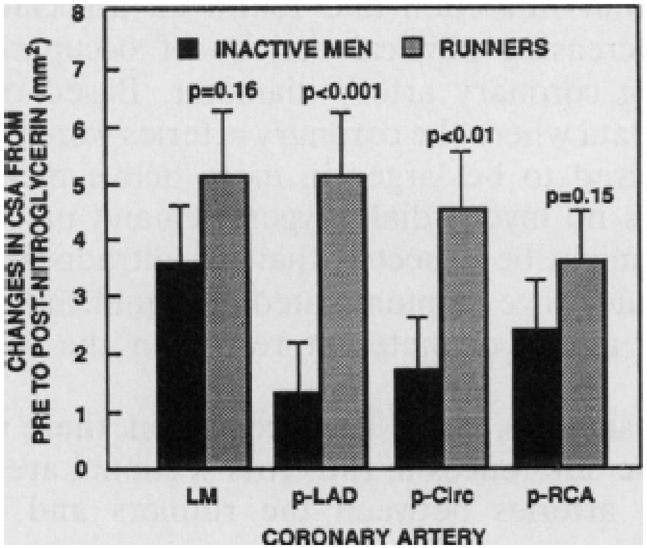

FIGURE 1. *Changes between before and after nitroglycerin in the cross-sectional area (CSA) (mm^2) for the left main (LM) and proximal left anterior descending (p-LAD), circumflex (p-Circ), and right (p-RCA) coronary arteries in physically inactive men and ultradistance runners.*

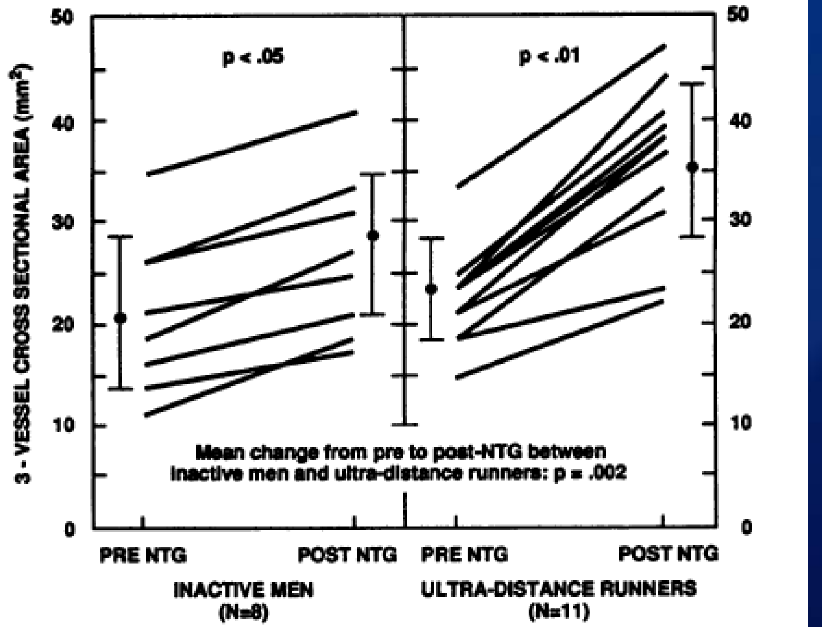

FIGURE 2. *Combined cross-sectional area (CSA) (mm^2) of the proximal right, left anterior descending, and circumflex coronary arteries before and after nitroglycerin for physically inactive men and ultradistance runners.*

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Haskell W et al. *Circulation* 1993:87:1076-1082

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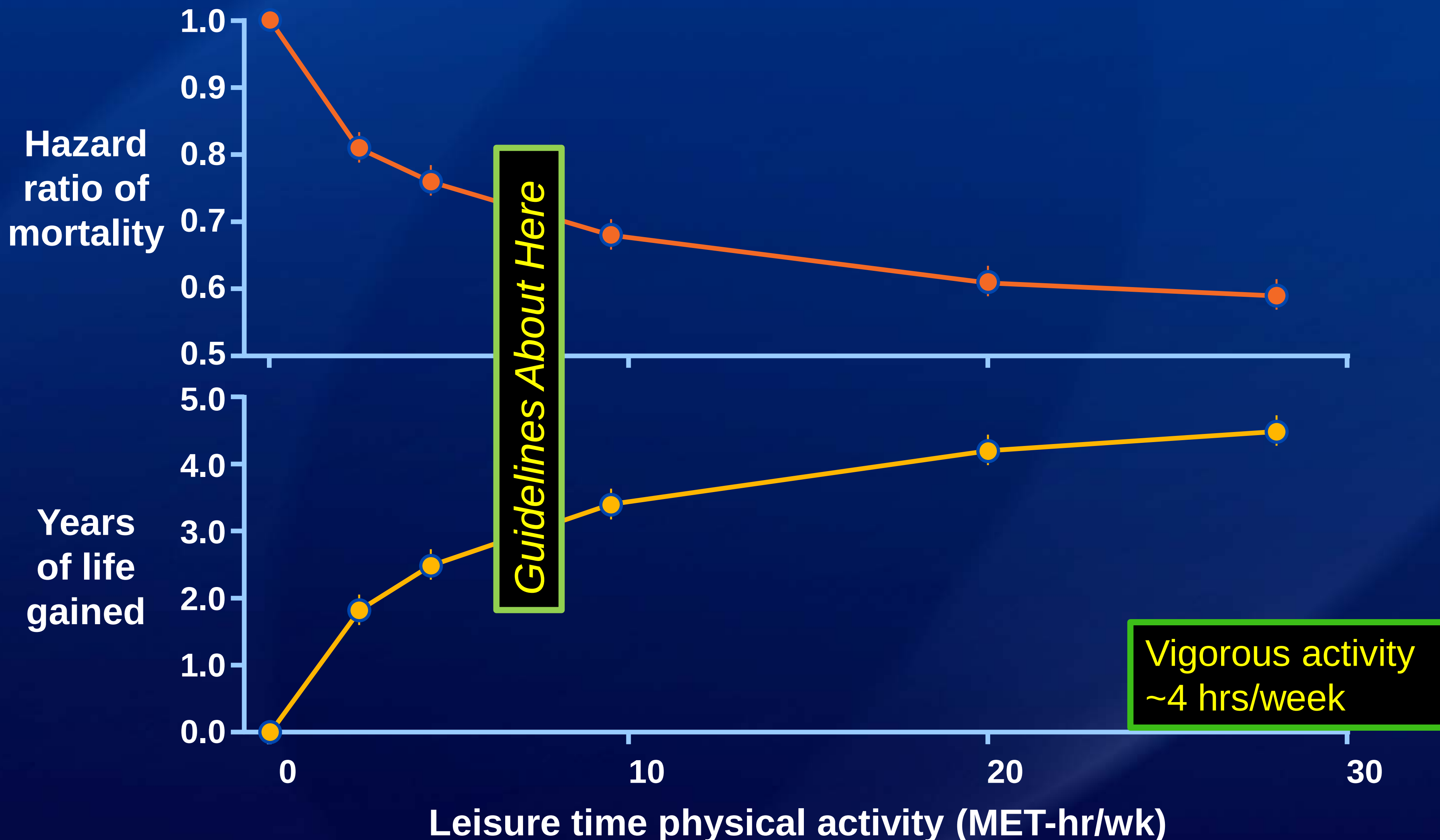
Physical Activity, Mortality & Longevity

650,000 Adults (Swedes & US, >40 yo)



Moore et al PLoS Med 2012

“Is it possible to have too much of a good thing?”

