Pulmonary Rehabilitation

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What do these patients have in common?

- 62 yo woman with a long standing history of COPD (FEV1 30%), dyspneic with showering and dressing, on maximal therapy (steroid/LABA, LAMA, oxygen), considering LVRS
- 70 yo man with moderate COPD (FEV1 74%), no history of exacerbations, dyspneic with one flight of stairs, brisk walking, on LABA/LAMA
- 61 yo woman with IPF (FVC 60%), dyspneic with most activities, occasionally walks for exercise

Exercise Intolerance in Chronic Respiratory Diseases

Factors contributing to exercise intolerance

- Ventilatory constraints
- Pulmonary gas exchange abnormalities
- Peripheral muscle dysfunction
- Cardiac dysfunction
- Anxiety/poor motivation

Factors contributing to exercise intolerance

- Ventilatory Limitation
  - Increased dead-space ventilation
  - Mechanical constraints
    - Flow limitation
    - Increased work of breathing
  - Impaired gas exchange
    - Augmentation of peripheral chemoreceptor output
    - Stimulation of lactic acid production
  - Increased ventilatory demands
    - Deconditioning
    - Peripheral muscle dysfunction

Factors contributing to exercise intolerance

- Cardiac Dysfunction
  - Increase in right ventricular afterload
    - Direct vascular injury
    - Hypoxic vasoconstriction
    - Erythrocytosis
  - Septal shifts decreasing left ventricular filling
  - Tachyarrythmias
  - Air trapping with rise in right atrial pressure
  - Cardiovascular deconditioning from inactivity

Factors contributing to exercise intolerance

- Skeletal muscle dysfunction
  - Peripheral muscle wasting occurs in approximately 30% of outpatients with COPD
  - Weight loss, inactivity-induced deconditioning, systemic inflammation, oxidative stress, corticosteroid use
  - Reduced capacity for aerobic metabolism -> increased lactic acidosis -> increased ventilatory demands

Factors contributing to exercise intolerance

- Respiratory muscle dysfunction
  - Diaphragm adaptation to chronic overload with greater resistance to fatigue
  - Hyperinflation - > mechanical disadvantage - > functional inspiratory muscle strength and endurance decreased

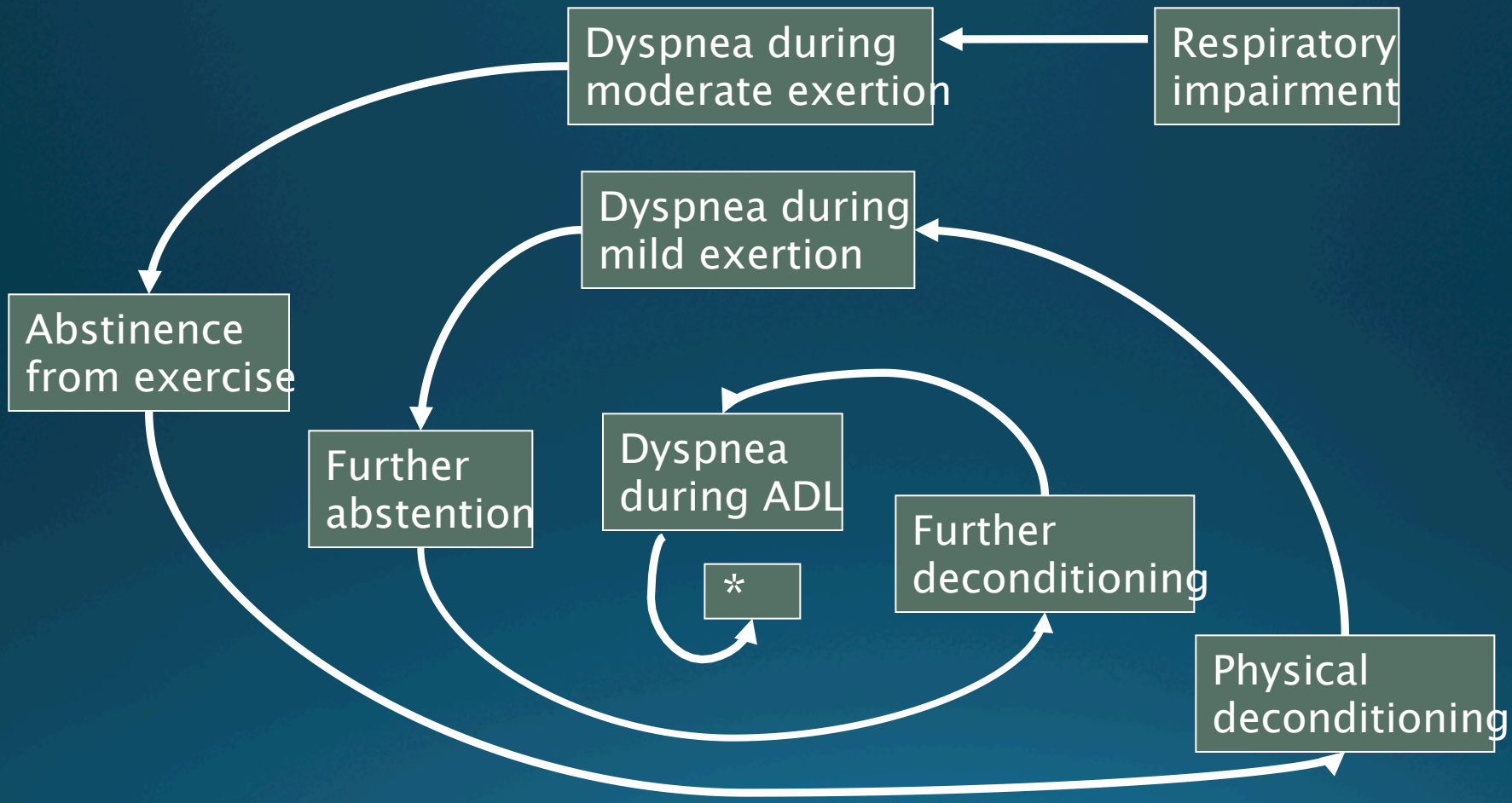
Pulmonary Rehabilitation Indications

Common indications for referral for pulmonary rehabilitation

- Respiratory disease resulting in
  - Breathlessness with activities
  - Limitations with
    - social activities
    - leisure activities
    - indoor and/or outdoor chores
    - basic or instrumental activities of daily living
  - Loss of independence

American Thoracic Society. *Am J Respir Crit Care Med*. 1999;159:1666–1682.

The Dyspnea Spiral



*Stay at home, depression, oxygen therapy, etc.

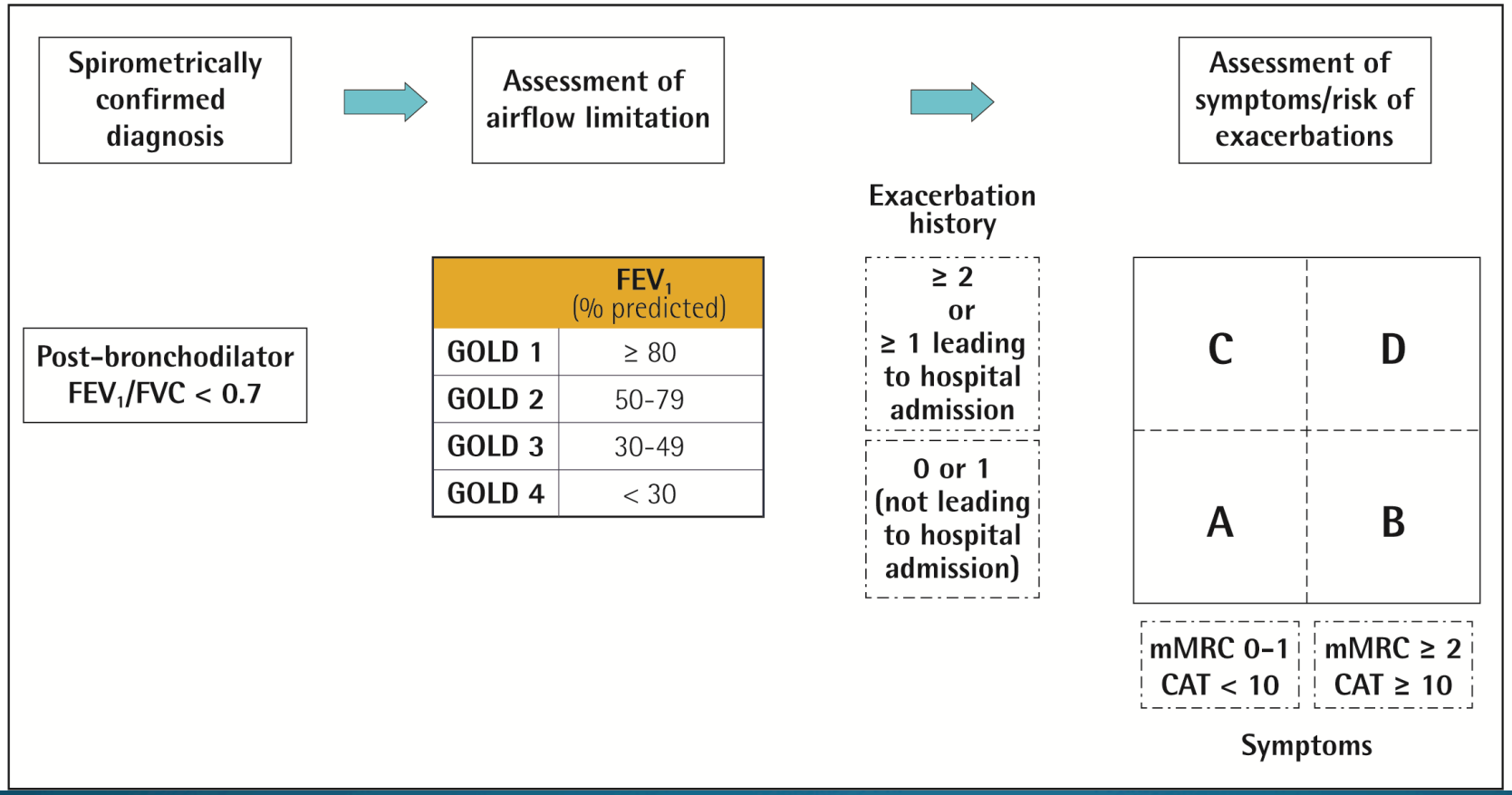
Adapted from Dennis O´Donnell, MD.

Timing of pulmonary rehabilitation

- Patients with less severe disease also improve significantly over several outcome areas (GOLD II, III, IV)
- During or immediately following an AECOPD
  - Gains in exercise tolerance, symptoms, QOL
  - Reduces health care use, readmissions, and mortality
- During acute respiratory failure

ABCD Assessment Tool

Figure 2.4. The refined ABCD assessment tool



Pulmonary Rehabilitation Components

Pulmonary rehabilitation ATS/ERS definition

"Pulmonary rehabilitation is a comprehensive intervention based on a thorough patient assessment followed by patient-tailored therapies that include, but are not limited to, exercise training, education, and behavior change, designed to improve the physical and psychological condition of people with chronic respiratory disease and to promote long-term adherence to health-enhancing behaviors."

Goals of pulmonary rehabilitation

- Reduce symptoms
- Decrease disability
- Improve health-related QOL
- Decrease health-care utilization
- Increase participation in physical and social activities
- Maintain long-term benefits through changes in lifestyle

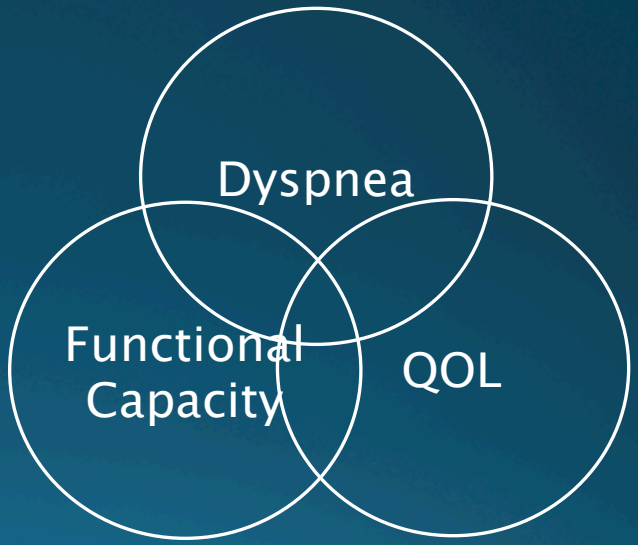
American Thoracic Society. *Am J Respir Crit Care Med*. 1999;159:1666–1682.
British Thoracic Society Standards of Care Subcommittee on Pulmonary Rehabilitation. *Thorax*. 2001;56:827–834.
ACCP/AACVPR Pulmonary Rehabilitation Guidelines Panel. *Chest*. 1997;112:1363–1396.

