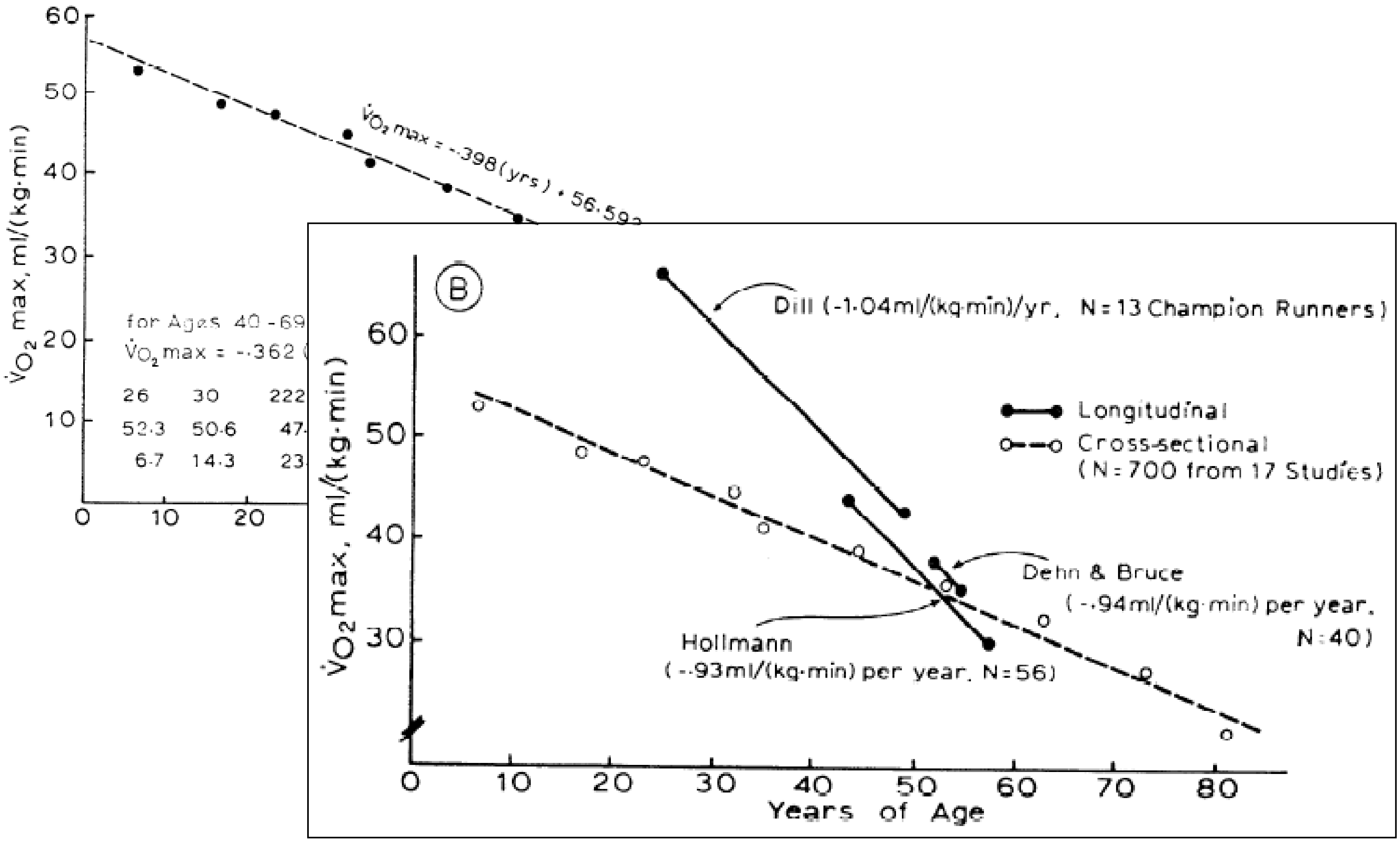
What is the evidence for age-related differences in the cardiovascular response to training programmes in elderly people?

Stephan Gielen, FESC
Dept. of Internal Medicine/Cardiology
University of Leipzig – Heart Center

1. How does the cardiorespiratory exercise capacity change with age?

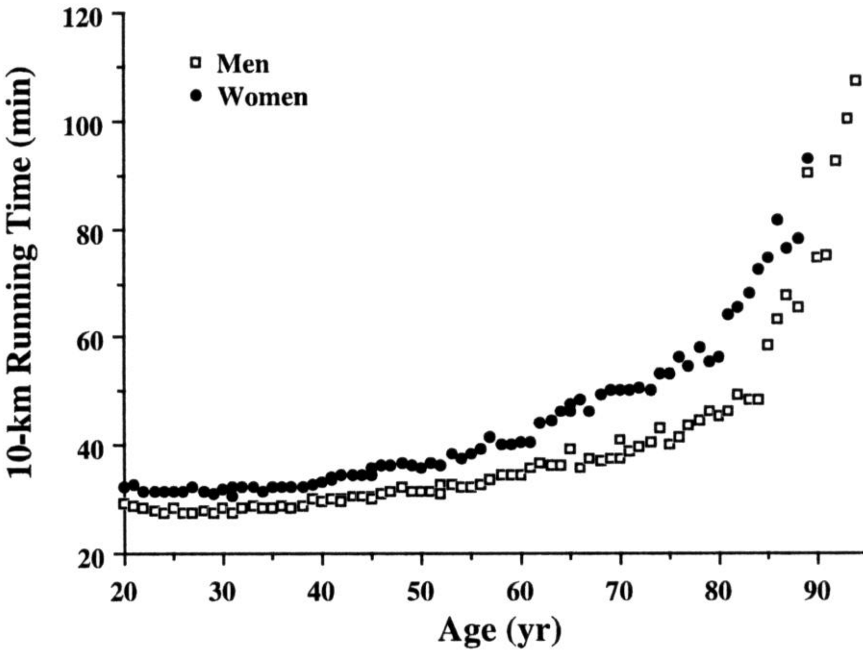
First Objective Evidence of Age-Related Decline in Maximal Exercise Capacity



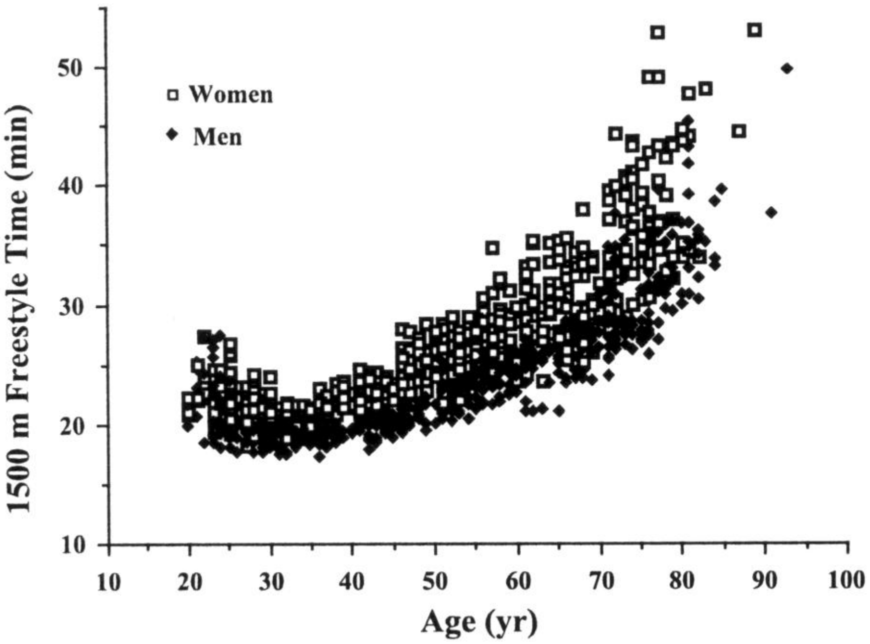
Dehn M, J Appl Physiol 1972(33):805-7

Physical Fitness and Age in Athletes

10.000 m Run



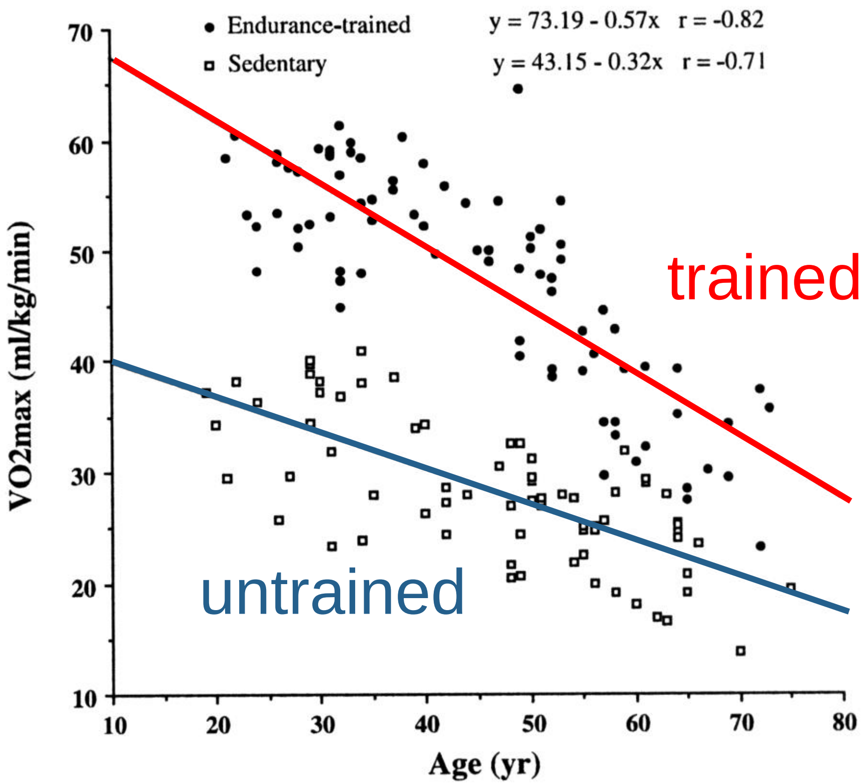
1.500 m Free-Style Swimming



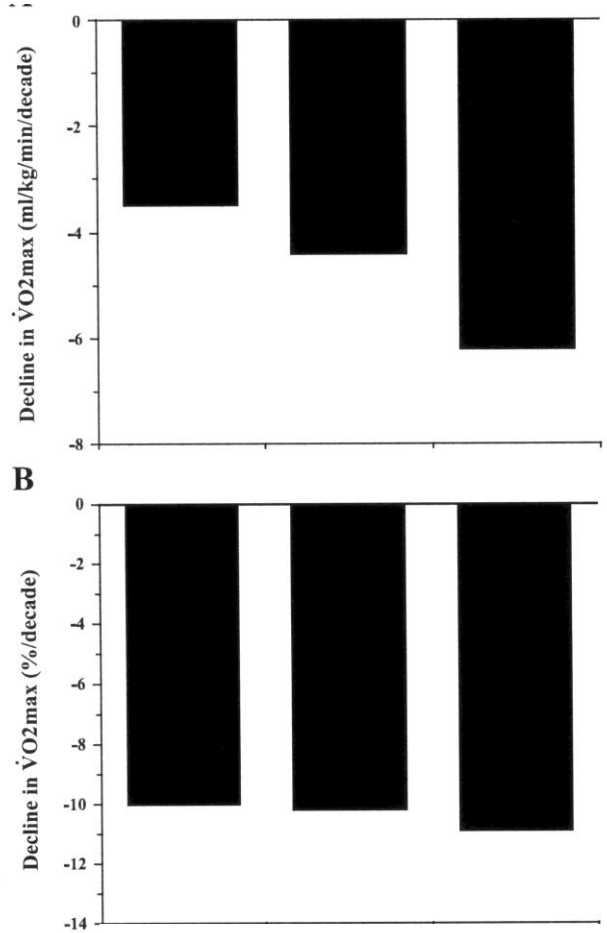
Tanaka H, Adv Exerc Sports Physiol 1998; Tanaka H, J Appl Physiol 1997

Age-Related Decline in Exercise Capacity in Normal Individuals and Athletes

Correlation VO_2 max - Age



Influence of the Training State on VO_2 max Decline



Evans SL, J Appl Physiol 1995(78):1931-41

Is the Age-Related Decline in Exercise Capacity Different Between Normal Individuals and Atheletes?