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Potential adverse cardiovascular effects from excessive endurance exercise

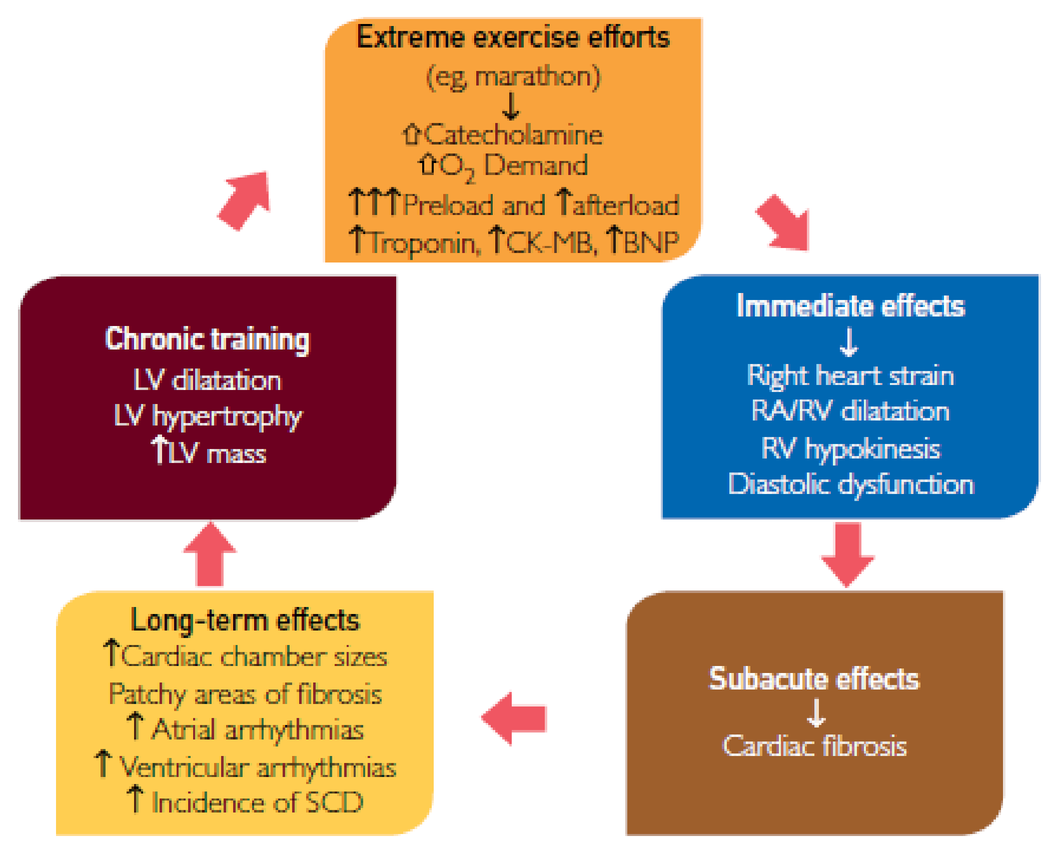

FIGURE 7. Proposed pathogenesis of cardiomyopathy in endurance athletes. BNP = B-type natriuretic peptide; CK-MB = creatine kinase MB; LV = left ventricle; RA = right atrium; RV = right ventricle; SCD = sudden cardiac death.

O'Keefe JH, *Mayo Clin Proc 2012;* 87:587–595

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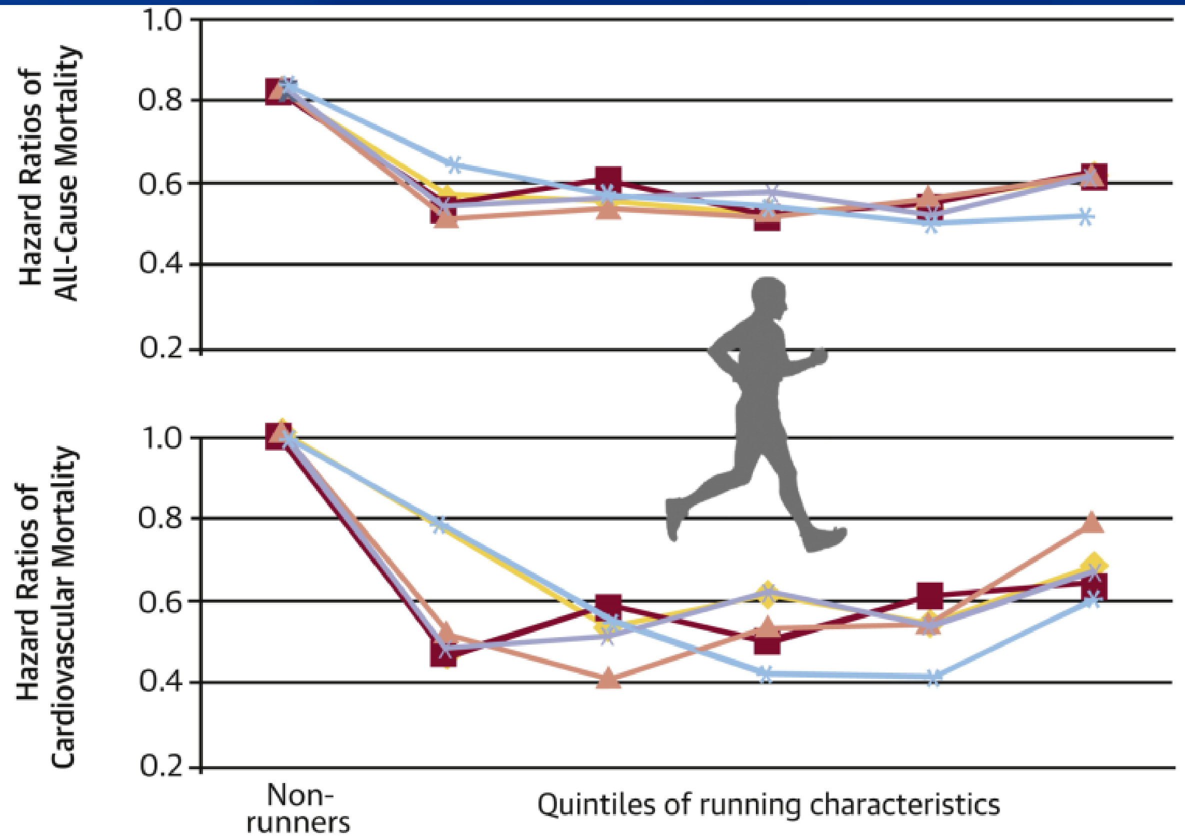
Leisure-Time Running Reduces All-Cause & CV Mortality Risk 55,137 adults, 18 -100 years of age (mean age 44)



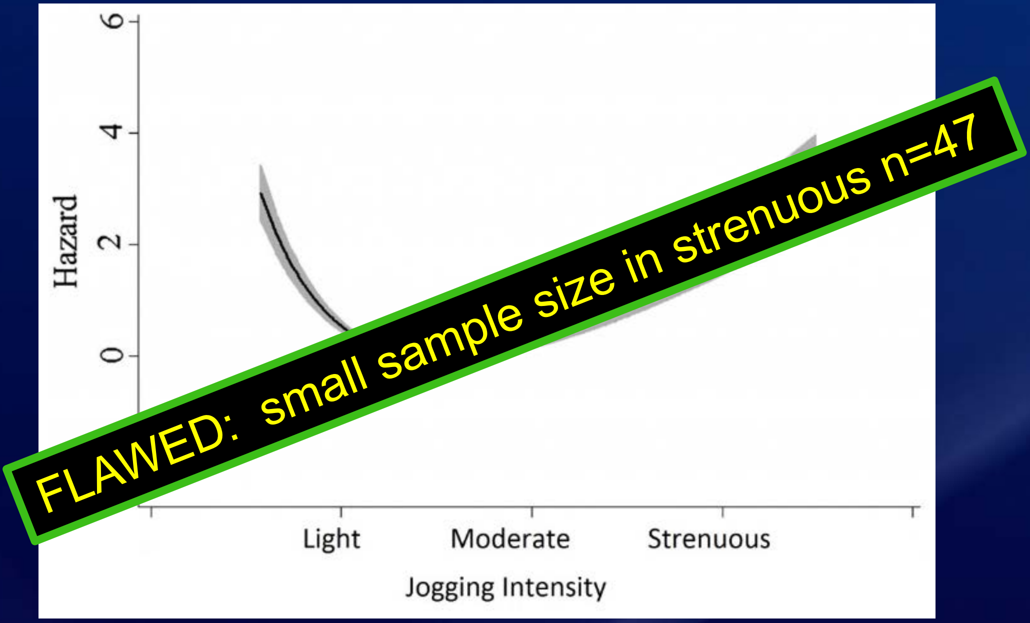
Time (min/wk)	0	<51	51-80	81-119	120-175	≥176
Distance (miles/wk)	0	<6	6-8	9-12	13-19	≥20
Frequency (times/wk)	0	1-2	3	4	5	≥6
Total amount (MET-min/wk)	0	<506	506-812	813-1199	1200-1839	≥1840
Speed (mph)	0	<6.0	6.0-6.6	6.7-7.0	7.1-7.5	≥7.6

