Exercise Training: The Foundation of Cardiac Rehabilitation

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Outline

- Background:
  - Established Benefits of Cardiac Rehabilitation (CR)
  - Demographic Trends
- Cardiopulmonary Fitness: Prognostic Significance
- Goals of CR Exercise:
  - Improve Fitness / Prognosis
  - Overweight Cardiac patients
  - Older Cardiac patients
- Conclusions

Core Components of Cardiac Rehabilitation/Secondary Prevention Programs

- Patient Assessment
- ***Exercise Training:*** ***"The glue".***
- Risk Factor Management:
  - Nutritional/Behavioral/ Medical
    - Lipids
    - Smoking Cessation
    - Diabetes
    - Physical Activity Counseling
    - Hypertension
    - Weight Management
    - Psychosocial
- Long-Term Follow-up

Circulation 2007 Balady, Ades, Williams et al.

Post MI Survival Benefit of CR: Meta-Analyses of RCT's

	CV Mortality	Total Mortality	Comment
Oldridge JAMA 1988	-25%	- 24%	3 year f/u
Heran BS Cochrane Database 2011	-26%	- 13%	3-5 year f/u
Suaya JACC 2009		- 21-34%	Medicare population > 600,000, 5 year f/u

Demographic Trends in CR (1996-2006)

Obesity Indices at Entry into CR

	1996-1998 (N=604)	2005-2006 (N=532)	P Value*
Weight (Kg)	84.7 ± 18.3	88.5 ± 19.0	0.0023
Waist (cm)	100.8 ± 14.0	103.6 ± 14.5	0.0050
Body Mass Index (Kg/m^2)	28.5 ± 5.4	30.1 ± 5.7	<0.0001
Obesity (%)	32.5	43.8	<0.0001

* For period 1 vs. period 5, by Chi^2

Audelin, Savage, Ades JCRP 2008

Demographic Trends in CR (1996-2006)

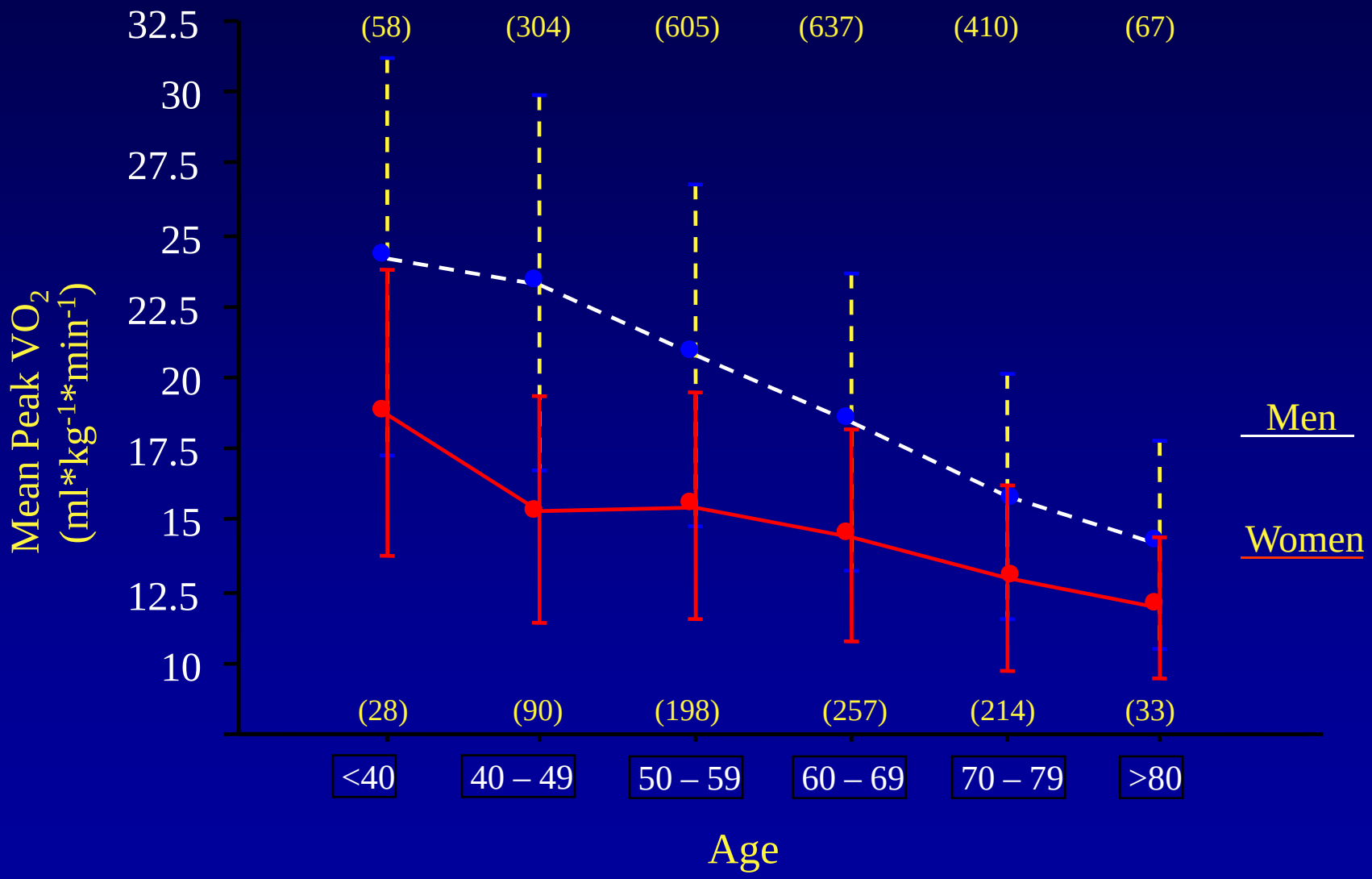
Demographic Characteristics at Entry into CR

	1996-1998 (N=604)	2005-2006 (N=532)	P Value*
Age (year)	60.6 ± 11.4	63.4 ± 11.1	0.0003
≥ 75 years (%)	10.4	16.5	0.0025

* For period 1 vs. period 5, by Chi^2 or Dunnett's

Audelin, Savage, Ades JCRP 2008

Aerobic Capacity Entering Cardiac Rehab.