What is pulmonary rehabilitation?

- Interventions

- Outcomes

  - Lower extremity training
  - Upper extremity training
  - Ventilatory muscle training
  - Psychosocial & Educational/ Behavioral training
  - Body Composition/Nutrition



What is Pulmonary rehabilitation?

- Training programs vary
  - Setting
    - Outpatient
    - Inpatient
    - Supervised home
  - Combination of interventions
    - Exercise training
    - Psychosocial and Educational/Behavioral Training
    - Body Composition/Nutrition

Exercise training

- Endurance Training
  - Prescription - > 60% maximal work rate for 20 to 60 minutes per session 3-5 times per week
    - Poorly defined in some individuals
    - Endurance versus interval training
  - Modality
    - Treadmill/walking
    - Cycle ergometer
  - Duration?
    - 7 weeks better than 4 weeks
    - 20 sessions better than 10 sessions
    - Typically 8 to 12 weeks with 2-3 sessions per week
  - Long-term maintenance?

Exercise training

- Resistance/strength training
  - Optimal approach is not known
  - Load ≥ 80% of one repetition maximum
- Upper extremity training
  - Weights/unsupported arm exercises
  - Arm-crank ergometer
  - Elastic band
- Breathing retraining
- Ventilatory muscle training
  - Inspiratory resistance

Exercise practice guidelines

- A minimum of 20 sessions at least three times per week (3 supervised or 2 supervised and 1 unsupervised)
- High intensity exercise should be encouraged, low intensity training for those who cannot achieve a high intensity
- Interval training for those who are more symptomatic
- Both upper and lower extremity training
- Combination of both endurance and strength training, emphasize strength training for patients with significant muscle atrophy

Maximizing the effects of exercise training

- Bronchodilator optimization
- Supplemental oxygen
- Non-invasive positive pressure ventilation
- Breathing strategies
  - Yoga breathing
  - Pursed lip breathing
  - Computer-aided breathing feedback
- Walking aids

Behavior change and collaborative self-management

- Pathophysiology of chronic respiratory disease
- Communicating with the health care provider
- Interpreting medical tests
- Breathing strategies
- Role and rationale for medications, oxygen
- Benefits of exercise and physical activity
- Energy conservation during ADLs
- Healthy food intake
- Early recognition and treatment of exacerbations
- Coping with chronic lung disease
- Advance care planning

Body composition abnormalities and interventions

- Low BMI → < 21 kg/m^2
  - Up to 1/3 of outpatients, 32 to 63% referred for rehab
- Decreased fat free mass
  - Skinfold anthropometry, bioimpedance analysis, DEXA
  - FFMI = FFM/height^2 → <16 kg/m^2 men / <15 kg/m^2 women
  - 35% referred for pulmonary rehab, 15% outpatients

Body composition impact

- Recent weight loss > 10% six months or > 5% past month → predictor of increased morbidity and mortality
- Lower exercise tolerance (walk distance, VO_2max)
- Decreased peripheral muscle strength
- Impaired respiratory muscle strength
- Greater impairment in HRQL (low FFM)

Body composition interventions

- Caloric supplementation
- Physiologic interventions
  - Strength and aerobic training

Pulmonary Rehabilitation Outcomes

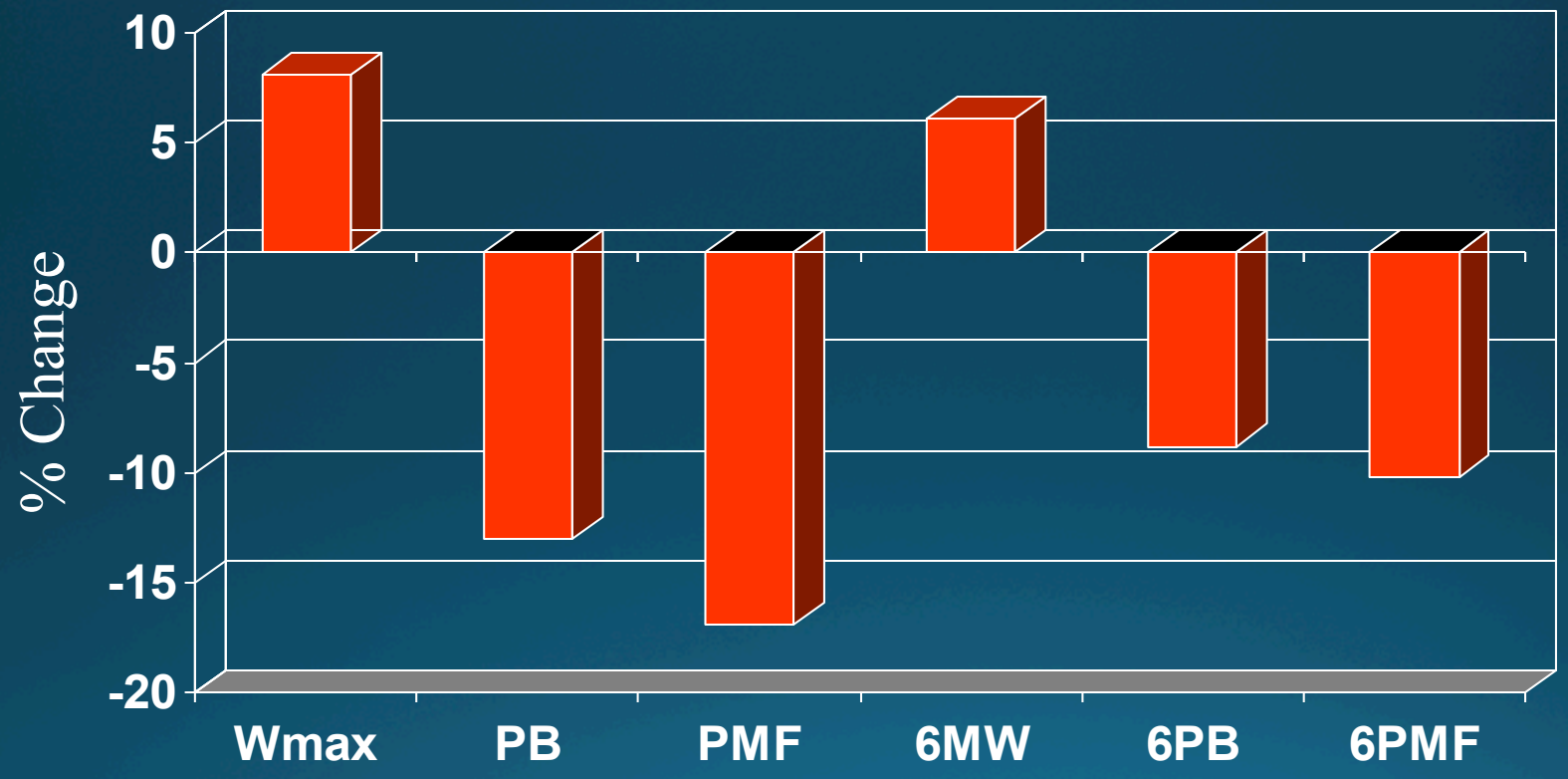
Pulmonary rehabilitation outcome measurements

- Exercise outcome measures
  - Timed Walk tests
  - Incremental treadmill
  - Stationary bicycle
  - Endurance
- QOL outcomes
- Dyspnea outcomes
- Health care utilization
- Mortality

Pulmonary rehab in NETT

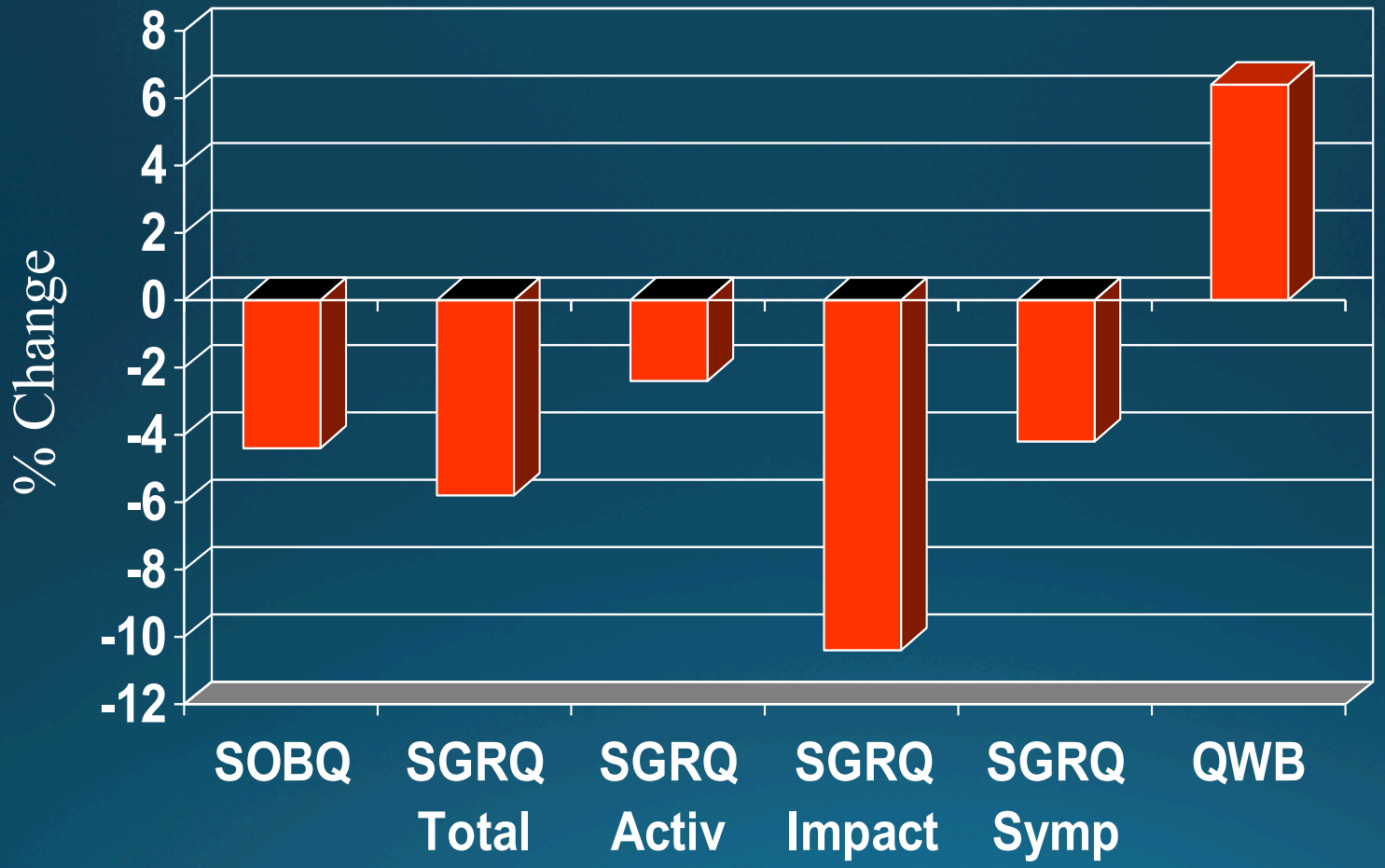
- Max medical Rx (with rehab) ± LVRS
- NETT centers + >400 rehab satellite centers
- Improved exercise, symptoms, QOL after rehab
- Slightly greater exercise at NETT centers vs. satellites; no difference symptoms/QOL