Lee D, Blair S. J Am Coll Cardiol. 2014;64(5):472-481

Dose of Jogging and Long-Term Mortality The Copenhagen City Heart Study

1,098 healthy joggersl 3,950 healthy nonjoggers prospectively followed since 2001

- Light joggers – HR = 0.22; 95% CI = 0.10 to 0.47
- Moderate joggers – HR = 0.66; 95% CI = 0.32 to 1.38
- Strenuous joggers – HR = 1.97; 95% CI = 0.48 to 8.14



Schnohr P, J Am Coll Cardiol 2015;65:411–9

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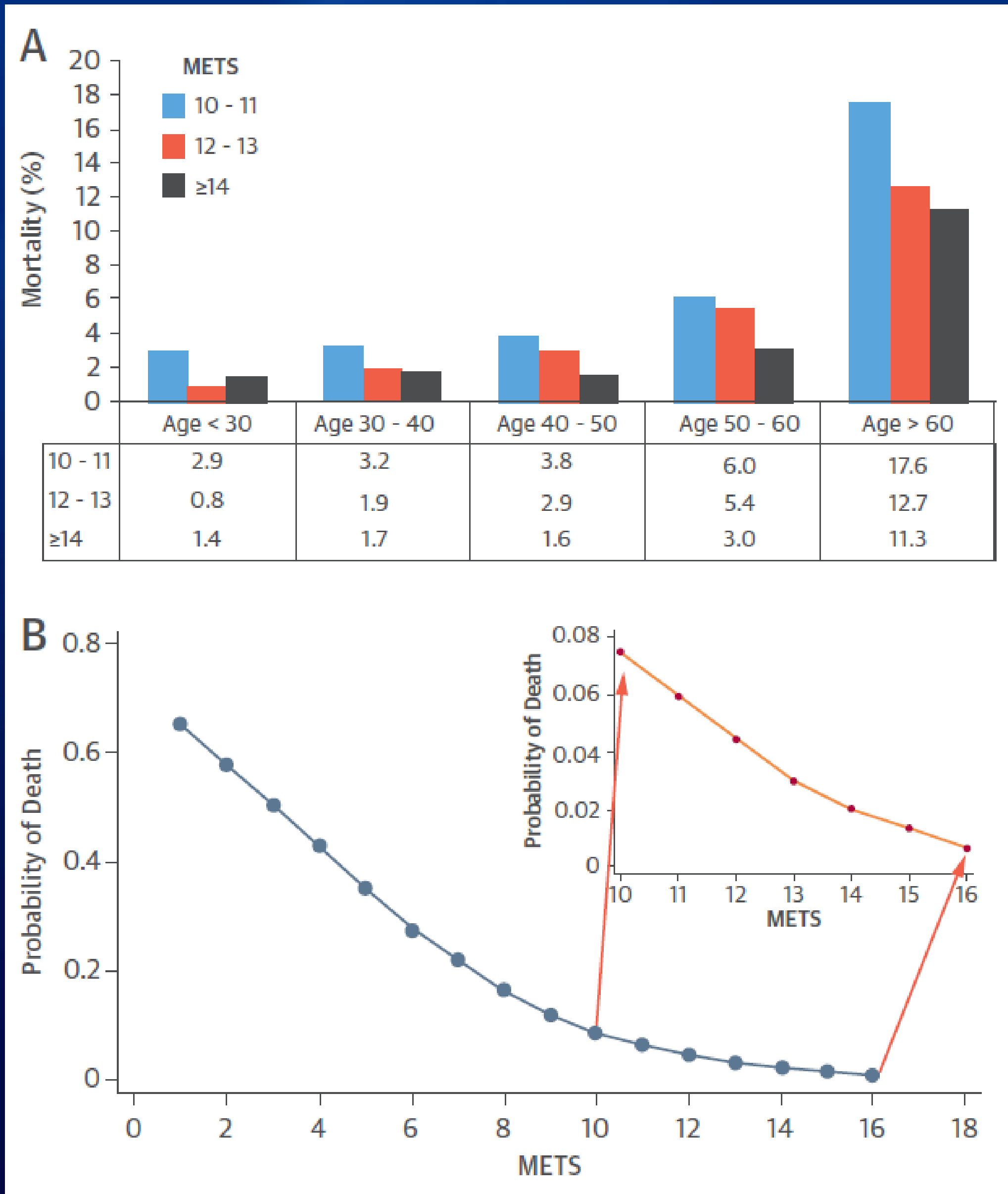
Too Much Exercise?



The FIT study, Detroit
N= 37,855. no CVD, high fitness
Mean age 50, 2/3 males

No upper threshold for mortality benefit w/ increasing fitness, even in the most highly fit subjects

"Our data caution against any public health message that might dissuade patients from routine vigorous physical activity with the goal of reaching the highest levels of cardiorespiratory fitness"

Feldman et al JACC 2015

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Physical activity in Extreme Environments

Let's move!

Microgravity wreaks havoc on the body. Astronauts in space work out 2 hours per day to keep their bones and muscles strong.

heart & vascular system

#LifeInOrbit

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196
102

Molecular Mechanisms of Exercise Training

- Endothelial function and NO availability
- Endothelial repair by stem cells
- Reduced arterial stiffness
- Increased production of microRNA
- Collateral growth

Schuler G et al. doi:10.1093/eurheartj/eht111; April 7, 2013

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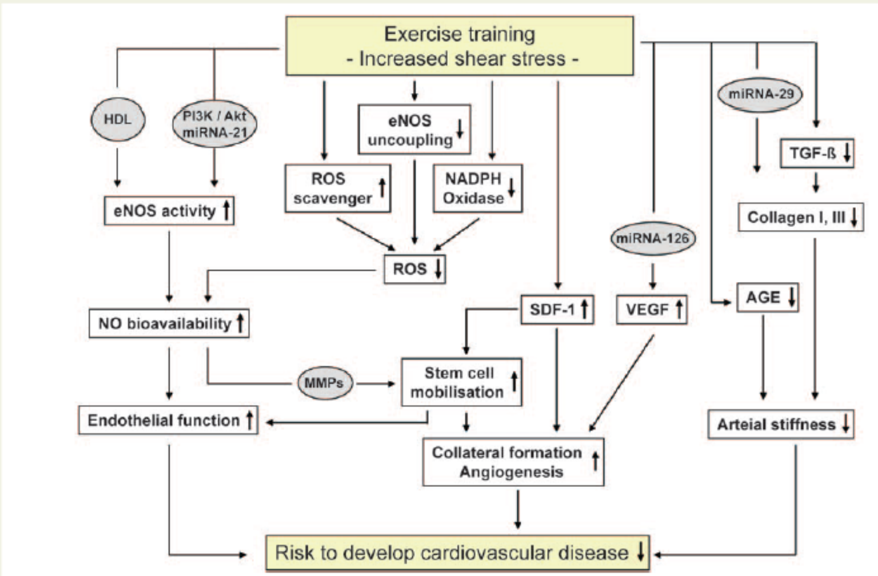

Figure 2 Possible signalling pathways how the beneficial effects of exercise training are translated into a reduced risk of developing vascular disease.

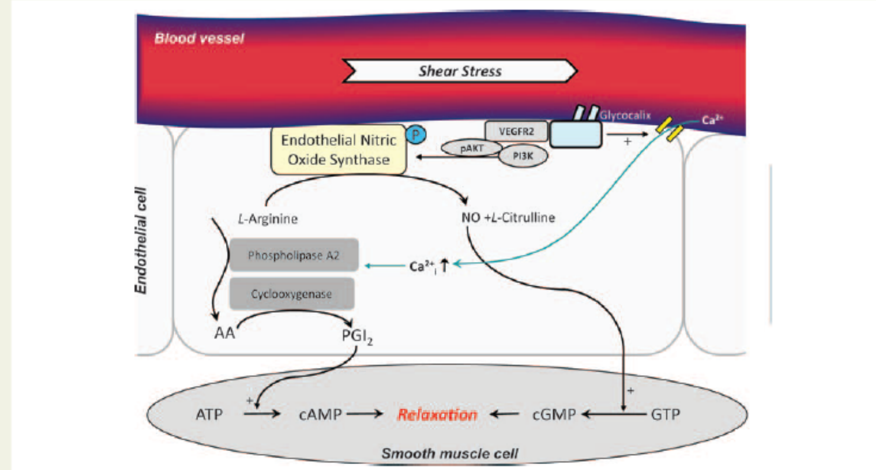

Figure 3 The majority of exercise effects on the vascular endothelium are mediated by intermittent increases of laminar shear stress. On the luminal side of the endothelial cells, direct signalling can occur through deformation of the glycocalyx activating phospholipase activity via an increase in intracellular Ca^{2+}, prostaglandin I2 (PGI2) release, and cAMP-mediated smooth-muscle-cell relaxation. VEGF receptor 2 (VEGFR2) can activate PI3K to phosphorylate Akt and induce AKT-mediated eNOS phosphorylation, leading to higher NO production. Akt indicates protein kinase B; AA, arachidonic acid; VEGF, vascular endothelial growth factor.