Ades PA, Savage PD, Brawner CA, Keteyian SJ. Circulation. 2006 ;11:2706-12

Current Profile CR Participants

- > 80% are ***Overweight*** (BMI > 25 kg/m^2)
  - > 50% Have Metabolic Syndrome
- ***Older*** : Mean Age > 64 years, 1 of 6 are >75 years
- ***Remarkably Unfit***: (50% below age norms)
  - Fitness predicts prognosis

Prognostic Significance of Aerobic Fitness in Cardiac Rehabilitation

- Studies of Kavanagh, Keteyian, Suaya.

Fitness on Prognosis (Cardiac Death) in CR: Toronto Experience

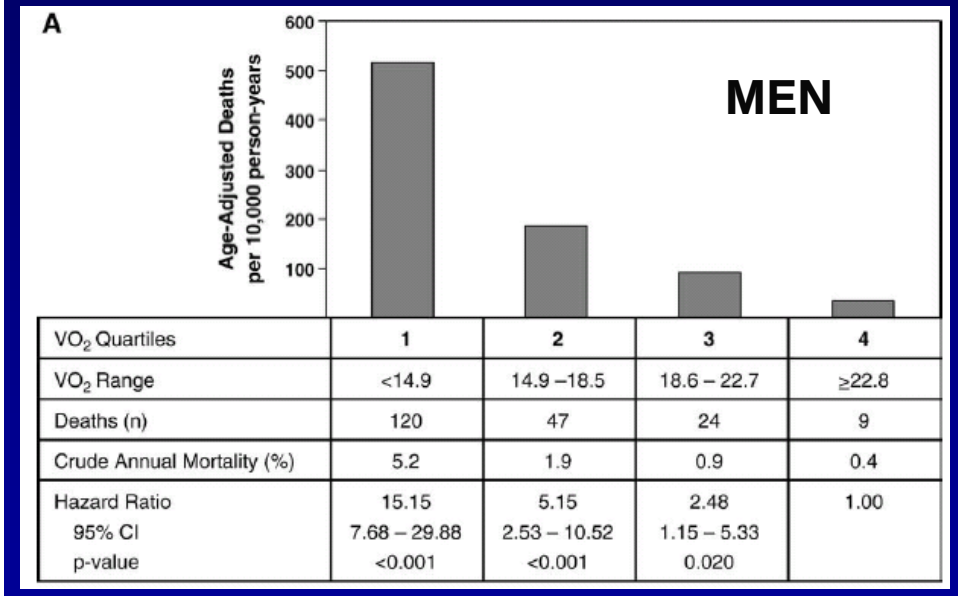
- 12,169 men entering CR*, (mean age 55.0 years)
  - VO_2 < 15.0 ml/kg/min RR 1.0
  - VO_2 15-22 ml/kg/min RR 0.62
  - VO_2 > 22 ml/kg/min RR 0.39

- 2,380 Women** (mean age 59.7 years)
  - VO_2 < 13 ml/kg/min RR 1.0
  - VO_2 > 13 ml/kg/min RR 0.5
  - In cross sectional analysis, 1ml/kg/min higher VO_2 associated with 10% lower cardiac mortality

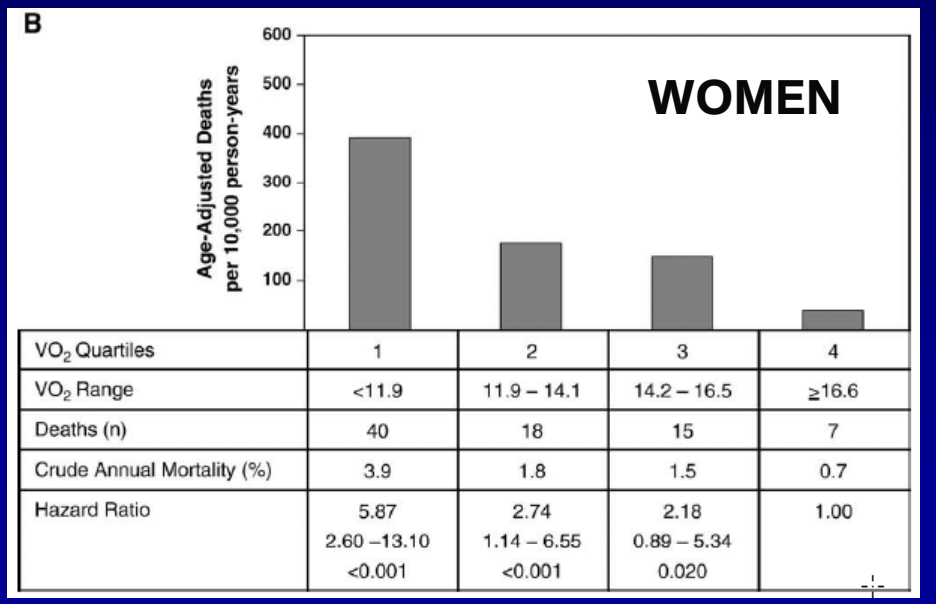
* Kavanagh, Mertens, Hamm et al. Circulation 2002. 106:666-671
**Kavanagh, Mertens, Hamm et al. JACC 2003. 42: 2139-2143

Peak Aerobic Capacity Predicts Prognosis in CAD*

Cardiac Rehabilitation Population (N = 2,812 1996-2004)



VO_2 Quartiles	1	2	3	4
VO_2 Range	<14.9	14.9 –18.5	18.6 – 22.7	≥22.8
Deaths (n)	120	47	24	9
Crude Annual Mortality (%)	5.2	1.9	0.9	0.4
Hazard Ratio 95% CI p-value	15.15 7.68 – 29.88 <0.001	5.15 2.53 – 10.52 <0.001	2.48 1.15 – 5.33 0.020	1.00



VO_2 Quartiles	1	2	3	4
VO_2 Range	<11.9	11.9 – 14.1	14.2 – 16.5	≥16.6
Deaths (n)	40	18	15	7
Crude Annual Mortality (%)	3.9	1.8	1.5	0.7
Hazard Ratio	5.87 2.60 –13.10 <0.001	2.74 1.14 – 6.55 <0.001	2.18 0.89 – 5.34 0.020	1.00

