



High-Intensity Aerobic Exercise Training in Early Outpatient Cardiac Rehabilitation

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Disclosures

- None

Outline

- Exercise and cardiac rehabilitation: historical perspective
- VO_{2peak} and mortality in CVD
- Definition and benefits of high-intensity interval training (HIT)
- Pioneers of HIT
- Safety concerns
- Mayo experience

Brief History of Exercise Training in Cardiac Rehabilitation

- 1950s: strict bedrest for 6+ weeks, realization that earlier mobilization improved outcomes
- 1960s: earlier mobilization, shorter hospital stay; low-moderate intensity outpatient exercise training, potential return to previous activity levels
- 1970s: pre-discharge GXT; ACSM Guidelines; outpatient cardiac rehabilitation programs

History of Exercise Training for CVD Patients

- 1980s: AACVPR; proliferation of University-based training/degree programs in Exercise Science, increase in numbers of CR facilities



Michael L. Pollock, PhD
(1939-1998)

Michael L. Pollock, Ph.D.

- Preeminent exercise physiologist and researcher, mentor and role model for many who followed him, including me
- Pioneer of aggressive Phase I and II rehabilitation after CABG surgery at Mt. Sinai Medical Center, Milwaukee, WI in the late 1970s
- My first job after graduate school was with Mike in Milwaukee in 1979!

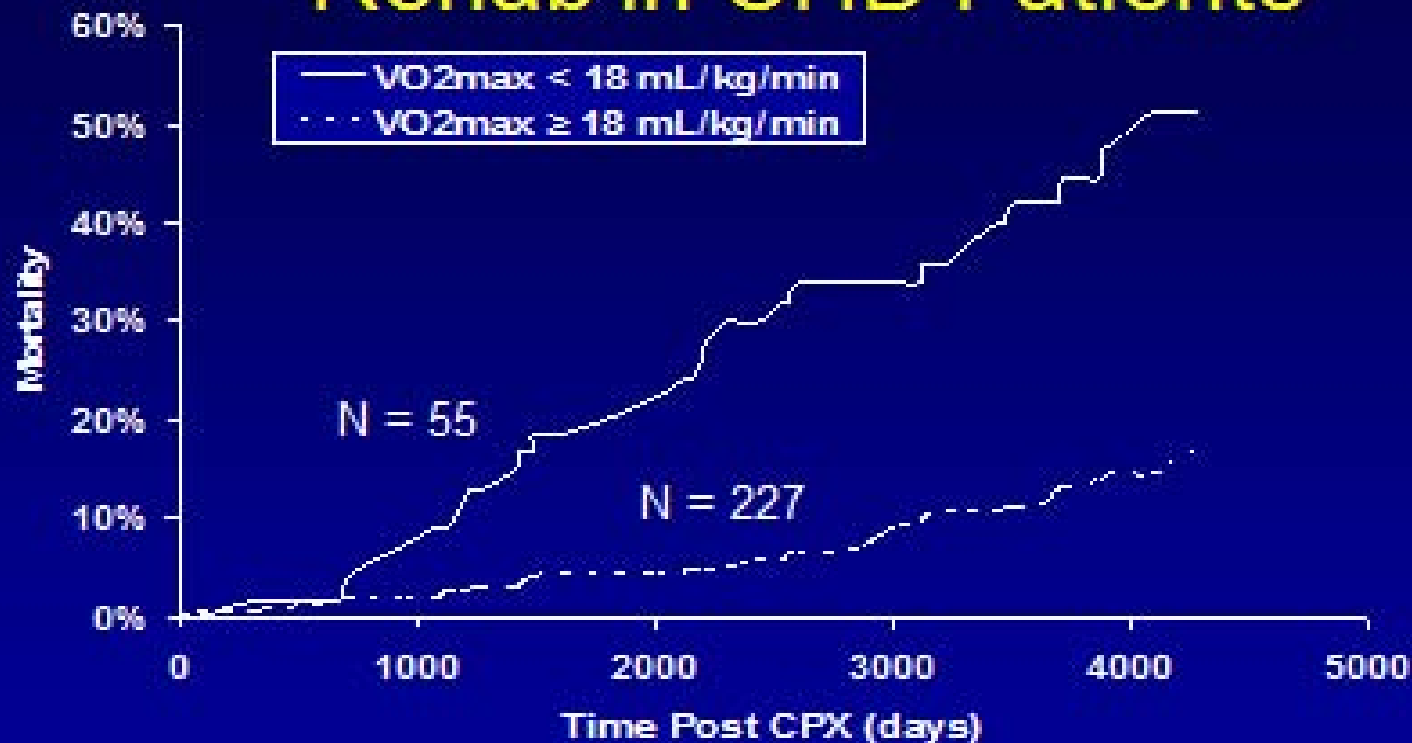
Exercise Capacity and Mortality in CHD Patients