Changes after rehab



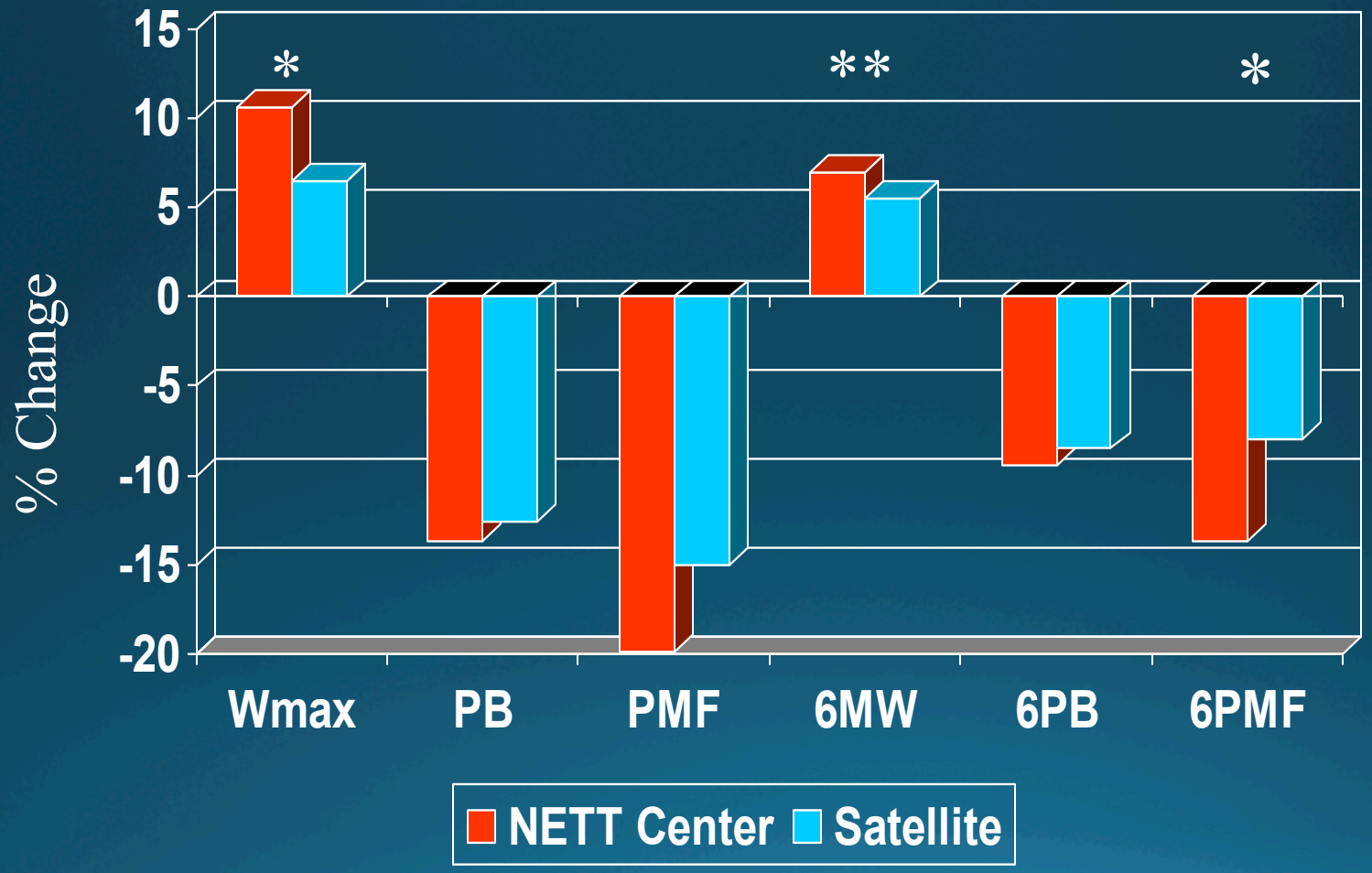
all $p < 0.0001$

Changes after rehab



all $p < 0.0001$

Effect of rehab location



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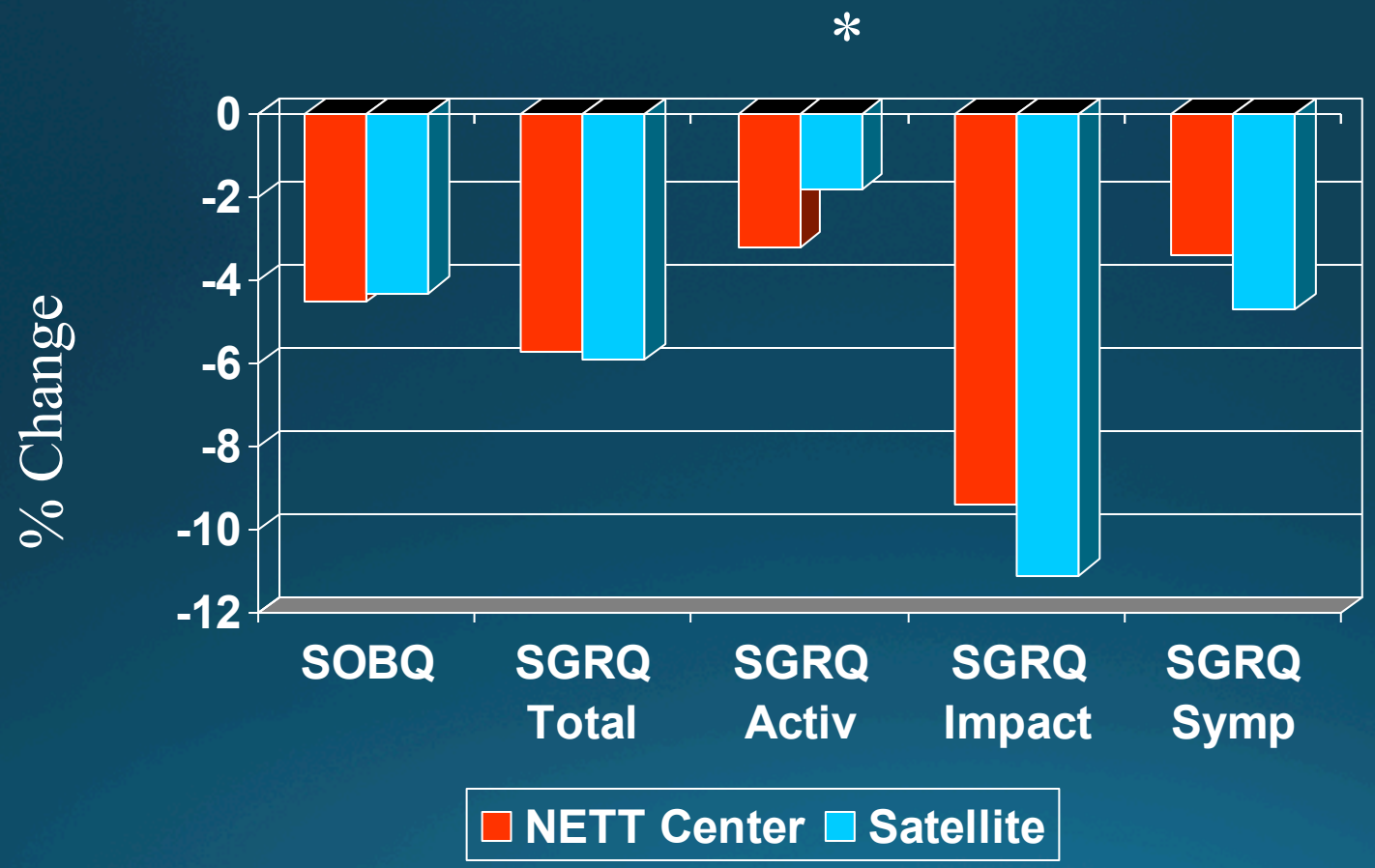
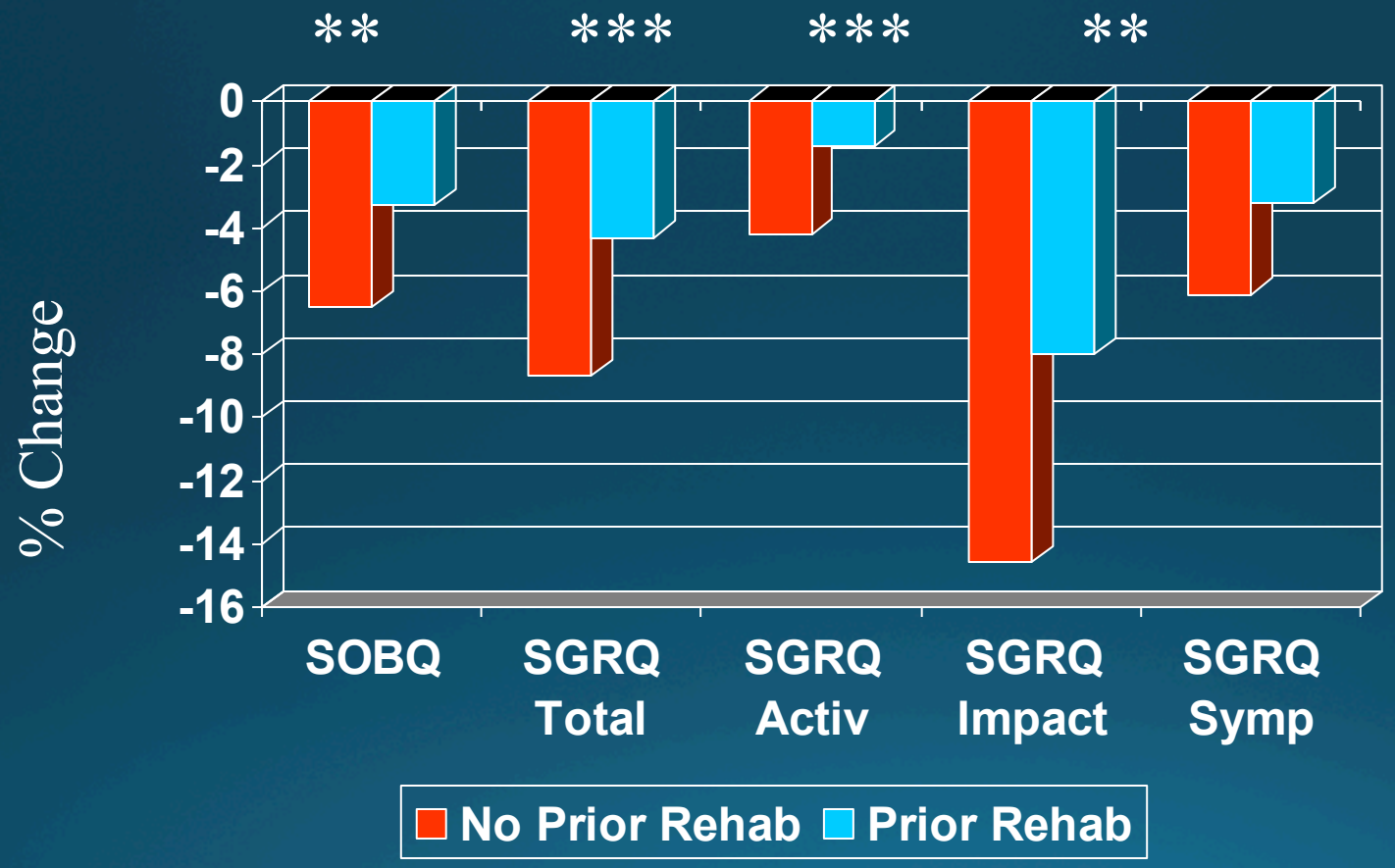
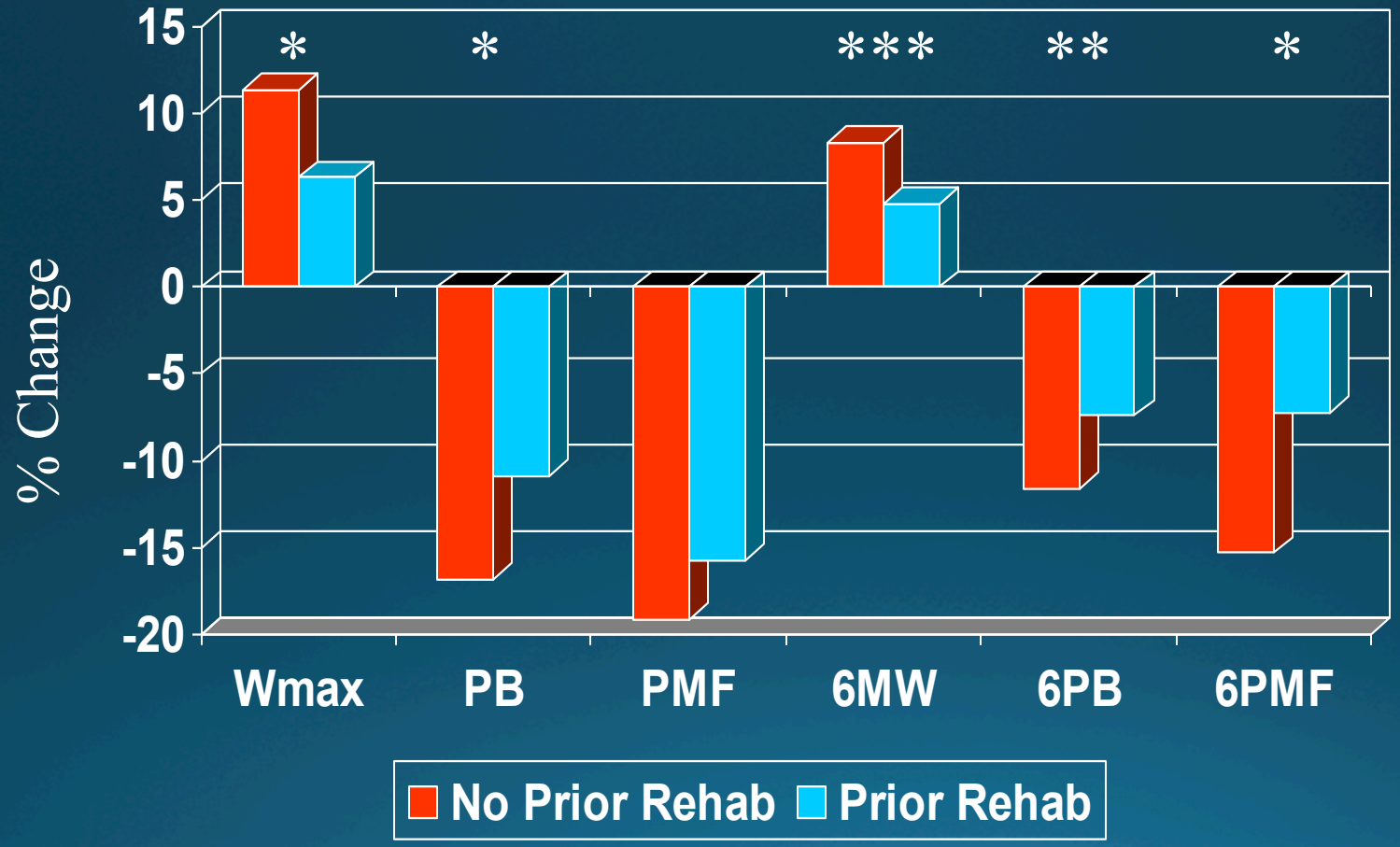