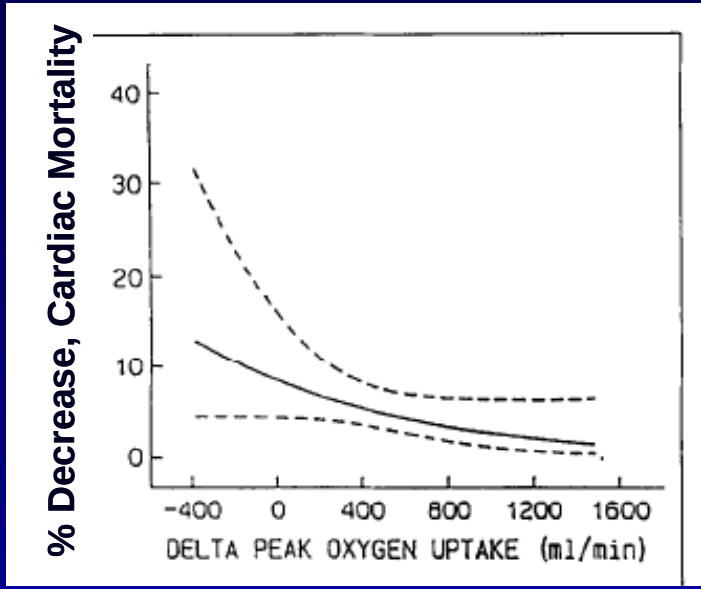
*Keteyian, Savage, Ades, et al. Am Heart J 2008;156:292-300

CR on Survival in Older Cardiac Patients

Suaya et al JACC 2009

- N = >600,000 U.S. Medicare Patients (Age $\geq$ 65)
- 5 Year Follow up
- Mortality Reduction 21-34% depending upon statistical technique (Propensity Matching, Regression Analyses, Instrumental Variables)
- Benefits manifest in all patient subsets (men, women, MI, CABG, CHF)

PROGNOSTIC VALUE OF *CHANGE* IN PEAK VO_2*



1 % ↑ peak VO_2
2 % ↓ Mortality

*Vanhees L, et al. Am J Cardiol 1995;76:101 - 1019

CR Exercise Protocols Largely Unchanged Since 1970's

NEHDP: A Multicenter U.S. Randomized Trial of Exercise Post-MI.
Shaw: Am J Cardiol 1981 48:39-46 (Performed 1976-1979)

- 25 minutes Treadmill Walking 5-10 min cycling
- 3 times per week, ECG monitored
- Intensity at 70-85% Max HR
- Yields a fitness improvement of $\pm$ 15% of peak aerobic capacity (Peak VO_2)

Training Response in CR

Peak VO_2 (ml/kg/min)

	Baseline	4 months	P Value
All	18.3 ± 5.9	21.4 ± 6.8 (+ 17%)	<0.0001
Men	19.3 ± 6.1	+ 18%	< 0.0001
Women	14.5 ± 3.9	+ 12%	< 0.0001

Ades PA, Savage PD, Brawner CA, Keteyian SJ. Circulation. 2006 ;11:2706-12

Superior Cardiovascular Effect of Aerobic Interval Training Versus Moderate Continuous Training in Heart Failure Patients

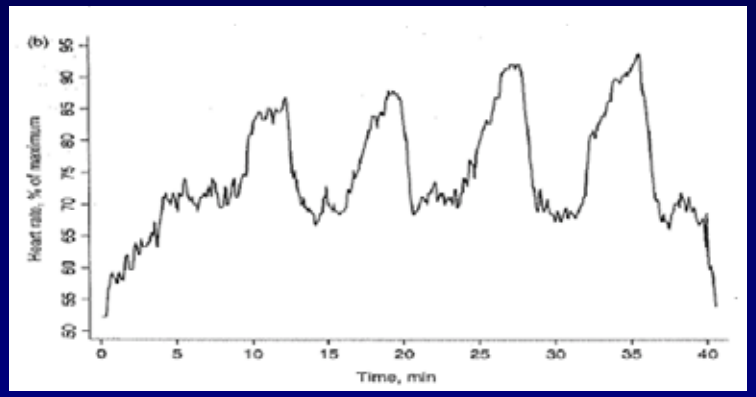
A Randomized Study

Ulrik Wisløff, PhD; Asbjørn Støylen, MD, PhD; Jan P. Loennechen, MD, PhD; Morten Bruvold, MSc; Øivind Rognmo, MSc; Per Magnus Haram, MD, PhD; Arnt Erik Tjønna, MSc; Jan Helgerud, PhD; Stig A. Slørdahl, MD, PhD; Sang Jun Lee, PhD; Vibeke Videm, MD, PhD; Anja Bye, MSc; Godfrey L. Smith, PhD; Sonia M. Najjar, PhD; Øyvind Ellingsen, MD, PhD; Terje Skjærpe, MD, PhD

Circulation. 2007;115:3086-3094.

- Randomized Controlled Trial
- 27 Patients (age=75), post-MI Chronic Heart Failure
- Moderate continuous (70% peak HR) vs Interval High Intensity (95%)
- 3 x's/wk (2 onsite, 1 @ home), 12 weeks,