Study Design

8 untrained women (63±2 J.)

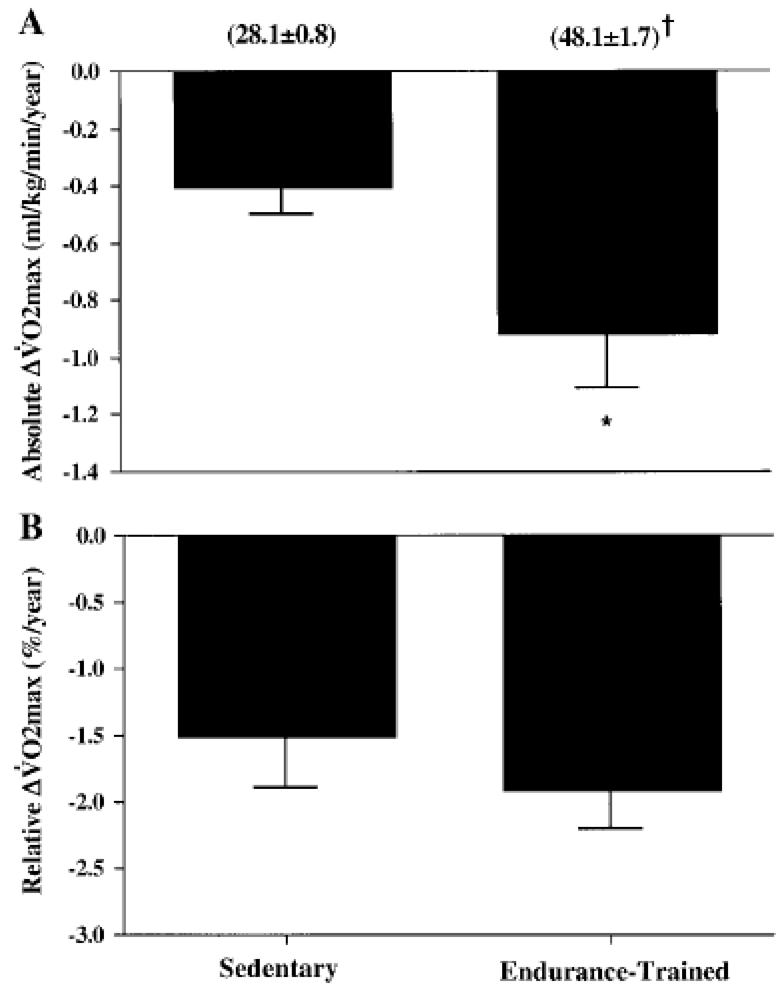
16 female athletes (57±2 J.)

Ergospirometry

7 Jahre
Mean Follow-up

Ergospirometry

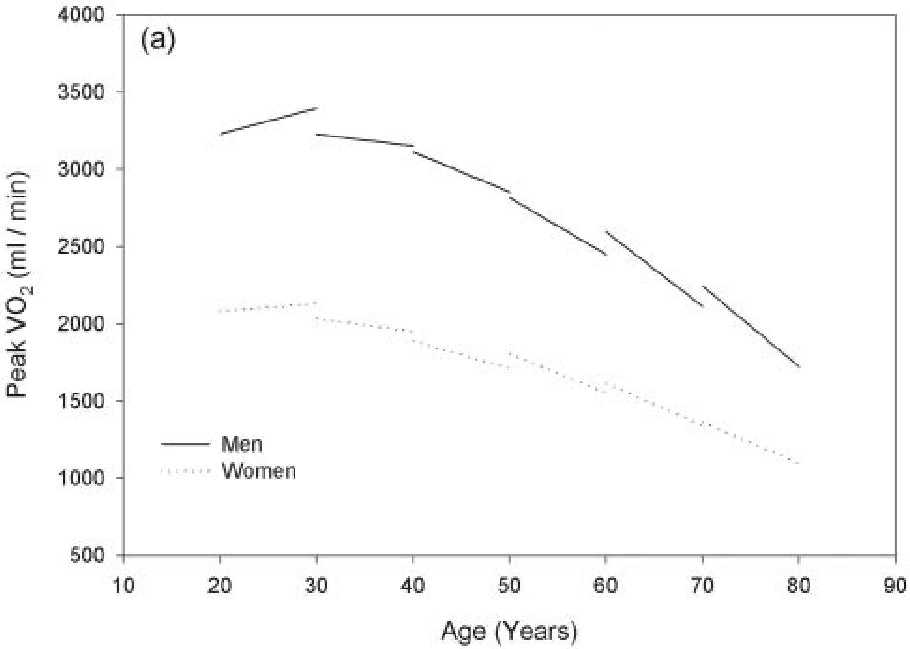
Absolute and Relative Decline in VO_2 max



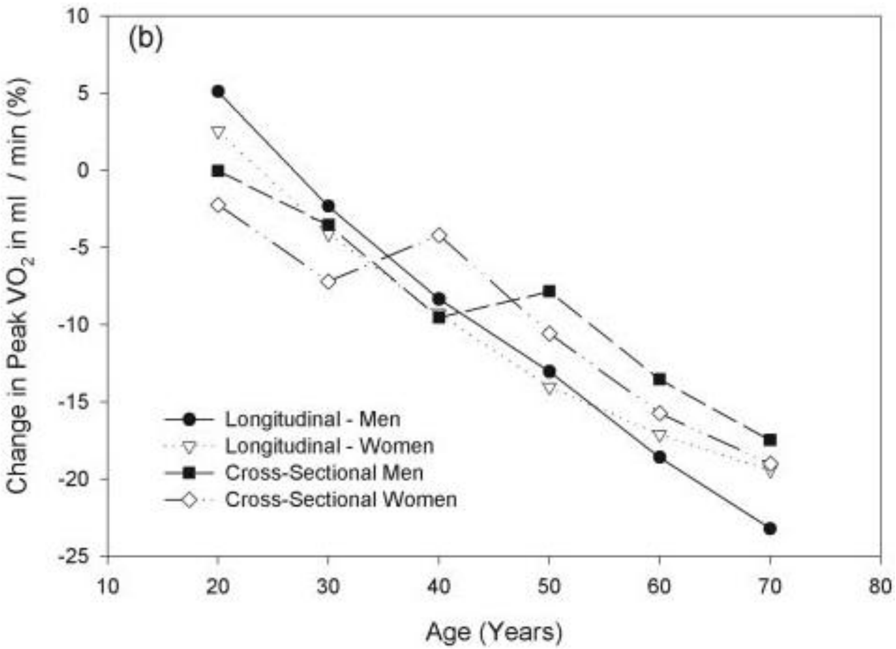
Eskurza I, J Appl Physiol 2002(92):2303-2308

Non-linear Decline of Exercise Capacity in the Baltimore Longitudinal Study of Ageing

Max. Oxygen Uptake (age- and sex-averaged) [mL/min]



Relative Decline of VO_2 max: Longitudinal versus Cross-Sectional Studies [%]

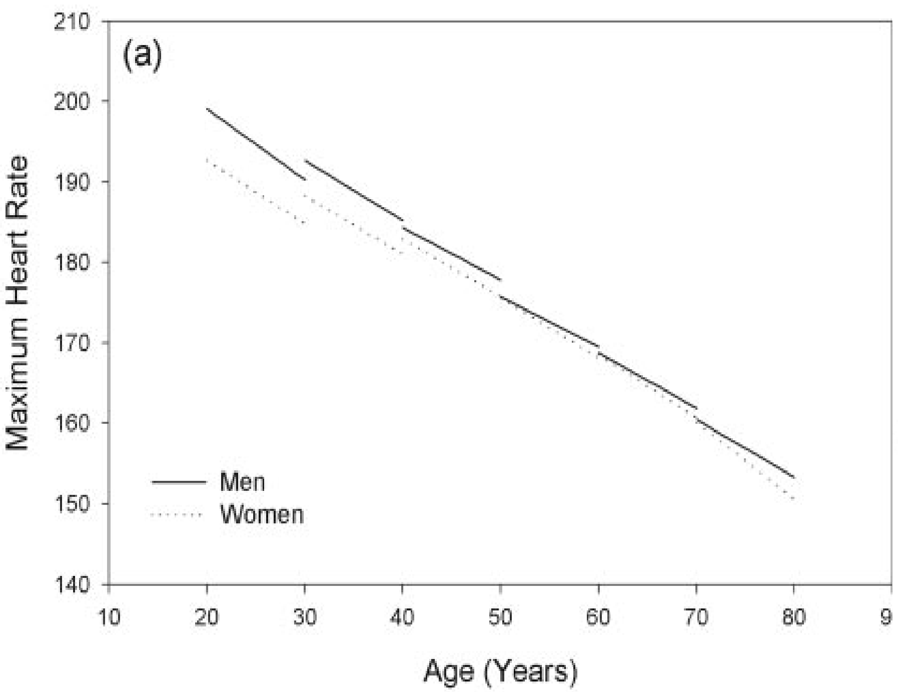


1. Cross-sectional studies undersetimate the decline in VO_2 max.
2. The decline of VO_2 max is not constant but accelerates from -8% in the 4th decade to -22% in the 8th decade.

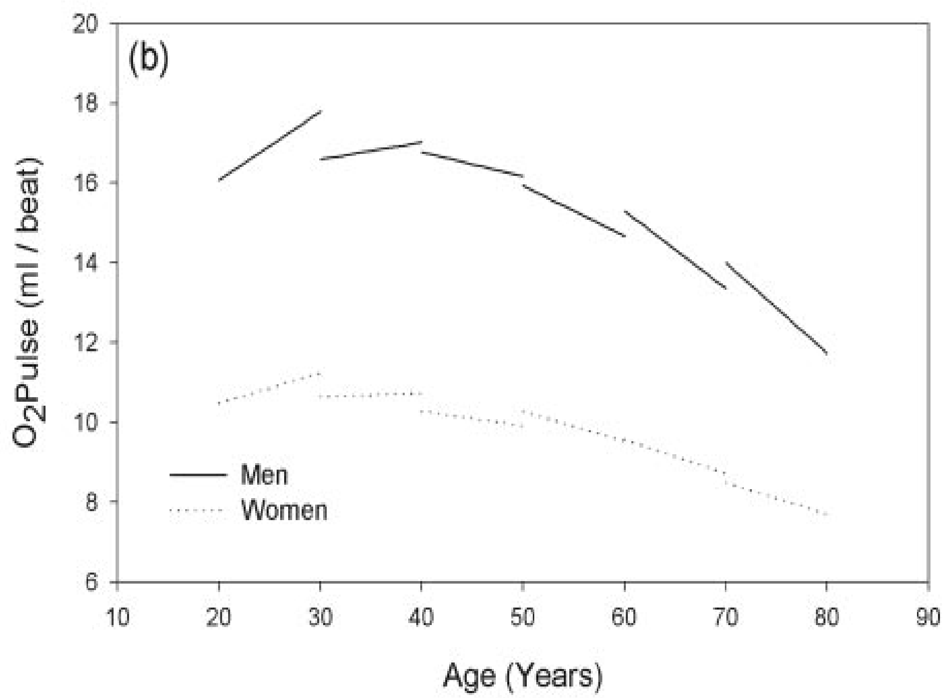
Fleg JL, Circulation 2005(112):674-682

Contribution of Cardiovascular Exercise Capacity to the Decline of Total Exercise Capacity

Age-dependent Decline of the Maximal Heart Rate



Decline of the Oxygen Pulse as Indicator of the O_2-Transport Capacity of the CV System per Heart Beat