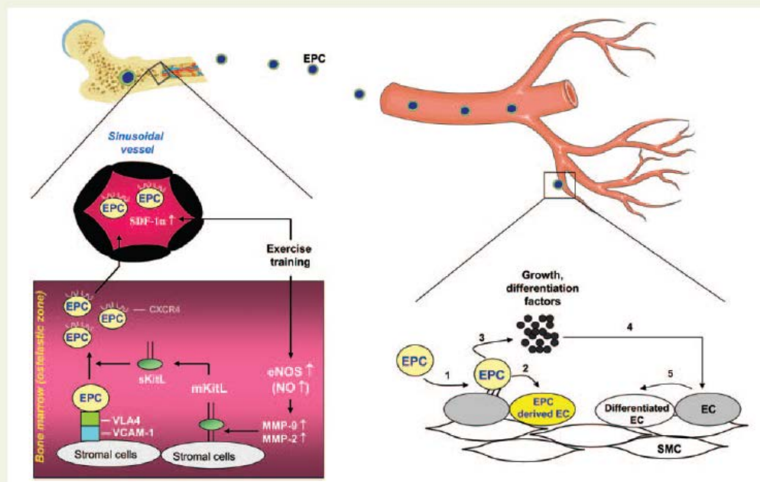

Figure 4 Exercise-induced mobilization of EPCs from the bone marrow leading to arteriogenesis or endothelial cell repair. Exercise-induced activation of eNOS and subsequently of MMP-2/9 results in the release of soluble cKit-ligand (sKitL). SkitL confers signals enhancing mobility of EPCs. Along an SDF-1 gradient, the EPCs are mobilized into the peripheral circulation. Once mobilized, the EPCs follow a gradient of SDF-1 or other factor to the site needed, where they bind to mature endothelial cells (EC) via specific cell-surface marker (1). After binding to EC, the EPC may have to find possible pathways to repair the damage in the endothelial cell layer. First, it fills in the gap and differentiates into a mature endothelial cell (2) or secondly it secretes growth differentiation factors (3) which in turn stimulate mature endothelial cells (4) to proliferate and thereby closing the gap in the endothelial cell layer (5). EPC, endothelial progenitor cells.

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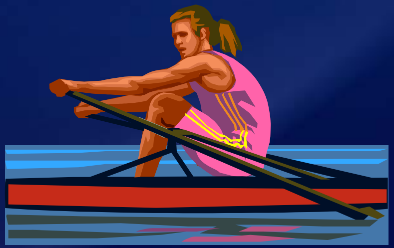
Schuler G et al. doi:10.1093/eurheartj/eht111; April 7, 2013

“The Athlete’s Heart”

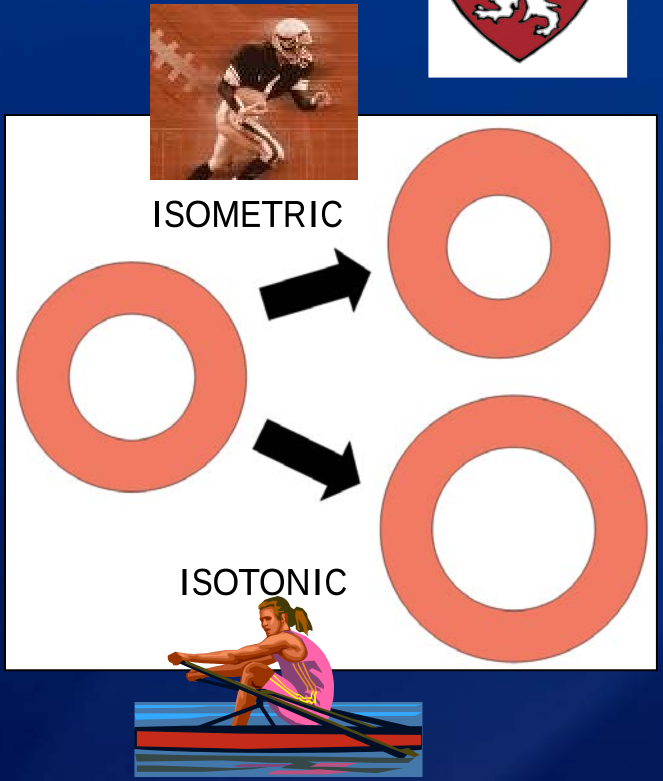
P Douglas, 1999

- Increased heart chamber sizes
- Thicker heart muscle
- Improved relaxation of heart
- “sucker heart”
- Slow heart rate



Cardiac Structural Adaptation to Intensive Training

- <u>Hypertrophy</u>
  - Eccentric
  - Concentric
  - Balanced
- Changes in cardiac dimensions:
  - <u>→⇑ RA/LA/LV dimensions</u>
  - <u>→⇑Diastolic function: “sucker” vs. “pusher” heart</u>



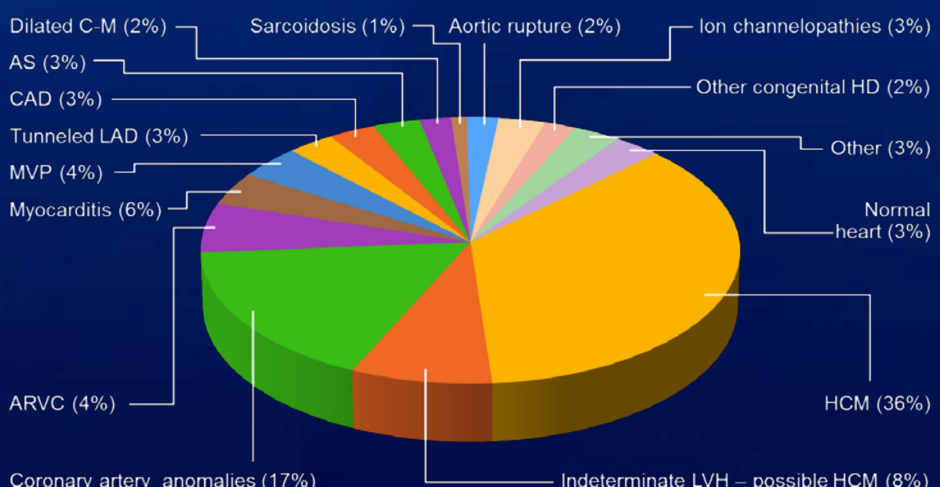
Baggish A, J Applied Physiology 2008

Pluim et al. *Circulation 1999*

Barbier J et al. *Eur J of Cardiovascular Prevention and Rehabilitation 2006*

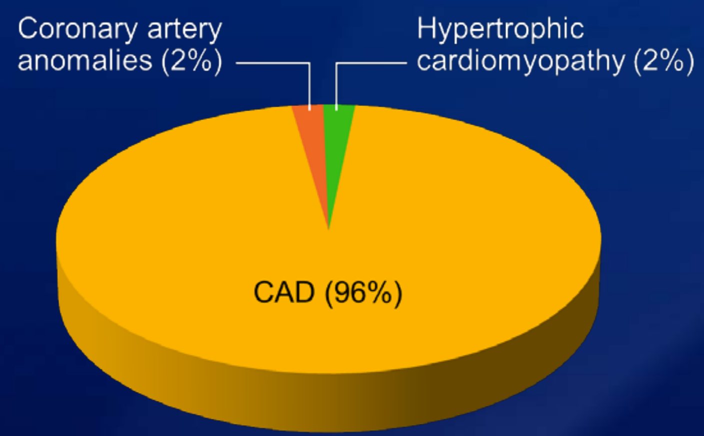
CV Causes of Sudden Death

1,435 Young Competitive Athletes



Maron BJ: Circulation 2007;115:1643

Older (Ages 31-65) Athletes



Waller: Exercise and the Heart, 1985


682
1169
8956

EXTREME PHYSICAL ACTIVITY
The Marathon

Pheidippides: Marathon -> Athens 490BC

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Marathon Running Physiology

- Unique blend of intensity and duration
  - Fast enough pace to require high VO2max
    - < 5:00/mile in elite men; < 5:30/mile in elite women
  - Long enough to cause problems with substrate availability
- Confounding problems
  - Heat transfer and hydration in warm conditions
    - Anything above 55°F