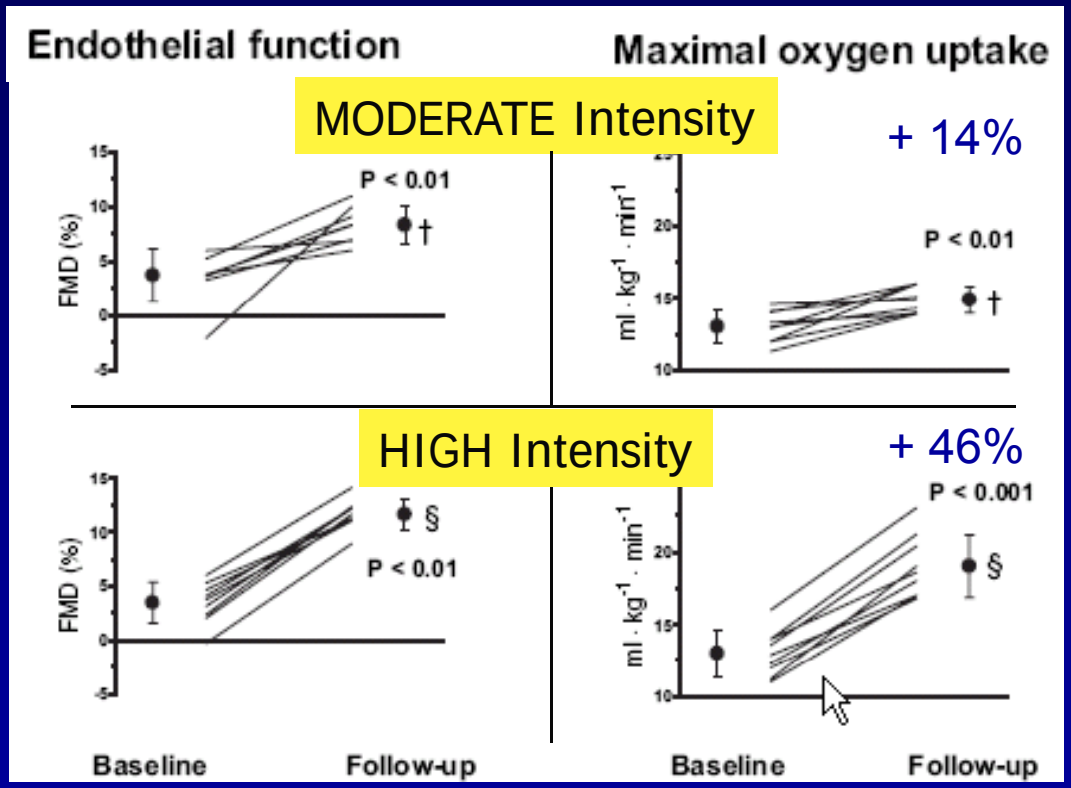
Exercise Training Protocols



- **<u>Interval Training Protocol</u>**
- 10’ treadmill slow warm-up
- 4’ intervals at 90-95% Max HR
- 3’ recovery periods at 50-70% Max HR
- Repeat 4 times
- Total training period 28 minutes + warm-up

- **<u>Moderate Continuous Training</u>**
- 70-75% Max HR
- Total training period 47’

Effects of Moderate vs High-Intensity Interval Exercise in Heart Failure Patients



Wisløff U, et al. *Circulation*. 2007;115:3086-3094.

Aerobic Interval Training in CR

- Maximizes fitness gains, potentially favorably affecting prognosis
- In small studies has not shown increases in adverse effects.
- Has also been shown effective in patients after Bypass Surgery, with Chronic Angina, and patients with Metabolic Syndrome
- *Caveats*:
  - Requires one-on-one supervision
  - Patients find it less boring

Exercise for Overweight Cardiac Patients

Hypothesis: An optimal exercise program for weight reduction would maximize exercise–related caloric expenditure.

High-Caloric Training in Obese Coronary Patients: A Randomized Controlled Trial (N=72)

- **Classic CR Training:** **3x/week**
  ± 750 cal/week
- ***High-Caloric Training*:**
  - **Lower Intensity, 60-65% Max**
  - **Primarily Walking**
  - **Gradually lengthen to > 45 Min/session**
  - **5-7 days per week**
  - **Eventually burns > 3,000 Kcal/week**

Both Groups received behavioral weight loss counseling.
Data at 4 months and 1 year

High Caloric Exercise vs. Standard CR Exercise

At 4 Months

	High Caloric	Standard CR
N	36	36
Weight (kg)	- 8 ± 4	- 4 ± 5 *
Fat Mass (kg)	- 6 ± 4	- 3 ± 3 *
Peak VO_2 ($ml*kg^{-1}*min^{-1}$)	+ 2 ± 4	+ 2 ± 3
Physical Activity Caloric Expenditure Week 15 (kcal/week)	+ 3500	+ 800

* = P<0.05 Between group

High-Caloric Exercise vs. *Standard* CR: Risk Factor Response

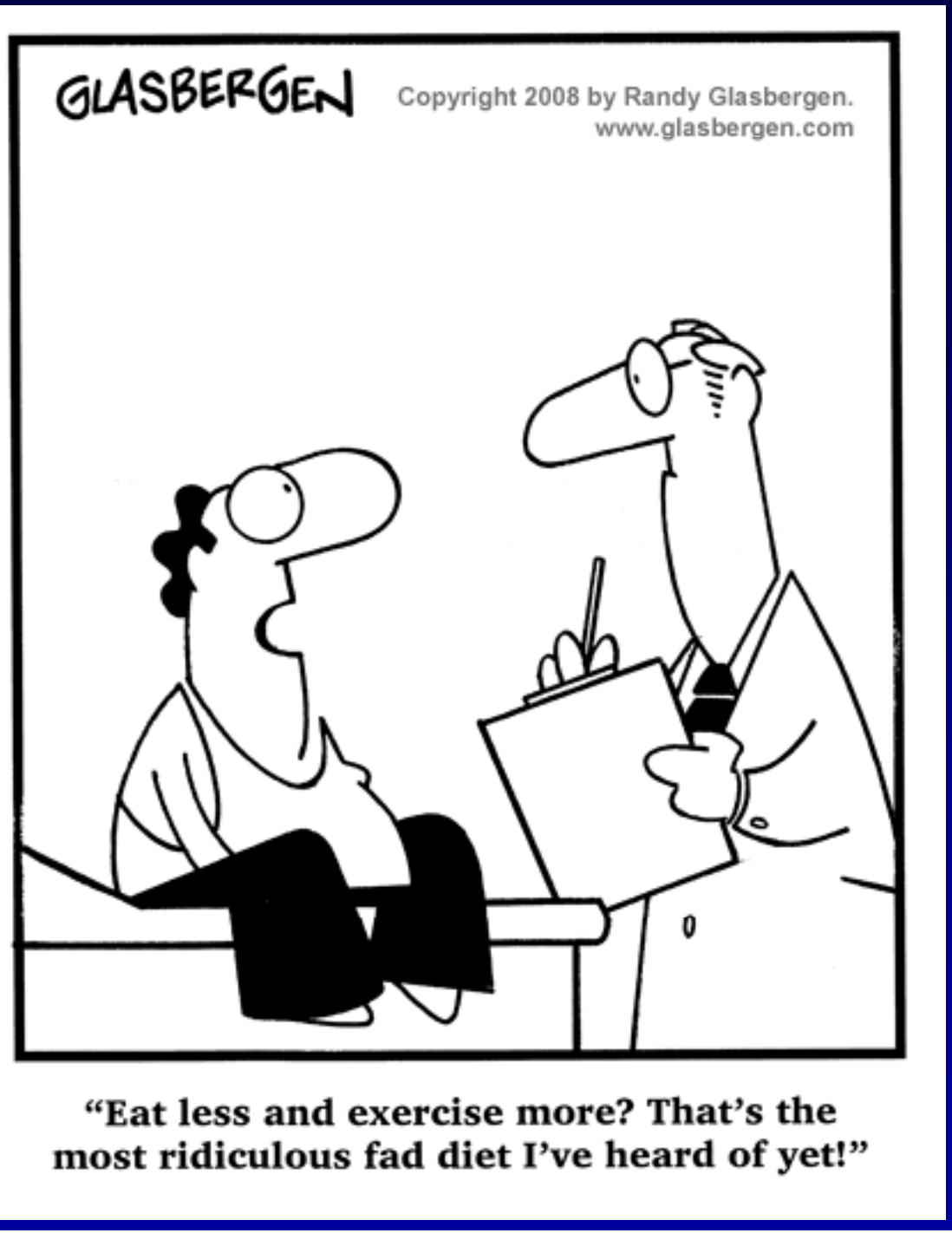
	Combined	High Cal.	Stnd CR	P Value B.Gps.
Glucose Disposal	+ 21% *	**+26%**	**+13%**	<0.01
Insulin	- 25% *	**-31%**	**-19%**	<0.01
Triglyc mg/dL	-20*	**-23**	**-6**	0.07
HDL-C	+3 (8%) *	**+12%**	**+5%**	NS
Chol/HDL	-10%*	**-15%**	**-3%**	<0.01
Mean BP mm Hg	-7 *	**-11**	**-7**	NS