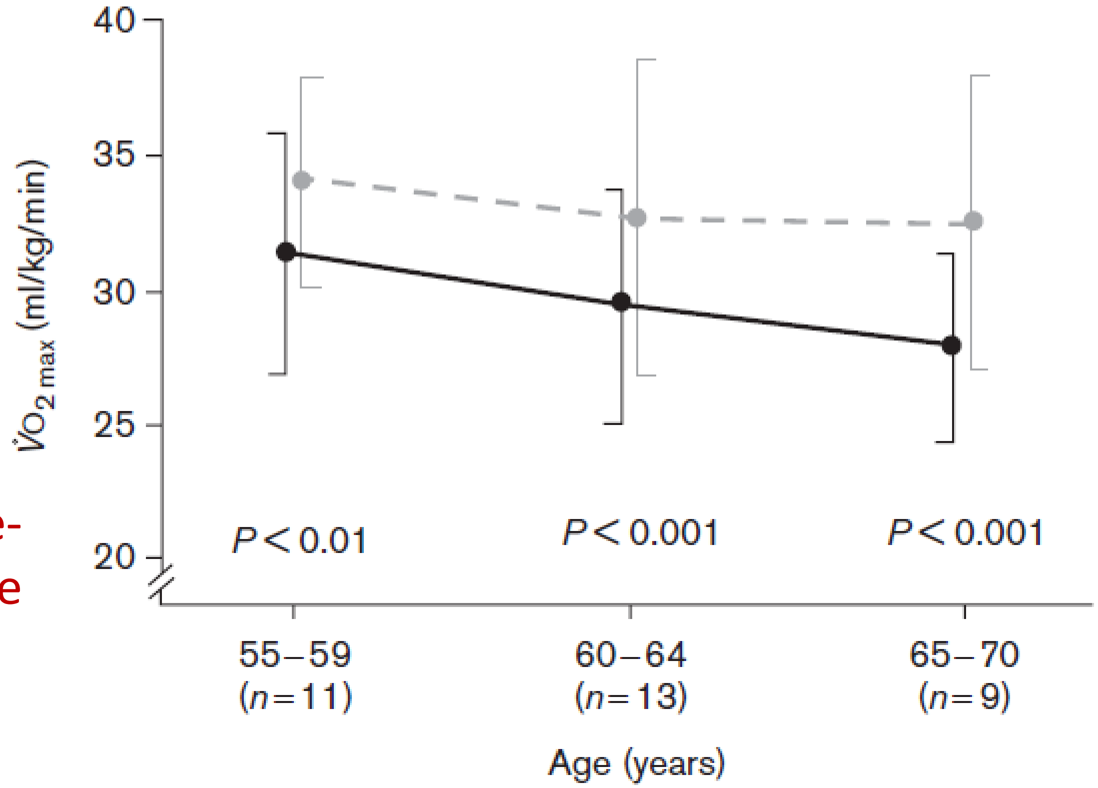
In healthy ageing the cardiovascular functional reserves are reduced while basal cardiac output is preserved.

Fleg JL, Circulation 2005(112):674-682

2.

Do elderly people benefit equally well from rehabilitation programmes?

Relative Effects of Endurance Training in Different Age-Groups in Healthy Subjects



Effects of a 8-week endurance-training course was undergone by clinically healthy men aged 55–70 years.
The maximum oxygen uptake increased on average by 18%, and the aerobic–anaerobic threshold to 4 mmol/l lactate by 22%.

Benefits of Exercise-Based Cardiac Rehabilitation in Very Old Patients Compared with Younger Patients

Study	Patients	Results
Ades et al (1993)[45]	N = 45 (<70 y; n = 29, ≥70 y; n = 16) Women = 33%	Lower baseline peak V_{O_2} (mL/kg/min) in older vs younger patients (15.9 vs 21.5, $P < .05$) Greater relative improvement after CR in older vs younger patients (21% vs 10%, $P < .16$)
Balady et al (1996)[47]	N = 778 (<65 y; n = 492, 65–75 y; n = 241, >75 y; n = 45) Women = 28%	Decreased baseline exercise tolerance (METS) with increasing age (<65 y, 8.9 vs 65–75 y, 6.6 vs >75 y, 5.7, $P < .001$) Similar relative improvement after CR for each age and gender groups (< 65 y: men, 36% and women, 41%, both $P < .001$ from baseline; 65–75 y: men, 36% and women, 50%, both $P < .001$ from baseline; >75 y: men, 36%, $P < .01$ from baseline and women, 32%, P = NS from baseline)
Lavie et al (1996)[46]	N = 283 (<60 y; n = 229, ≥75 y; n = 54) Women = 25% (<60 y; 15% ≥75 y; 28%)	Lower baseline exercise tolerance (METS) in older vs younger patients (4.4 vs 7.6, $P < .0001$) Greater relative improvement in exercise tolerance after CR in older vs younger patients (39% vs 31%, $P = .06$, both $P < .001$ from baseline) Lower baseline QOL (SF-36) and SF-36 physical function scores in older vs younger patients Greater relative improvement in QOL (20% vs 14%, $P < .05$) and physical function (27% vs 20%, P = NS) (all $P < .0001$ from baseline) scores after CR in older patients vs younger patients
Lavie et al (2000)[49]	N = 182 (<55 y; n = 125, >70 y; n = 57) Women = 18% (<55 y; 15% >70 y; 26%)	Lower baseline peak V_{O_2} (mL/kg/min) in older vs younger patients (14.7 vs 18.1, $P < .01$) Lower relative improvement in peak V_{O_2} after CR in older vs younger patients (13% vs 18%, $P < .01$) (both $P < .0001$ from baseline) Lower baseline QOL (SF-36) and SF-36 physical function scores in older vs younger patients Greater relative improvement in QOL (20% vs 14%, $P = .03$) and SF-36 physical function (27% vs 20%, $P = .02$) (all $P < .0001$ from baseline) scores after CR in older vs younger patients

Audelin MC, J Cardiopulm Rehab Prev 2008(28):163-73

Exercise Training to Treat Diastolic Dysfunction in the Elderly

Leipzig Exercise Intervention in Chronic heart failure and Aging

Healthy Subjects
(n=60)

<55 J.
(n=30, 46±3 J.)

>65 J.
(n=30, 68±4 J.)

CHF-Patients
(n=60)

<55 J.
(n=30, 45±3 J.)

>65 J.
(n=29, 68±3 J.)

Ergospirometry, Echocardiography, Endothelial Function, Muscle Bx.

Aerobic ex. training
60 to 70% of the HRR
4 x 20 min/day

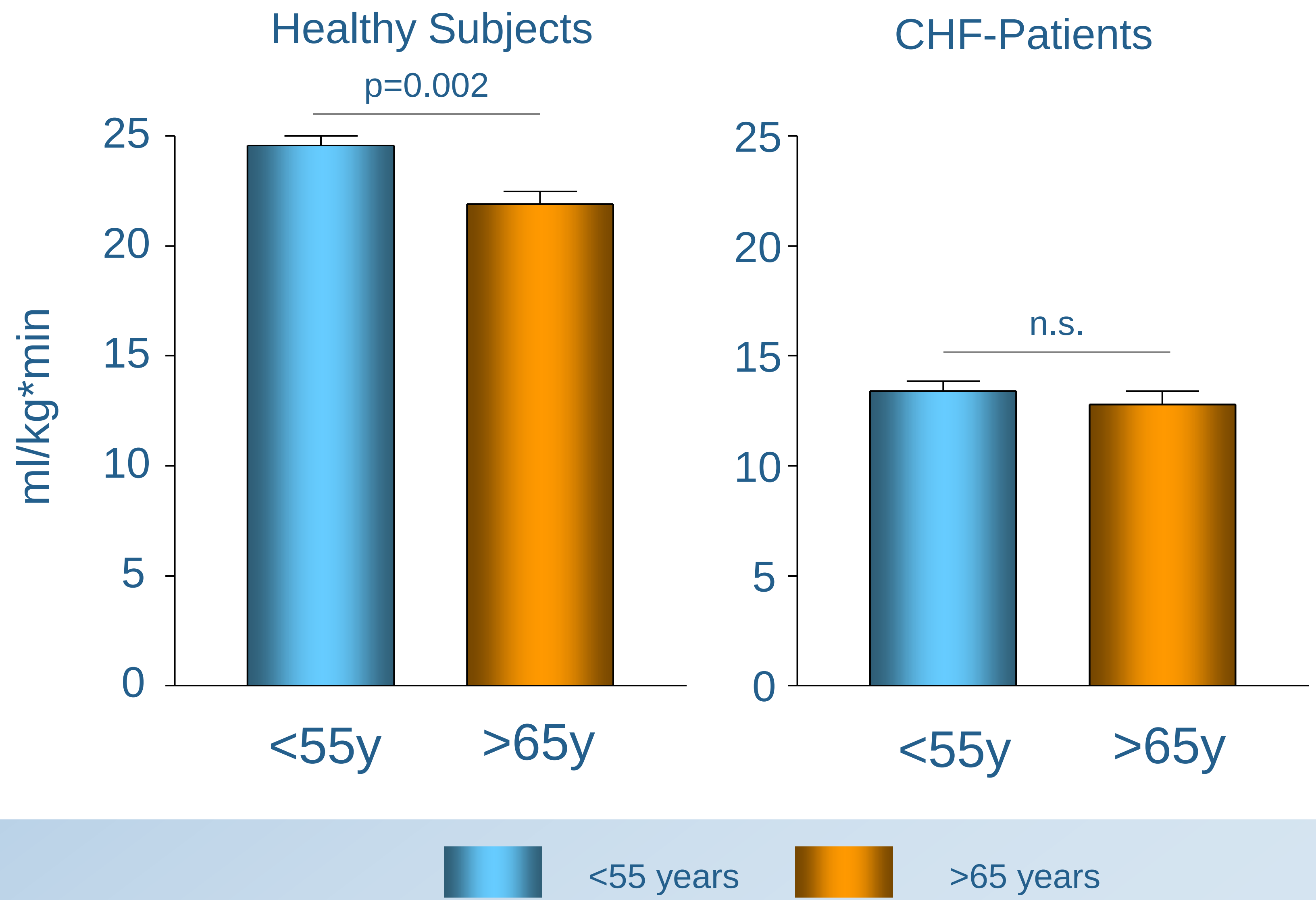
Control Group

4 Wks.

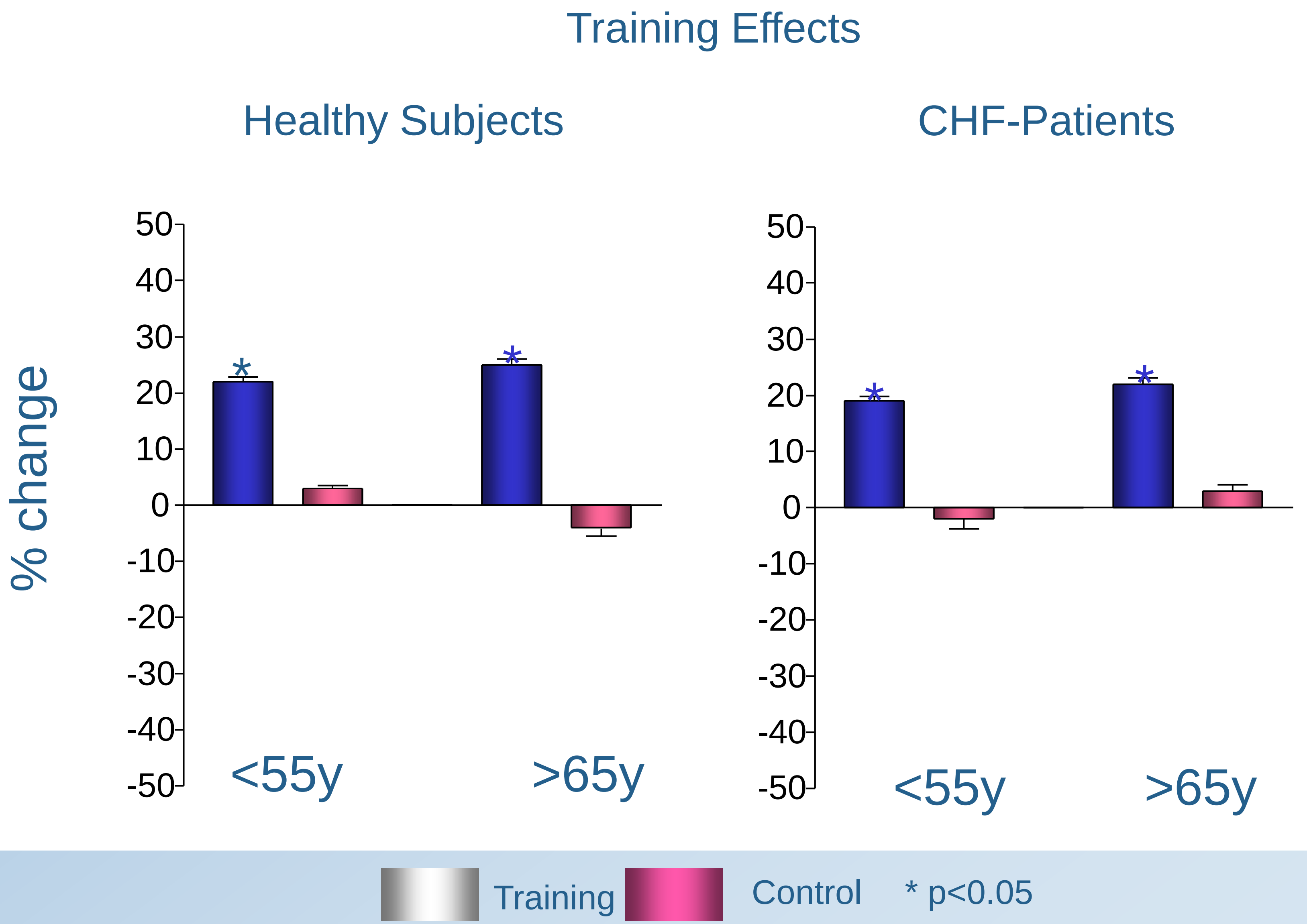
Ergospirometry, Echocardiography, Endothelial Function, Muscle Bx.

