Benefits/science of Exercise

Katy Black, MD

November 3, 2016

"Give about two of them [hours] every day to exercise; for health must not be sacrificed to learning. A strong body makes the mind strong."

What is fitness?

Body burns oxygen to do work

Better fitness = more work = more oxygen used

1. Pulmonary gas exchange (loading blood with oxygen
2. Cardiovascular performance (delivering blood to body)
3. Skeletal muscle metabolism (extracting oxygen)

Peak exercise capacity is defined as “the maximum ability of the cardiovascular system to deliver oxygen to exercising skeletal muscle and of the exercising muscle to extract oxygen from the blood”.

How do we measure fitness?

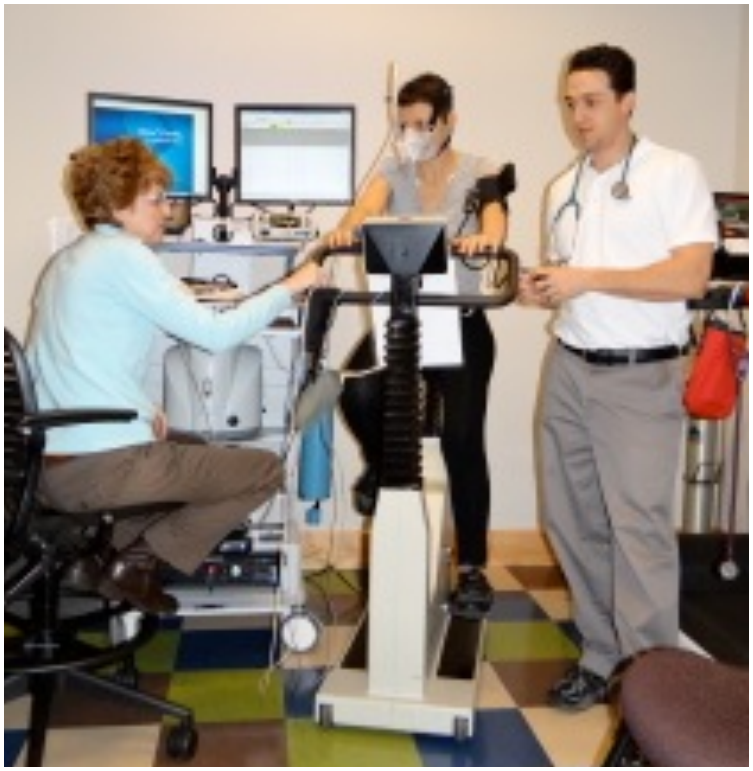
Oxygen consumption (VO_2) =

cardiac output * oxygen use (arterial -venous oxygen content)

- $VO_{2\ (mL/kg/min)} = (SV \times HR) \times (CaO_2 - CvO_2)$

- $VO_2max = (SVmax \times HRmax) \times (CaO_2max - CvO_2max)$

Cardiopulmonary exercise testing



- Evaluate maximum exercise possible = maximum exercise consumption (VO_2max)
- If VO_2max is low, determine whether heart/lungs/muscles are culprit

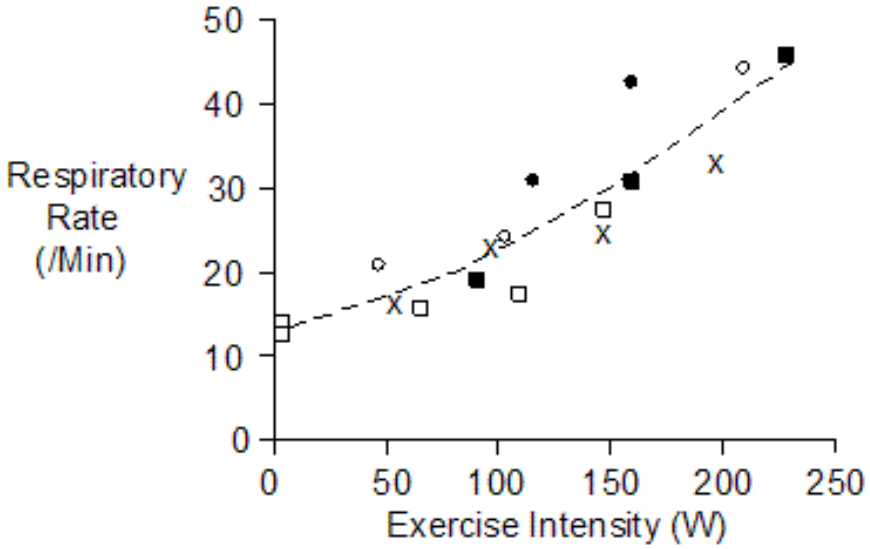
http://www.workwellfoundation.org/testing-for-disability/

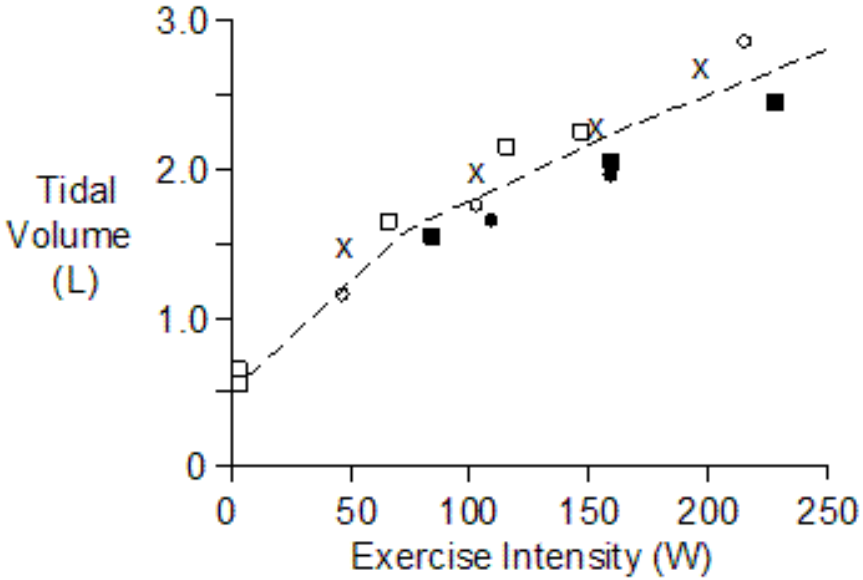
What happens to breathing during exercise?

Exercise and breathing

- **Faster, deeper breaths**
  - peak ventilation increases
  - Resistance to flow stays low
  - Smaller lungs at peak exhalation; easier to take next breath
  - Peak inspiratory muscles only about half max strength
- **Increased blood flow to lungs**
  - No increase in capacity for blood flow with exercise
  - More blood per heart beat compensates for faster heart rate
  - Increased oxygen demand with better fitness; may outstrip capacity for gas exchange (diffusing capacity)

Increased resp rate and tidal volume with exercise





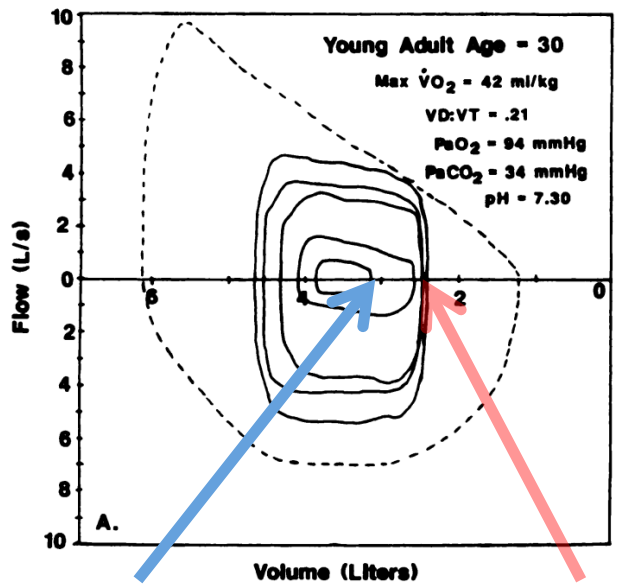
https://www.umc.edu/Education/Schools/Medicine/Basic_Science/Physiology_and_Biophysics/Core_Facilities%28Physiology%29/Physical_Exercise_-_Ventilation.aspx

Exercise and breathing: problems

- **Faster deeper breaths**
  - **No improvement in muscle strength or resistance with exercise**
  - Resistance to flow increases in older lungs- harder to exhale
  - Lung are hyperinflated at exhalation
    - harder to take next breath
  - Peak inspiratory muscles reach the limits of strength
- **Increased blood flow to lungs**
  - **No increase in capacity for blood flow with exercise**
  - Limited capacity for gas exchange (diffusing capacity)
  - Problem for pulmonary fibrosis