Additional favorable effects on vasodilatory capacity, platelet reactivity, other clotting factors (PAI-1), and hs-C reactive protein.

High Caloric Exercise: Conclusions

"Walk Daily and Walk Far"

- High-Caloric Exercise Training is a more effective weight loss intervention for overweight CHD patients than standard CR Exercise.
- Greater Weight Loss was associated with greater changes in risk factors
- These results should alter the training approach for > 80% of CR patients in the U.S.

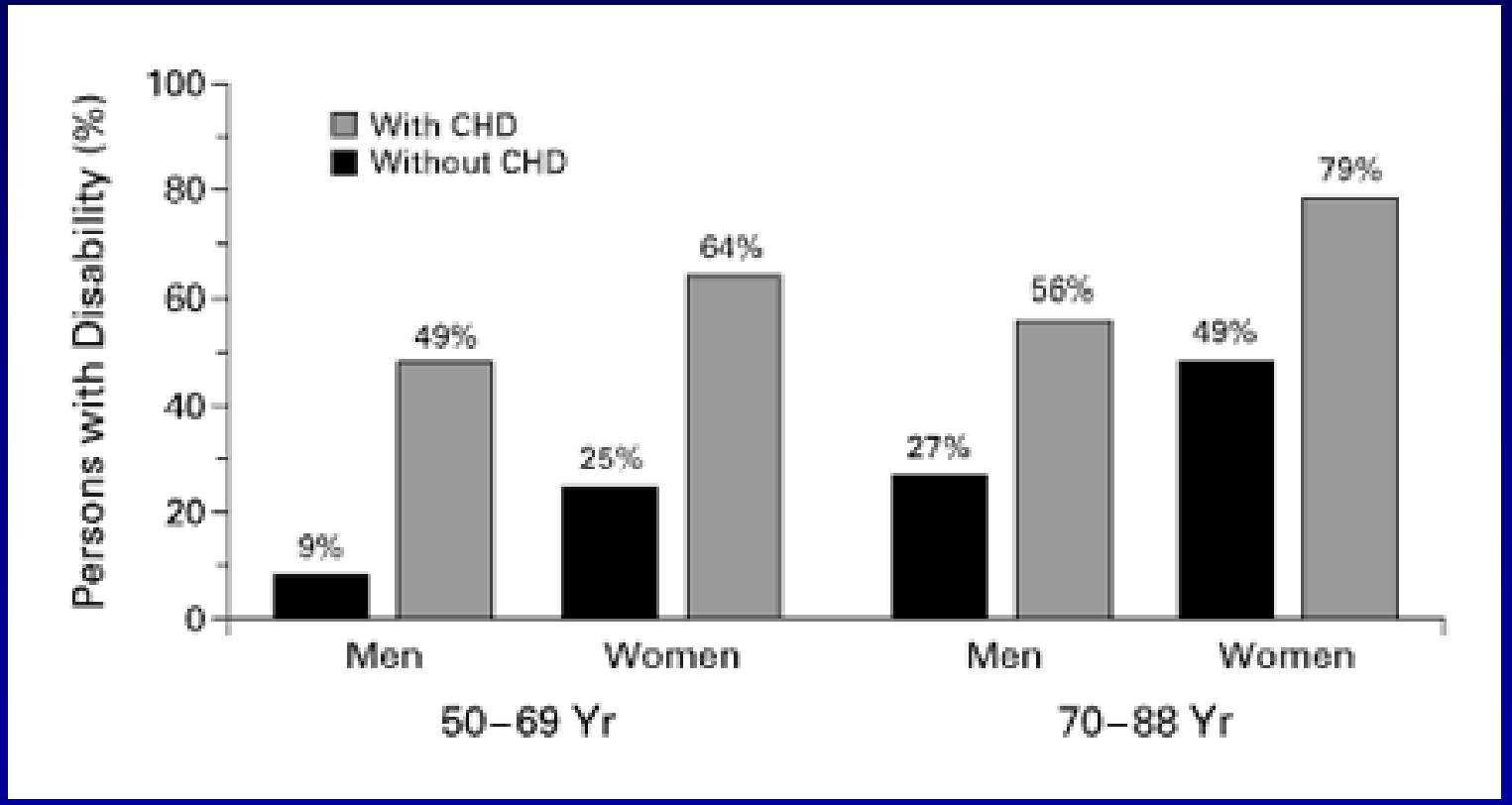


"Eat less and exercise more? That's the most ridiculous fad diet I've heard of yet!"

