Non-Pharmacologic Treatment of COPD : Pulmonary Rehabilitation (PR)

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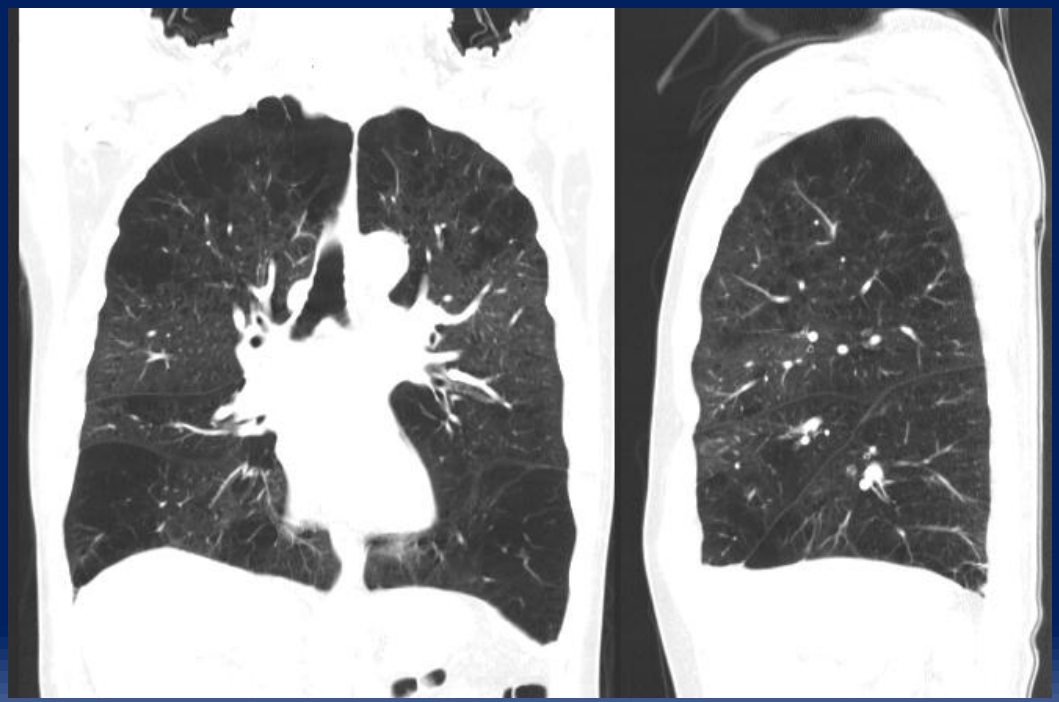
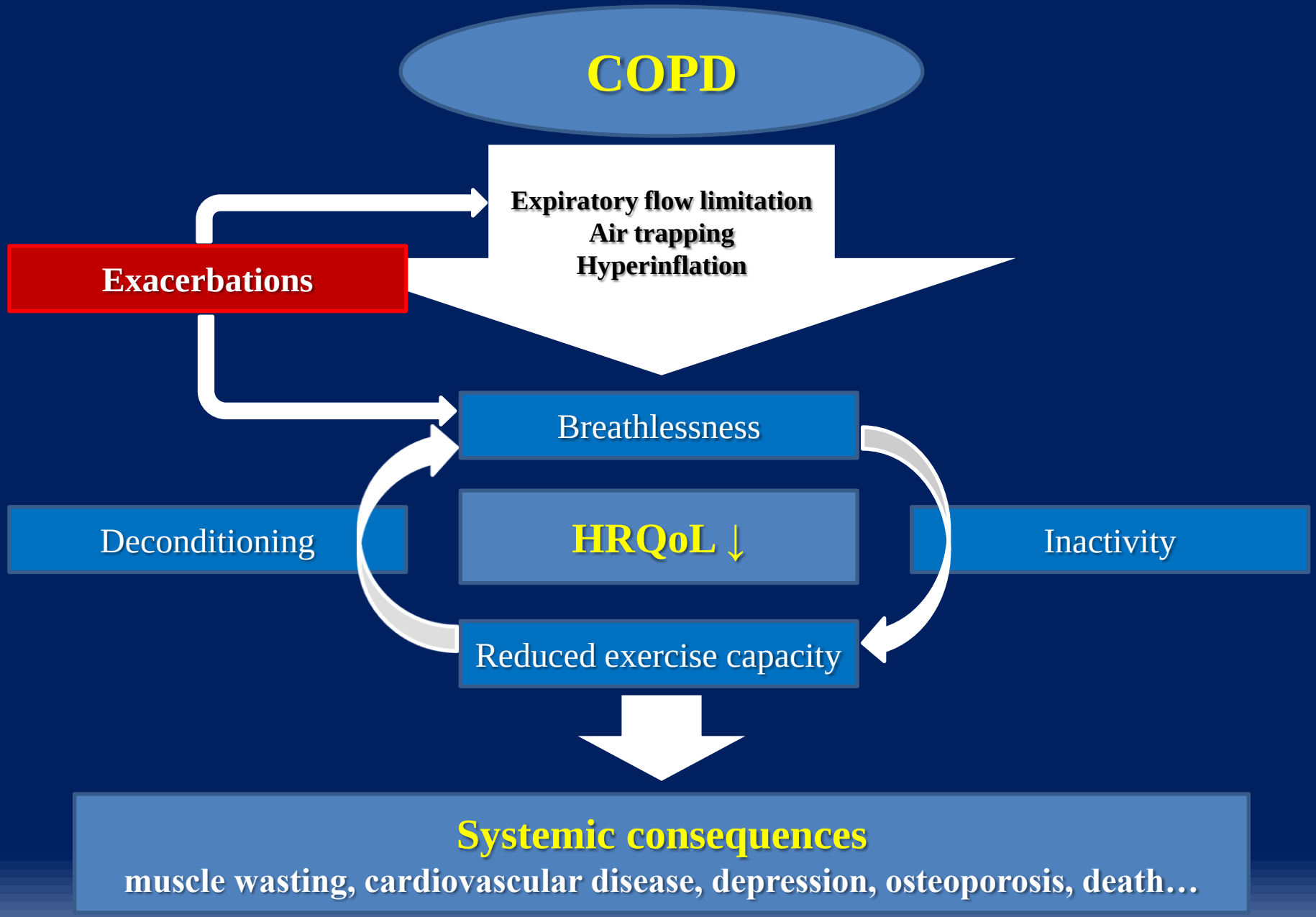
M/71, Ex-smoker (50 PYR), DOE mMRC 3, AE 2 times for the last year