Ergospirometry

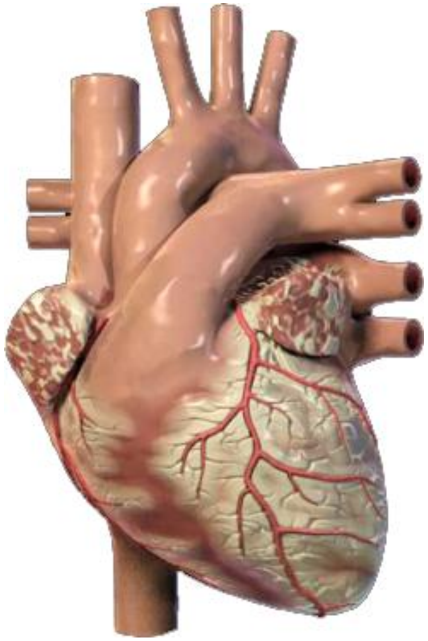
Baseline



Ergospirometry

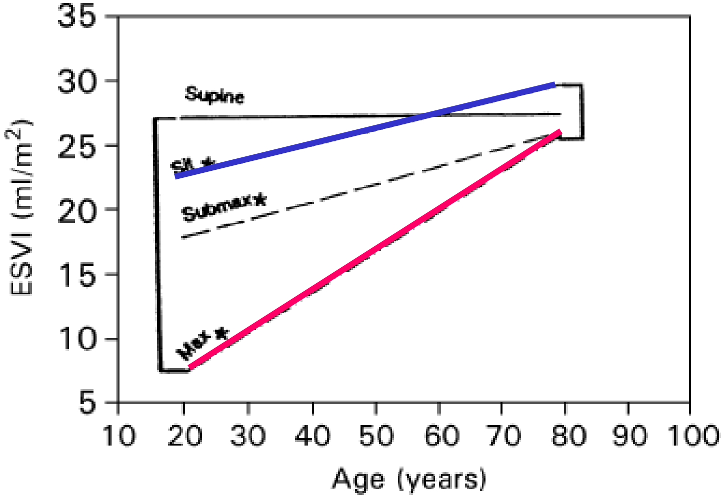


3.
Cardiac effects of exercise in elderly people

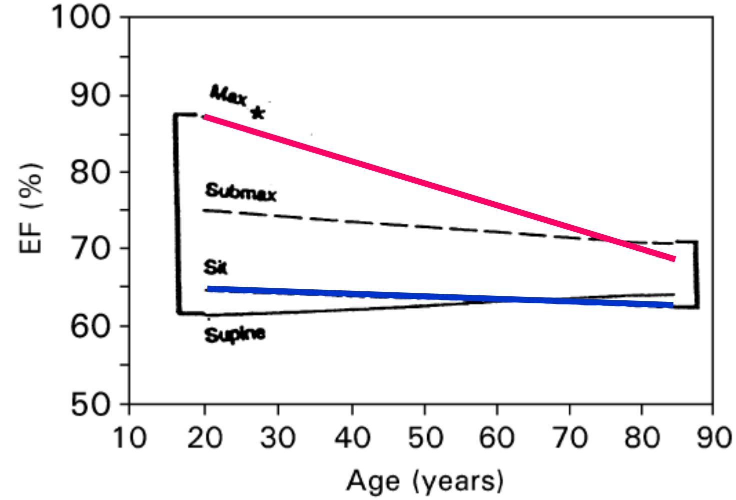


Age-dependent Change of LV-Function During Physical Exertion
- Clinical & Epidemiological Data -