CR Exercise for Older Cardiac Patients

- Goals of CR in Elderly
  - Improve quality of life and physical function
  - Extend disability-free survival
- Important Role of Resistance Training

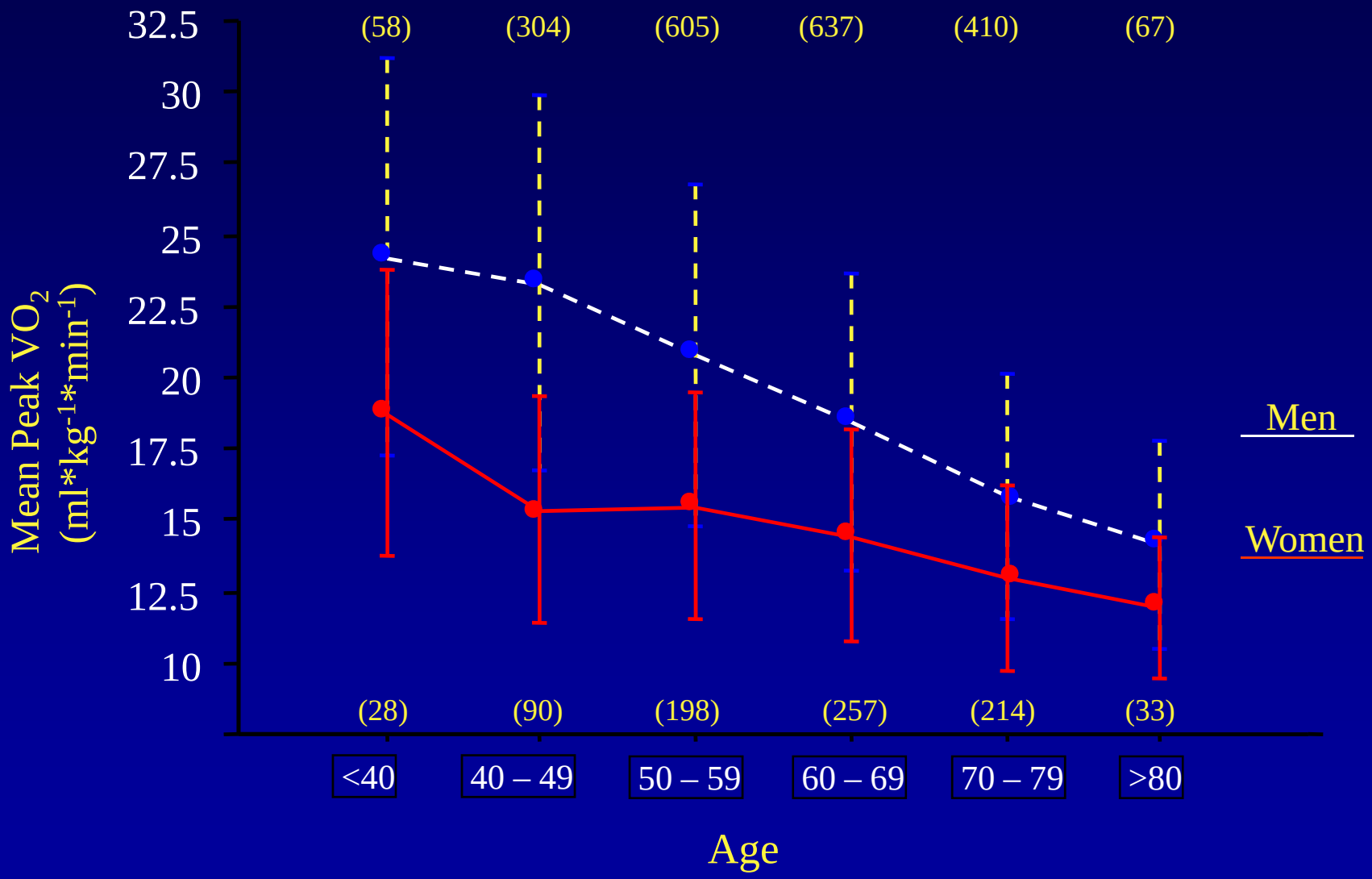
Framingham Disability Study: Effects of CHD, Age and Gender on Mobility Limitations (Disability).



Adapted from Pinsky et al Am J Public Health 1990

Figure from Ades PA. N Engl J Med 2001

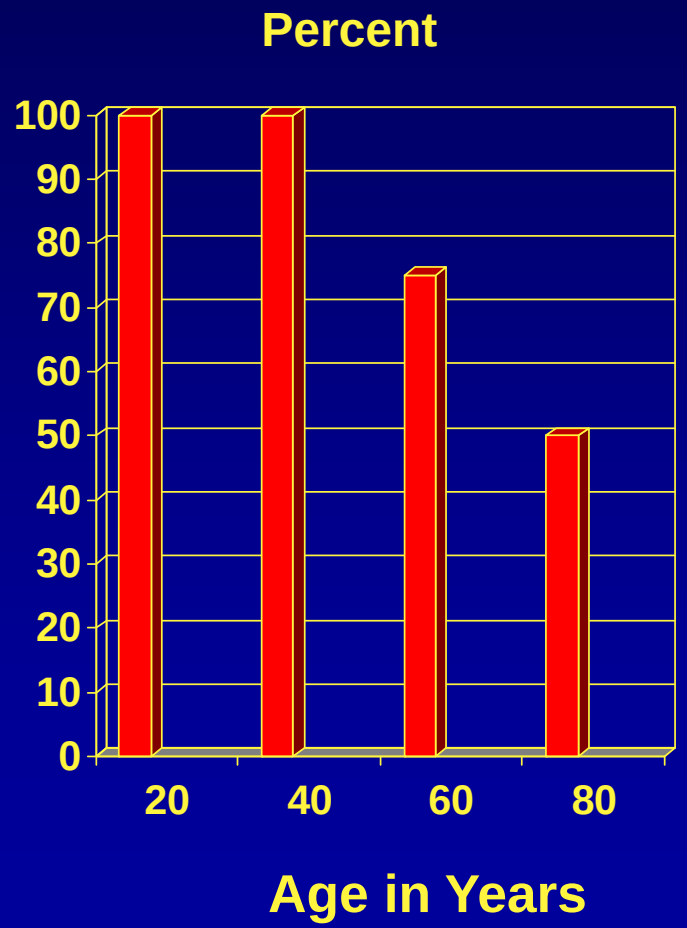
Aerobic Capacity Entering Cardiac Rehab.