	2013/07	2013/09	2014/03	2014/04
Post-BD FEV_1	0.72 (25%)	0.67 (25%)		0.69 (25%)
DL_{CO}	45%	58%		53%
TLC				6.18 (105%)
RV				3.65 (171%)
6MWD				202 m
Pharmacotherapy	LAMA		+ ICS/LABA	+ PDE4-i

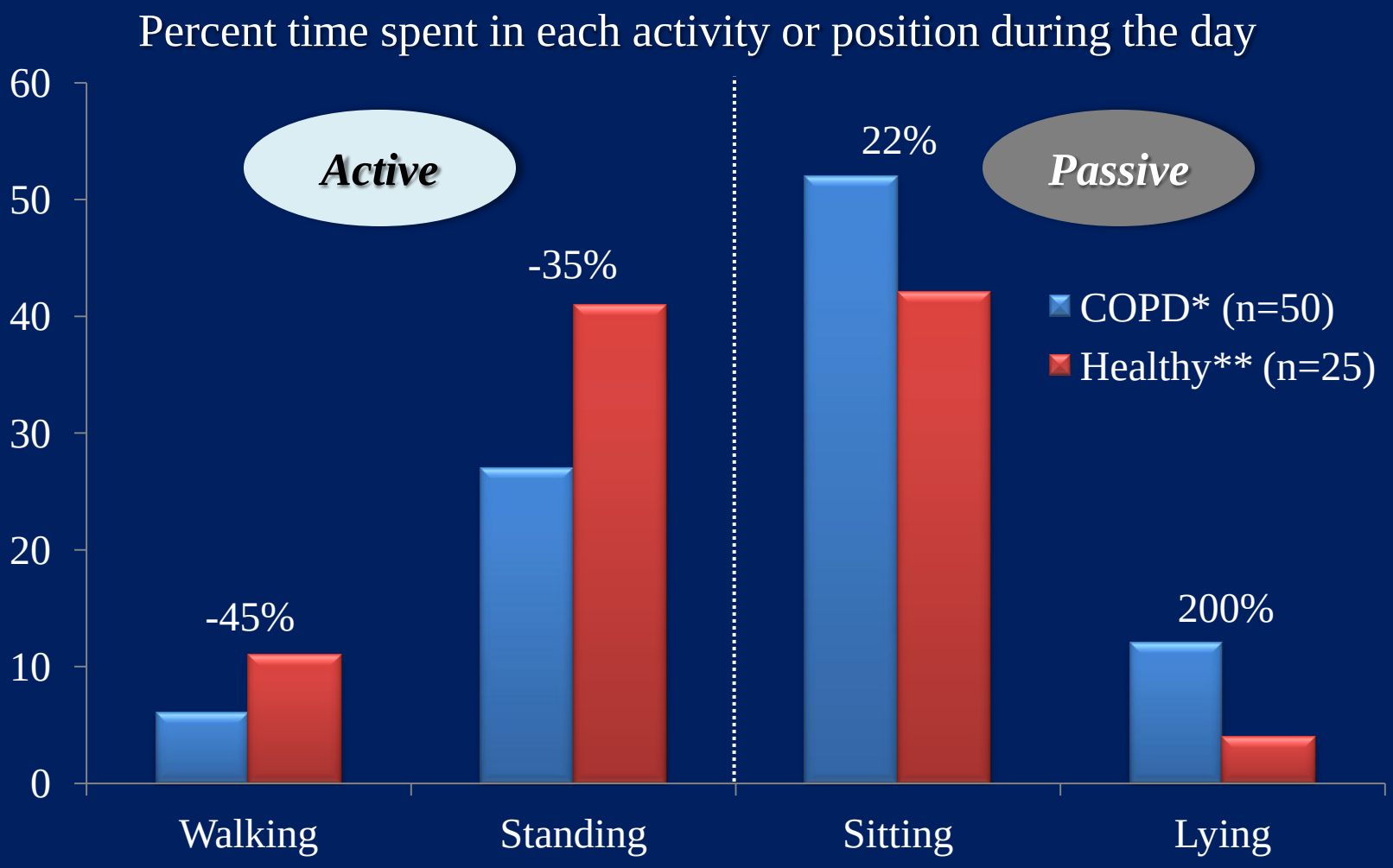


Additional treatment ?

1. 환자 교육 (금연, 질병 관련 정보, 위험요소 관리...)
2. 폐용적축소술 고려
3. 호흡재활


COPD
Expiratory flow limitation
Air trapping
Hyperinflation
Exacerbations
Breathlessness
Deconditioning
HRQoL ↓
Inactivity
Reduced exercise capacity
Systemic consequences
muscle wasting, cardiovascular disease, depression, osteoporosis, death…

Physical Activities in Daily Life



* Average age 64±7 years; FEV_1 43±18% predicted
** Average age 66±5 years; FEV_1 111±20 predicted

Am J Respir Crit Care Med 2005;171:972-7

Benefit of PR in COPD, GOLD 2014

Evidence A

Exercise Capacity ↑

Health-related QoL ↑

Intensity of Breathlessness ↓

No. of Hospitalizations ↓

Days in the Hospital ↓

Anxiety & Depression a/w COPD ↓

Recovery after Exacerbation ↑

Evidence B

Survival ↑

Strength & Endurance training of Upper limbs: Arm function ↑

Effect of Long-acting Bronchodilator ↑

Benefits extend beyond PR period

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Definition of Pulmonary Rehabilitation