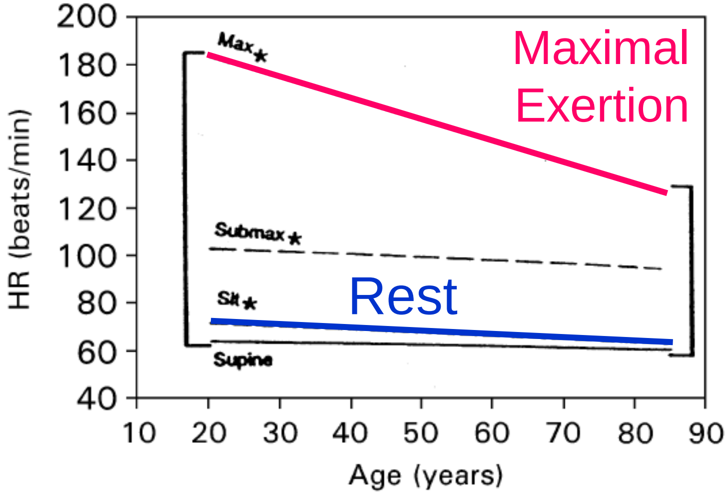
Endsystolic Volume



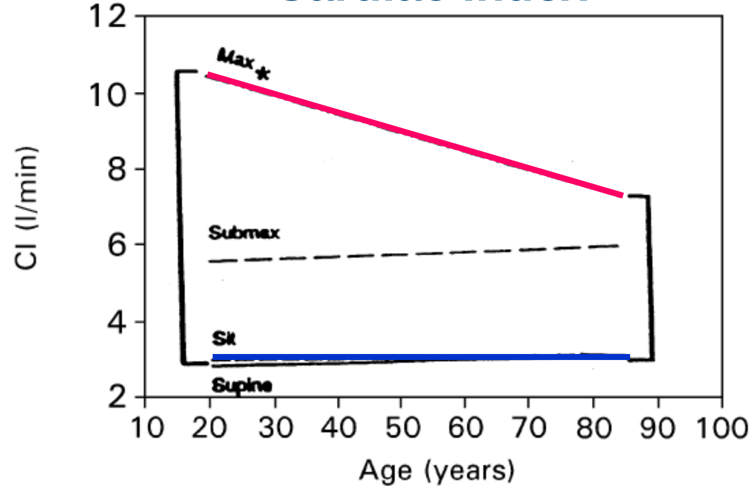
Ejection Fraction



Heart Rate

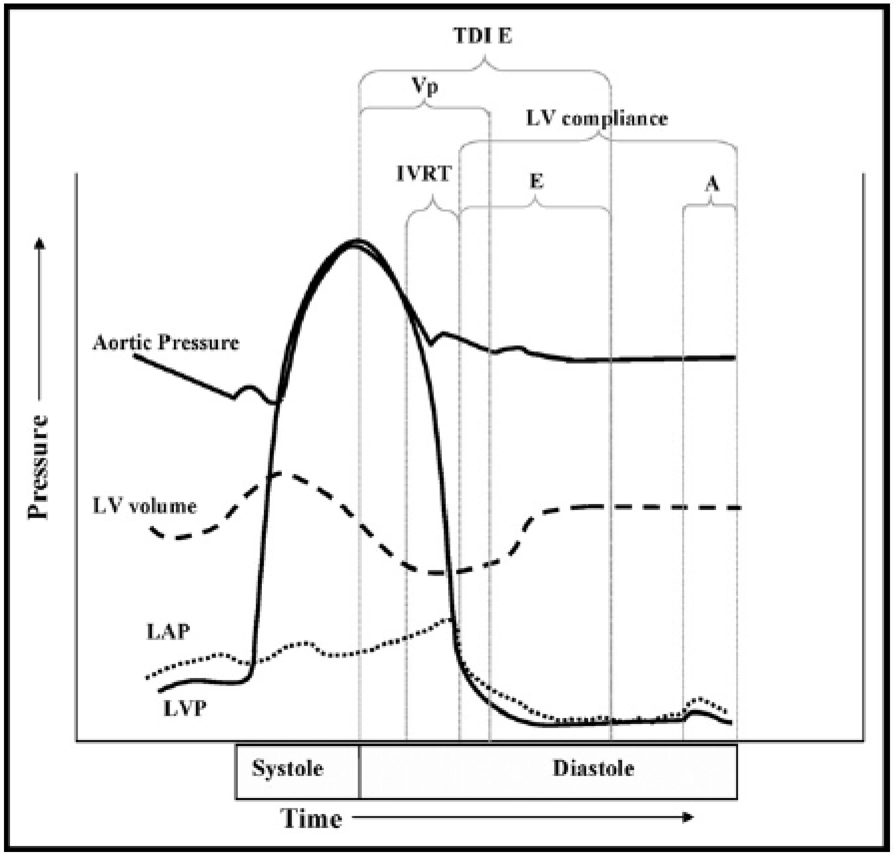


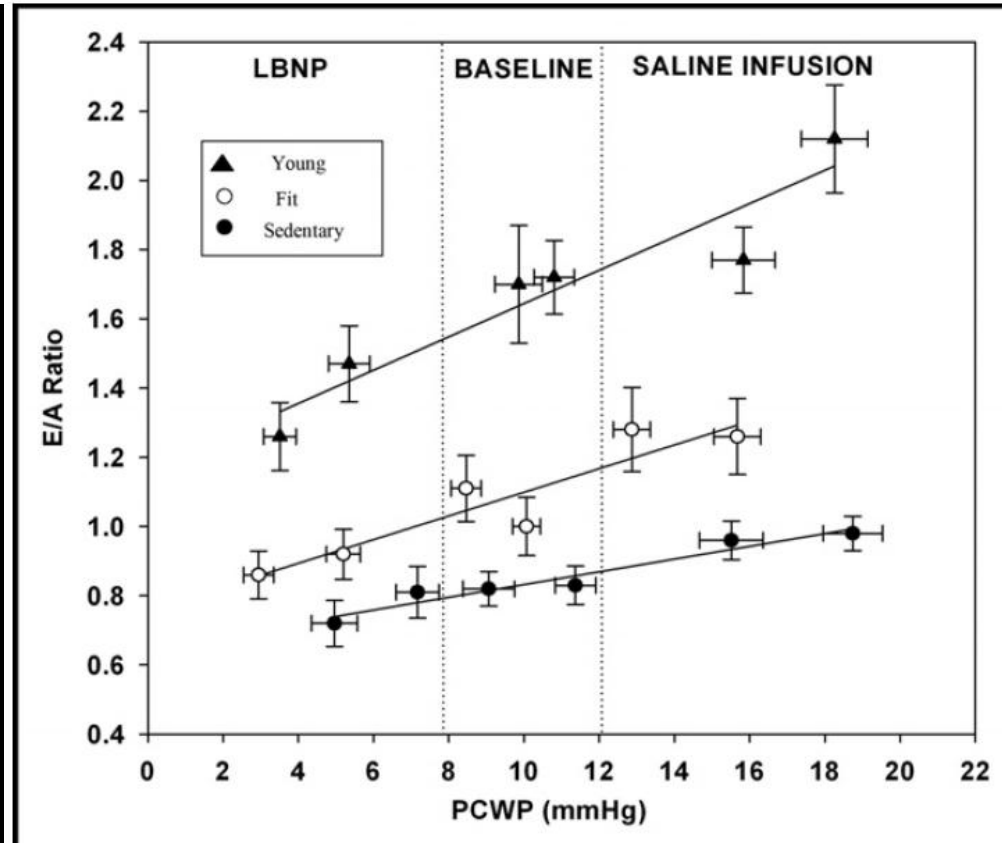
Cardiac Index



Fleg JL, J Appl Physiol.1995; 78: 890-900

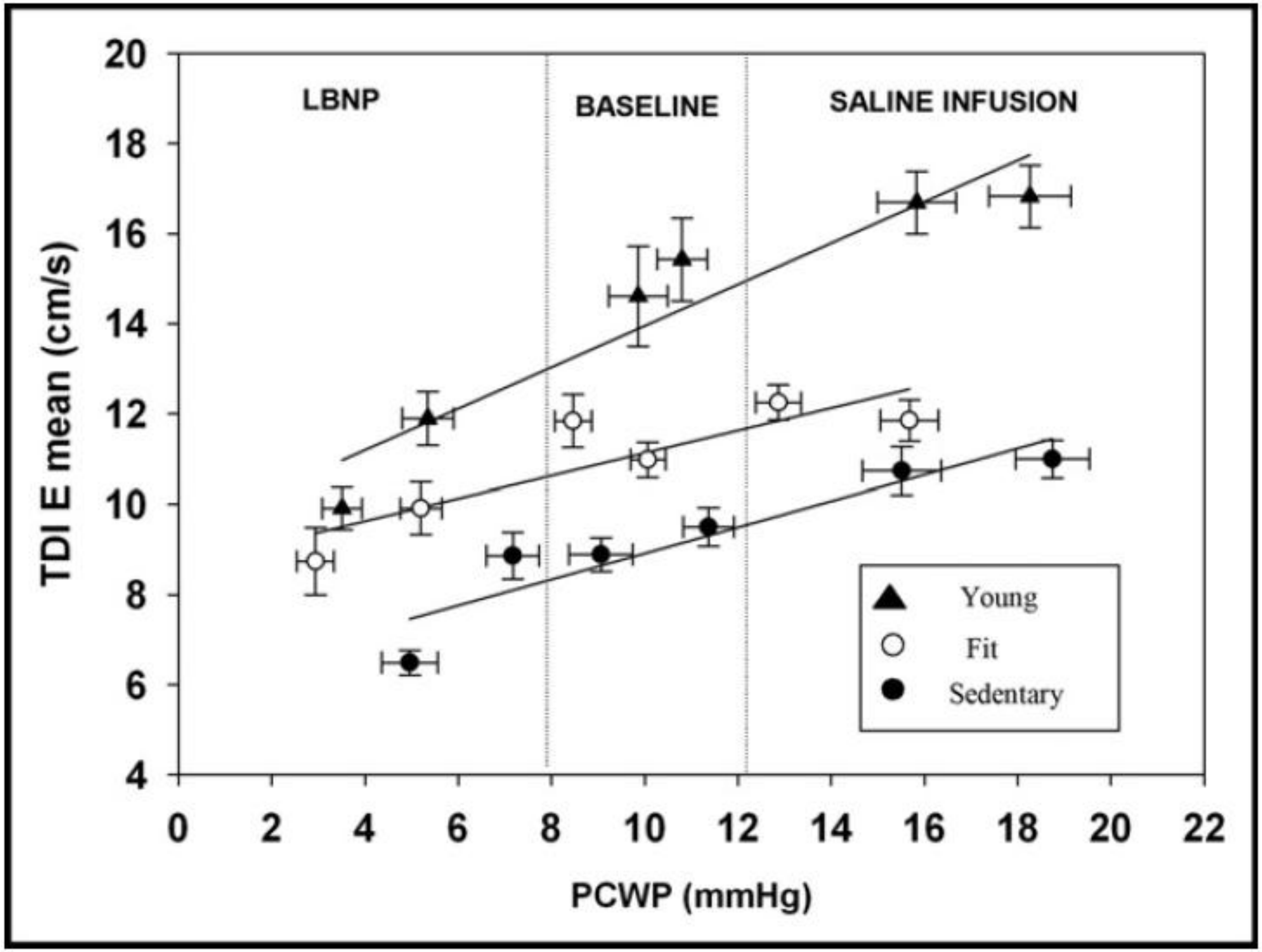
Effects of Habitual Physical Exercise on Diastolic Function in Healthy Subjects of Different Ages (Echocardiography)





Prasad A, Am J Cardiol 2007;99:1629 –1636

Effects of Habitual Physical Exercise on Diastolic Function in Healthy Subjects of Different Ages (Echocardiography)

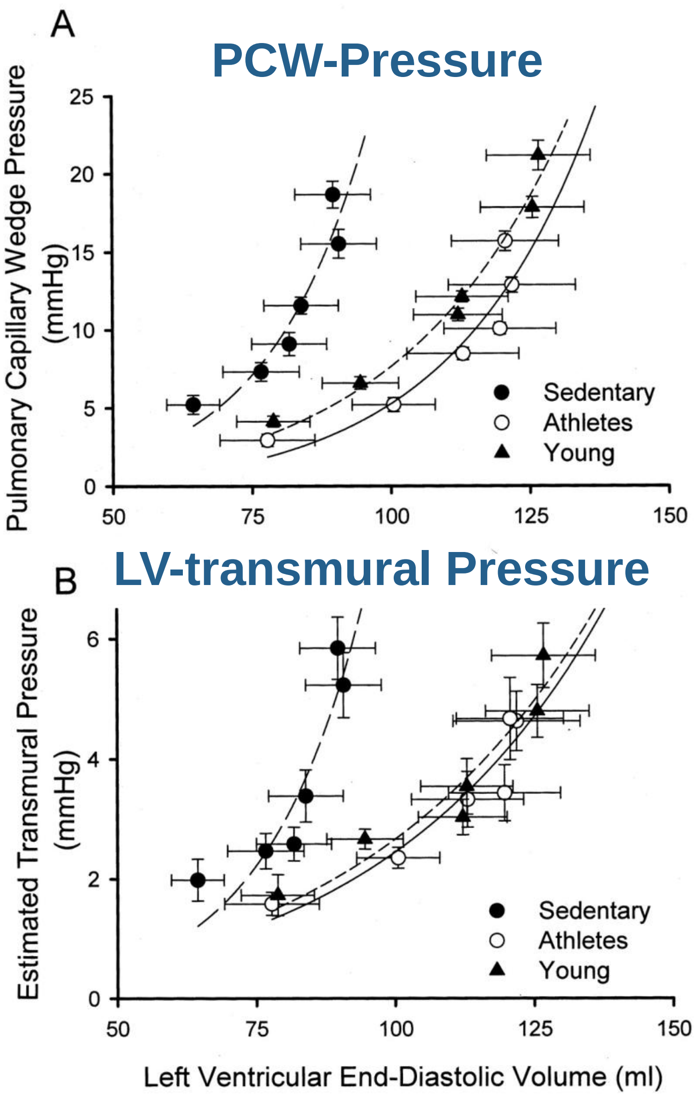


Prasad A, Am J Cardiol 2007;99:1629 –1636

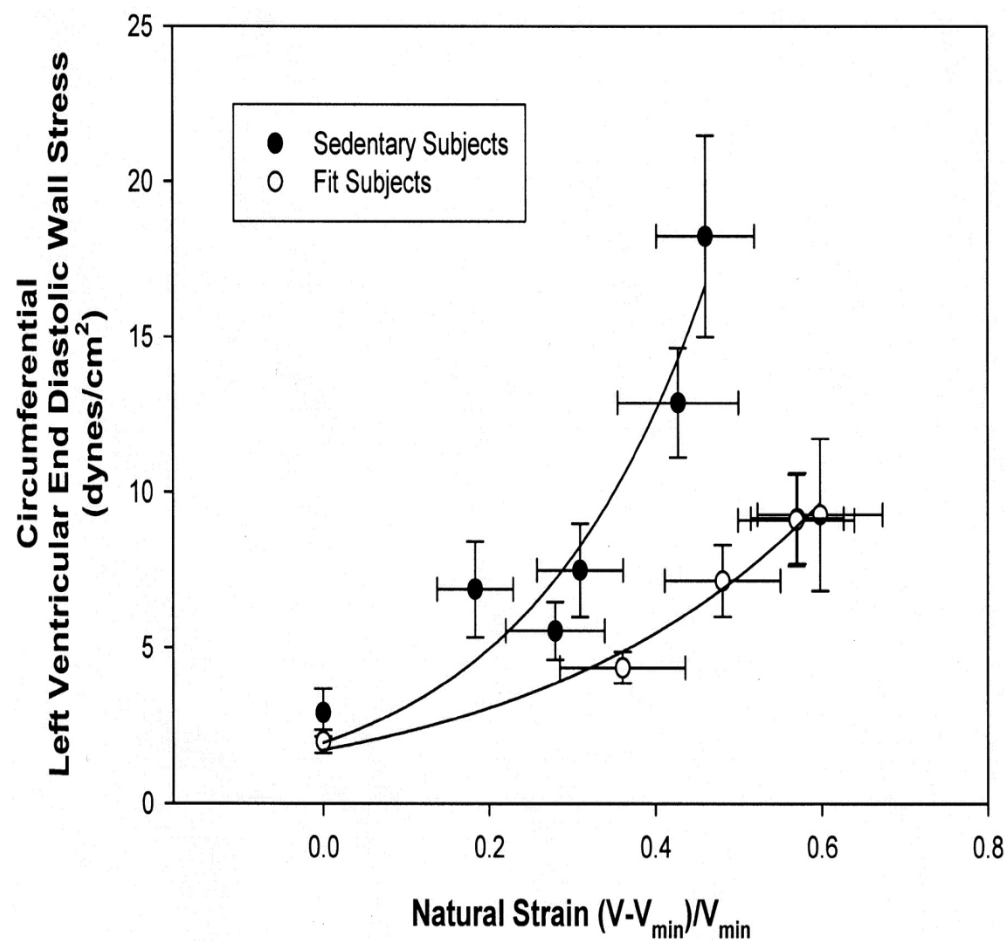
Physical Activity and Diastolic LV-Function (Hemodynamics)