Ades PA, Savage PD, Brawner CA, Keteyian SJ. Circulation. 2006 ;11:2706-12

Muscle Mass with Aging

- Muscle mass begins to decrease in your 40’s
- Measurably decreased by age 60
- Muscle mass increases only with intensive and prolonged resistance training.
- Increases in strength are much more readily attained.
- Prevention of muscle loss readily achievable.



Resistance Training on Physical Function in Older Women with Coronary Heart Disease

Resistance Training on Physical Function in Older Women with Coronary Heart Disease

N=51

- **Resistance Training:**
  - 3 x Weekly, x 6 months
  - 50-80% Single Repetition Max
  - **7 Exercises: (leg ext, bench press, biceps curl, shoulder press, lat pulldown, leg curl, leg press)**
- **Control Group**
  - **Non-strength Yoga**
  - **Breathing/ Stretching**

Brochu et al J Appl Physiol 2002
Ades PA et al Med Sci Sp Ex 2003

Strength and Fitness Response

	Resistance		Controls		
	Pre	**Post**	**Pre**	**Post**	**P value** (Betw Gp)
Bench Press	19± 5	**+ 60% ***	20± 3	**- 2%**	<0.0001
Leg Extension	32±9	**+ 46% ***	39± 13	**+ 10% ***	<0.004
Handgrip	24± 5	**+ 7% ***	21± 8	**+ 1%**	<0.02
Peak VO_2	16± 3	**+ 9%**	17± 3	**+ 2%**	NS

* = P< 0.05 within group

Physical Functional Performance Testing (CSPFP):

A battery of observed and measured functional tests

Light	Medium	Heavy
Scarf Pickup	Kitchen Pot-Carry	Grocery Carry
Jacket on/off	Sweeping	Suitcase on bus
Milk jug pour	Empty Wash	Stairs
Up from Tub	Load Dryer	6 minute-walk
Open Fire-Door	Make Bed	Vacuuming-(Oats^{AHA})

Cress ME Arch Phys Med Rehabi 1996;7:1243

Resistance Training in Older Women with CHD

- Total Physical Performance Score: +24%*
- Domains:
  - Upper Body Strength + 18%*
  - Lower Body Strength + 23%*
  - Balance and Coordination + 29%*
  - Upper Body Flexibility +10%
  - Endurance +26%*
  - 6-Minute Walk +15%*

* = Improved vs. Controls (P<0.05)

Brochu M, Ades PA. J Appl Physiol. 2002: 92;672-678.

Conclusions: Strength Training

- Resistance Training results in a substantial improvement in multiple domains of ***measured*** physical performance in older women with CHD.
- Resistance Training should be incorporated into the exercise program of older individuals, particularly older women, in cardiac rehabilitation to treat and prevent disability.

Summary

- New Approaches to CR Exercise include:
  - High-caloric expenditure exercise for weight reduction
  - Resistance Training for Older Patients, especially women
  - Interval Training to maximize fitness
- These approaches should be relevant to preventive exercise programs in the outpatient practice setting.

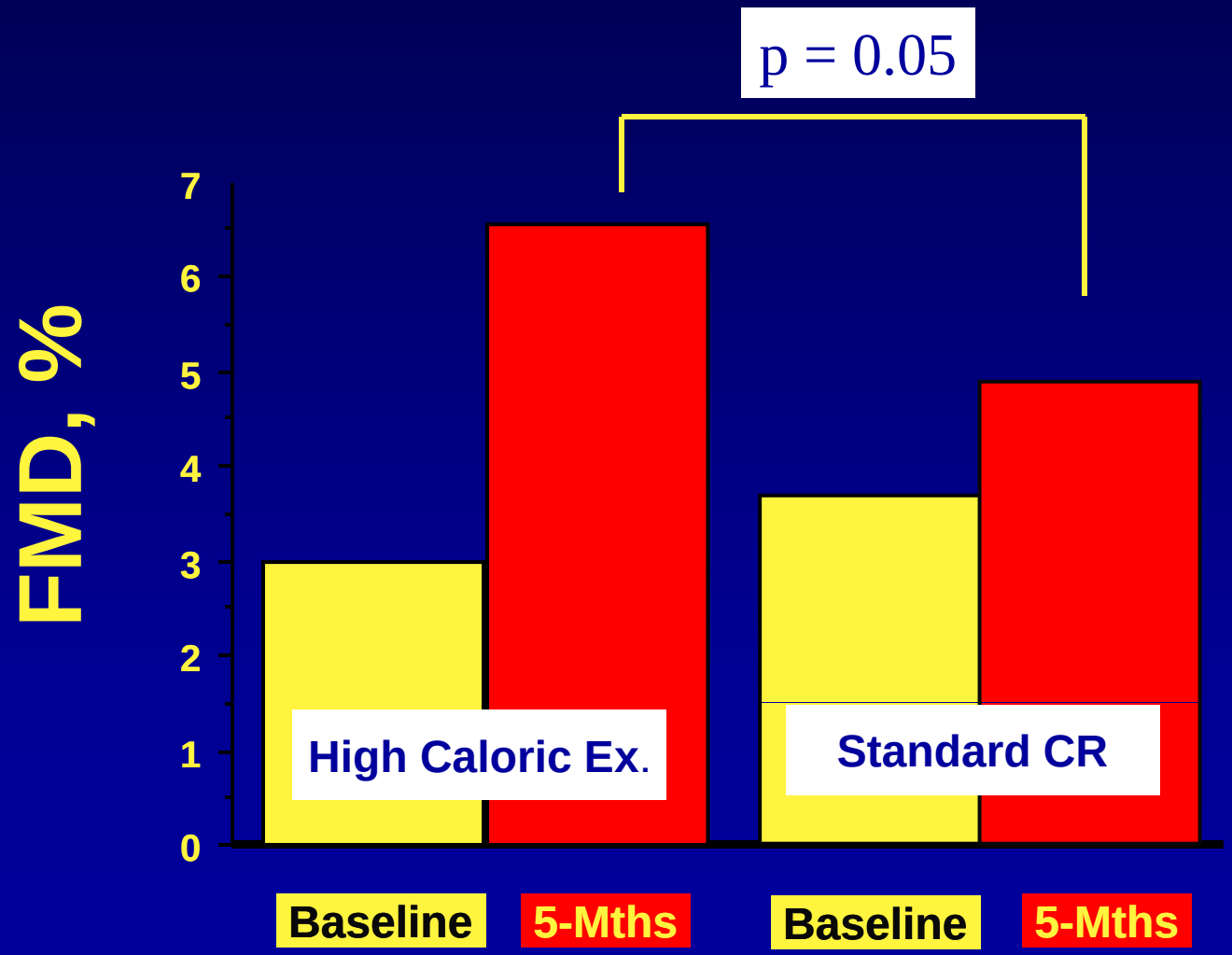
"What fits your busy schedule better, exercising one hour a day or being dead 24 hours a day?"