Effect of prior rehab



Effect of prior rehab



Lessons from NETT

- Effectiveness of pulmonary rehab
  - Multiple centers
  - Patients with severe disease
- Important adjunct to surgery
  - Preparation for surgery
  - Recovery from surgery
- CMS coverage for LVRS – requires pulmonary rehab pre- and post-op
- No mortality benefit

Lessons from NETT

- Effectiveness of pulmonary rehab
  - Multiple centers
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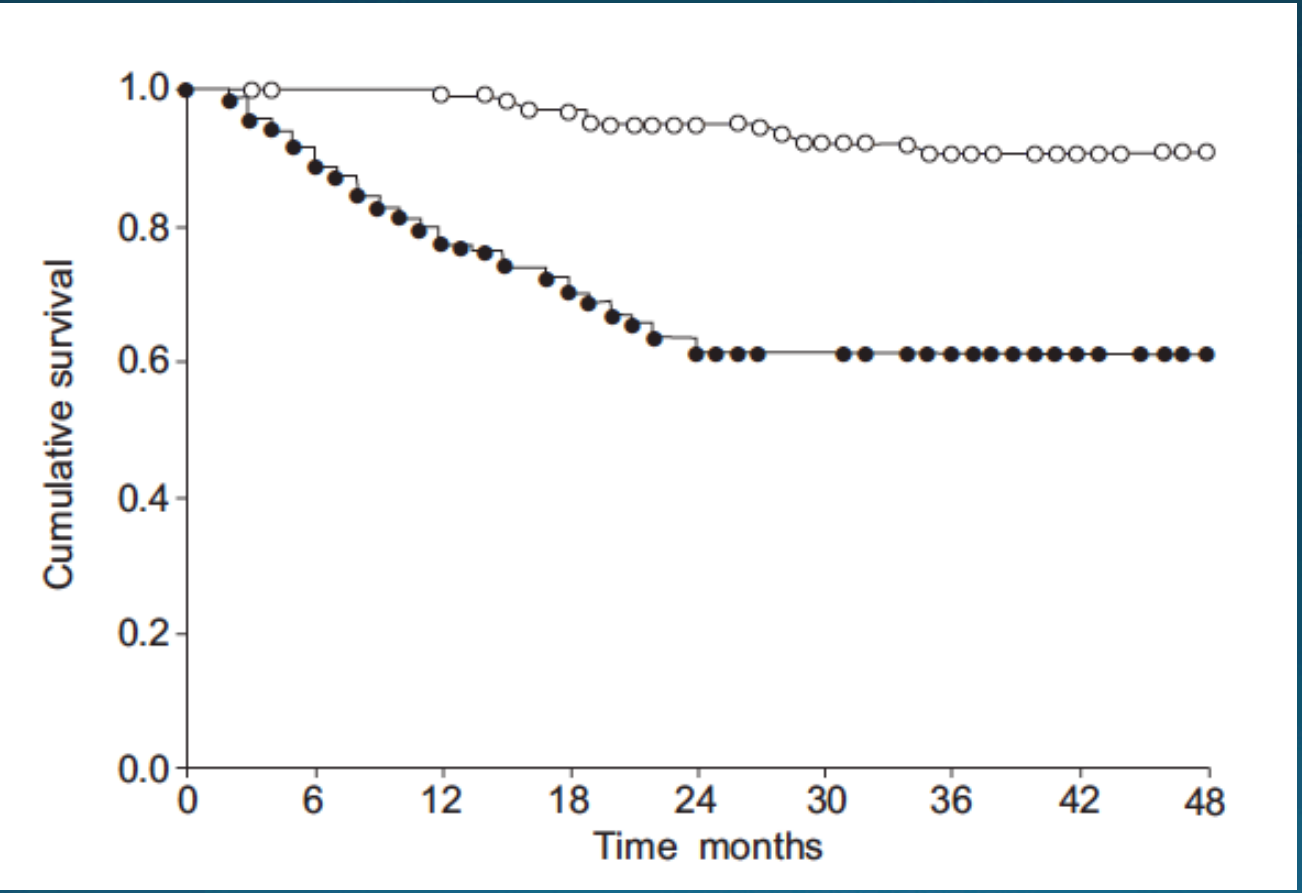
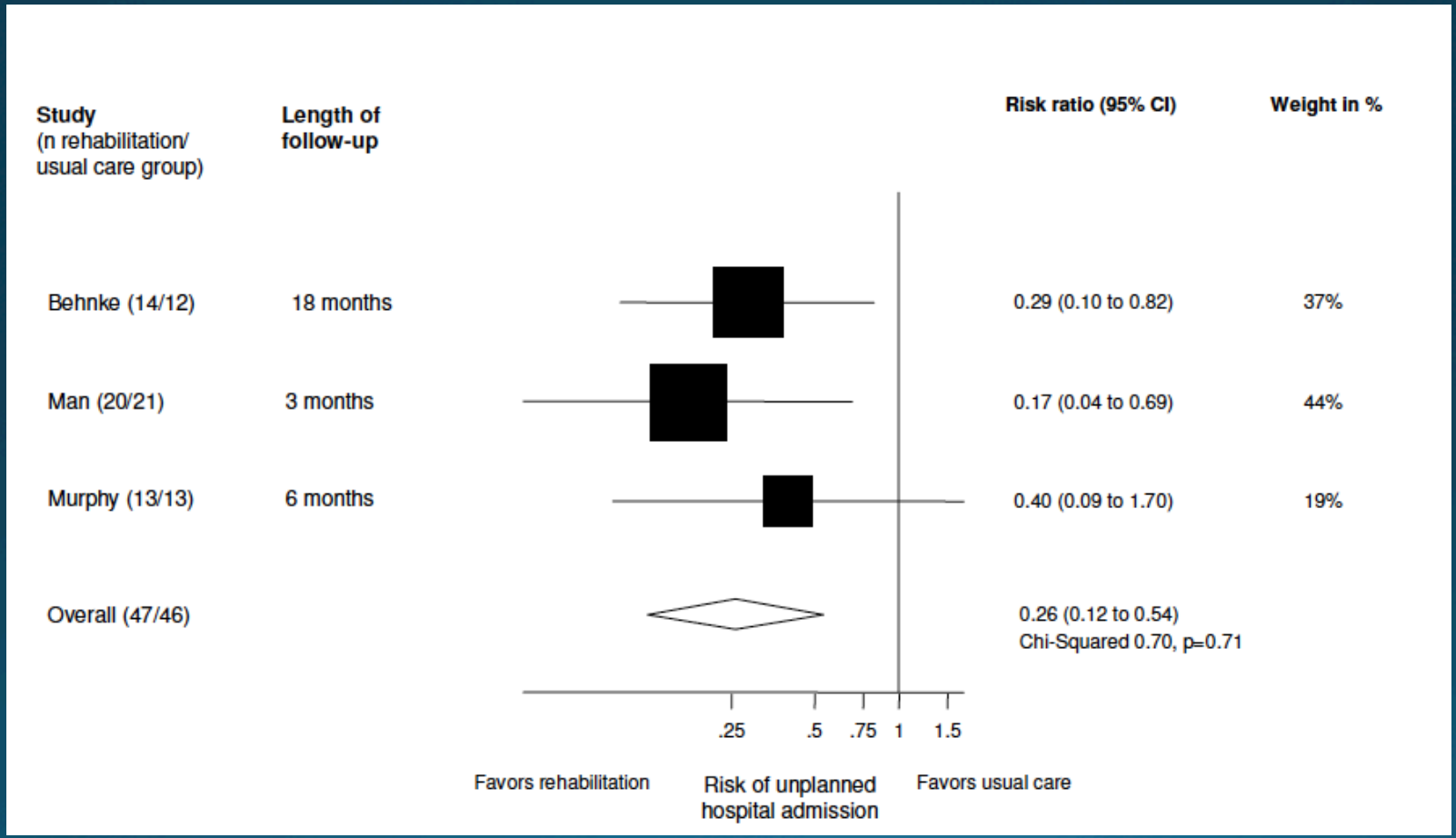
  - Preparation for surgery
  - Recovery from surgery
- CMS coverage for LVRS – requires pulmonary rehab pre- and post-op
- **No mortality benefit**