PCW-Pressure

LV-transmural Pressure

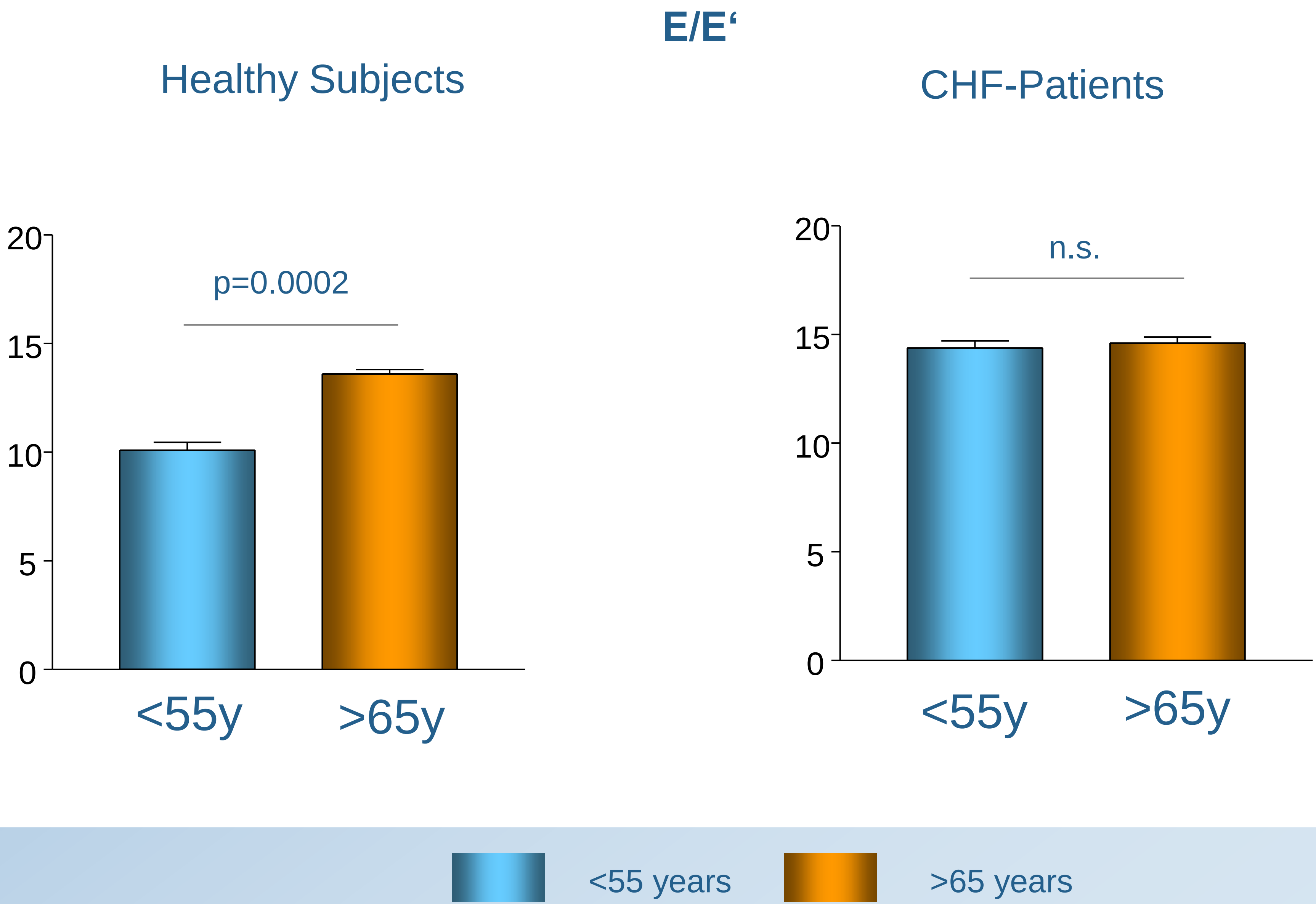


Volume Load & Wall Tension

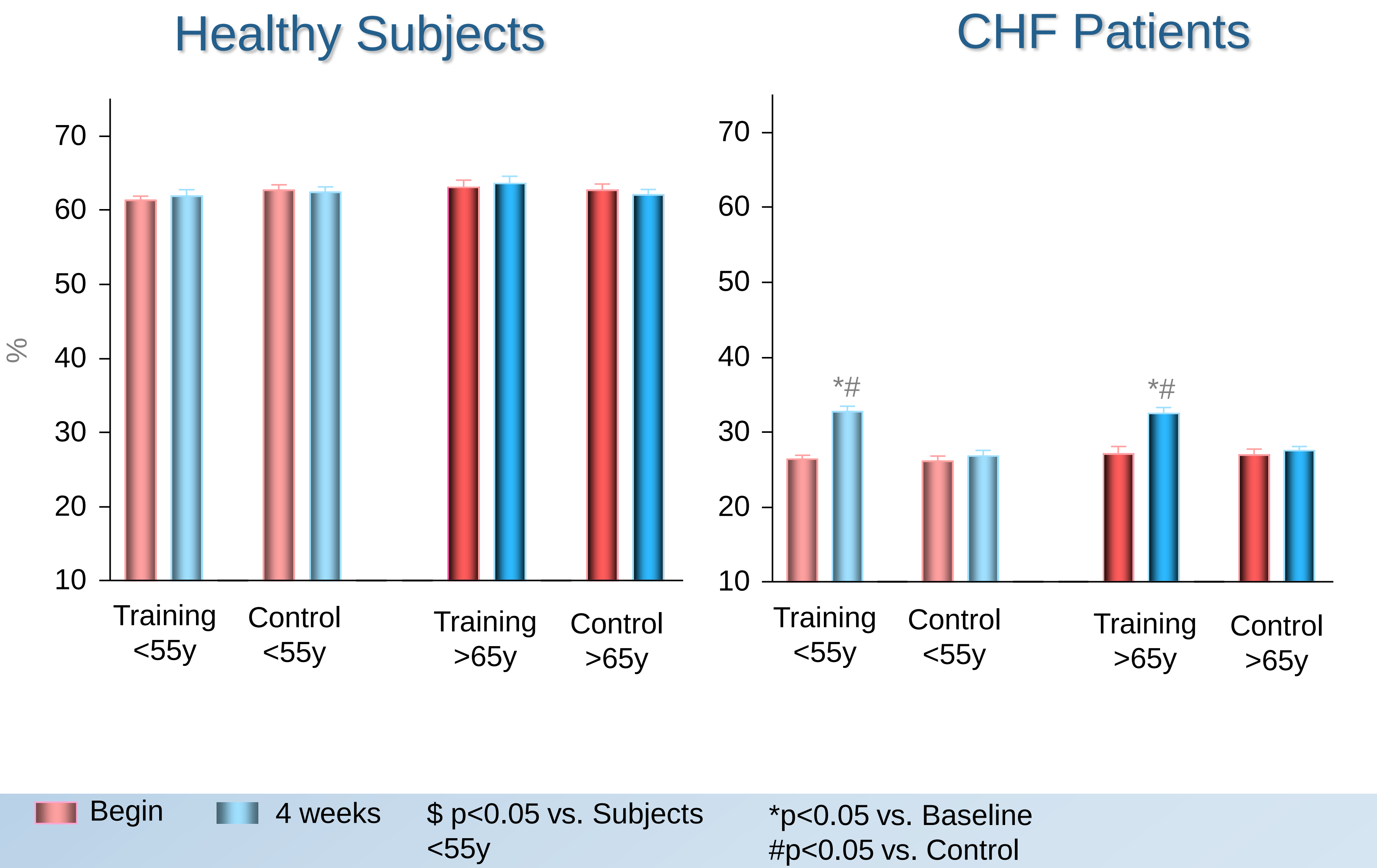


Arbab-Zadeh A et al., *Circulation* 2004;110:1799-1805

Diastolic Dysfunction
Baseline



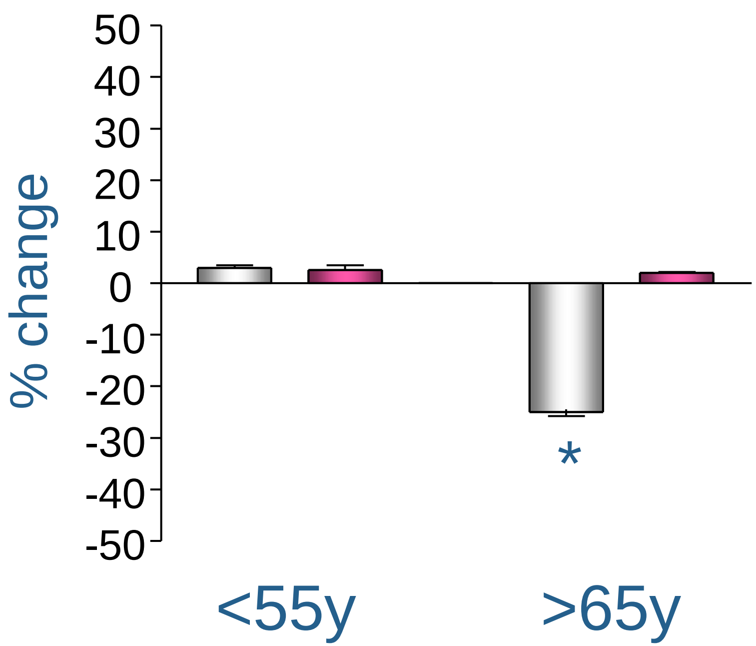
Changes in Systolic LV-Function after 4 Weeks of Exercise Training