Thank You

The Weight Loss Equation:

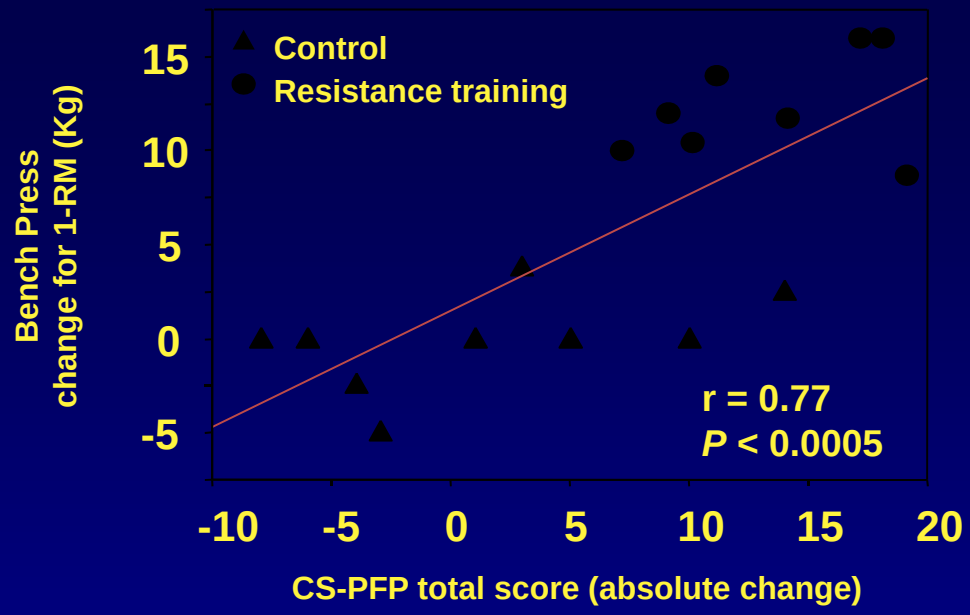
- In Steady State: Intake = Expenditure
- Intake = Food (cal)
- Expenditure (cal)
  - Resting Metabolic Rate (60-70%)
  - Thermic Effect of food/digestion (10%)
  - *Physical Activity* (20-30%)
- Any combination of decreased intake (cal) or increased energy expenditure (cal) that equals a net deficit of 3500 Kcal results in a loss of 1 lb of weight (mostly fat).

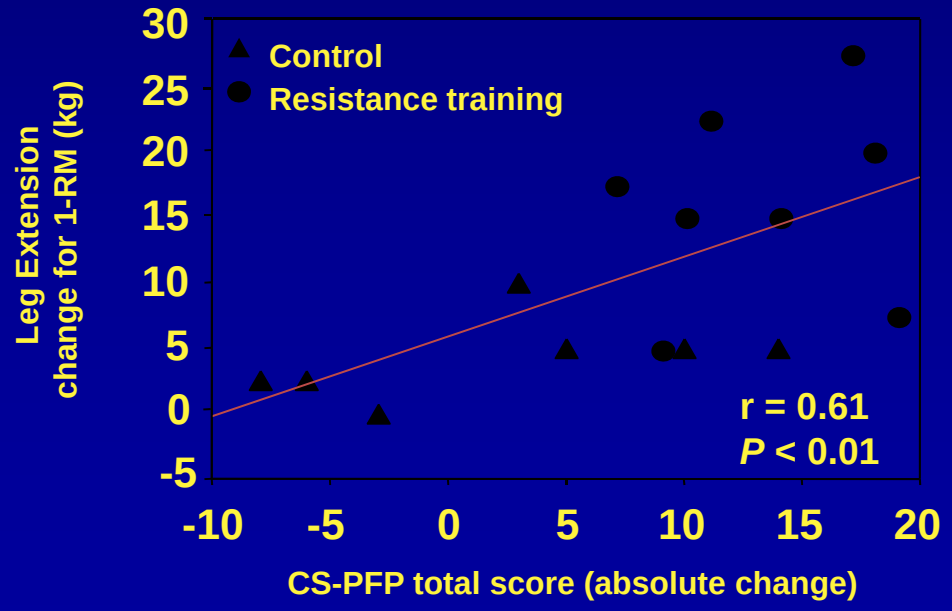
Change in Endothelial Function, Separated by Group



High Caloric Exercise Training

- HCT is not for individuals who are significantly deconditioned (Peak VO_2 <14 $ml*kg^{-1}*min^{-1}$), have orthopedic/co-morbitities issues, or just hate to exercise.
- Self monitoring is important, keep exercise records, count calories.
- Use gadgets to motivate/educate (HR monitors, accelorometers, pedometers, calorie-counters on ergometers, etc).
- Be aware of overuse injuries.
- Closely monitor patients with diabetes.
- Emphasize the benefits of exercise beyond those related to weight loss.
- Maximize “lifestyle” exercise.
- Introduce in Phase II CR, Optimize in Phase III and in Community


Control
Resistance training
Bench Press
change for 1-RM (Kg)
15
10
5
0
-5
-10
-5
0
5
10
15
20
r = 0.77
P < 0.0005
CS-PFP total score (absolute change)


Control
Resistance training
Leg Extension
change for 1-RM (kg)
30
25
20
15
10
5
0
-5
-10
-5
0
5
10
15
20
r = 0.61
P < 0.01
CS-PFP total score (absolute change)

Aerobic Training in Older CHD patients.

- **Caveats**:
  - Importance of Intermittent/Interval Training on treadmill or walking course
  - Baseline stress test is often submaximal
  - Older patients will not spontaneously advance intensity
  - Importance of Resistance Training
  - High prevalence of balance problems and other co-morbidities: arthritis, diabetes, PVD, mental depression.
  - Low levels of “executive function” (includes scheduling) so be clear and/or write out instructions.