- Each 1 MET increase in functional capacity is associated with an 8% to 35% (median, 16%) reduction in total mortality
- VO_{2peak} is the best predictor of mortality
- Dose-response relationship between exercise intensity and $\uparrow VO_{2peak}$

Boden, Franklin, Wenger, JAMA 2013; 309:143

Kavanaugh et al, Circulation 2002; 106:666

10+ Year Mortality after Cardiac Rehab in CHD Patients



Unaffected by adjustment for
any potential confounders

Allison TG et al. 2005 AHA

High-Intensity Aerobic Exercise Training (HIT): Definition and Benefits

- Alternating relatively brief periods of intense aerobic exercise with periods of mild/moderate intensity aerobic exercise or passive recovery
- Used by athletes for many decades
- Elicits a greater training stimulus and results in greater improvements in $\text{VO}_{2\text{peak}}$ and other markers of CV health: endothelial function, LV function, and CV risk factors than moderate intensity training (MIT) in CVD patients

HIT: Review Article and Meta-Analysis

- Cornish et al, Eur J Appl Physiol 2011; 111:579
 - Reviewed 7 studies, 213 subjects, all with CVD
 - HIT subjects increased $\text{VO}_{2\text{peak}}$ by 17% to 46% (mean = 29%)
- Hwang et al, J Cardioplumonary Rehab Prev 2011; 31:378
 - Meta-analysis of 6 studies, 153 subjects, all with either CVD or metabolic syndrome

HIT: Review Article and Meta-Analysis

- Compared with MIT, HIT increased $\text{VO}_{2\text{peak}}$ by an additional 3.6 ml/kg/min

High-Intensity Aerobic Exercise Training (HIT)

- If HIT leads to improved aerobic capacity and other markers of CV health, should we encourage patients with CVD to include it in their exercise programs?
- Risks?

Pioneer in HIT for CHD patients:1981



Ali A. Ehsani, M.D.
Washington University Medical Center, St Louis, MO

HIT after Myocardial Infarction: Ehsani et al, Circulation 1981; 64:1116-1124

- N=10 exercise, 8 controls; >4 months post MI, 3 months of MIT prior to study
- 30-60 minutes, 3 sessions/week for 52 weeks
- Intensity: 70% VO_{2peak} with 2-3 intervals of 2-5 minutes at 80%-90% VO_{2peak} (walk-jog)
- Increased VO_{2peak} by 40%!

Pioneer in HIT for CHF Patients



Katharina Meyer, Ph.D.
Herz-Zentrum Bad Krozingen, Germany 1996
(University Hospital, Bern, Switzerland at present)

HIT in CHF: Dr. Katharina Meyer

- N=18, LVEF $21 \pm 1\%$, $VO_{2\text{peak}}$ 12.2 ± 0.7 ml/kg/min
- Exercise tests: traditional cycle ramp CPX (measure $VO_{2\text{peak}}$) , steep cycle ramp CPX (set exercise intensity)
- 3 week cycle exercise training program, 15 min duration, 5 sessions/week