Limits on air flow

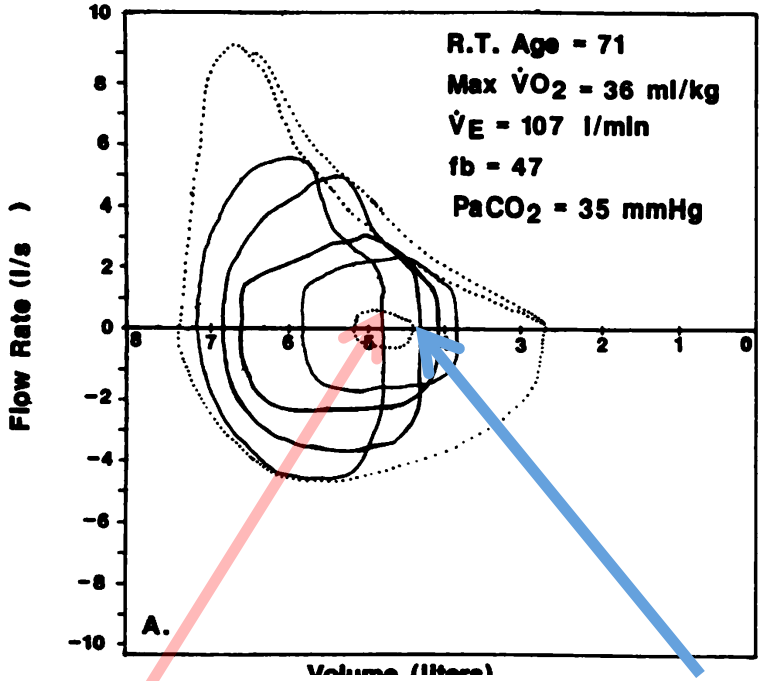
Young healthy



Reserve volume at rest

Reserve volume in exercise

Older athlete



Reserve volume in exercise

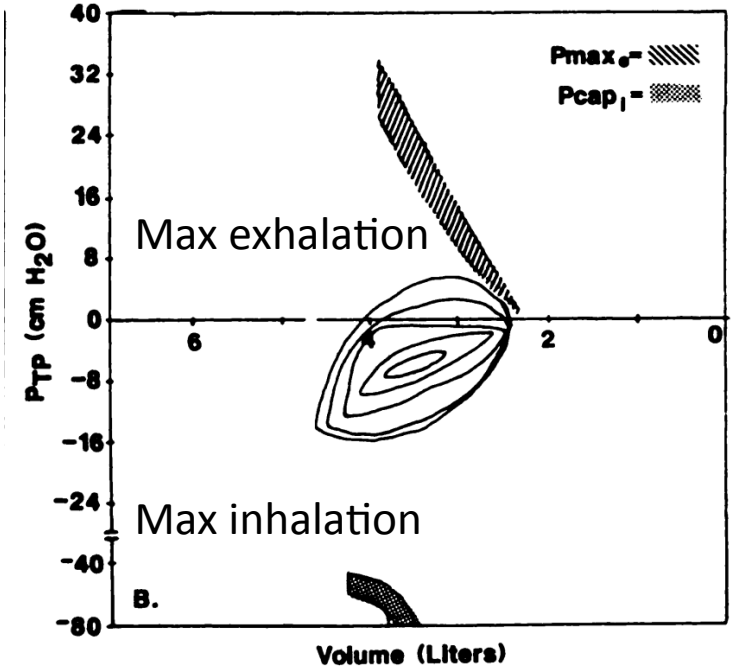
Reserve at rest

Dempsey, Johnson, Saupe, *Chest*, 97 (3 Suppl.) (1990), pp. 81S–87S

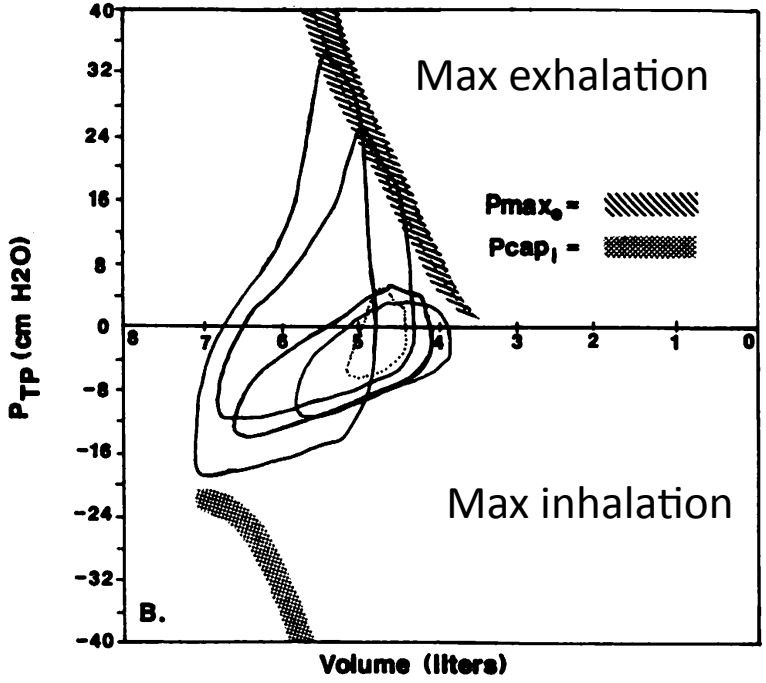
How does obesity effect breathing?

Limits on breathing muscles with age

Young healthy athlete



Older healthy athlete

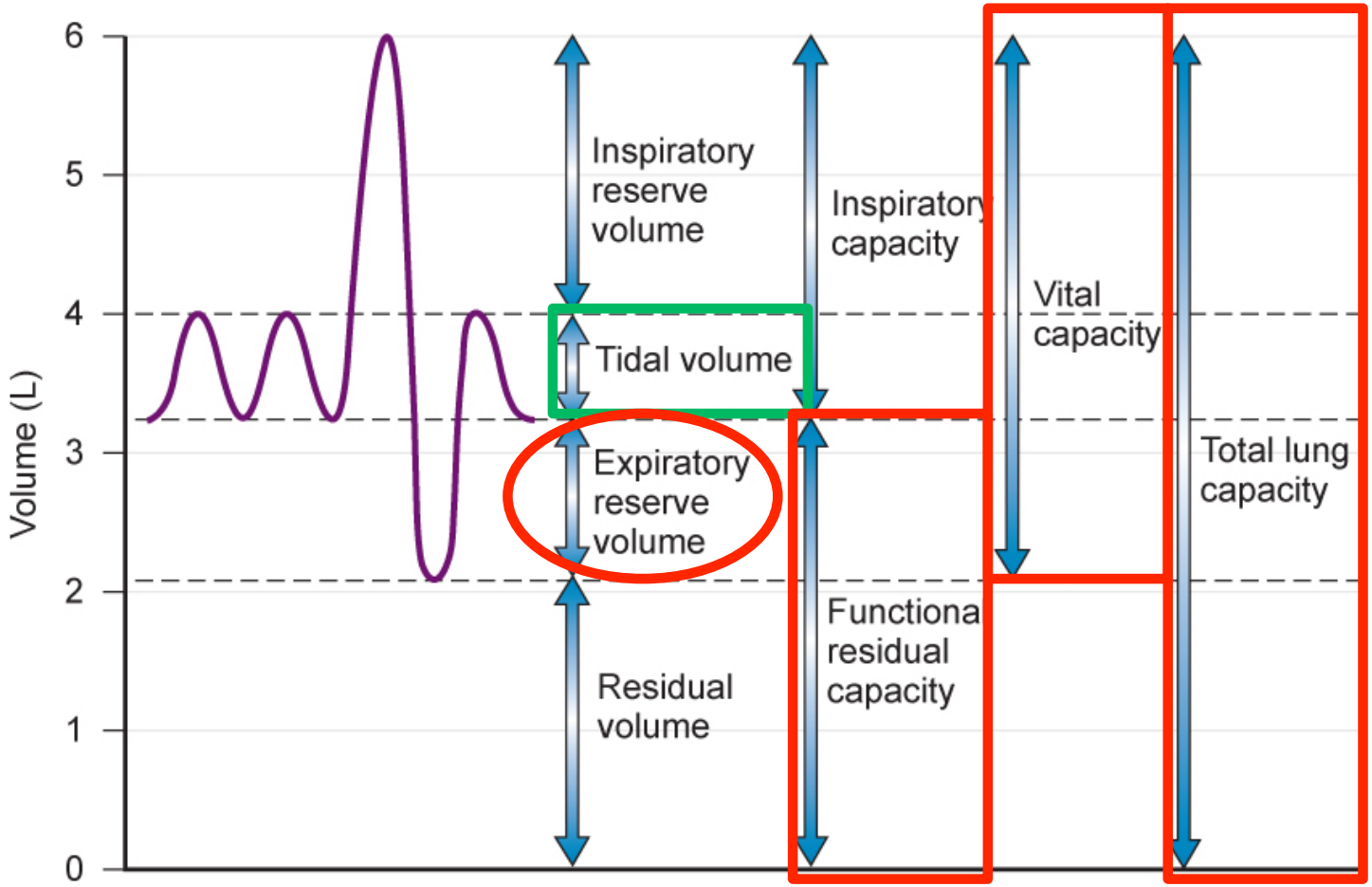


J.A. Dempsey, B.D. Johnson, K.W. Saupe

Adaptations and limitations in the pulmonary system during exercise

Chest, 97 (3 Suppl.) (1990), pp. 81S–87S

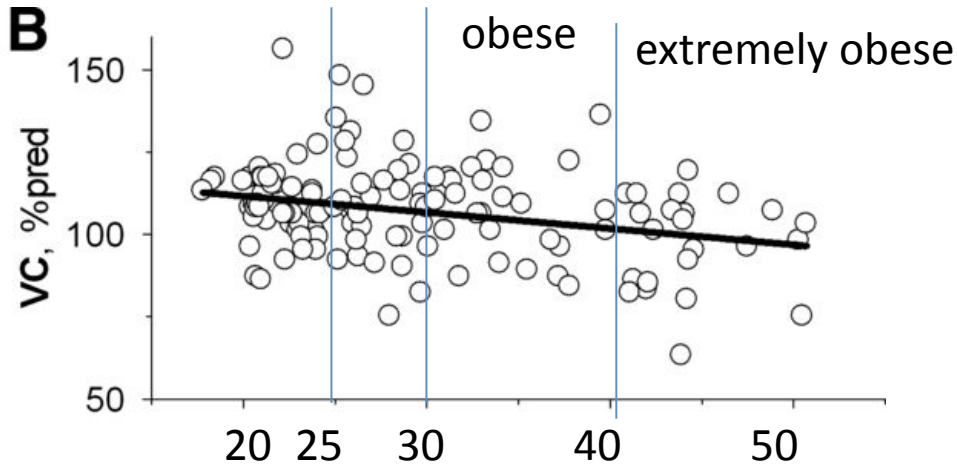
Obesity decreases lung volumes



http://www.clevelandclinicmeded.com/medicalpubs/diseasemanagement/pulmonary/pulmonary-function-testing/
(Adapted from Albert RK, Spiro SG, Jett JR (eds): Comprehensive Respiratory Medicine. St Louis: Mosby, 1999, p 43.)