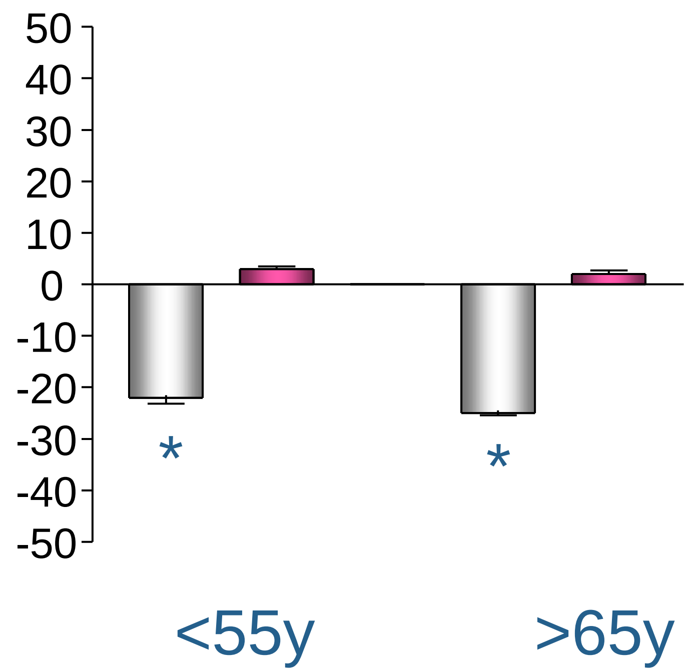
Diastolic Dysfunktion
Training Effects

E/E‘

Healthy Subjects



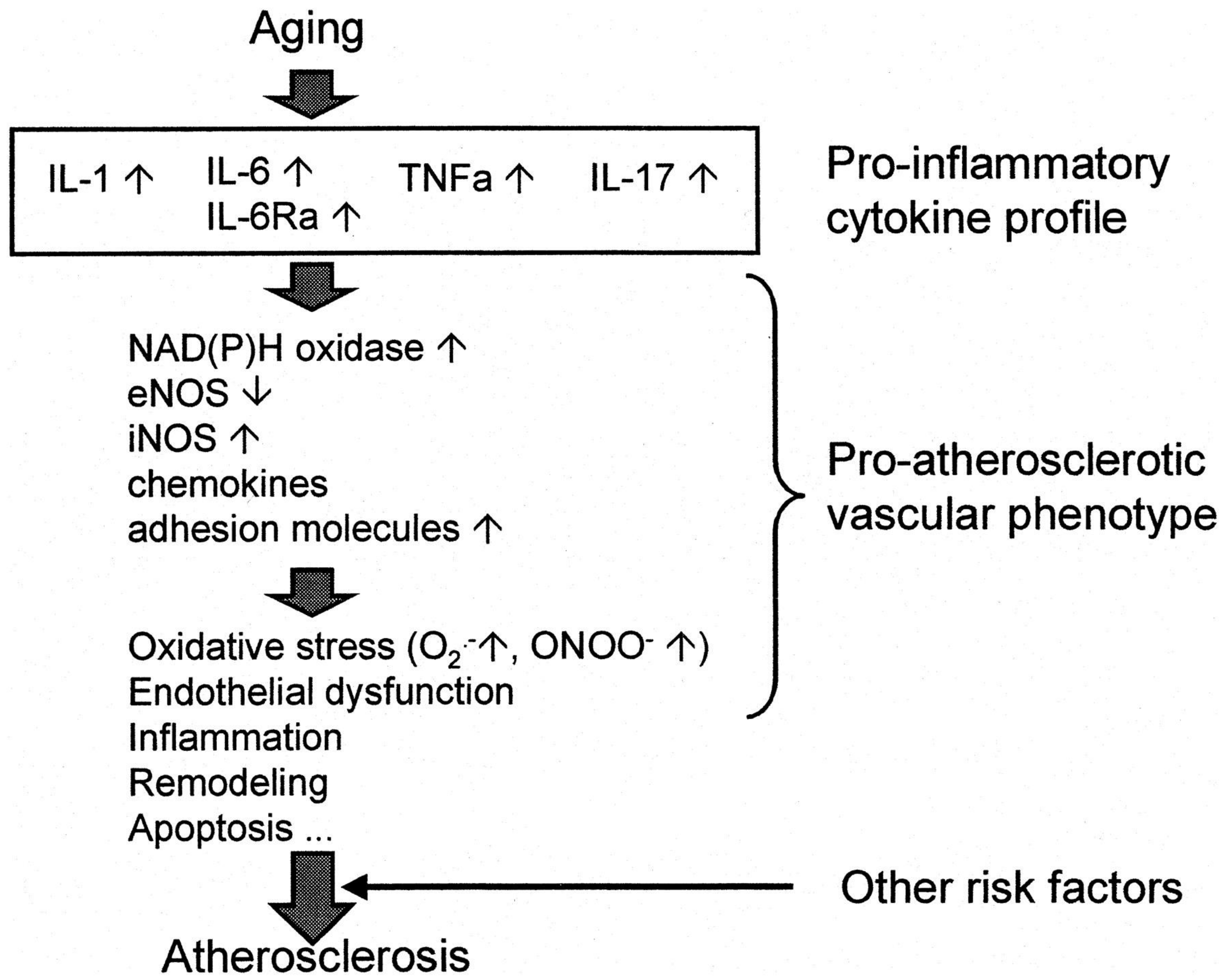
CHF-Patients



Training Control * p<0.05

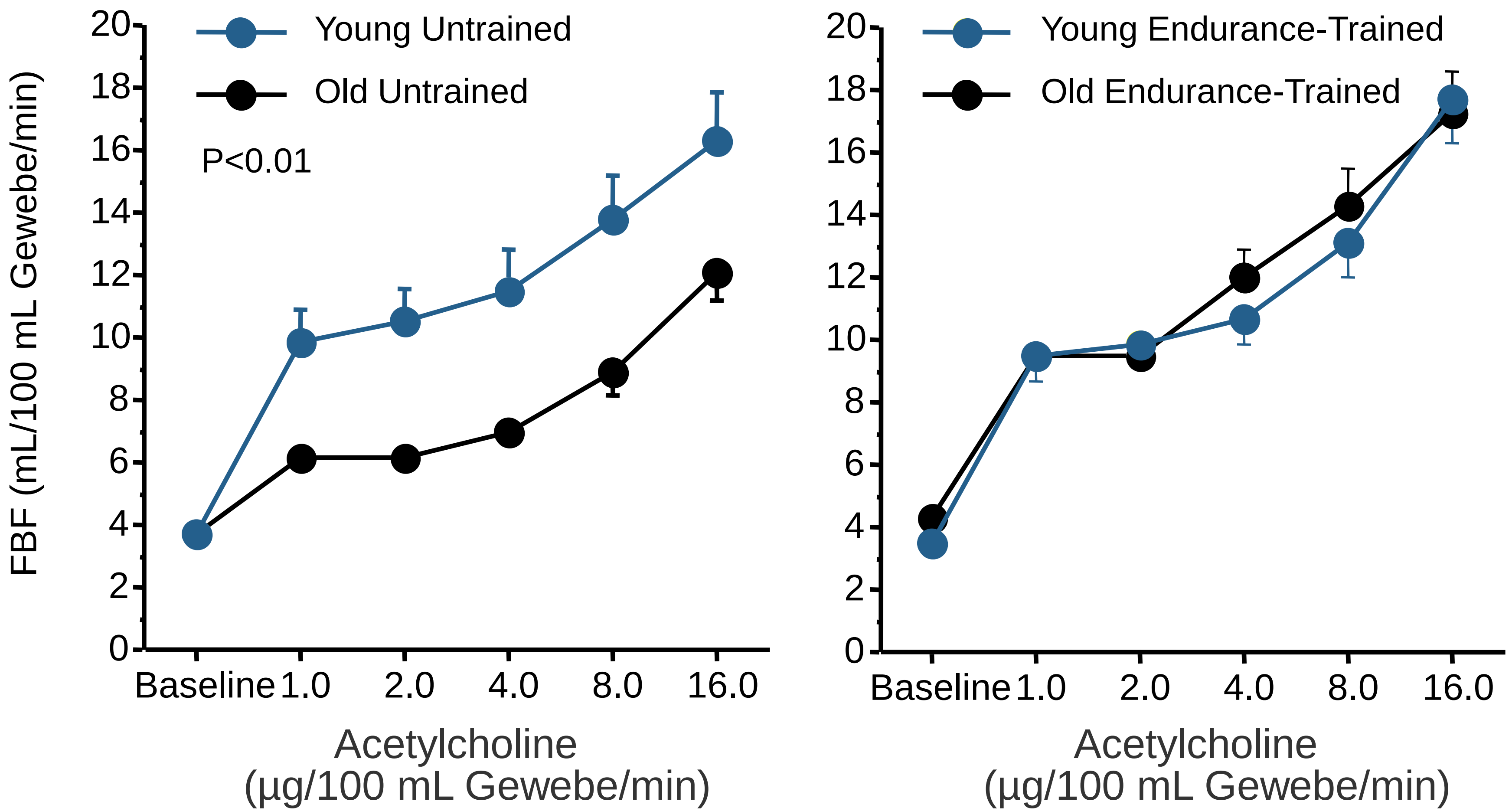
4.
Age-related Training Effects on the Vascular Endothelium

Inflammatory Causes of ROS and Endothelial Dysfunction in Ageing



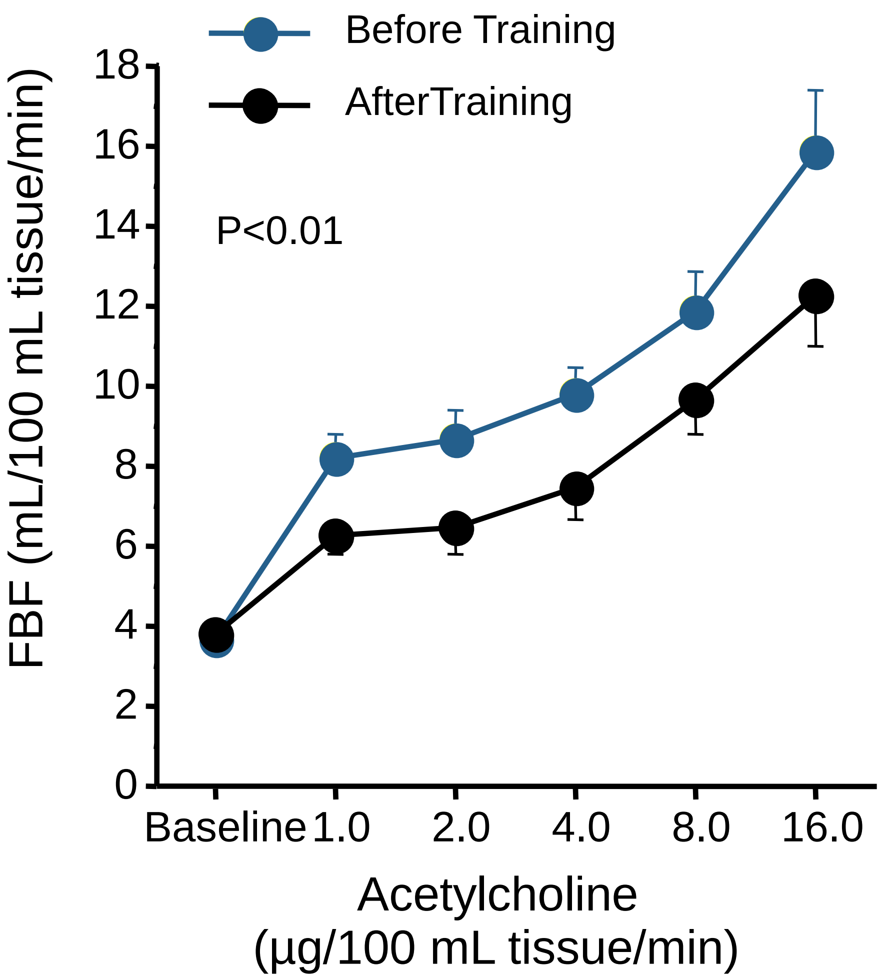
Csiszar A, FASEB J 2003(17):1183-85

Habitual Physical Activity Prevents Endothelial Dysfunction in the Elderly



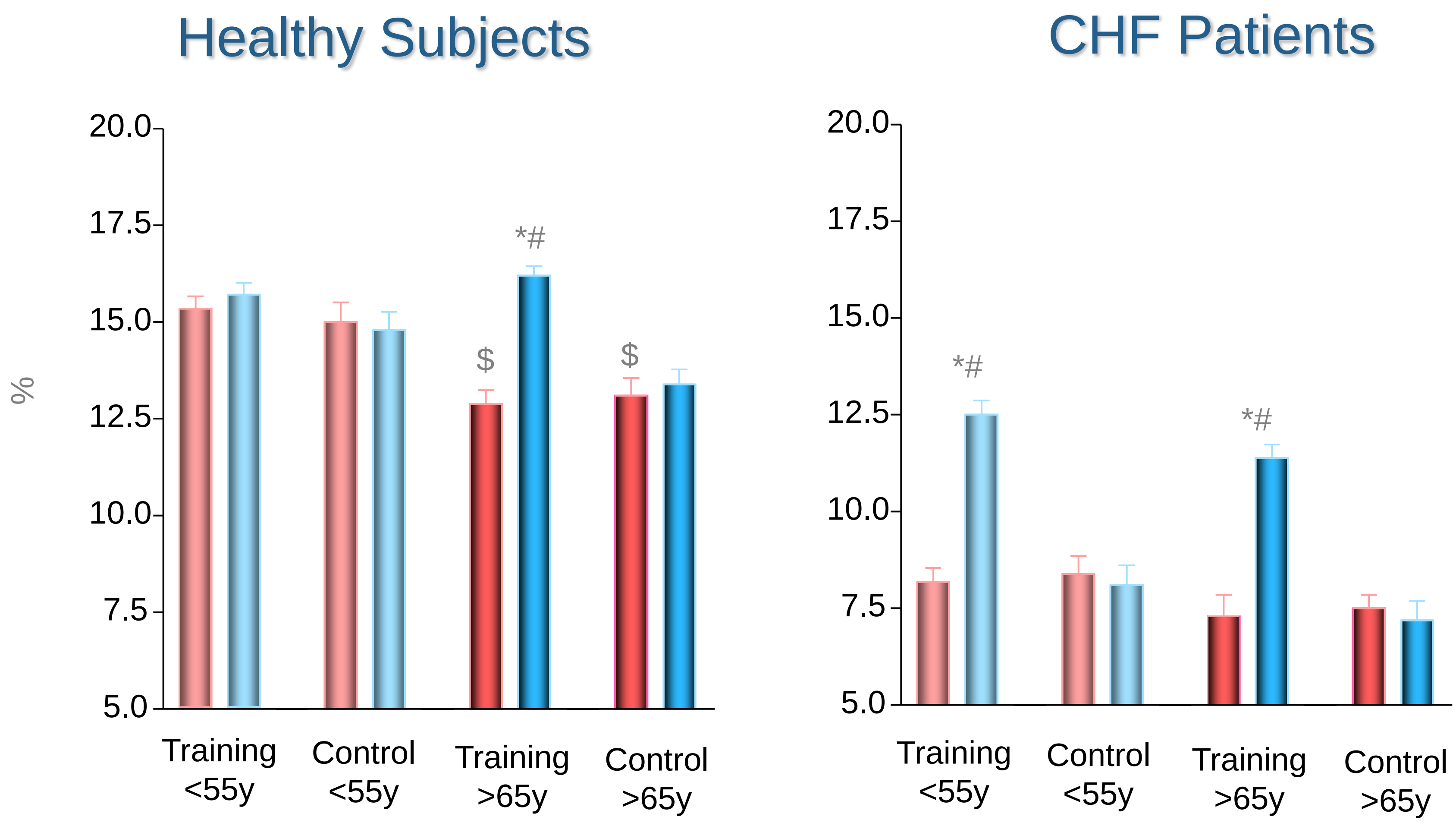
DeSouza et al., *Circulation* 102:1351-1357, 2000

Daily Walking Training Improves Endothelial Function in Elderly Subjects



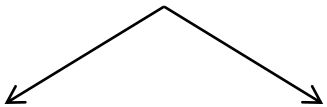
DeSouza et al., *Circulation* 102:1351-1357, 2000

Improvement of Endothelial Funktion (FMD) in the Elderly After a 4-Week Endurance Training Programme (LEICA-Studie)



Habitual Voluntary Physical Activity –
A Potential Vascular Anti-Aging Intervention