Survival increased in COPD patients participating in pulmonary rehabilitation



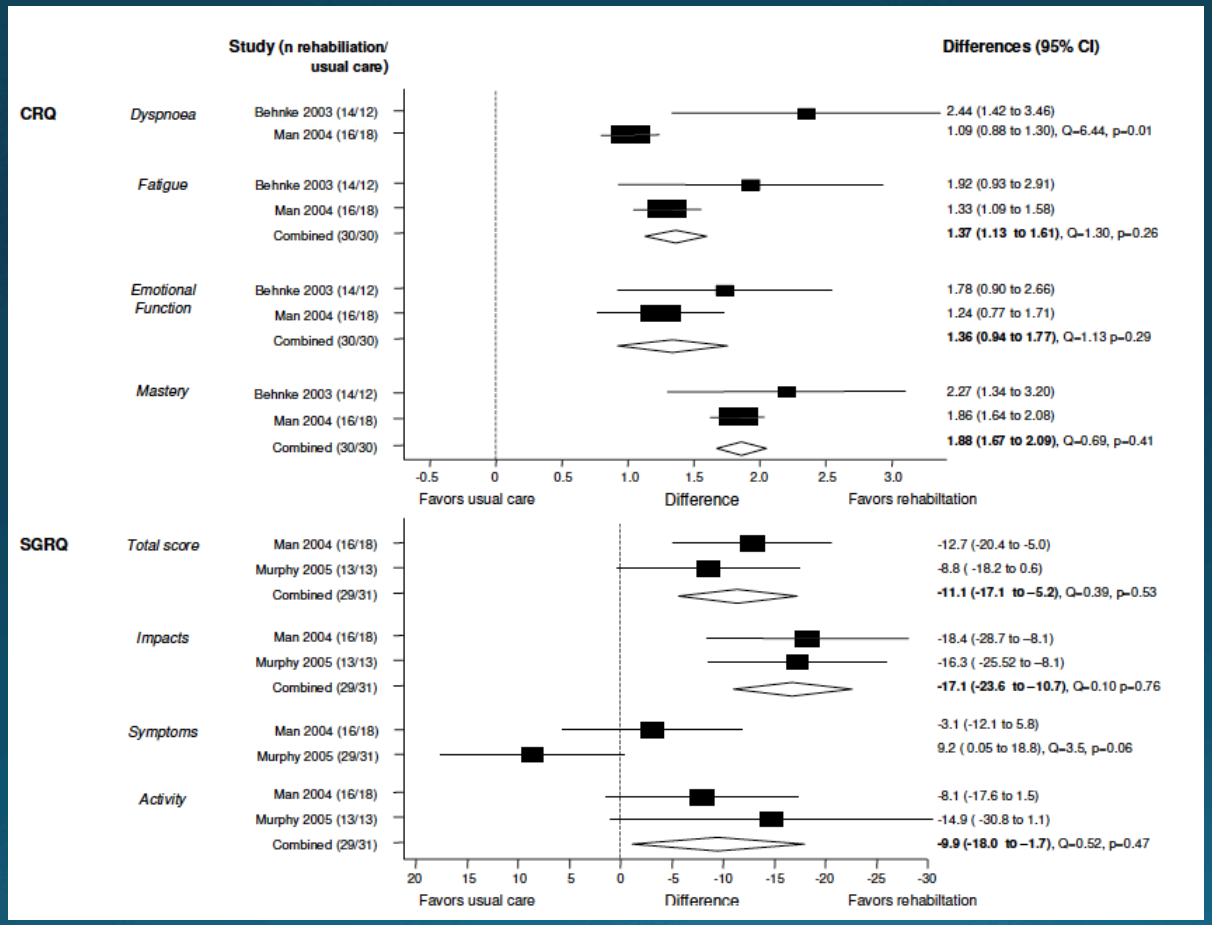
Cote et al. ERJ 2005; 26.

Pulmonary rehabilitation impact on hospital admissions



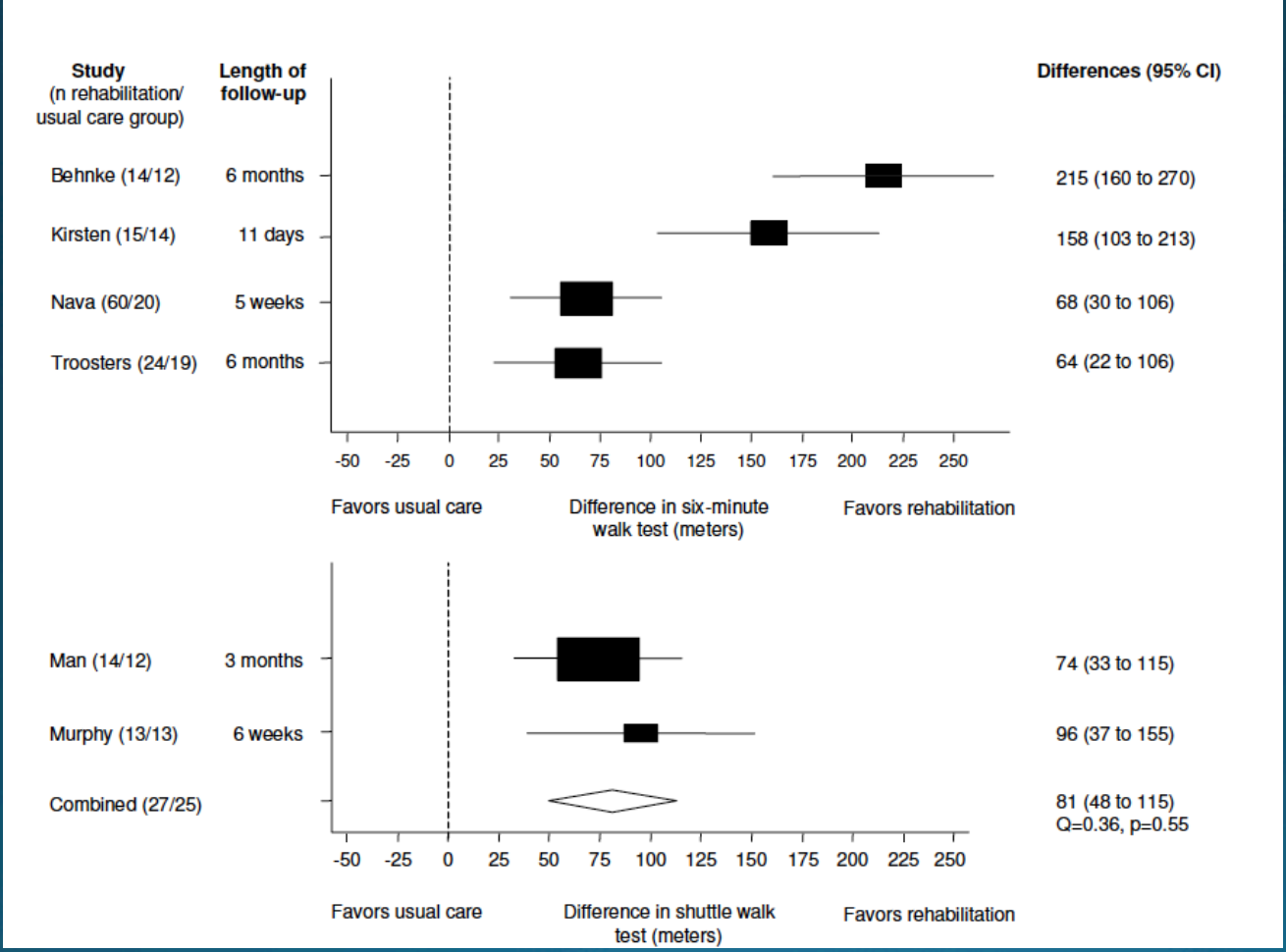
Puhan et al. Respiratory Research 2005; 6.

Pulmonary rehabilitation impact on HRQOL



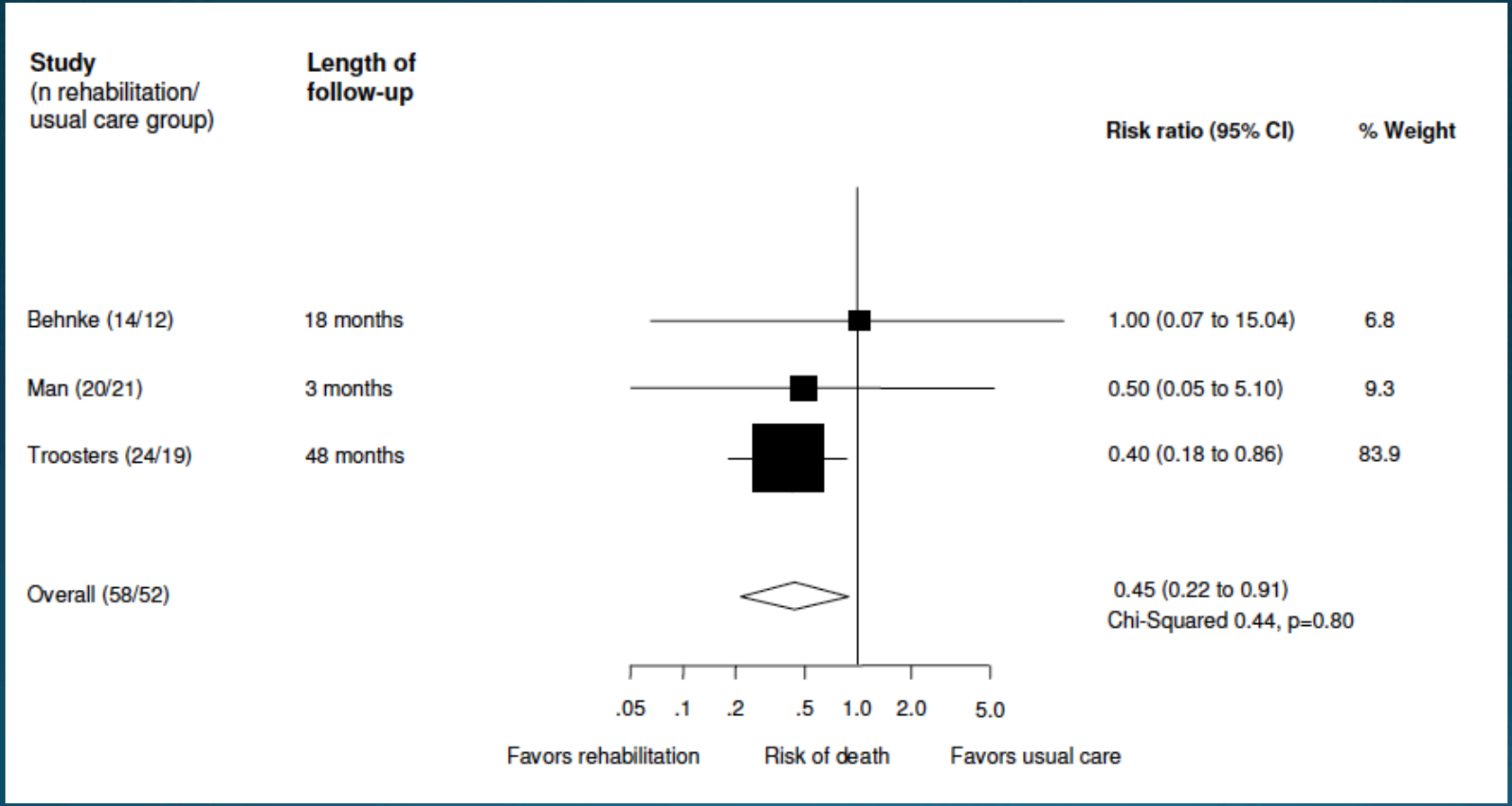
Puhan et al. Respiratory Research 2005; 6.

Pulmonary rehabilitation impact on exercise capacity



Puhan et al. Respiratory Research 2005; 6.

Pulmonary rehabilitation impact on mortality



Puhan et al. Respiratory Research 2005; 6.

Outpatient Pulmonary Rehabilitation: *Study Objective and Design*

- Objective: to assess the effect of outpatient pulmonary rehabilitation on use of health care and patients' well-being after 1 year
- Design: randomized controlled trial
- 200 patients with disabling chronic lung disease were randomized to either
  - 6-week multidisciplinary out-patient rehabilitation program (18 visits)
  - Standard medical management
- Assessments were performed at baseline, after the 6-week program, and at 1 year

Griffiths TL et al. *Lancet*. 2000;355:362–368.