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Effects of Marathon Running on the Heart of “non-elite” athletes

MJ Wood 2006

- Boston Marathon 2004-5 (30/yr)
- Portable echos
- Blood tests
- Population Characteristics
    - 41 males, 19 females
    - Mean age: 41years (21-65 years)
    - Mean training mileage: 42 $\pm$ 9 mi/wk
    - avg finish time: 4hr 5 mins (range 2 hr 55mins to 5hr 55mins)

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Effects of Marathon Running on the Heart of “non-elite” athletes

MJ Wood 2006

- Transient alterations in systolic and diastolic function right > left ventricle
- Elevation of cardiac biomarkers
  - used to diagnose MI, CHF
  - **These findings were directly associated with training mileage: <35-40 miles/wk**

Circulation Nov 2006; Eur Heart J May 2006

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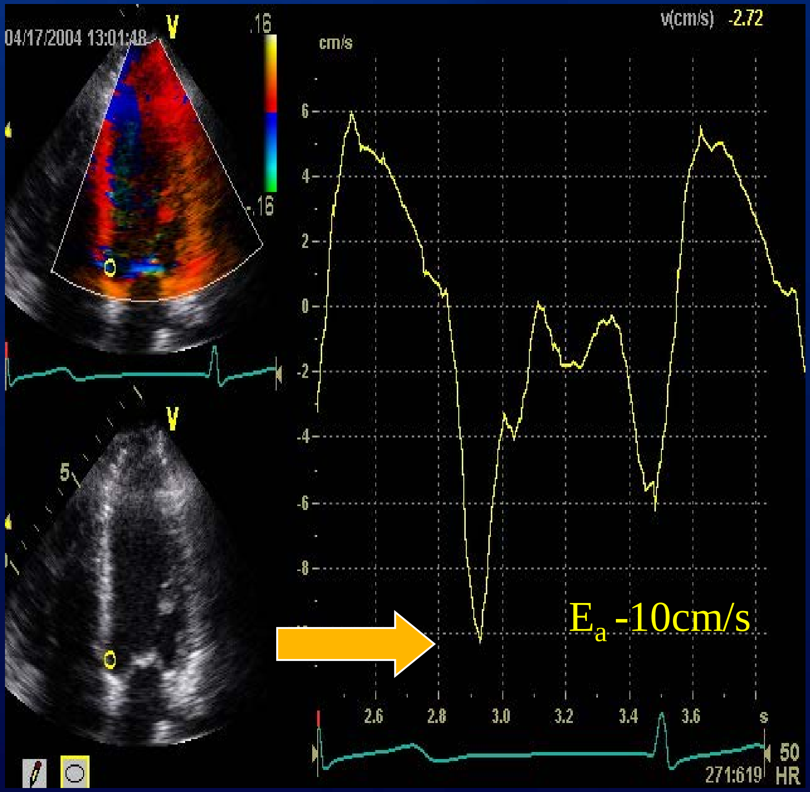
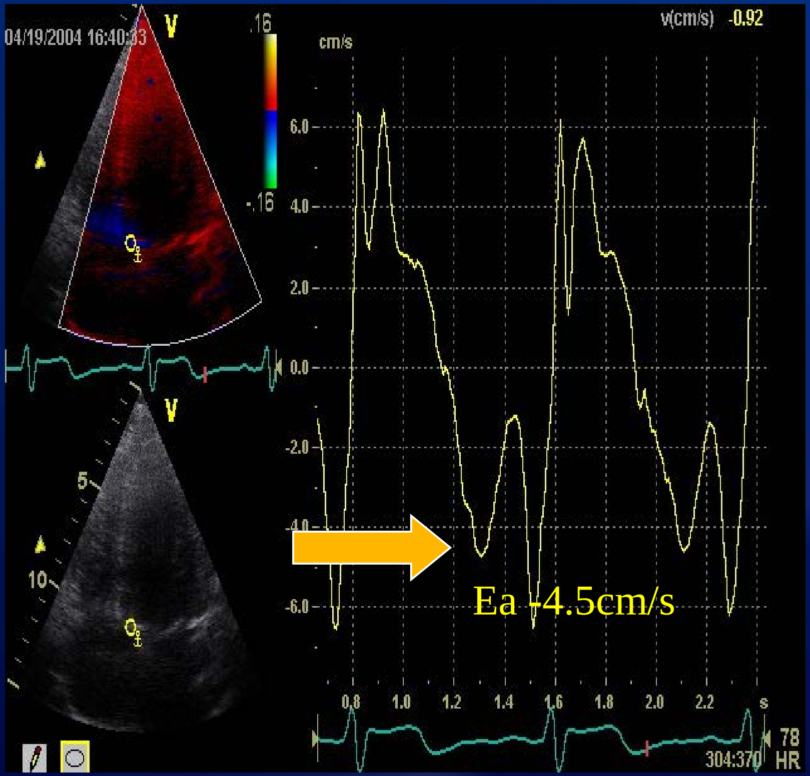
42 y/o male runner Tissue Doppler Pre and Post Marathon (3:28 marathon)