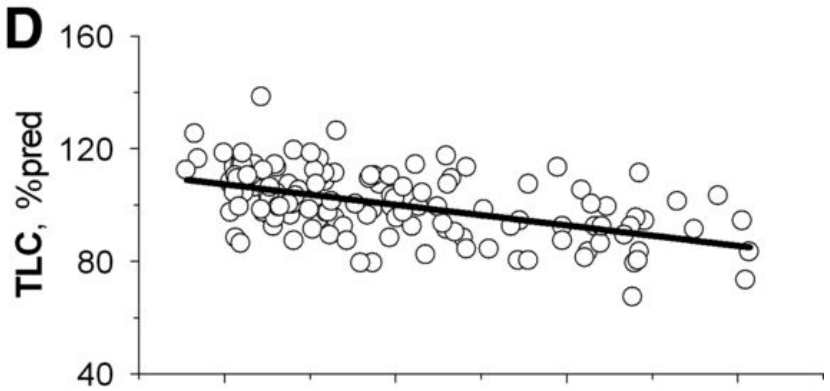
Obesity lowers lung volumes

Vital capacity



Body Mass Index

Total lung capacity



Body Mass Index

Riccardo Pellegrino et al. J Appl Physiol 2014;116:1175-1181

Obesity and breathing

- Increased chest wall weight = lower lung volumes
- Oxygen consumption by respiratory muscles estimated 4x higher than non obese
- Work of breathing estimated 70% more
- Shifts more air to top of lungs
  - Mismatch between air and blood flow
  - Can lower oxygen

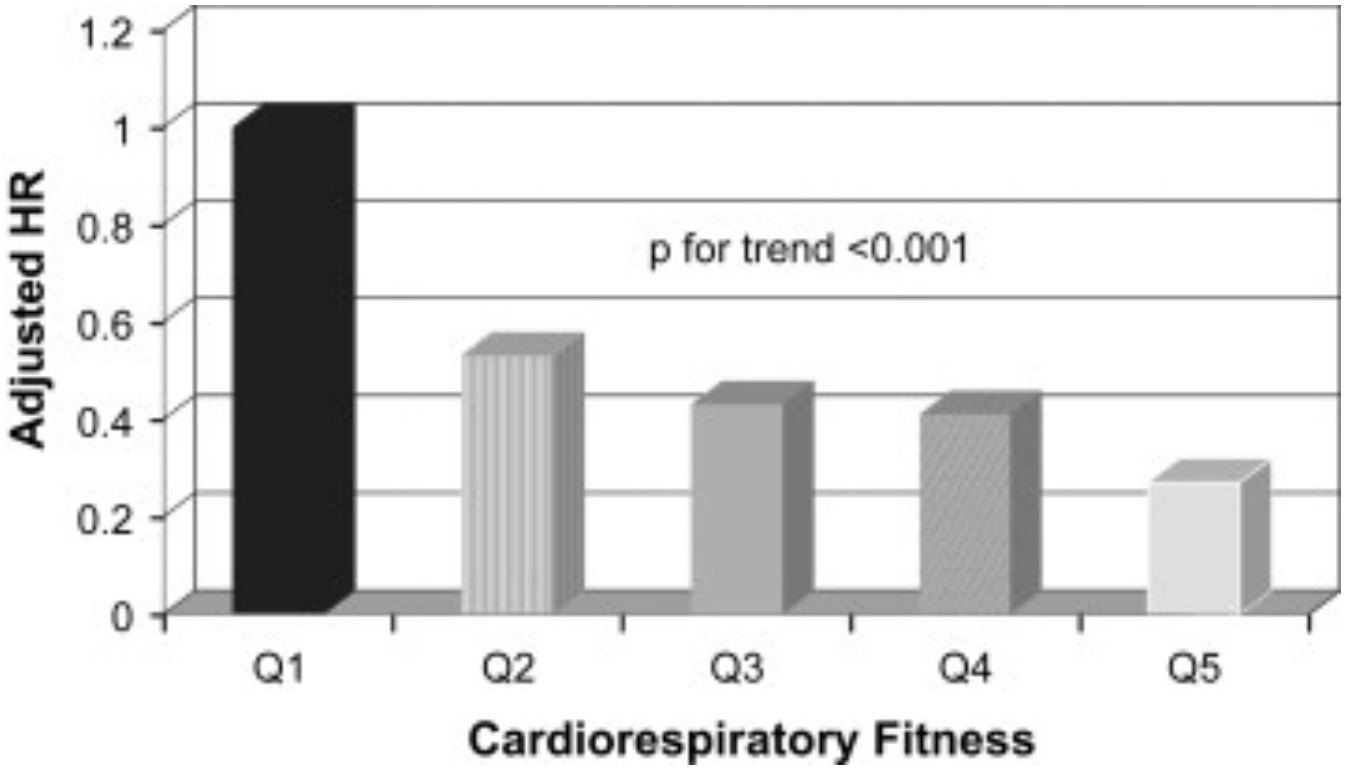
Some things do improve with exercise

- Exercise helps the heart
- Exercise helps the muscles
- Exercise helps the mind (we think)

All-cause mortality by fitness groups

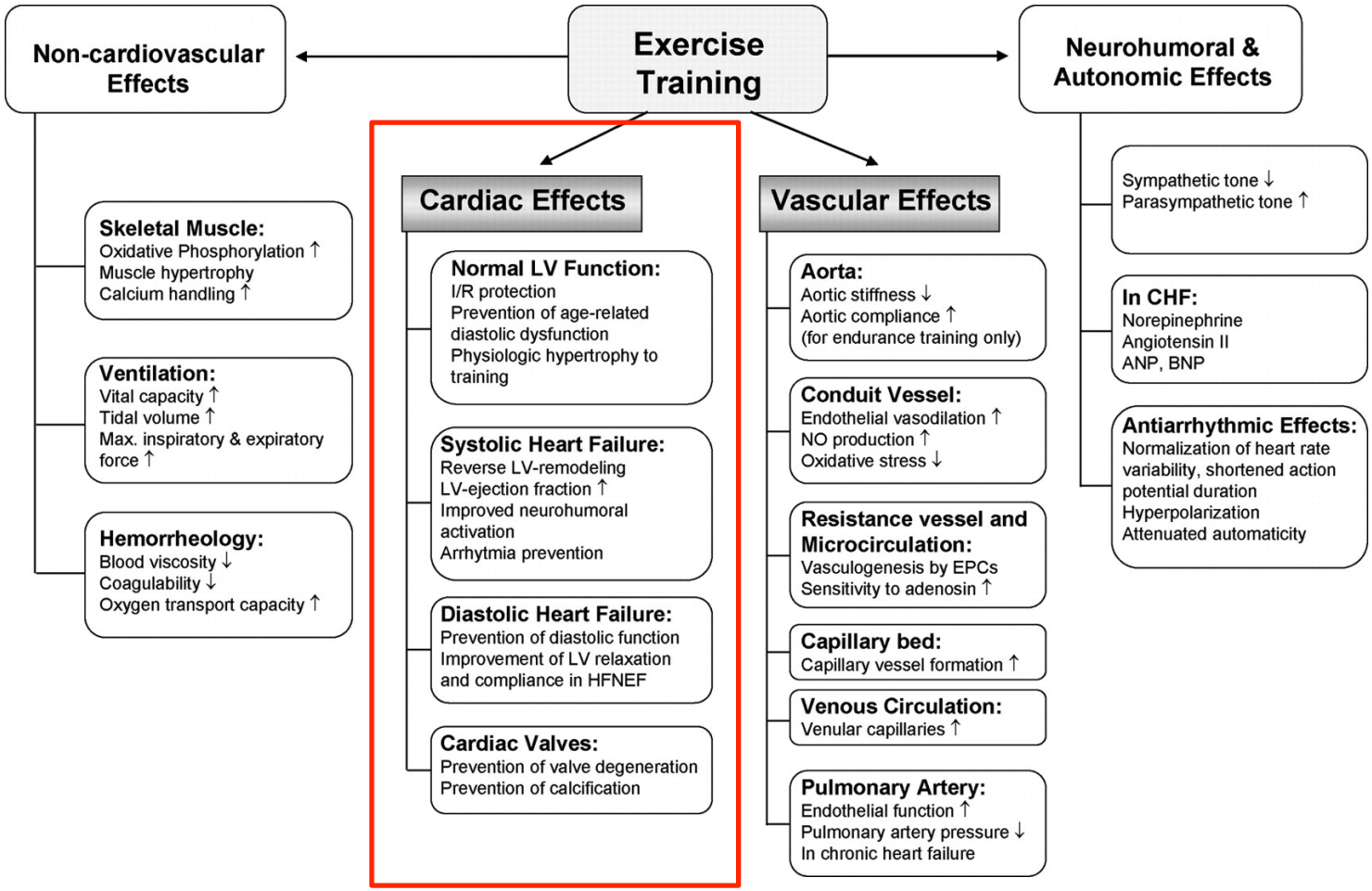
2603 adults 60+ years of age.