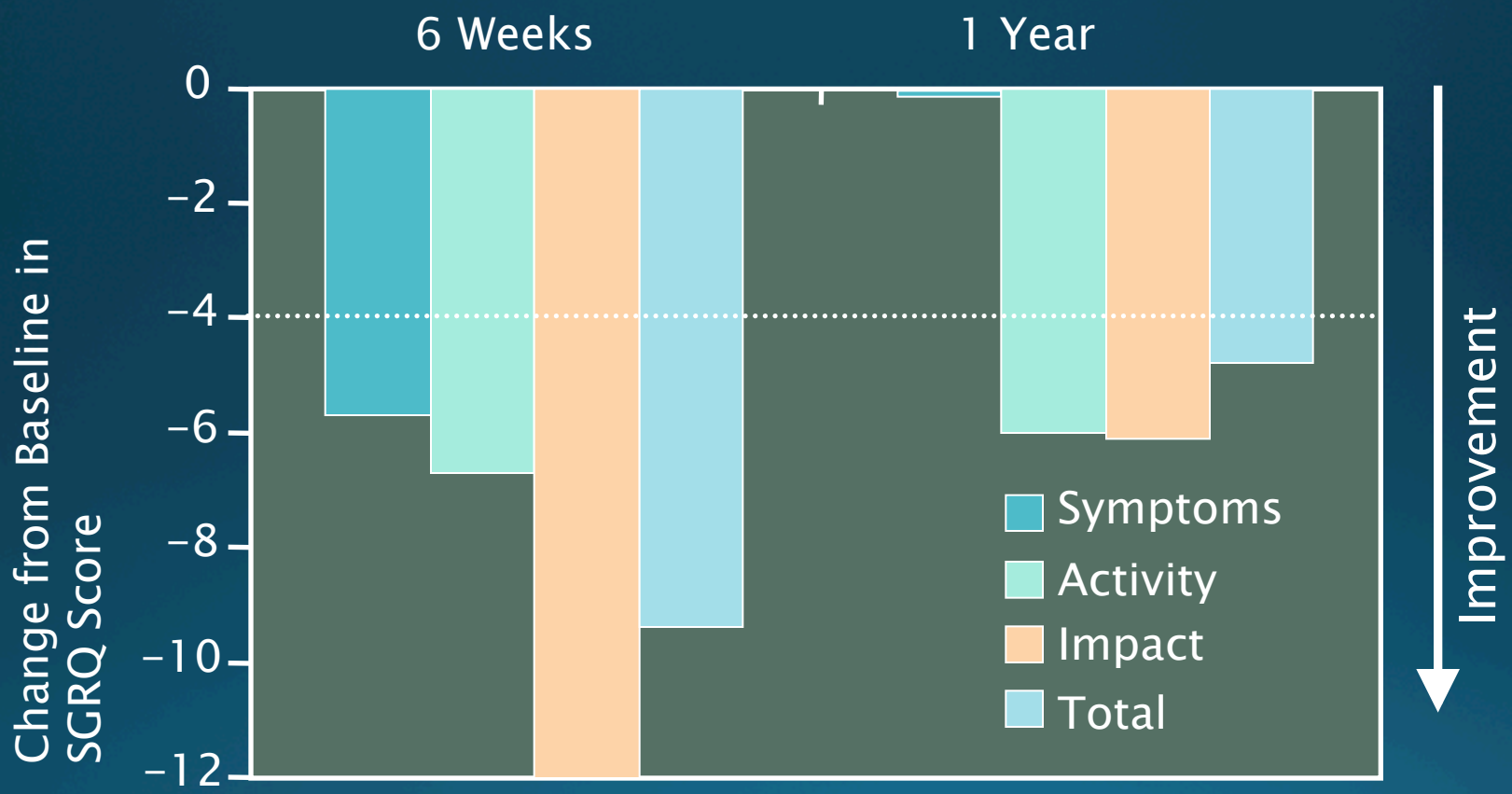
Outpatient Pulmonary Rehabilitation: *Study Results*

- The rehabilitation group spent fewer days in the hospital compared with the control group
- Rehabilitation group showed greater improvements in walking ability (shuttle walk test) and health status (SGRQ and CRDQ)
- Differences, though smaller, remained significant after 1 year

SGRQ = St. George's Respiratory Questionnaire; CRDQ = Chronic Respiratory Disease Questionnaire.

Griffiths TL et al. *Lancet*. 2000;355:362–368.

The effect of pulmonary rehabilitation on health status



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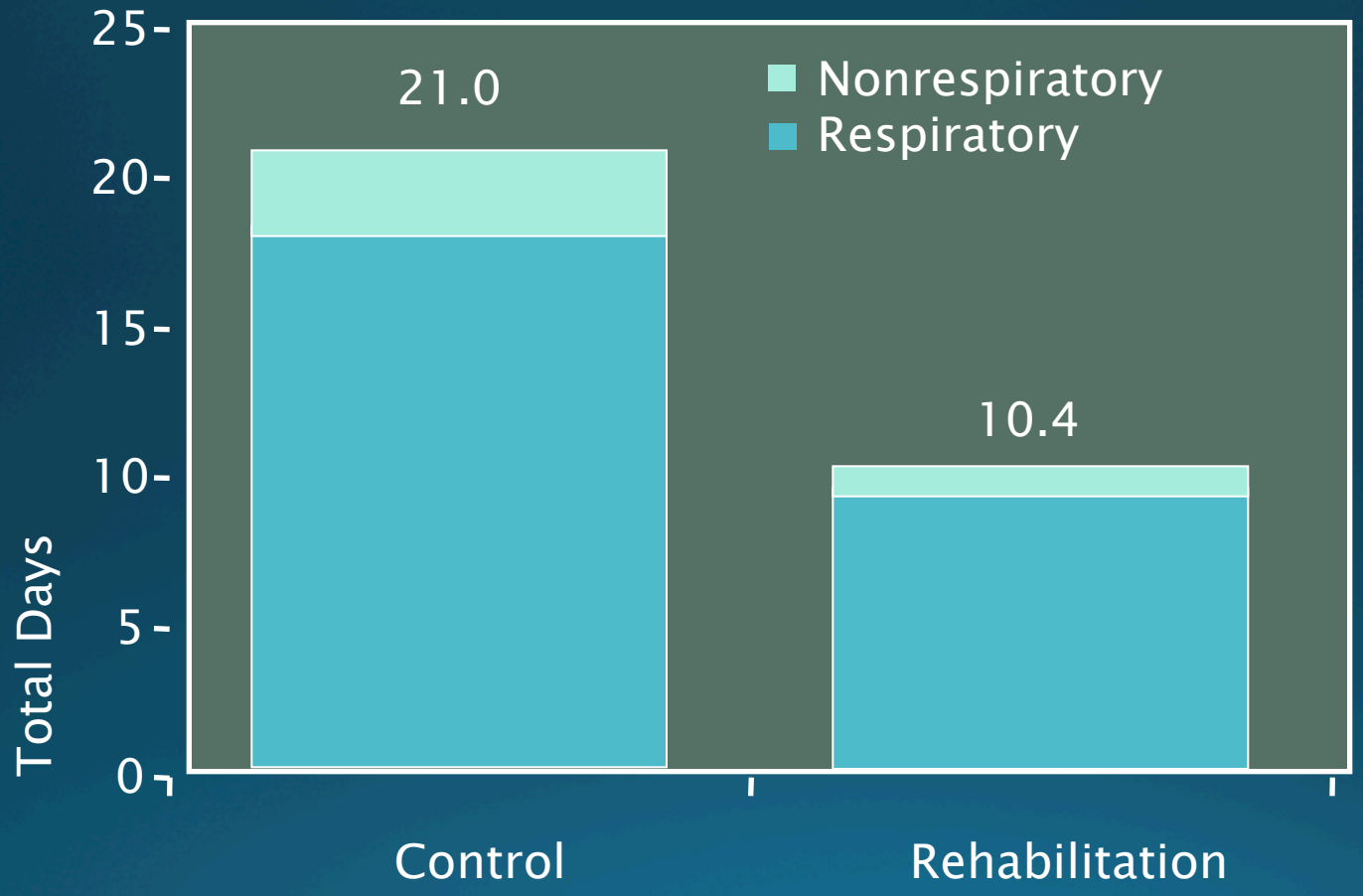
Pulmonary rehabilitation and days spent in hospital



$P = .021$.

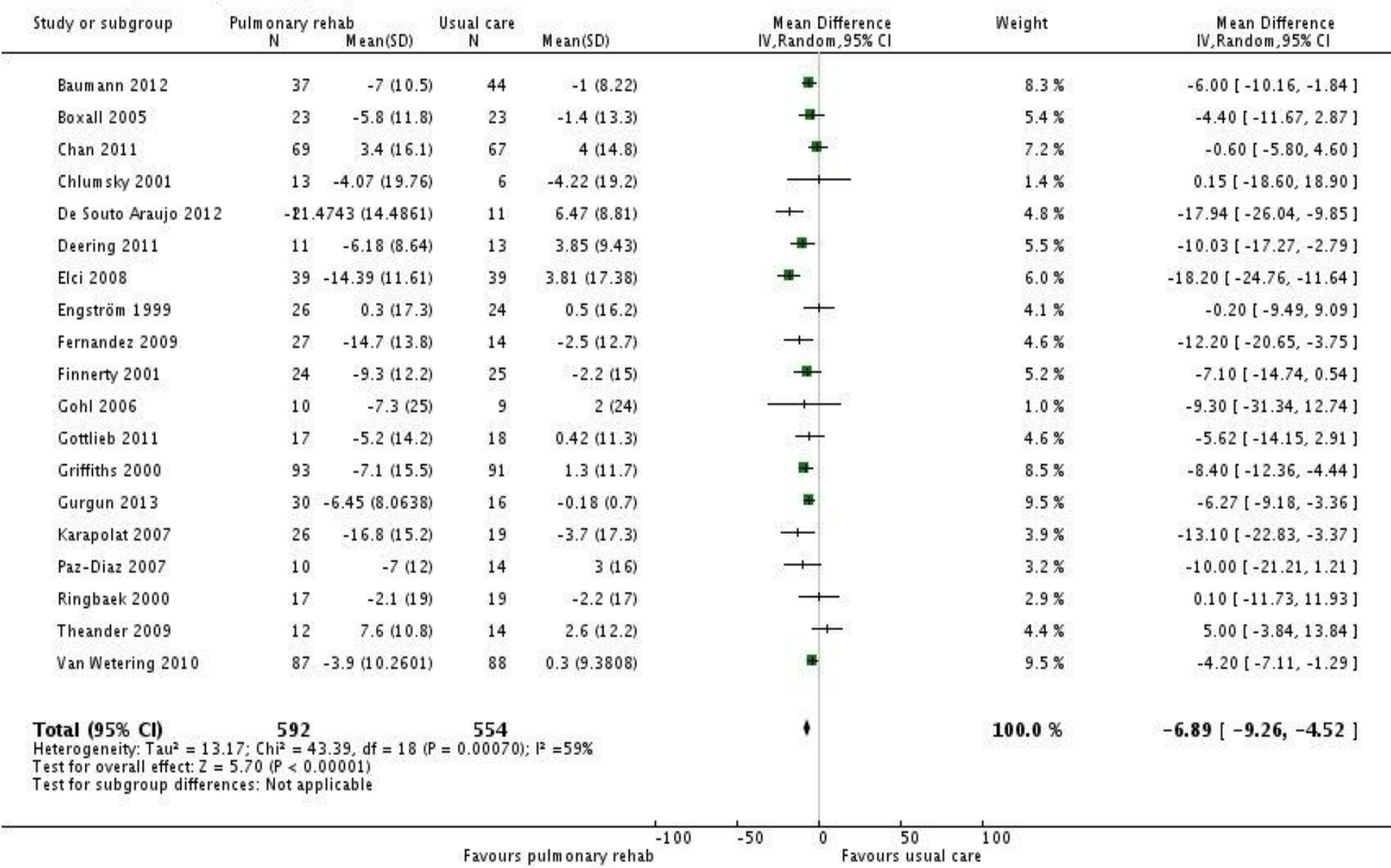
Griffiths TL et al. *Lancet.* 2000;355:362–368.