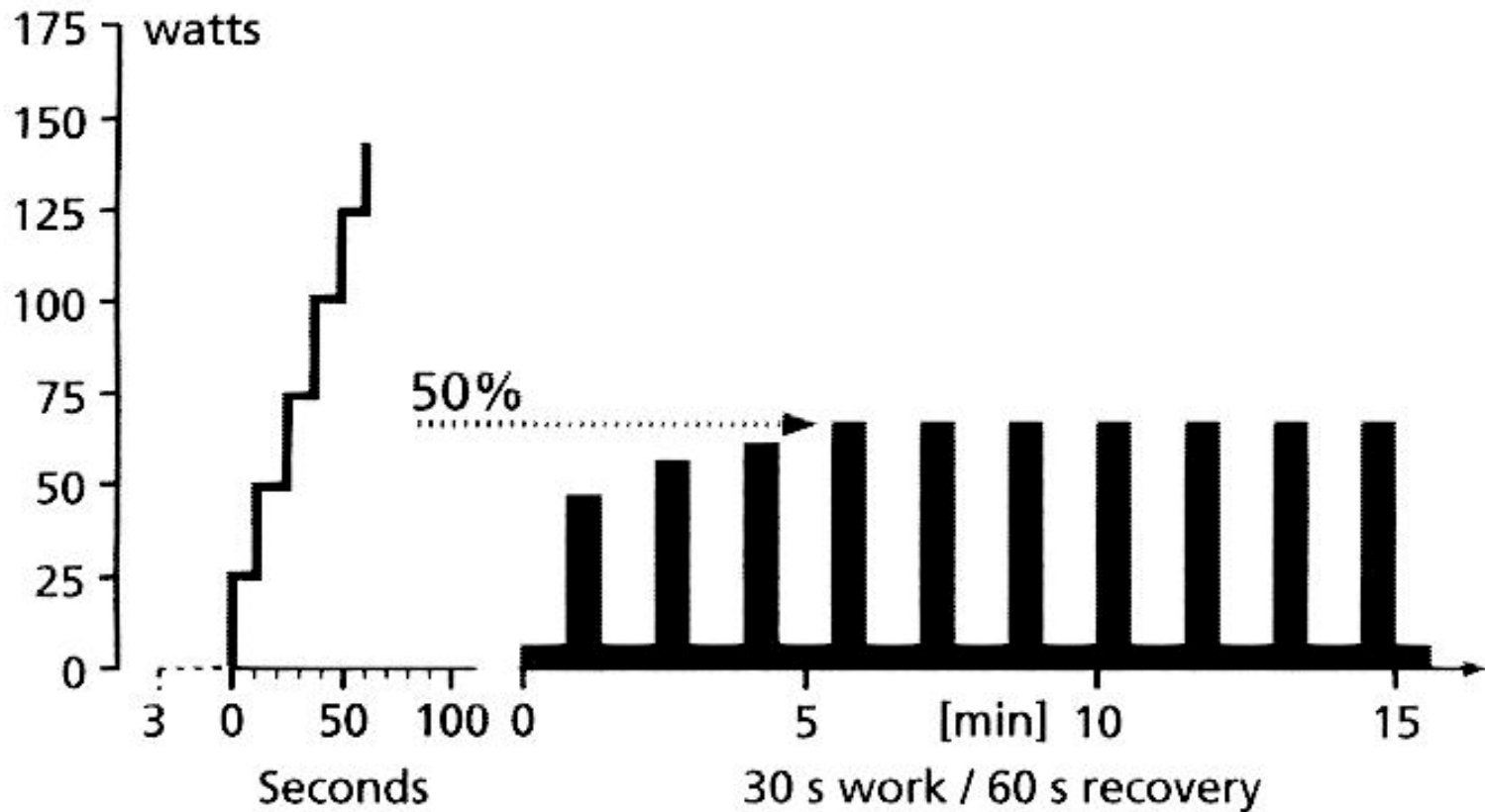
Am J Cardiol 1996; 78:1017

Med Sci Sports Exerc 1997; 29:306