Hazard Ratio for death during follow up



Annals of Epidemiology, Volume 19, Issue 4, 2009, 253–256

Exercise improves heart function



Stephan Gielen et al. Circulation. 2010;122:1221-1238

American Heart Association.

CORONARY HEART-DISEASE AND PHYSICAL ACTIVITY OF WORK

J. N. MORRIS
M.A. Glasg., M.R.C.P., D.P.H.

J. A. HEADY
M.A. Oxfd

OF THE SOCIAL MEDICINE RESEARCH UNIT, MEDICAL RESEARCH COUNCIL

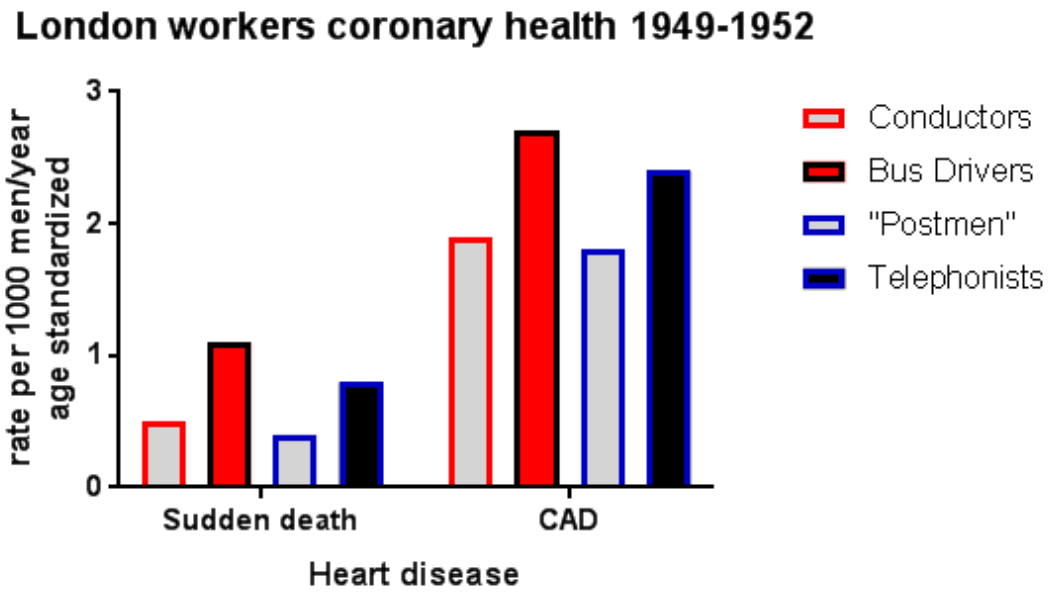
P. A. B. RAFFLE
M.D. Lond., D.P.H., D.I.H.

OF THE MEDICAL DEPARTMENT, LONDON TRANSPORT EXECUTIVE

C. G. ROBERTS
B.A., M.D. Camb.

J. W. PARKS
M.B.E., M.D. Camb., D.C.H.

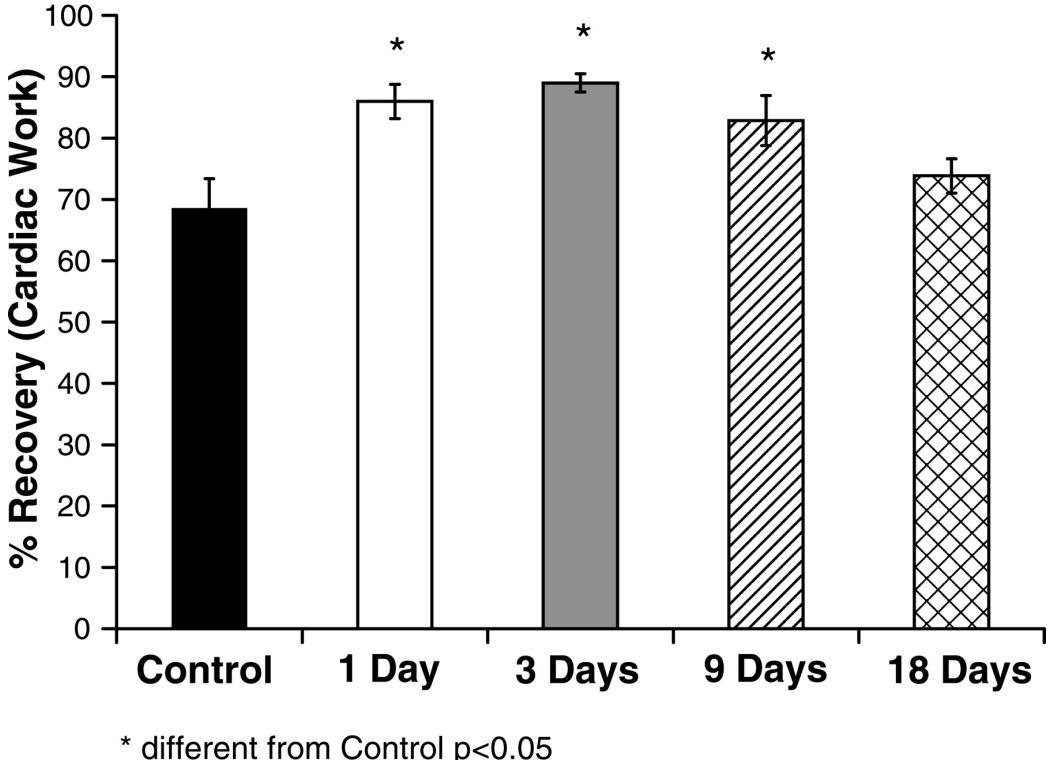
OF THE TREASURY MEDICAL SERVICE



Data from The Lancet, November 1953

Exercise protects against heart attacks: possible mechanisms from rat studies

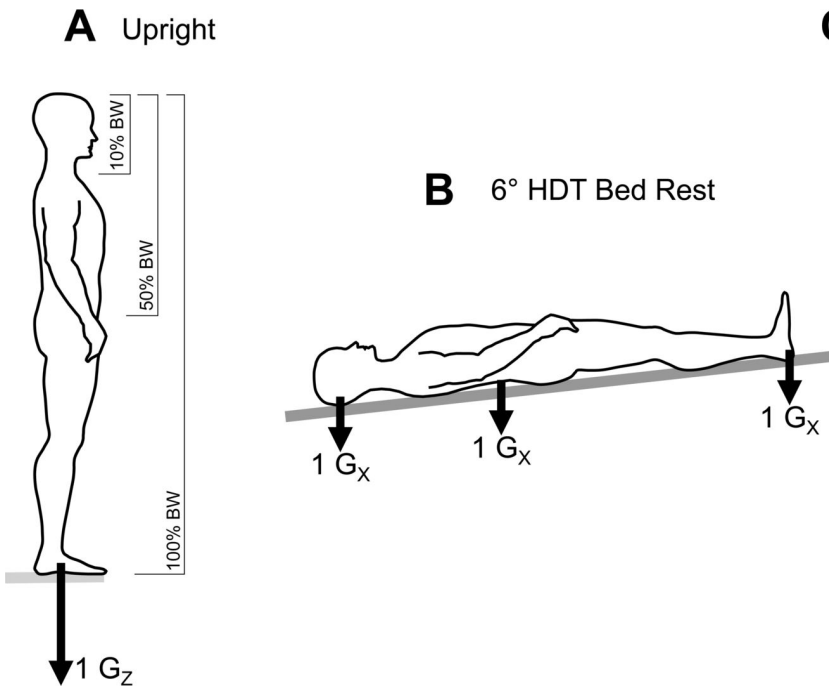
Heart muscle activity assessed after ischemia in rats



Heart antioxidant levels and protective protein "heat shock protein 72" also rose after 8 days of exercise