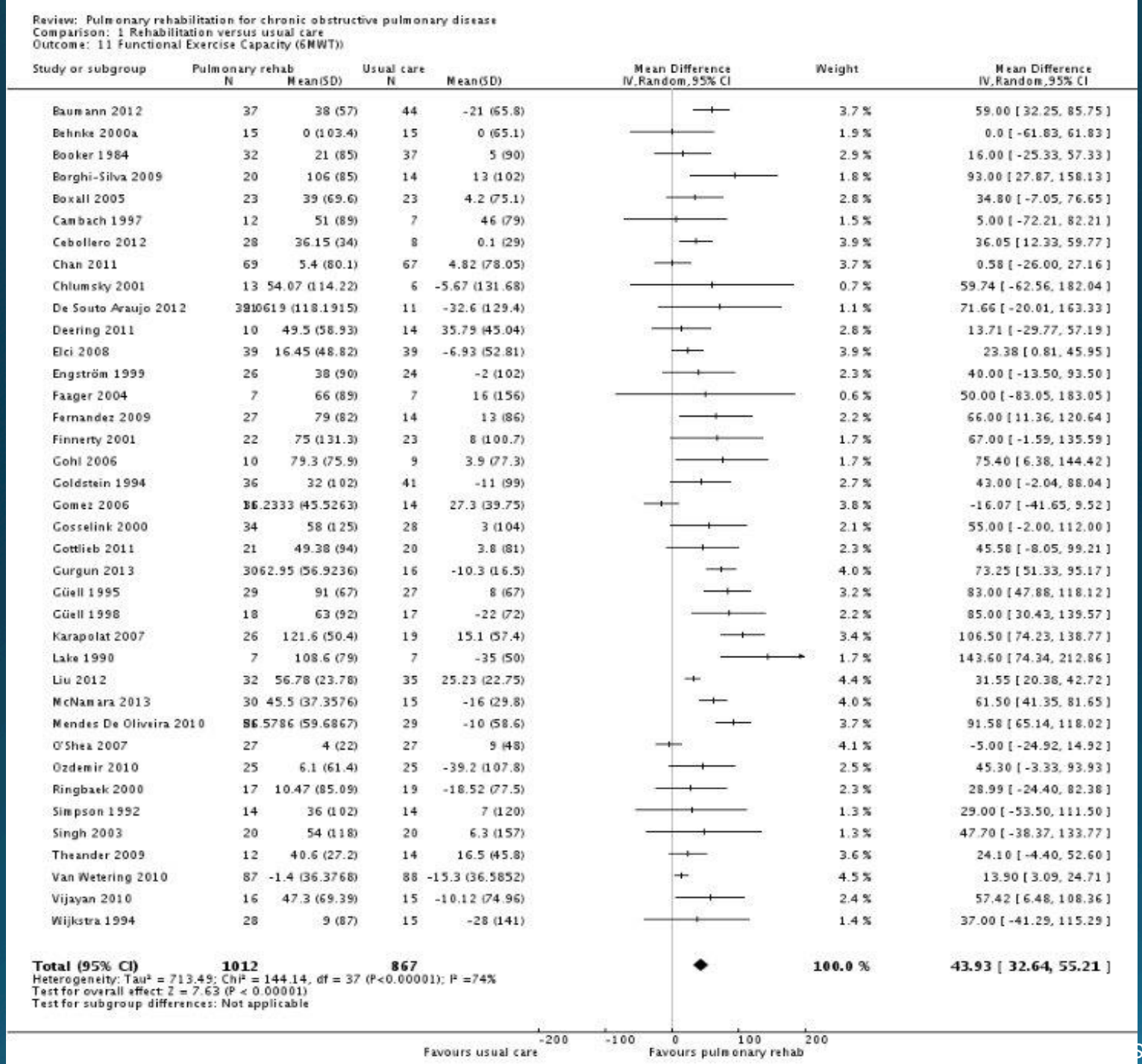
Cochrane meta-analysis

- RCT measuring HRQoL and/or functional or maximal exercise capacity
- Exercise training for ≥ 4 weeks
- 65 trials, 3822 participants
- Mean FEV1 39.2% vs. 36.4%
- 2:1 males:females
- Hospital based, community based
- 4-52 week programs

McCarthy et al. *Cochrane Database Syst Rev. 2015;2.*

Review: Pulmonary rehabilitation for chronic obstructive pulmonary disease
Comparison: 1 Rehabilitation versus usual care
Outcome: 5 QoL - Change in SGRQ (Total)





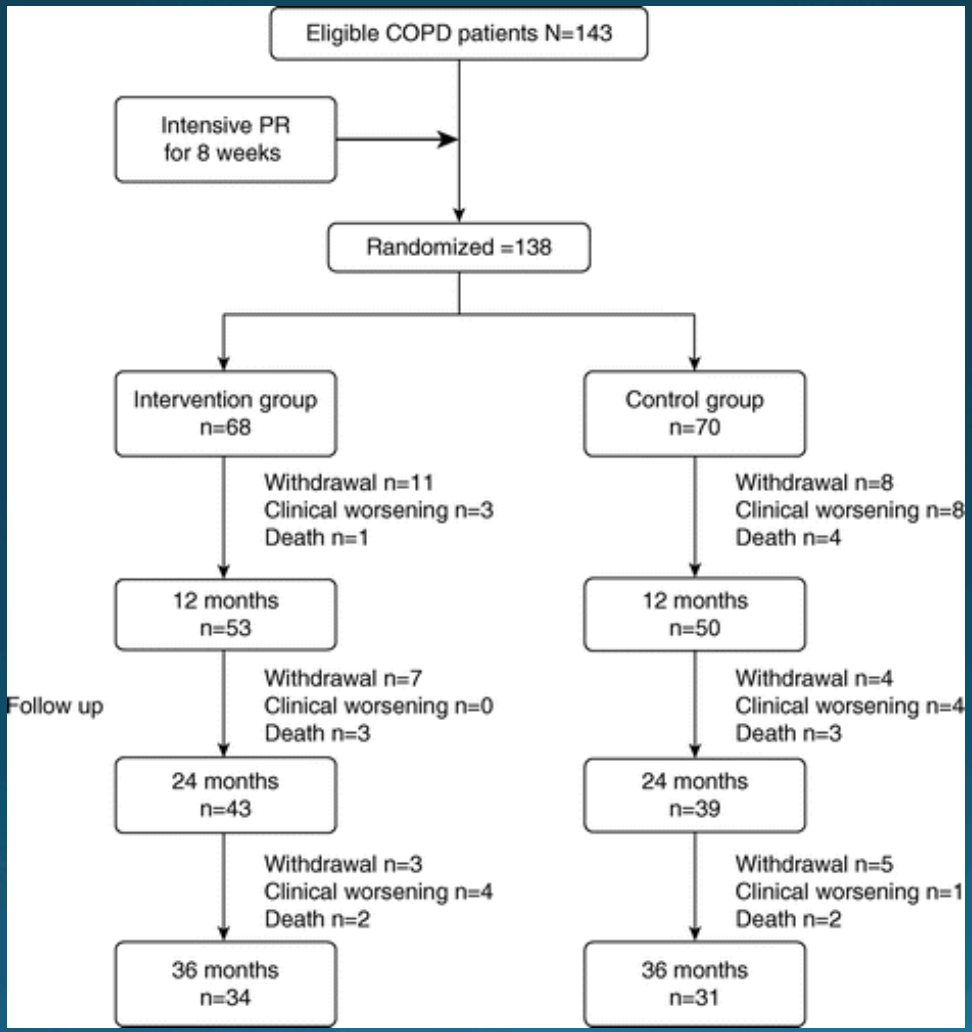
Syst Rev. 2015;2.

Conclusions

- Additional RCT comparing pulmonary rehabilitation versus usual care in COPD are not warranted
- Future research should focus on:
  - Essential components of PR
  - Ideal length and location
  - Degree of supervision and intensity of training required
  - Duration of treatment effect

McCarthy et al. *Cochrane Database Syst Rev. 2015;2.*

Benefits of Long-Term Pulmonary Rehabilitation Maintenance Program in Patients with Severe COPD



Guell et al. *AJRCCM* 2017:195; 622-29.

Benefits of Long-Term Pulmonary Rehabilitation Maintenance Program in Patients with Severe COPD

Outcome Measure	Month 0			Change: Month 12 − Month 0			Change: Month 24 − Month 0			Change: Month 36 − Month 0				
	IG (*n* = 68)	CG (*n* = 70)	*P* Value*	IG (*n* = 53)	CG (*n* = 50)	*P* Value†	IG (*n* = 43)	CG (*n* = 39)	*P* Value‡	IG (*n* = 34)	CG (*n* = 31)	*P* Value§	Time‖	Group × Time¶
6MWD, m	405 ± 111	423 ± 88	0.287	+13	−27	0.004	+2	−32	0.046	−4	−33	0.119	<0.001	0.042
BODE index	4.0 ± 1.6	3.7 ± 1.4	0.408	−0.3	+0.1	0.344	0	+0.8	0.043	−0.1	+0.5	0.181	<0.001	0.228
SF36f	42 ± 15	43 ± 18	0.732	−1	−1	0.613	−3	−1	0.783	−1	−1	0.719	0.142	0.787
SF36m	57 ± 18	56 ± 2	0.708	−2	−1	0.312	−5	−2	0.203	−3	−4	0.244	0.001	0.478
CRQ dyspnea	4.8 ± 1.3	4.8 ± 1.4	0.921	−0.3	0	0.468	−0.4	−0.3	0.617	−0.2	−0.3	0.287	0.003	0.294
CRQ fatigue	4.7 ± 1.4	4.6 ± 1.4	0.529	−0.2	−0.1	0.481	−0.5	−0.4	0.380	−0.5	−0.2	0.193	<0.001	0.610
CRQ emotional factor	5.2 ± 1.3	5.0 ± 1.4	0.624	−0.4	−0.2	0.967	−0.6	−0.3	0.734	−0.7	−0.2	0.274	<0.001	0.690
CRQ mastery	5.3 ± 1.5	5.0 ± 1.5	0.244	−0.3	−0.1	0.653	−0.6	0	0.100	−0.3	−0.1	0.894	0.023	0.204

Definition of abbreviations: 6MWD = 6-minute-walk test distance; BODE = body mass index, airflow obstruction, dyspnea, and exercise capacity; CG = control group; CRQ = Chronic Respiratory Questionnaire; IG = intervention group; SF36f = physical dimension of the Short Form-36; SF36m = mental dimension of the Short Form-36.

Values shown at Month 0 are means ± SD. Changes shown between visits are mean changes with respect to Month 0 (baseline) values.

*P values for the comparison of outcome variables between groups at Month 0.

†P values for the comparison of mean changes of outcome variables from Month 0 to Month 12 between groups.

‡P values for the comparison of mean changes of outcome variables from Month 0 to Month 24 between groups.