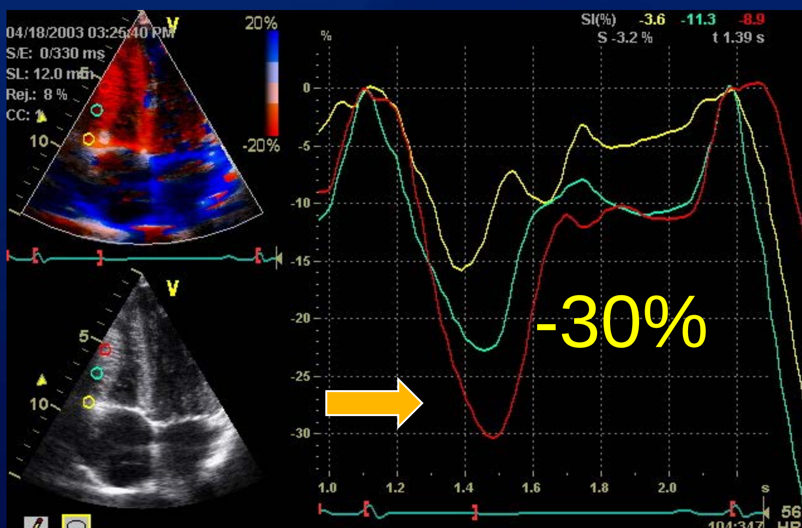




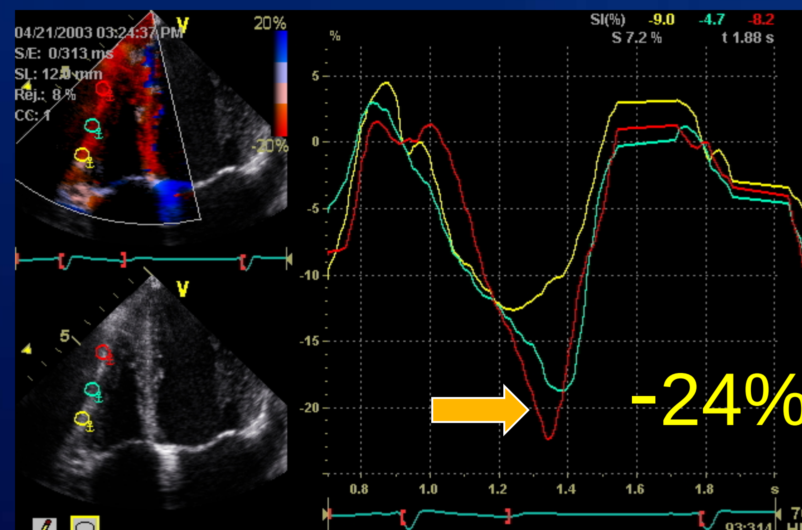
Courtesy of Dr. MJ Wood

RV Strain

Pre-marathon
RV free wall ε



Post-marathon
RV free wall ε



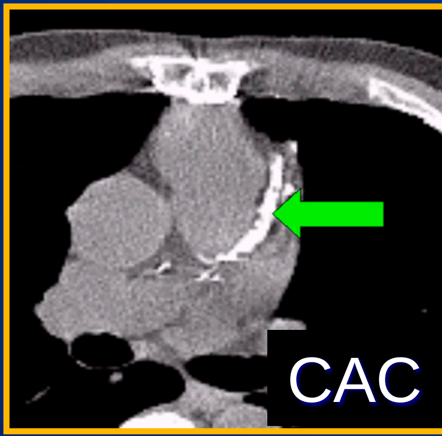
Courtesy of Dr. MJ Wood

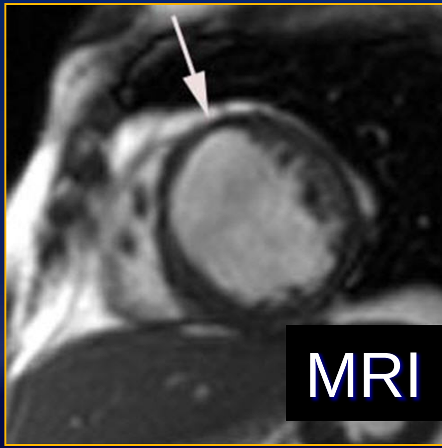
Running: the Risk of Coronary Events

Prevalence and prognostic relevance of CAD in marathon runners

Essen Marathon Study, Germany: Eur Heart J, April 2008

- 108 “healthy” male runners >50 yo
  - >5 marathons in 3 yrs
- Methods: FRS, CAC, MRI
- Conclusions:
  - Fram Risk score underestimated CAC
  - Higher CAC with more marathons
  - As CAC ↑ so did “heart scar” on MRI
- Limitations: -no women
  - selection bias: pre-existing disease?





Incidence of SCA

- 5.4 per million marathon participants
- 18.6 per million per NCAAathlete/yr

54% > 35 years old
57% female

	1990	1995	2000	2005	2010	2011	2012	2013
Female	1,199,200	2,215,500	3,619,600	4,494,400	6,929,000	7,685,700	8,699,000	10,844,200
Male	3,597,800	4,708,000	4,998,400	4,947,600	6,071,000	6,288,300	6,835,000	8,180,800

http://www.runningusa.org/2014-state-of-the-sport-part-III-us-race-trends
accessed 10-19-2015

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Kim JH, N Engl J Med. 2012;366:130-40
Harmon KG, Circulation. 2015;May 14:[Epub ahead of print].

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Thursday, October 8, 2015 - 1:27 p.m.

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September 29th, 2015 · Leave a Comment

Saving a Life While Barely Breaking Stride

By *intheloop*

Sports-related SCA is more likely to be a witnessed event, suffer ventricular fibrillation, receive timely CPR and have higher survival to hospital discharge

Marijon E, Circulation. 2015;131:1384-91

Bystander CPR and use of AED for rapid cardiac defibrillation --strongest independent predictors for survival to hospital discharge among sports-related SCA patients-hands only CPR – mass training pre-marathon events

Kim JH, N Engl J Med. 2012;366:130-40

Sports Paradox

- vigorous activity (>6 METs) acutely and transiently increases the risk of SCA and AMI (~5X)
- regular habitual exercise mitigates that risk
- relative risk of SCA and exercise:
  - inversely related to habitual exercise level
  - ~50 X higher in sedentary
  - ~40% lower among men with highest level of habitual vigorous activity

Mittleman MA *N Engl J Med*. 1993;329:1677-83
Albert CM N Engl J Med. 2000;343:1355–61
Siscovick DS, N Engl J Med. 1984;311:874–7

Sudden Cardiac Arrest (SCA) During Sports Activity

- Overwhelmingly, the majority of sports-related SCAs have occurred in ***men (HR 18X)***
- Potential explanations include:
  - historically lower participation rates for women in events
  - women tend to develop atherosclerosis ~10 yrs later than men
  - gender differences
    - atherosclerotic plaque morphology
    - ventricular electrical activity
    - autonomic factors

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Marijon E, Circulation. 2011;124:672–81
Kim JH, N Engl J Med. 2012;366:130-40
Harmon KG, Circulation. 2015;May 14:[Epub ahead of print].

What is the effective dose of exercise?

Physical Activity Recommendations: Given the extensive CV benefits of exercise

- ≥150 min/wk of moderate, or 75 min/wk of vigorous exercise training (or an equivalent combination of both)

- Minimum 30 min of moderate-intensity physical activity (continuous or in 10-minute increments), preferably most days of week
- Equivalent to ~1.5 miles/day of brisk walking
- Even 15 min/day or 90 min/wk is associated with a survival benefit compared with physical inactivity

Haskell WL, Circulation. 2007;116(9):1081-1093
Fletcher GF,Circulation. 2013;128:8
Global Recommendations on Physical Activity for Health. World Health Organization. Available at: http://www.who.int/dietphysicalactivity/factsheet_recommendations/en/.
Physical Activity Guidelines for Americans. U.S. Department of Health and Human Services. Available at: http://health.gov/paguidelines

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Recommendations for your patient

- Assess the potential impact of increased physical activity for the individual patient
- Start with a level of exercise appropriate to the baseline fitness and activity level of the patient
- Progressively advance the exercise prescription until risk factors are optimally controlled … or limits of tolerance are reached

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Implications of Recent Trials

- High intensity interval training more effective than continuous low-moderate intensity training
- Supervised training superior to home programs
  - Both HF-ACTION and LOOK AHEAD had more frequent supervised sessions initially, tapering off to home program as study progressed

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Exercise is great medicine, but sometimes it can be a hard pill to swallow

Explains negative results in LOOK AHEAD and HF-ACTION

COMPLIANCE ISSUES

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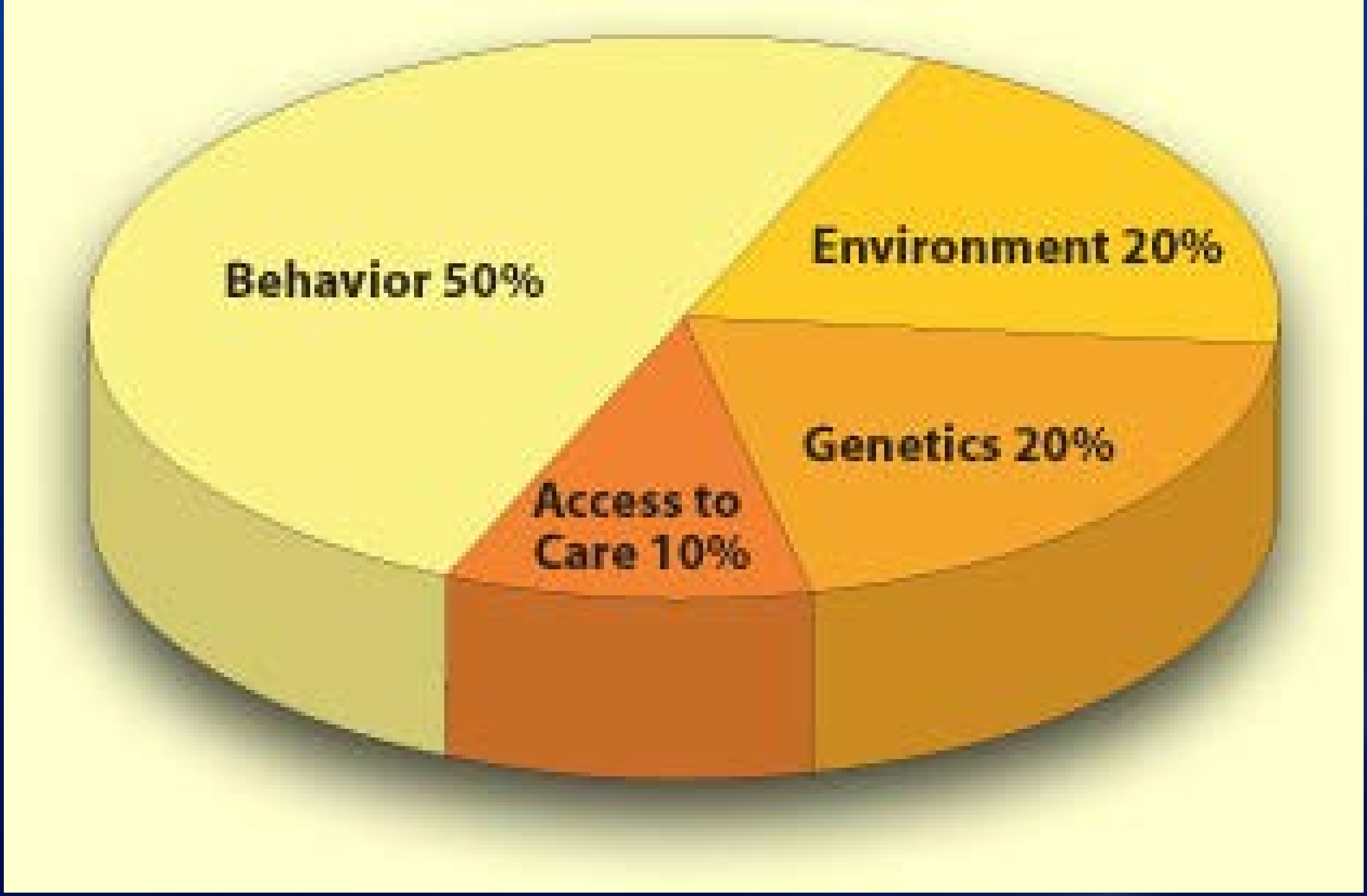
Determinants of Health