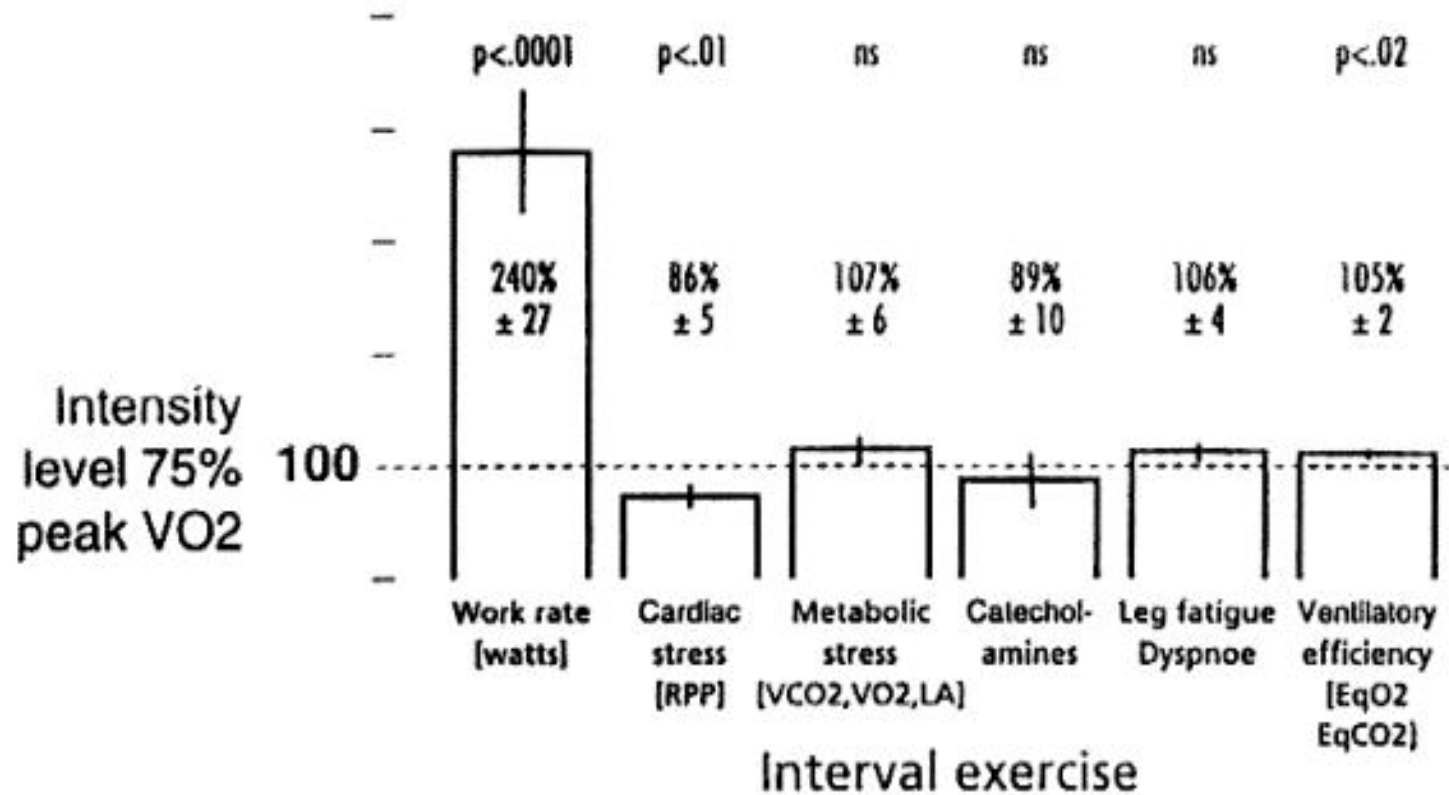
Steep Ramp Test

Max. short time exercise capacity

Interval Exercise



Ordinary ramp test [%]