Shannon L. Lennon et al. J Appl Physiol 2004;96:1299-1305

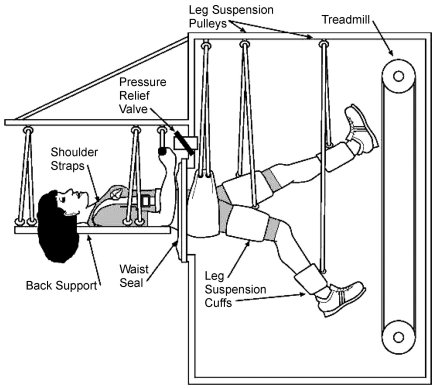
Bed rest leads to loss of heart mass



Head down tilt bed rest mimics weightlessness : extreme of sedentary lifestyle

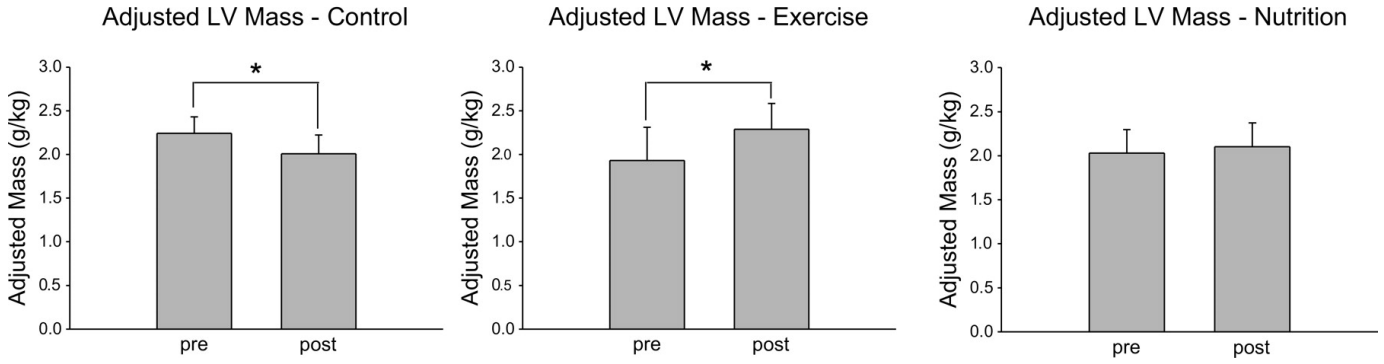
Todd A. Dorfman et al. J Appl Physiol 2007;103:8-16

Exercise prevented bed rest-induced heart mass loss



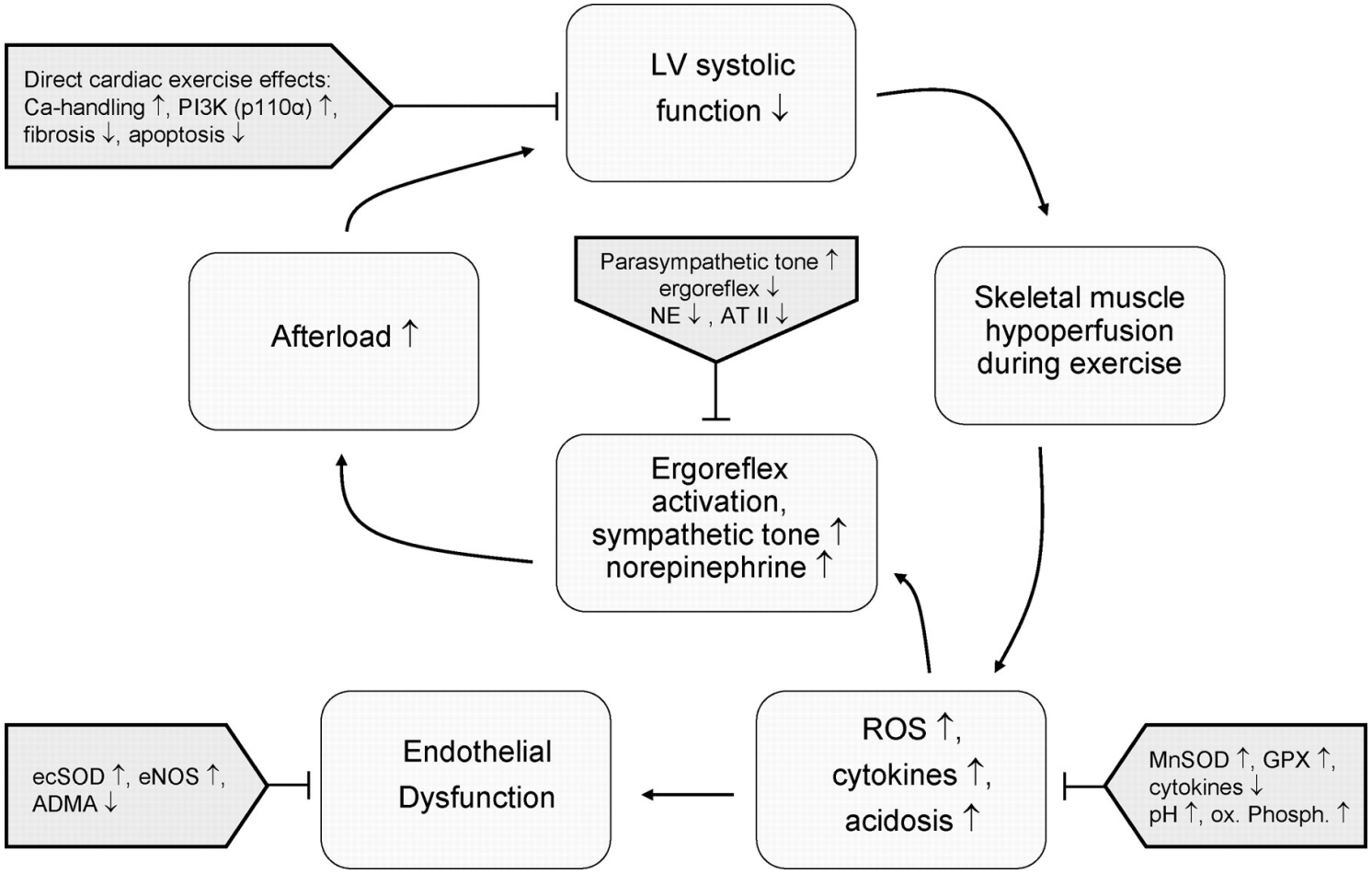
Head down tilt mimics weightlessness.

Exercise increased heart mass more than nutritional supplement



Todd A. Dorfman et al. J Appl Physiol 2007;103:8-16

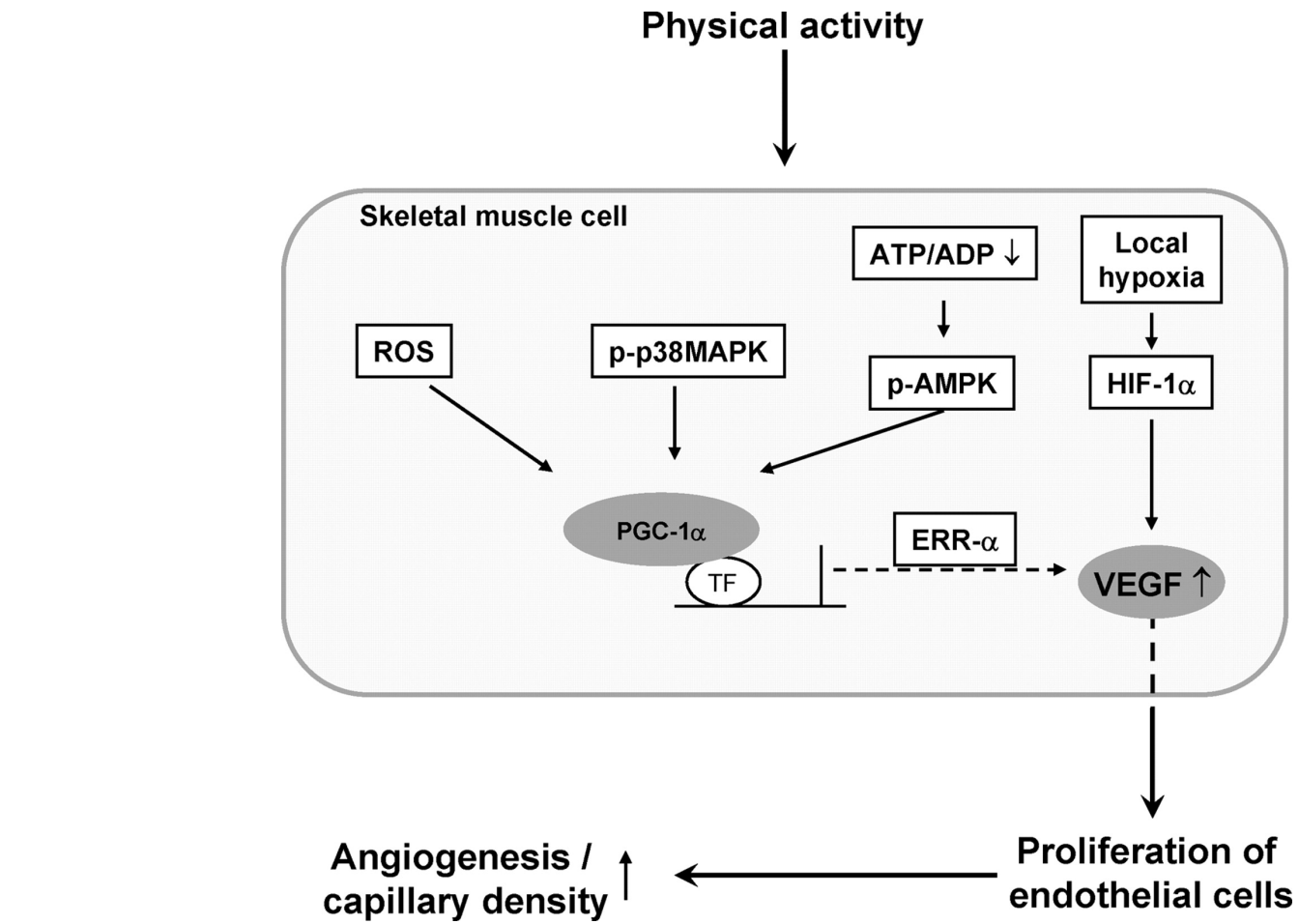
Exercise can help reverse heart changes seen in heart failure



American Heart Association.