CDC 2000

Behavior Changes When Observed

Personal Activity Monitors – Many Types

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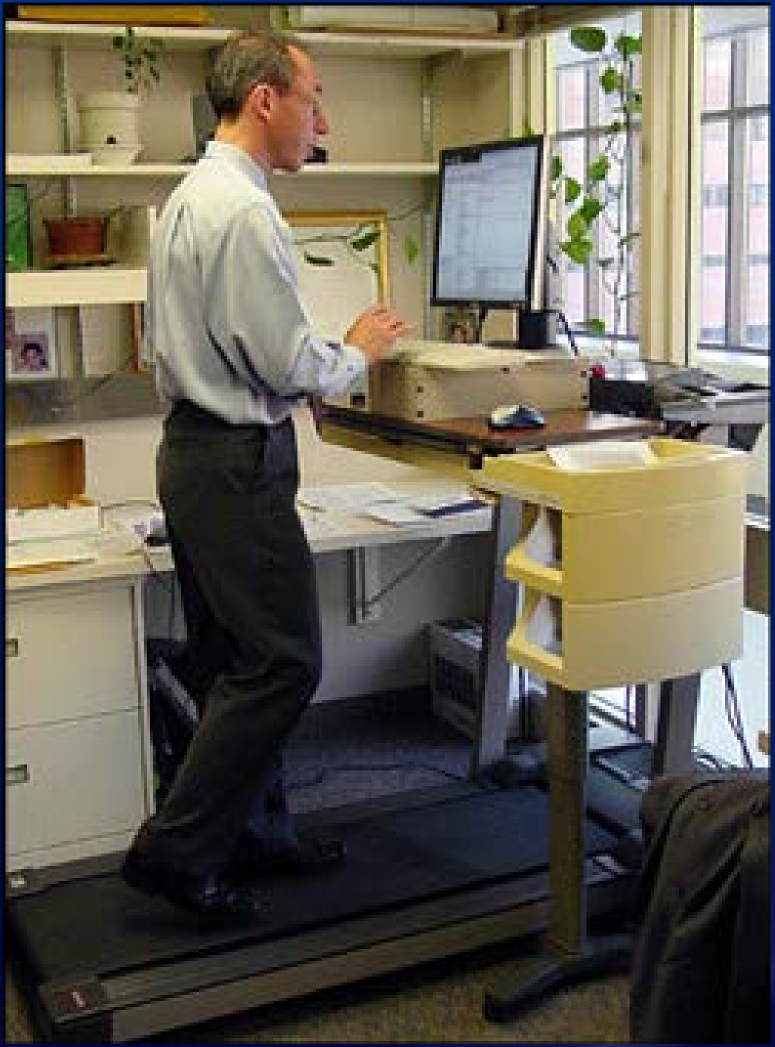
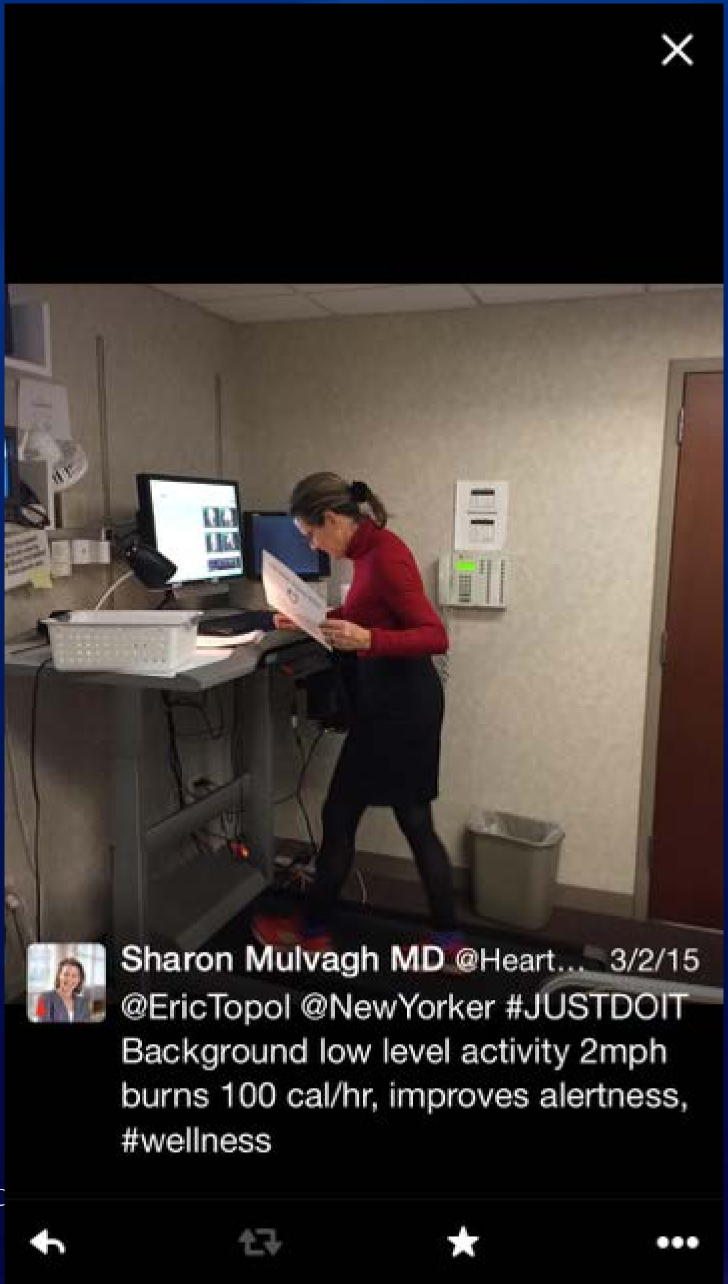
Incorporating Physical Activity into your workday: "The Active Office"



Workout while you work!

Dr. James Levine & Walking Workstation

MAYO ECHOLAB



MSP AIRPORT

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STATE-OF-THE-ART PAPERS

Sports and Exercise Cardiology in the United States

Cardiovascular Specialists as Members of the Athlete Healthcare Team

CrossMark

Christine E. Lawless, MD,*† Brian Olshansky, MD,‡ Reginald L. Washington, MD,§ Aaron L. Baggish, MD,|| Curt J. Daniels, MD,¶ Silvana M. Lawrence, MD, PhD,# Renee M. Sullivan, MD,** Richard J. Kovacs, MD,†† Alfred A. Bove, MD, PhD‡‡

Chicago, Illinois; Lincoln, Nebraska; Iowa City, Iowa; Denver, Colorado; Boston, Massachusetts; Columbus, Ohio; Houston, Texas; Columbia, Missouri; Indianapolis, Indiana; and Philadelphia, Pennsylvania