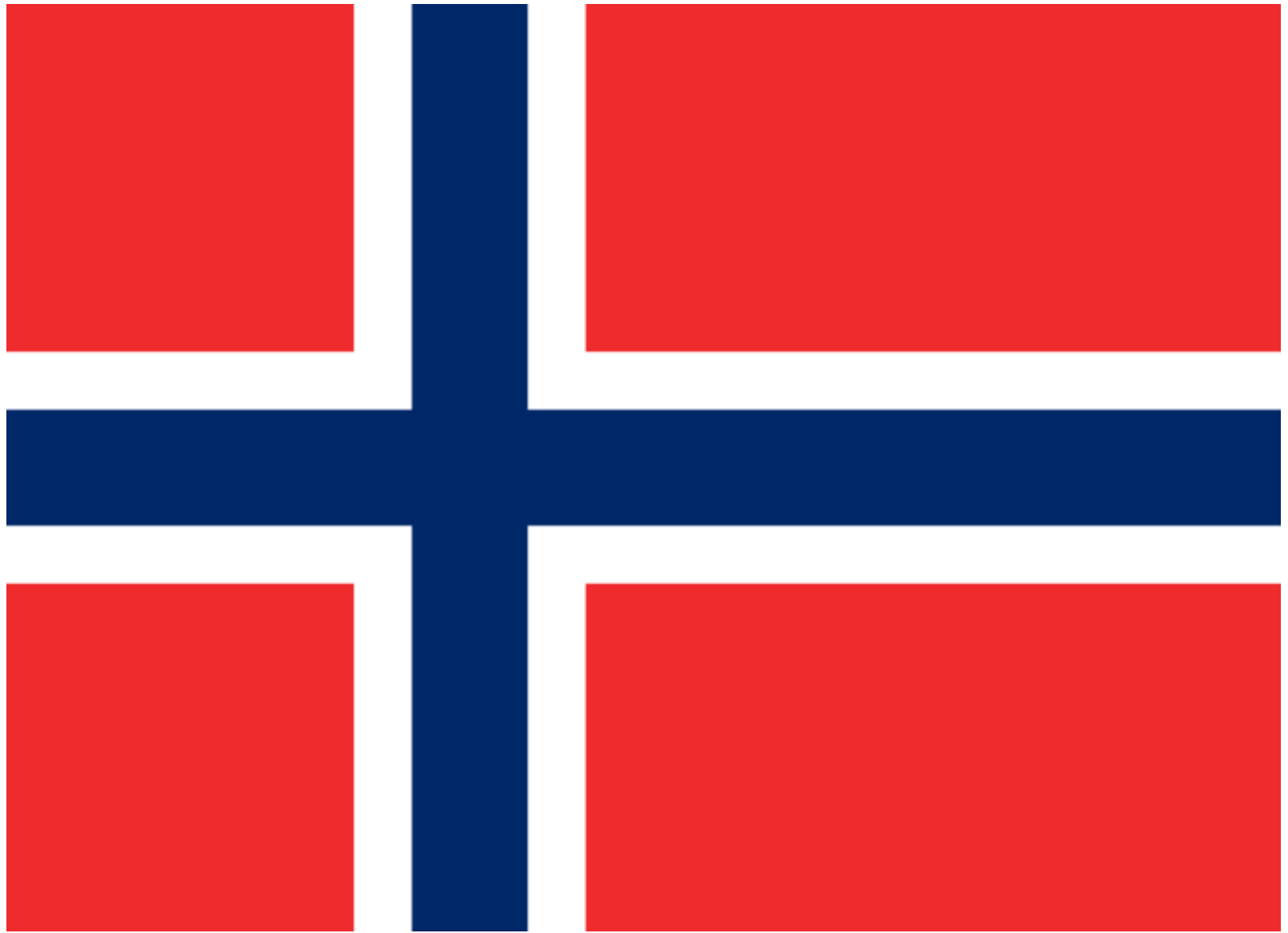


HIT in CHF: Dr. Katharina Meyer

- After **3 weeks** of training, $\text{VO}_{2\text{peak}}$ increased from 12.2 ± 0.7 ml/kg/min to 14.6 ± 0.7 ml/kg/min, $P < 0.001$ (**↑20%!**)
- A few patients were removed from the transplant list
- **Dr. Meyer visited the Mayo Clinic in 1998**

Am J Cardiol 1996; 78:1017

Med Sci Sports Exerc 1997; 29:306



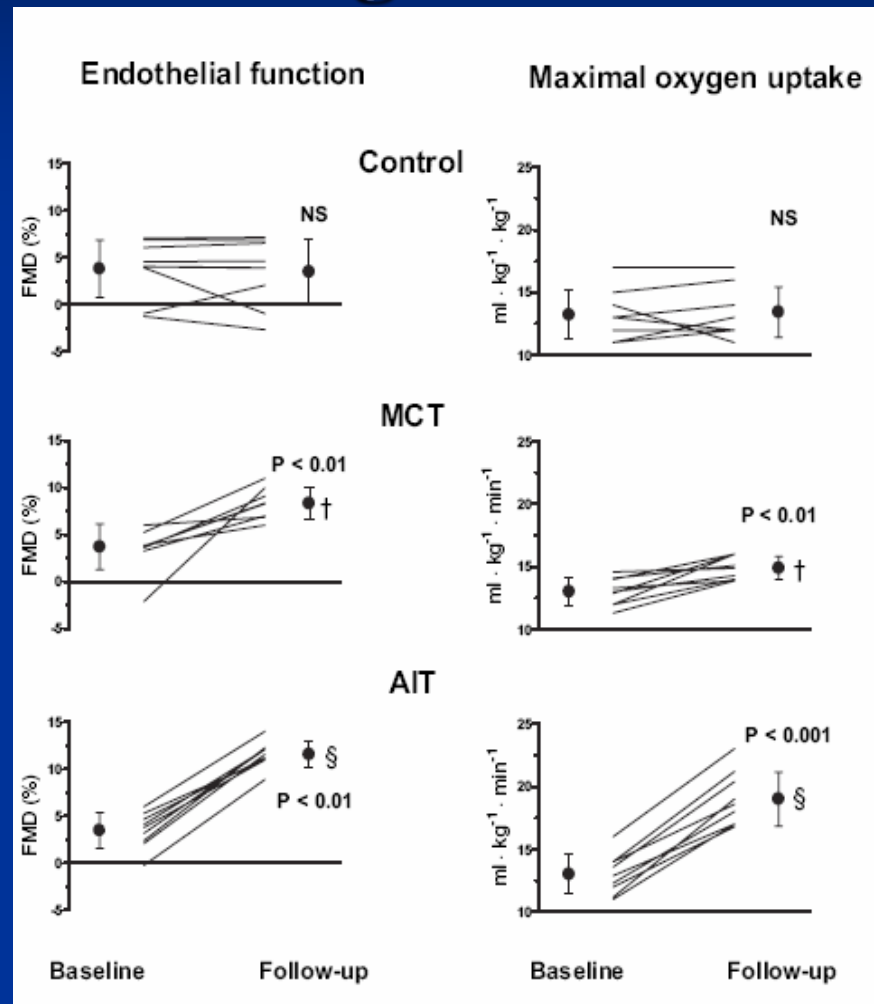
Norway: The Leader in HIT for CVD Patients