Stephan Gielen et al. Circulation. 2010;122:1221-1238

Exercise increases blood supply to muscles



Stephan Gielen et al. Circulation. 2010;122:1221-1238

Exercise increases energy production of muscles

- Mitochondria provide energy to cells
  - Use oxygen to make ATP
- Exercise increases number and size of muscle mitochondria
- Many possible mechanisms

Does exercise help everyone?

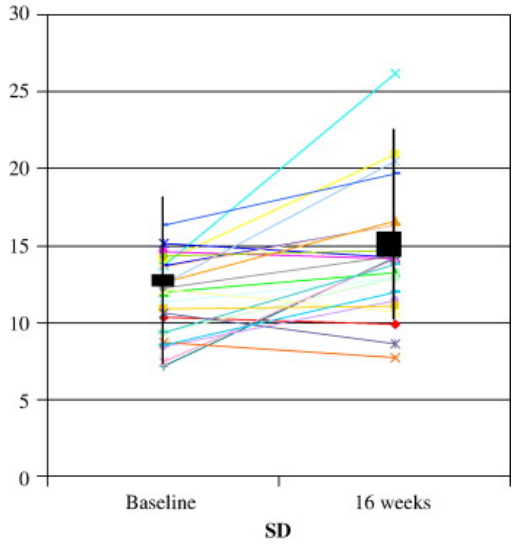
Exercise improves fitness in heart failure

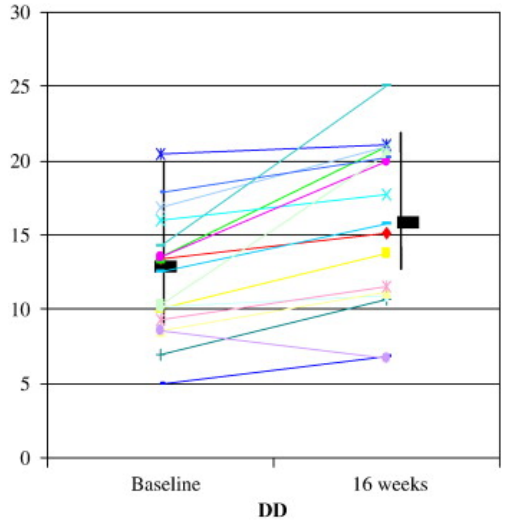
51 short of breath patients with heart failure;
16 weeks of exercise bike, then bike + resistance exercises

Systolic heart failure (n = 25-1)

diastolic heart failure(n= 26-8)

VO2max





Improved quality of life – specifically physical and functional QOL

Heart transplant: VO2 of less than 14 mL/kg /minute

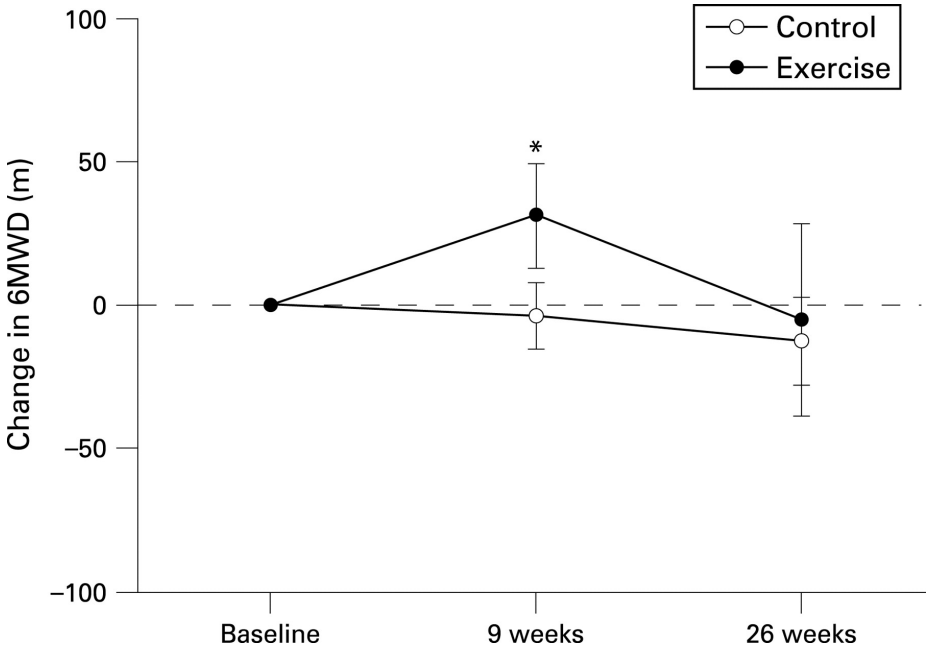
Smart et al. American Heart Journal, Volume 153, Issue 4, 2007, 530–536

Exercise improved walk distance ILD

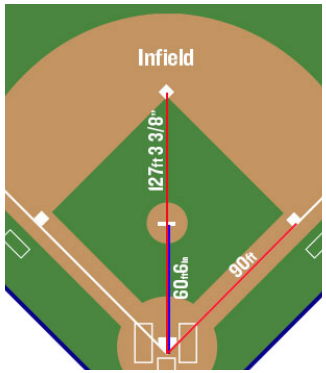
57 subjects with ILD (34 IPF); 8 weeks

Improved 6MWD

No change in $VO_{2\ max}$



mean increase 35 m (25 m in IPF, 43 non IPF)