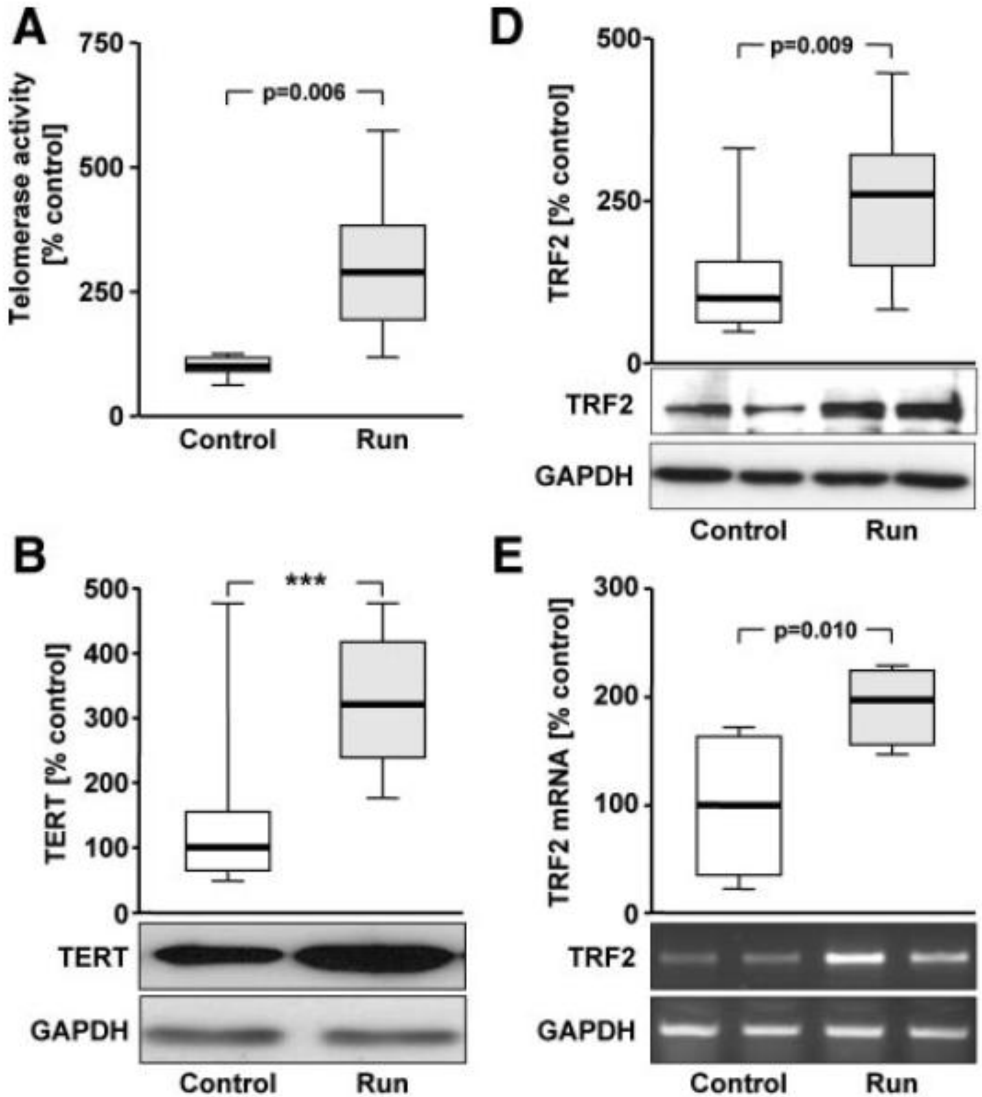
8 wks. old
C57/Bl6 Mice



Voluntary Running (3 weeks)

Sedentary (3 weeks)

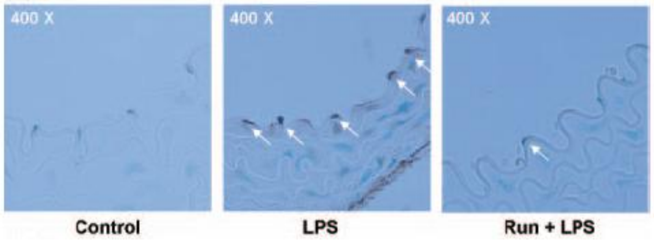
Habitual exercise increases telomerase activity and protein expression, telomerase reverse transcriptase (TERT) and telomere repeat-binding factor 2 expression.



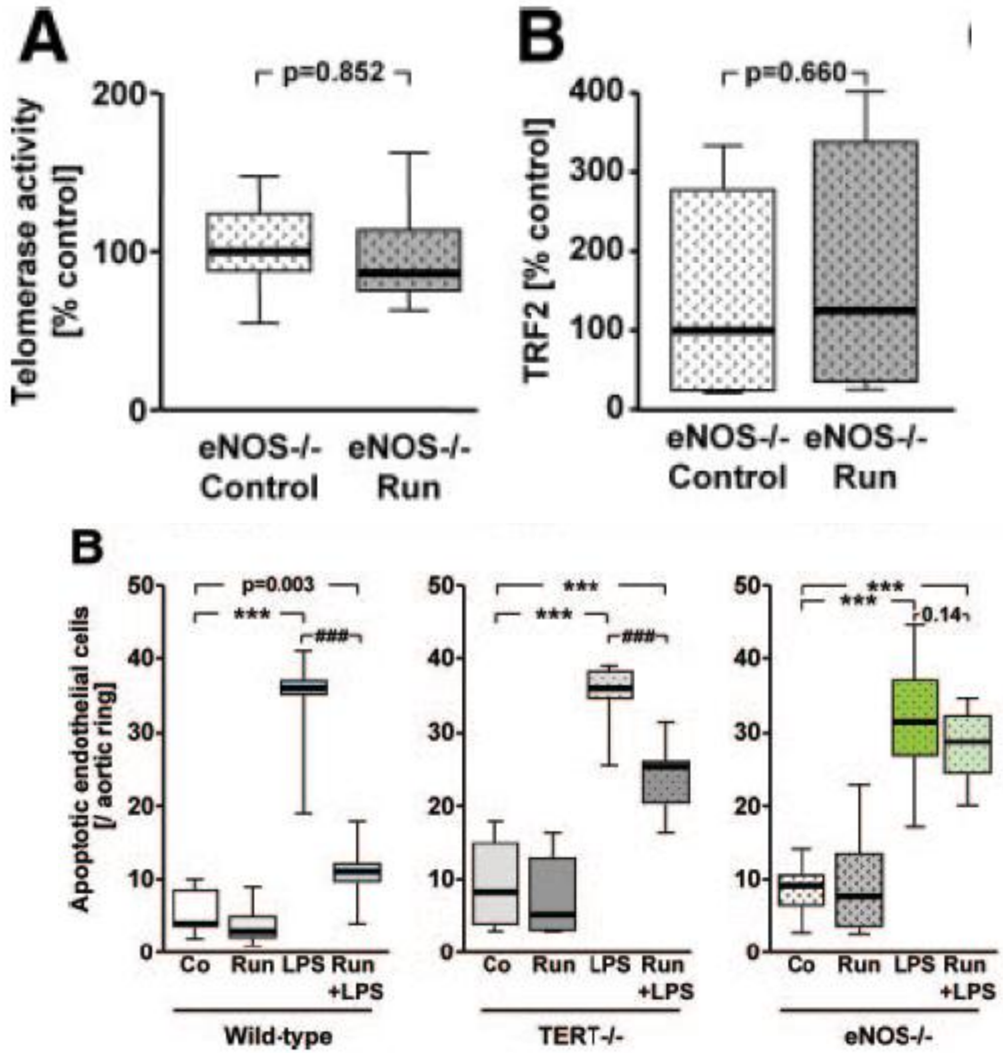
Werner N, Circulation 2009(120):2438-2447

Habitual Voluntary Physical Activity – Antiapoptotic Effects in the Vascular Wall

The effects of habitual exercise on telomerase activity and telomere repeat-binding factor 2 depend on intact eNOS.



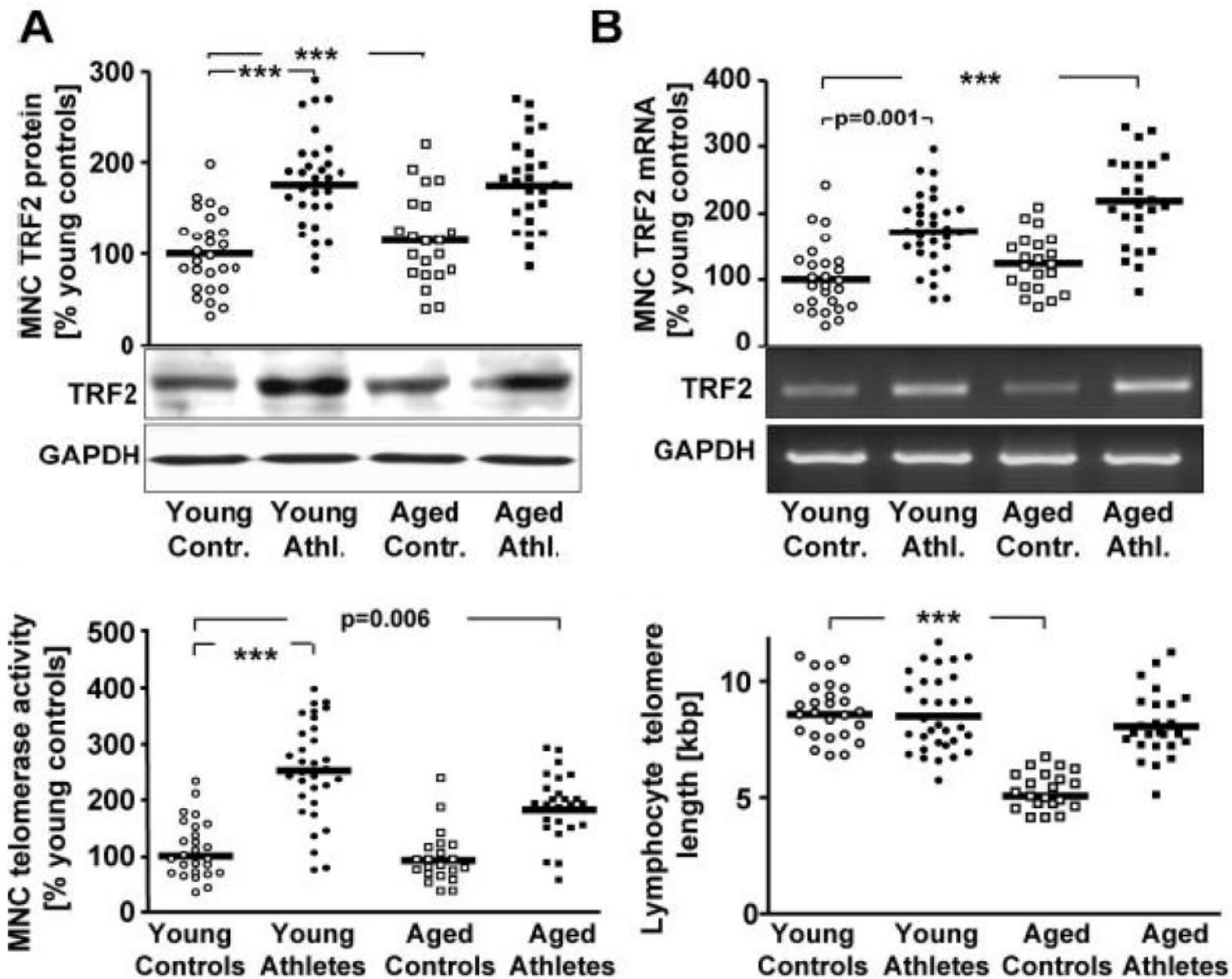
Habitual exercise increases telomerase activity and protein expression, and telomere repeat-binding factor 2 protein and mRNA expression.



Werner N, Circulation 2009(120):2438-2447

Life-long Exercise Training in Humans: Does it provide a protection against ageing?

Telomere and telomere repeat-binding factor 2 (TRF2) in athletes (Athl.) and control subjects (Contr.).



Werner N, Circulation 2009(120):2438-2447

5.
Summary

Summary

Physical exercise programmes in elderly healthy subjects and cardiovascular patients

- Lead to a similar relative increase in exercise capacity,
- Improve diastolic left ventricular function (systolic in CHF)
- Improve endothelium-dependent vasorelaxation by
  (1) increased endothelial NO production through eNOS activation
  (2) increased release of endothelial progrenitor cells
  (3) through improving the oxidative stress tolerance and reducing endothelial cell apoptosis
- Training programmes among elderly patients are currently underused and underestimated. The potential benefit is actually greatest in this group with the most significant limitation of exercise capacity!

Thank you for your kind attention!

The old university buildings

UNIVERSITÄT LEIPZIG 1409 2009 ALMA MATER LIPSIENSIS

The new campus