- Wisloff and Rognmo: Trondheim, Norway
- Munk and Larsen: Stravanger and Bergen, Norway
- Multiple publications 2004-2012
- **Consistent exercise training protocol:** HIT at up to 95% of HR_{peak} , RPE 15-17, gradually increase duration to up to 4 minutes, alternate with 3 minutes of MIT at 60% to 70% of HR_{peak} , RPE 12-14, 60 minute sessions

Norway: The Leader in HIT for CVD Patients

- Separate MIT only and HIT sessions with exercise frequency 3/week (1/3 of sessions typically include HIT)
- The time interval between the cardiac event and starting HIT was not clear in most publications
 - HIT as early as 11 days post PCI (2009)
- Home-based HIT after CABG (2012)

Aerobic Interval Training in CHF: Comparison with Moderate Continuous Training after 12 Weeks



↑15%

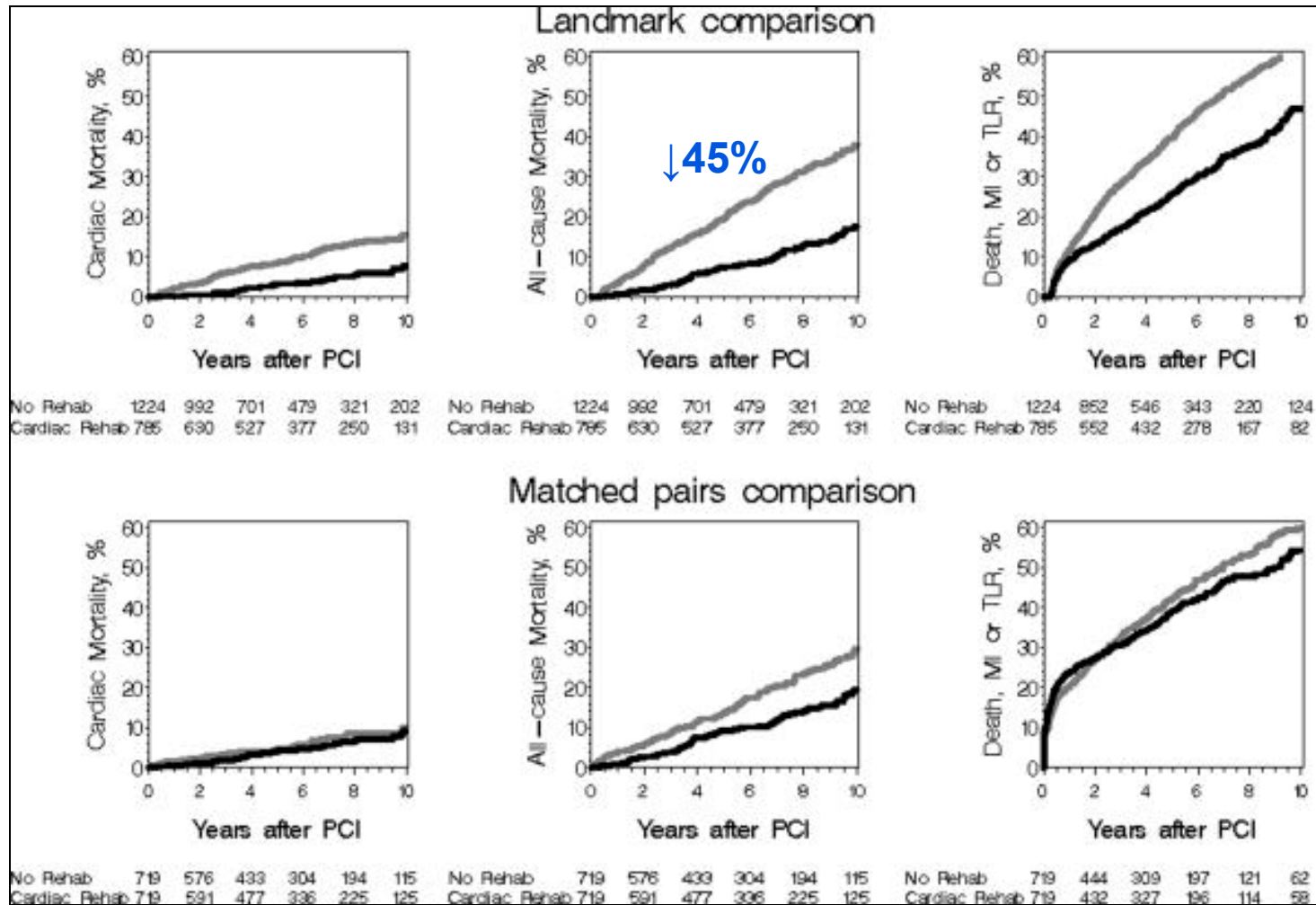
↑46%!