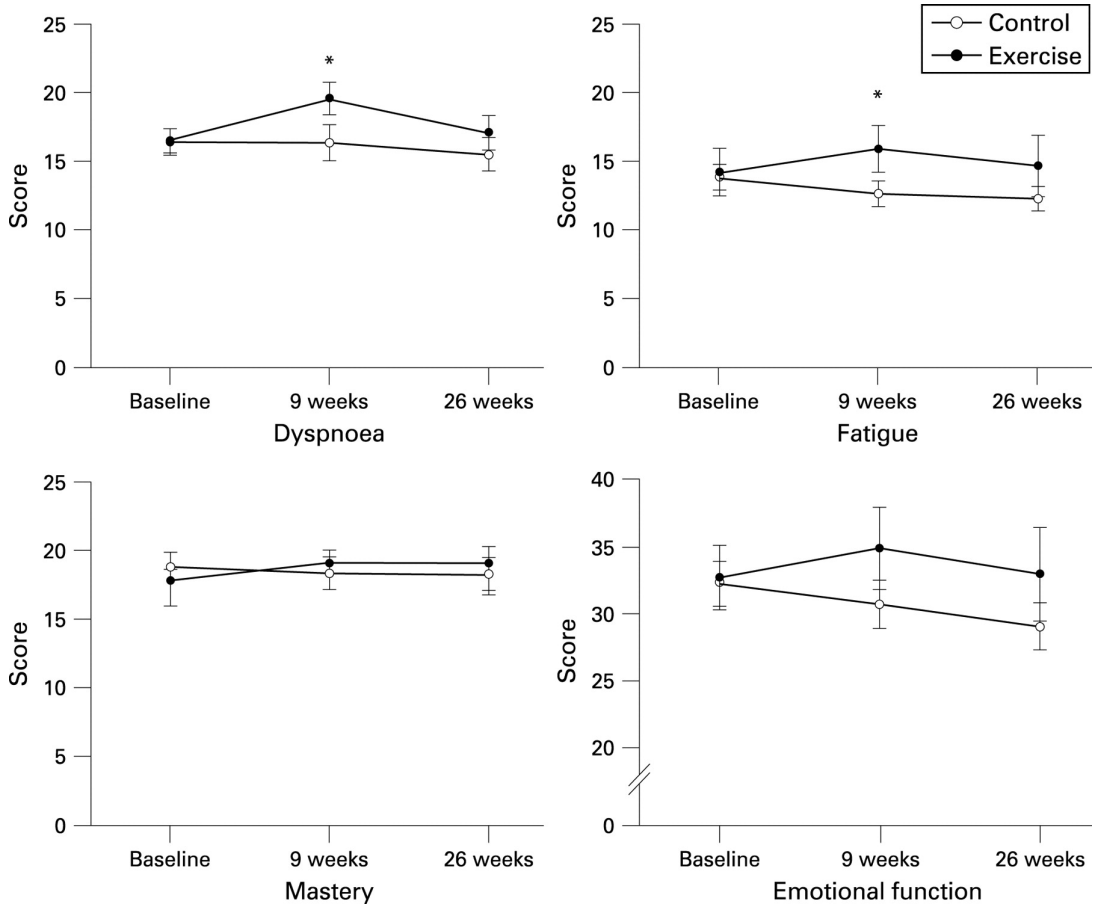
35m = 114 feet

Respiration. 2014;88(5):378-88

http://m.mlb.com/glossary/rules/field-dimensions

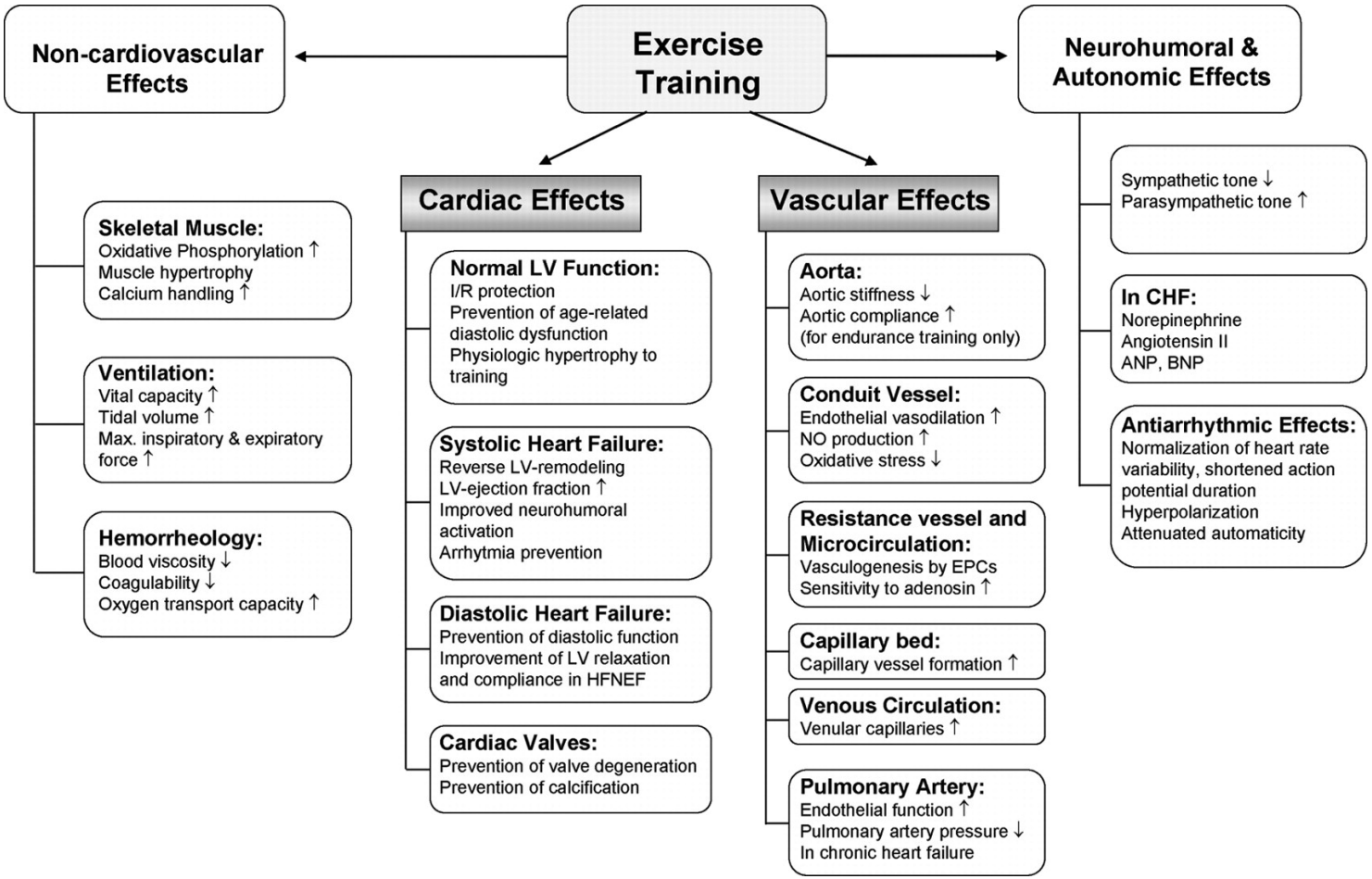
Exercise improved QOL in ILD

Health related quality of life
Chronic Respiratory Disease Questionnaire.



A E Holland et al. Thorax 2008;63:549-554

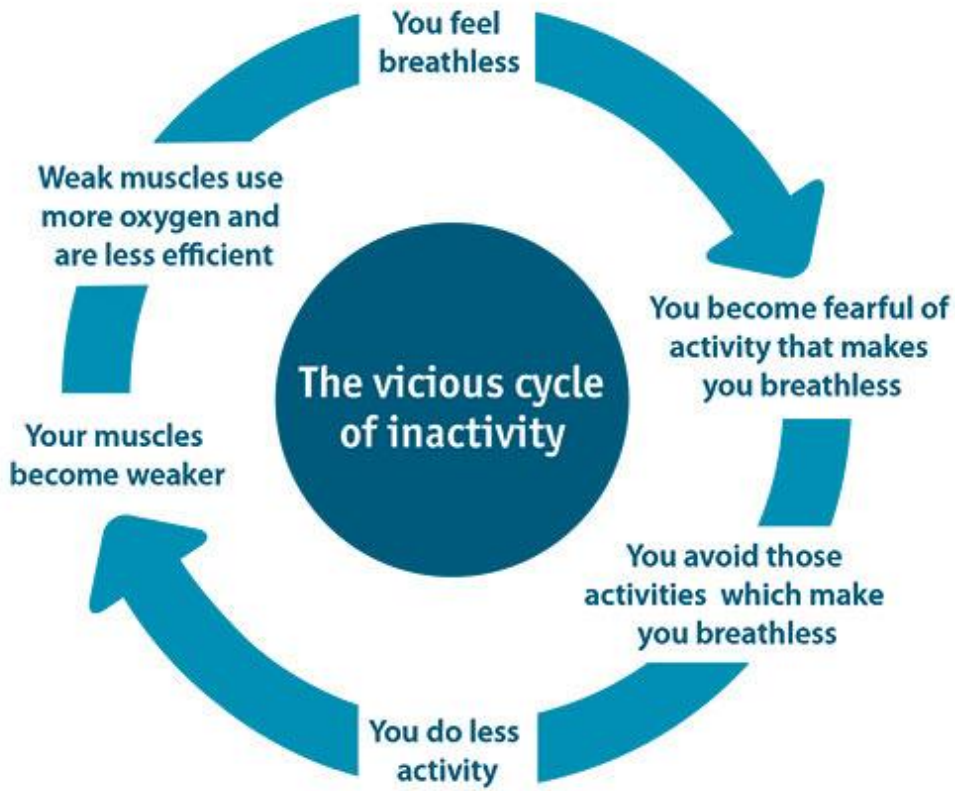
Positive effects of exercise



Stephan Gielen et al. Circulation. 2010;122:1221-1238

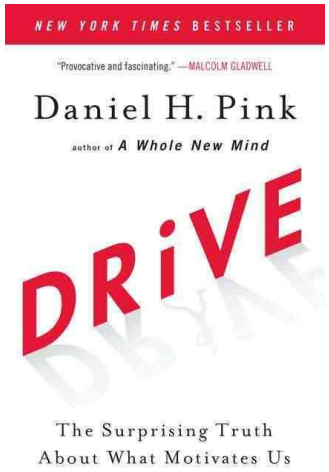
American Heart Association.

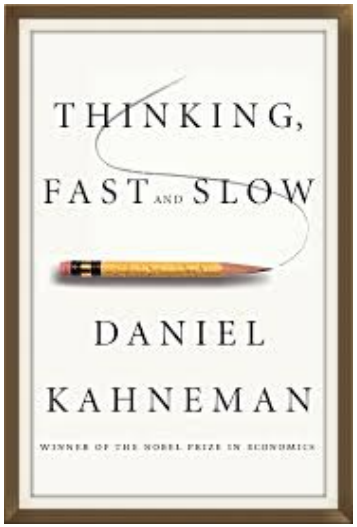
Still hard to exercise

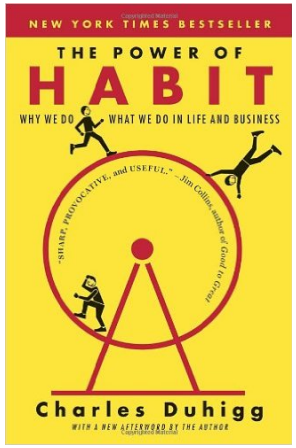


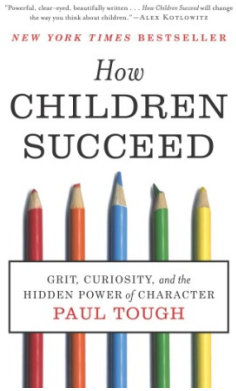
https://www.blf.org.uk/support-for-you/exercise/why-is-it-important

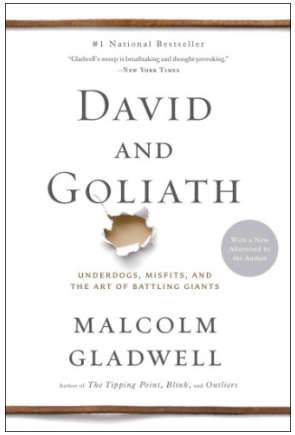
How to motivate?