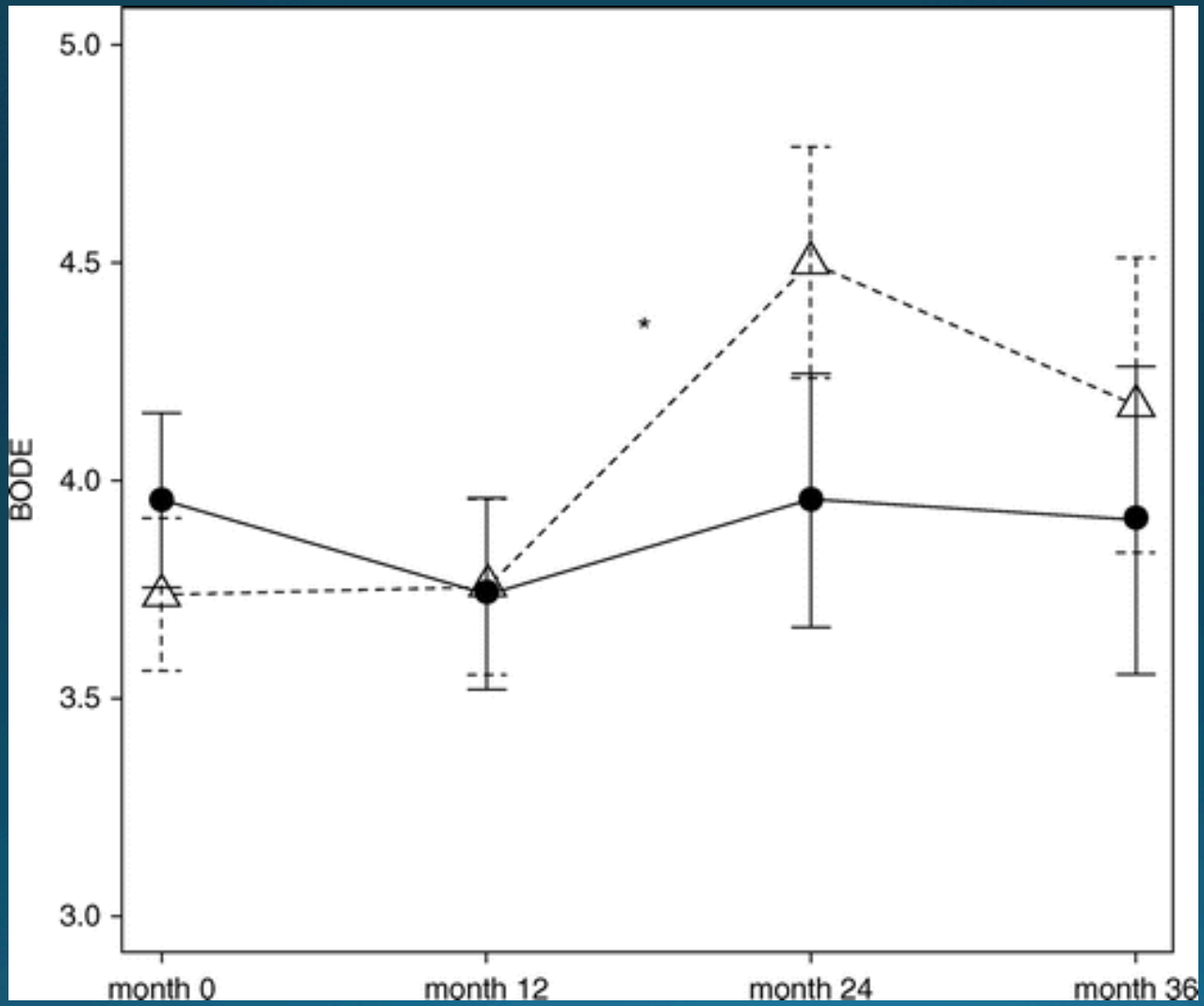
§P values for the comparison of mean changes of outcome variables from Month 0 to Month 36 between groups.

‖P values for tests of time effects (within-group changes over follow-up time).

¶P values for tests of time by group interaction (assessment of differences in time change patterns between groups).

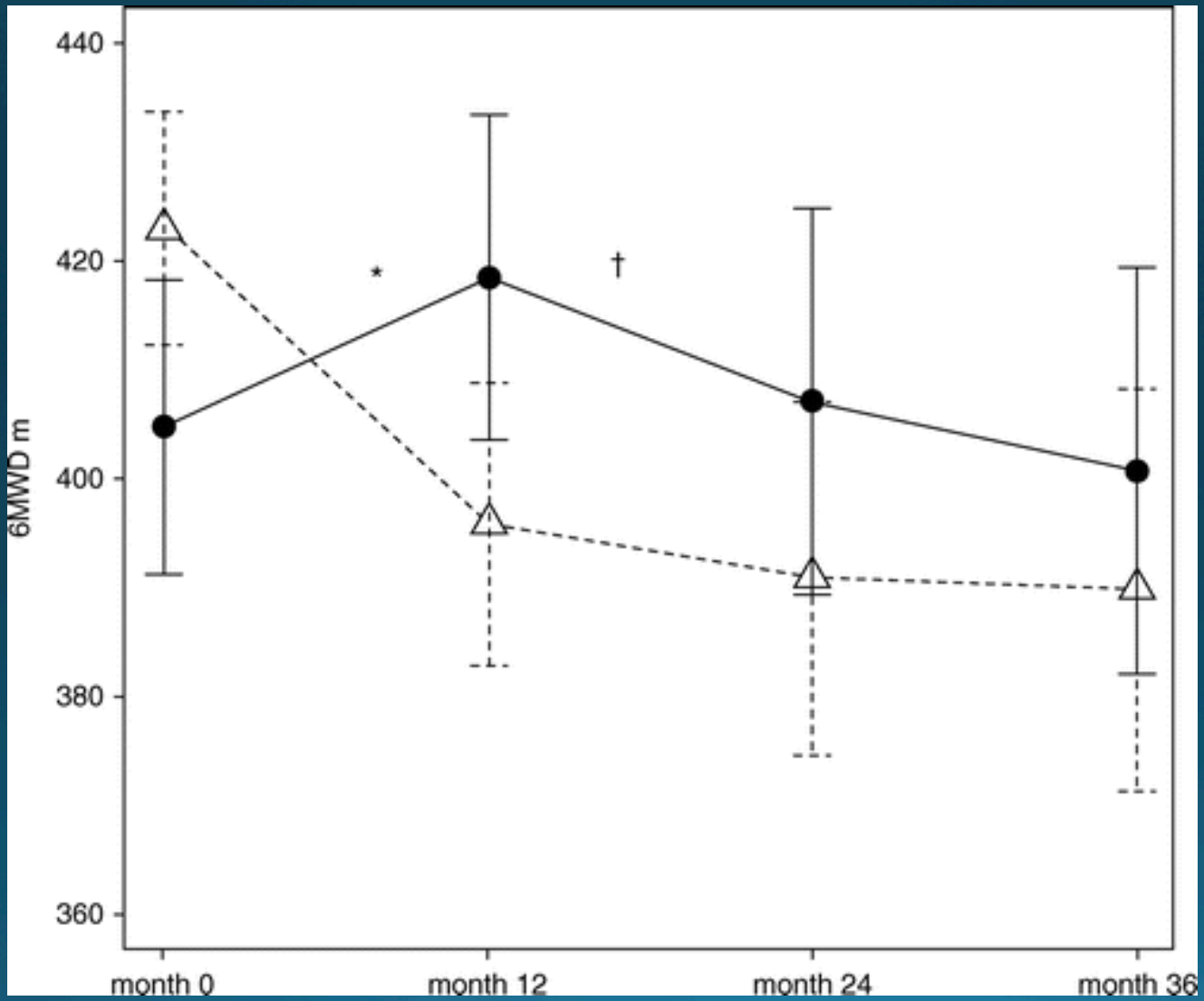
Guell et al. *AJRCCM* 2017:195; 622-29.

Impact of Long-Term Pulmonary Rehabilitation Maintenance Program on BODE



Guell et al. *AJRCCM* 2017:195; 622-29.

Impact of Long-Term Pulmonary Rehabilitation Maintenance Program on 6 Minute WD



Guell et al. *AJRCCM* 2017:195; 622-29.

Benefits of Long-Term Pulmonary Rehabilitation Maintenance Program in Patients with Severe COPD

- Two-year beneficial effect of a rehabilitation maintenance program on the BODE index and 6 minute walk distance compared to usual care (8-week outpatient program with encouraged exercise post-rehab)

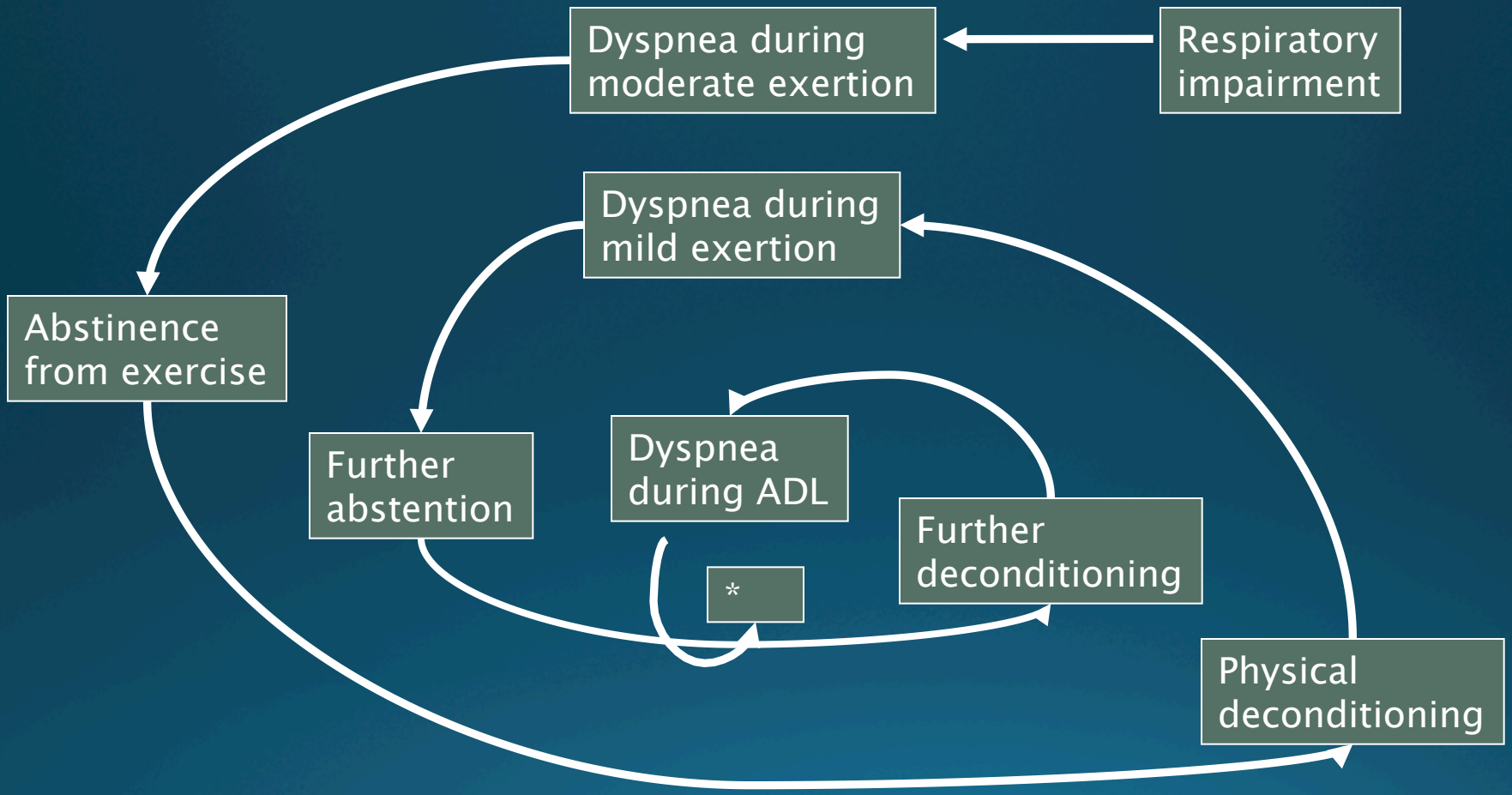
- The beneficial effect of maintenance rehabilitation disappears after two years of follow-up

Guell et al. *AJRCCM* 2017:195; 622-29.

Summary: Impact of pulmonary rehabilitation

- Improved exercise capacity and perceived dyspnea
- Improved health-related quality of life
- Reduced hospitalizations and days in the hospital
- Decreased anxiety and depression related to COPD
- Improved recovery rate after hospitalization for AECOPD
- Reduced extent of functional decline and hastened recovery
- Improved survival??

The Dyspnea Spiral



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