Wisloff, Circulation 2007; 115:3086.

Exercise Training in Patients with CVD

- “Two edged sword”
- CR including exercise training reduces total mortality by 30%+
- Acute exercise increases the risk of a CVD event
- For HIT, is the risk/benefit ratio acceptable?

Effect of CR on Mortality after PCI



Goel et al, Circulation 2011; 123:2344

Exercise Training in Patients with CVD

- “Two edged sword”
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- For HIT, is the risk/benefit ratio acceptable?

Safety of HIT for CVD Patients

- N=4,846 patients, 70% men in 3 Norwegian CR centers, 2004-2011
- 175,820 hours of supervised exercise
- Separate MIT and HIT sessions (36% included HIT)
- Outcome measures: cardiac arrest, MI during exercise or within 1 hour after exercise

Safety of HIT for CVD Patients

- Results: 1 fatal cardiac arrest during MIT, 2 nonfatal cardiac arrests during HIT, no MI
- Event rates: 1/129,456 patient-hours of MIT, 1/23,182 patient-hours of HIT
- Conclusion: Event rates are very low, inadequate power to detect difference between HIT and MIT

Safety of HIT for CVD Patients

- Keteyian editorial, *Circulation* 2012; 126:1431 pointed out that to adequately address safety a RCT including >20,000 subjects would be needed
- RCTs not always feasible (my view)

Why HIT in Early Outpatient CR at Mayo?

- That's where the patients are
- We perform 9-10K GXTs per year, many on higher risk patients with very few medical emergencies
- At Mayo, we have a history of pushing the envelope in CR
 - 1980s: early entry into Phase II after hospital dismissal, cardiac transplant, CHF, weight training, long-term case management system for secondary prevention

Why HIT in Early Outpatient CR at Mayo?

- The truth: we thought about it for a long, long time
- Finally, four years ago, we convinced ourselves that the time for HIT in Phase II CR was right

HIT in Early Outpatient CR at Mayo Clinic



HIT in Early Outpatient CR at Mayo Clinic

- Patients begin the program within 1-2 weeks of hospital dismissal
- CPX for non-cardiothoracic surgery patients, 6-minute walk for patients with surgery
- MIT at 60%-70% HRR, RPE 12-14, starting at 5-15 minutes, progressing to 30-45 minutes (+warm-up/cool-down), 2-3 supervised sessions/week (includes resistance training), 2-3 independent sessions/week
- HIT is introduced when patients can perform 20 minutes of MIT (second week of CR)

HIT in Early Outpatient CR at Mayo Clinic

- Begin with 2-3 intervals of 30-60 seconds at RPE 15-17 interspersed with 1-5 minutes of MIT
- HIT modes of exercise: jog or walk with incline on treadmill, increased watts on ergometer
- Progress to 5 intervals of 1-4 minutes at RPE 15-17 during 30-45 minutes of training
- HIT performed only during supervised sessions

HIT at Mayo Clinic: Practice Improvement Data

- 537 consecutive patients referred from January 2010 through December 2011
- Diagnoses: MI, PCI, CABG, valvular surgery, stable angina, cardiac transplant, CHF, apical ballooning syndrome, coronary endothelial dysfunction
- HIT exclusion criteria: impaired cognition, language barrier, musculoskeletal limitations, angina with low-intensity exercise, patient refusal

HIT at Mayo Clinic: Practice Improvement Data

- 376/537 patients (70%) performed 6,768 exercise sessions that included HIT
- HIT began an average of 31 days post event
- No major medical events occurred
- Patients actually enjoyed HIT: “I feel like I accomplished something if I go through these intervals. I get a little better each time.”