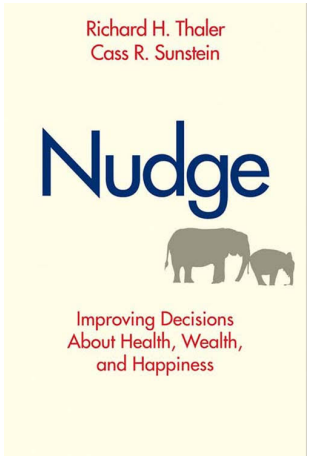


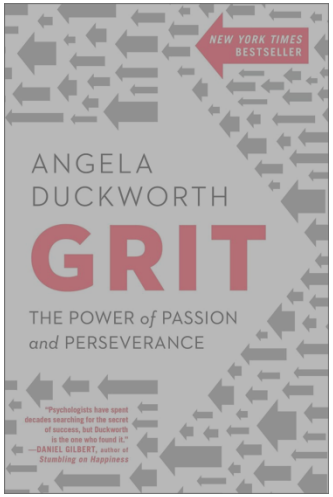












Strategies for success: motivation and volition

- Motivation: "Threat and coping appraisal"
  - Do I really feel worried about deconditioning?
  - Do I really believe exercise will help me?
- Volition: "goal setting, action planning and coping planning
  - "Good intentions" vs. "implementation intentions"

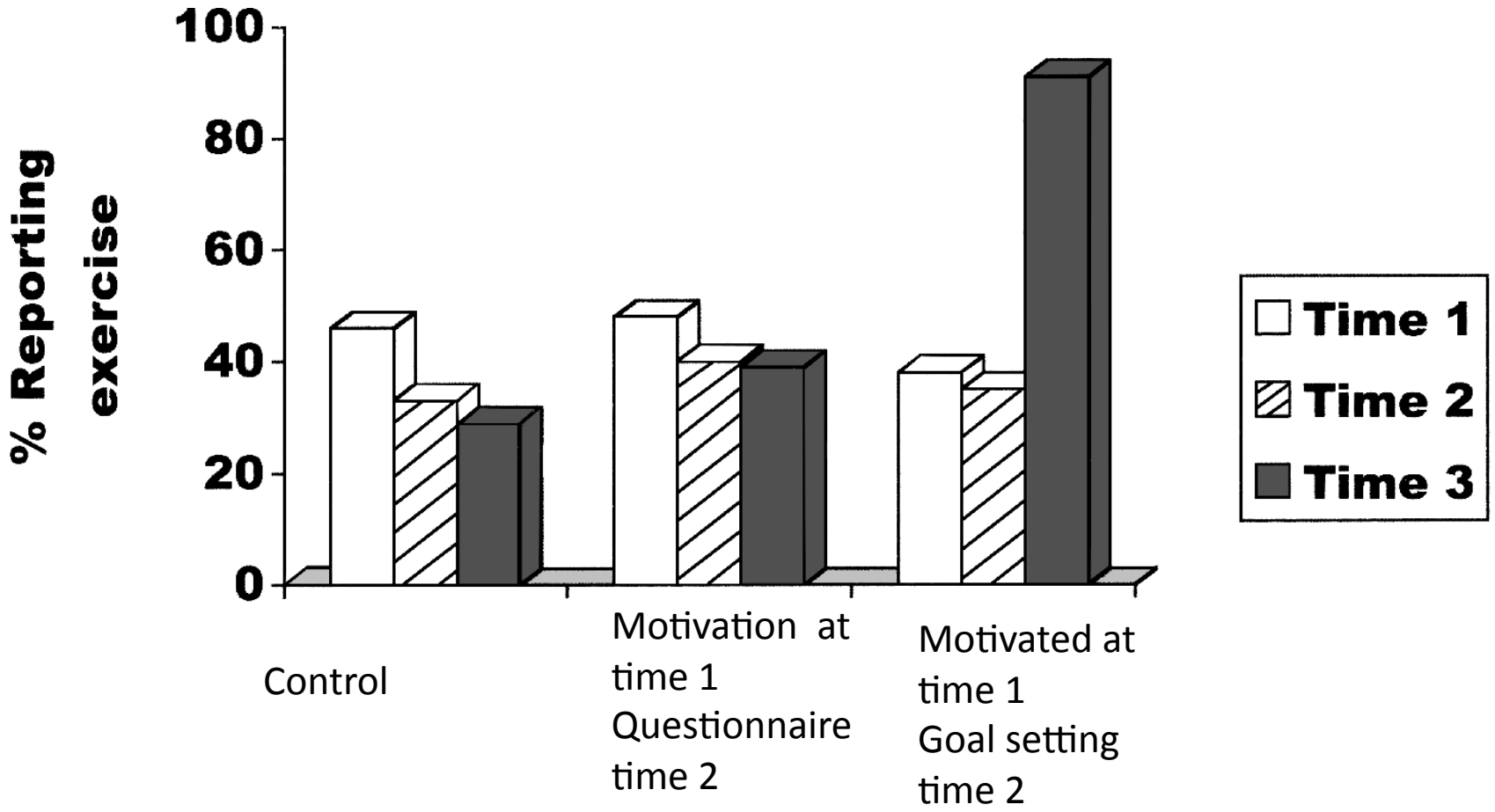
Gollwitzer Journal of Personality and Social Psychology 1997, Vol. 73. No. 1, 186-199
French DP[1], Stevenson A, Michie S. Psychol Health Med. 2012;17(2):127-35.. 2011 Jul 11.

Motivation + volition

- Motivation: read pamphlet
  - Told that heart disease beginns early in life, can be prevented by 20 minutes of vigorous exercise weekly
- Volition: made exercise plan
  - During next week I will partake in at least 20 minutes of vigorous exercise on (day or days)_____ at _____(time of day) at/or in (place)_____.

Milne et *al British Journal Health Psychology* Volume 7, Issue 2
May 2002 163–184

Results


% Reporting exercise
100
80
60
40
20
0
Time 1
Time 2
Time 3
Control
Motivation at time 1 Questionnaire time 2
Motivated at time 1 Goal setting time 2

Set specific goals, using If…then

- If it's Monday, Wednesday, or Friday, I'll go for a twenty minute walk at 3:30pm

- If I'm at the grocery store, I'll buy apples not cookies.

Be ready for obstacles

- If it rains on Monday, then I'll walk at the mall
- If I miss a walk on Monday, then I'll walk Tuesday
- If I buy cookies, then I will close the bag and bring them to work to give away

Gollwitzer July 1999 • American Psychologist

Strengthen volition

Loss aversion

– Arrange to lose money if you don't meet your goals
  - http://www.gym-pact.com/

Accountability

– Promise group you'll be there

Some references

- Postgrad Med J. 2007 Nov; 83(985): 675–682.
- doi: 10.1136/hrt.2007.121558
- PMCID: PMC2734442
- **Cardiopulmonary exercise testing and its application**
- K Albouaini, M Egred, and A Alahmar, D J Wright
- http://www.nature.com/scitable/topicpage/mitochondria-14053590
- J.A. Dempsey, B.D. Johnson, K.W. Saupe
- **Adaptations and limitations in the pulmonary system during exercise**
- Chest, 97 (3 Suppl.) (1990), pp. 81S–87S

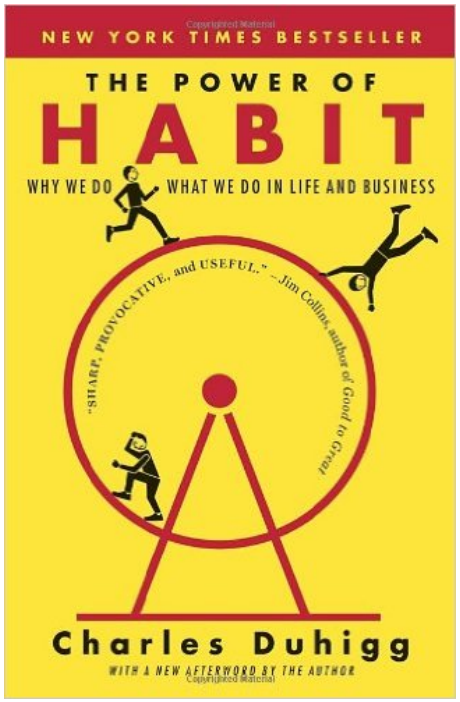
References cont

- J Exerc Rehabil. 2015 Apr 30;11(2):74-9. doi: 10.12965/jer.150190. eCollection 2015.
- **Pulmonary rehabilitation and exercise in pulmonary arterial hypertension: An underutilized intervention.**
- Sahni S[1], Capozzi B[2], Iftikhar A[1], Sgouras V[3], Ojrzanowski M[4], Talwar A[5].
- J Exerc Rehabil. 2015 Apr; 11(2): 74–79.
- Respiration. 2014;88(5): 378-88. doi: 10.1159/000367899. Epub 2014 Oct 23.
- **Exercise training-based pulmonary rehabilitation program is clinically beneficial for idiopathic pulmonary fibrosis.**
- Vainshelboim B[1], Oliveira J, Yehoshua L, Weiss I, Fox BD, Fruchter O, Kramer MR.

Improving our habits

THE FRAMEWORK:

- **Identify the routine**
- **Experiment with rewards**
- **Isolate the cue**
- **Have a plan**



http://charlesduhigg.com/how-habits-work/

Improving our habits

THE FRAMEWORK:

- **Identify the routine: watching TV at 3pm instead of exercising**
- **Experiment with rewards: Can watch cable tv at gym**
- **Isolate the cue: at 3pm show comes on**
- **Have a plan: set alarm for2:45**

http://charlesduhigg.com/how-habits-work/