In recent years, athletic participation has more than doubled in all major demographic groups, while simultaneously, children and adults with established heart disease desire participation in sports and exercise. Despite conferring favorable long-term effects on well-being and survival, exercise can be associated with risk of adverse events in the short term. Complex individual cardiovascular (CV) demands and adaptations imposed by exercise present distinct challenges to the cardiologist asked to evaluate athletes. Here, we describe the evolution of sports and exercise cardiology as a unique discipline within the continuum of CV specialties, provide the rationale for tailoring of CV care to athletes and exercising individuals, define the role of the CV specialist within the athlete care team, and lay the foundation for the development of Sports and Exercise Cardiology in the United States. In 2011, the American College of Cardiology launched the Section of Sports and Exercise Cardiology. Membership has grown from 150 to over 4,000 members in just 2 short years, indicating marked interest from the CV community to advance the integration of sports and exercise cardiology into mainstream CV care. Although the current athlete CV care model has distinct limitations, here, we have outlined a new paradigm of care for the American athlete and exercising individual. By practicing and promoting this new paradigm, we believe we will enhance the CV care of athletes of all ages, and serve the greater athletic community and our nation as a whole, by allowing safest participation in sports and physical activity for all individuals who seek this lifestyle. (J Am Coll Cardiol 2014;63:1461–72) © 2014 by the American College of Cardiology Foundation

Confirmation of the benefits of exercise (1–4), increased participation in organized athletics, and efforts to combat the obesity epidemic have led to marked increases in the numbers of Americans participating in sports and exercise in all major demographic groups over the last decade (5–9). Among athletes ≤35 years of age, 44 million youth (≤18 years of age) participate annually in organized sports, with 7.7 million and 463,202 engaged at the high school and collegiate levels, respectively (6,7). Older, or master, athletes (≥35 years of age), are particularly drawn to endurance sports. Marathon finishers have increased from 353,000 in 2000 to over 500,000 in 2011 (8); U.S. triathlon memberships have increased from 21,341 to more than 146,000 during the same period (9). Simultaneously, as children and adults with established heart disease are living longer with improved quality of life, many have contemplated participation in sports and exercise (10).

Paradoxically, despite its favorable effects on well-being and survival, exercise can acutely increase the risk of myocardial infarction (11,12), aortic dissection (13,14), arrhythmias (15–19), and sudden cardiac arrest (SCA) (Online Appendix) and/or death (SCD) (20,21). Chronically,

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CONFERENCE REPORT

Protecting the Heart of the American Athlete

CrossMark

Proceedings of the American College of Cardiology Sports and Exercise Cardiology Think Tank
October 18, 2012, Washington, DC

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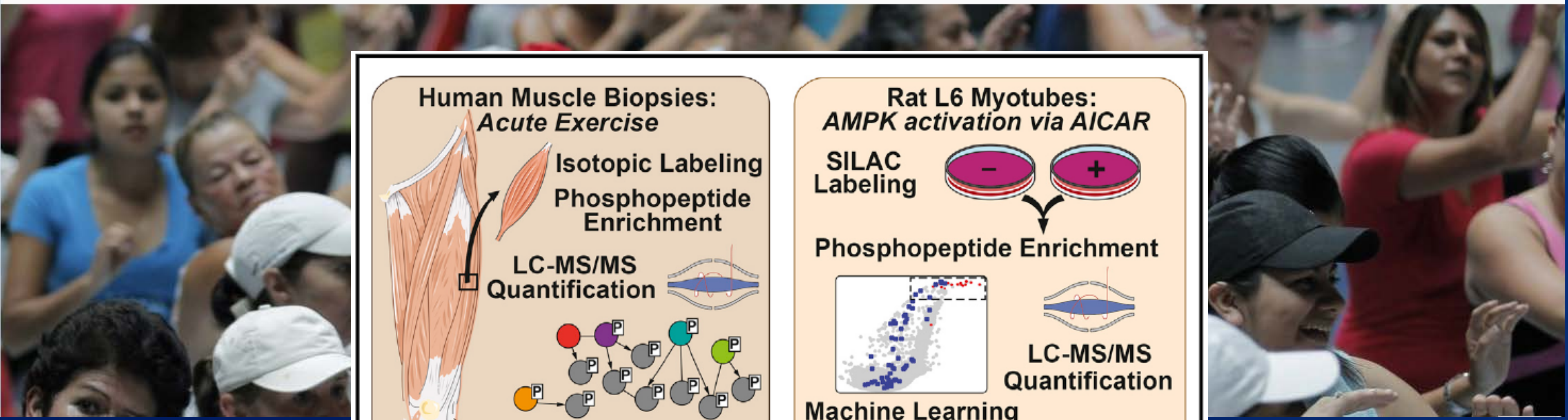

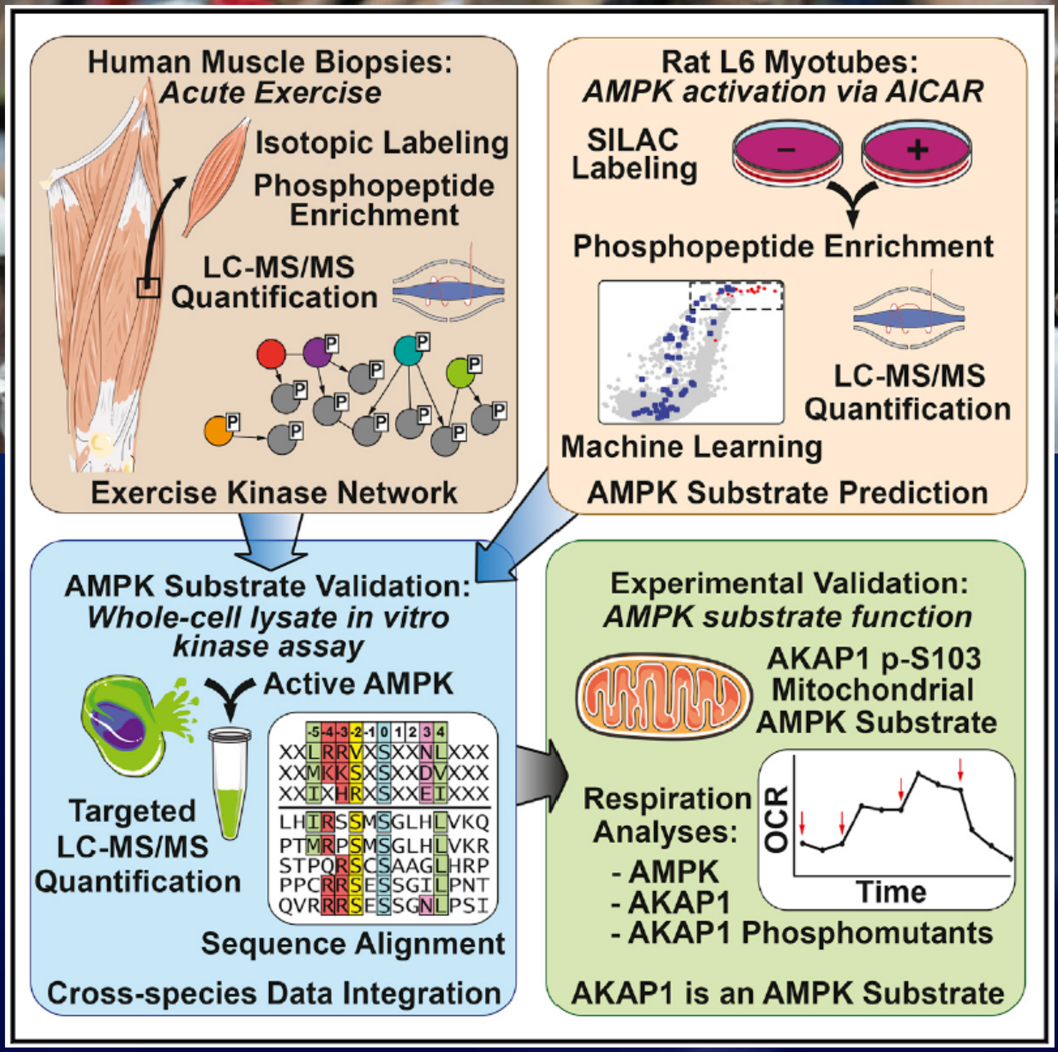

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Hoffman et al., 2015, Cell Metabolism 22, 1–14;November 3, 2015 http://dx.doi.org/10.1016/j.cmet.2015.09.001

Summary
Effects of Physical Activity on the Heart

- Benefits on decreasing CV disease risk; 1º & 2º prevention
- Controversy regarding “dose of exercise”, potential adverse effects of extreme endurance exercise
- Perspective on SCA during sports activities; rare, but increasing due to increasing participation, predisposing factors; “prevention gap”
- Current physical activity recommendations for heart health
- IT solutions to improving adherence

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The long-term benefits outweigh the short-term risks related to physical activity.

"If you survive exercise, which you almost certainly will, you will undoubtedly live longer and healthier"

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Gracias! Thank You!

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