CR Case Report: Richard, Age 81, Active


- CABG 1996: LAD, D1, OM1, RCA
- March 2012: NSTEMI; PCI to RCA graft and native Cx; LVEF 62%
- 1st CPX: RER 1.21, VO_{2peak} 1383 ml/min, 21.6 ml/kg/min, weight = 64 kg
- 35 supervised exercise sessions, treadmill, recumbent cycle, weight training, interval training

CR Case Report: Richard, Age 81, Active

- 2nd CPX: RER 1.13, $\text{VO}_{2\text{peak}}$ 1661 ml/min ($\uparrow 20\%$), 27.4 ml/kg/min ($\uparrow 27\%$), weight = 60.6 kg
- Plan: continue independent exercise with 2-3 HIT sessions/week, 2-3 MIT sessions/week, 2-3 weight training sessions/week, see back in 3 months

Concern: HIT is Not Mentioned in the Guidelines

- ACSM Guidelines (8th edition, 2010) on exercise intensity for CVD outpatients: RPE 11-16, 40% to 80% HRR (or VO_2R or $\%VO_{2peak}$)
- AACVPR Guidelines (4th edition, 2004): 50% to 80% of capacity, RPE 11-15
 - Neither guideline addressed HIT



Aerobic Exercise Intensity
Assessment and Prescription
in Cardiac Rehabilitation

A JOINT POSITION STATEMENT OF THE EUROPEAN ASSOCIATION
FOR CARDIOVASCULAR PREVENTION AND REHABILITATION,
THE AMERICAN ASSOCIATION OF CARDIOVASCULAR AND
PULMONARY REHABILITATION, AND THE CANADIAN
ASSOCIATION OF CARDIAC REHABILITATION

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Trine Moholdt, PhD,⁵ James A. Stone, MD, PhD,⁶ Axel Urhausen, JP, MD, MPH, PhD,⁷ and Mark A. Williams, PhD⁸

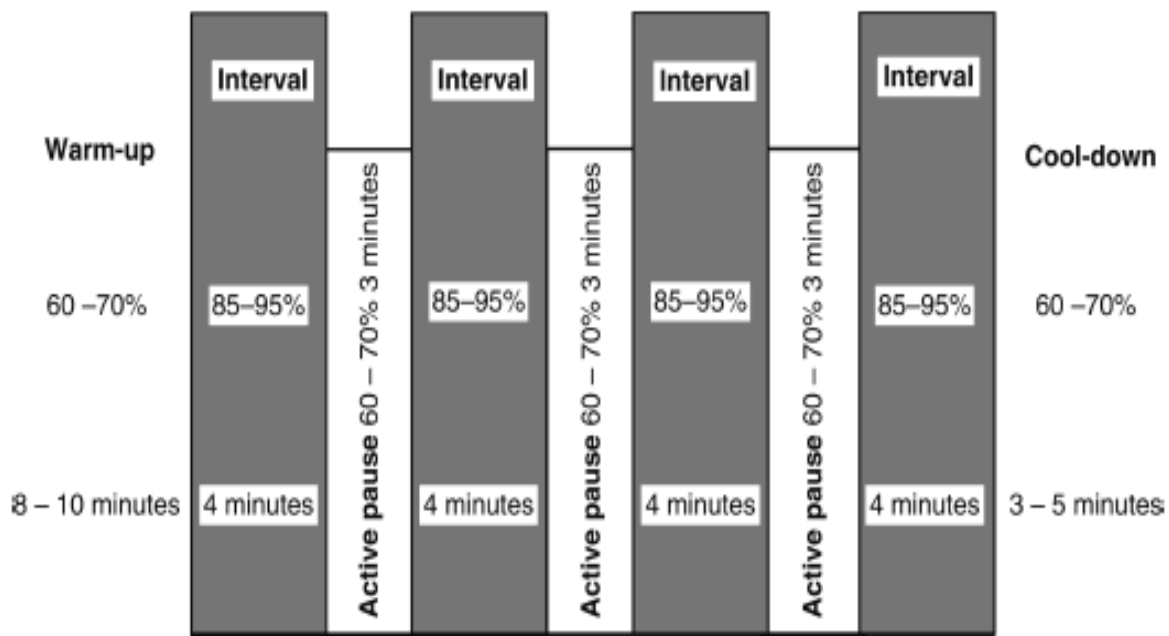


Figure 5. The 4 × 4 min aerobic interval training model. Intensity is given as percentage of peak heart rate.

Summary: HIT in Early Outpatient CR

- VO_{2peak} is the most important determinant of mortality in patients with CVD
- HIT results in greater improvement in VO_{2peak} and other markers of CV Health than does MIT
- Data from Norwegian CR centers suggests that HIT is relatively safe
- Mayo Clinic's experience with HIT has been favorable
- Additional data concerning safety and long-term outcomes are needed



Thank you!