Interdisciplinary team

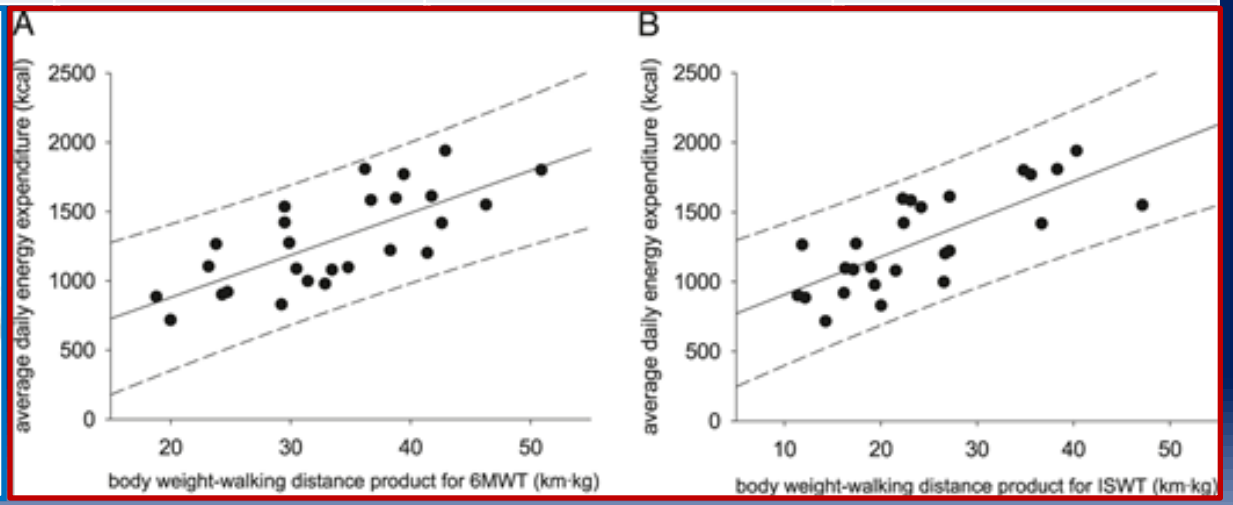
Physician, Physiotherapist, Respiratory therapist, Exercise physiologist, Nurse, Nutritionist, Psychologist, Social worker…

	2006	2(
	Evidence-based, multidisciplinary, and comprehensive intervention	Comprehensive intervention based on a thorough patient assessment
For	Patients with chronic respiratory diseases who are symptomatic and often have decreased daily life activities	People with chronic respiratory disease
Through	Stabilizing or reversing systemic manifestations of the disease	Exercise training, education, and behavior change
Designed to	Reduce symptoms Optimize functional status Increase participation Reduce healthcare costs	Improve physical & psychological condition Promote long-term adherence of health-enhancing behaviors

ATS/ERS statement: Pulmonary Rehabilitation 2013;188:e13

Patient Assessment

Symptoms Lung function…	Multidimensional Indices	Exercise Capacity	Physical Activity	HR-QoL
Dyspnea : mMRC, Borg	BODE index (BMI, airflow Obstruction, Dyspnea Exercise capacity)	6MWT (Six-Minute Walk Test)	Self-reported Questionnaies	SGRQ (St George's Respiratory Questionnaire)
Anxiety & Depression scale	ADO index (Age, Dyspnea, airflow Obstruction)	ISWT (Incremental Shuttle Walk Test)	Pedometers	CRQ (Chronic Respiratory Questionnaire)
Lung function	DOSE index (Dyspnea, airflow Obstruction, Smoking status, Exacerbation frequency)	ESWT (Endurance Shuttle Walk Test)	Accelerometers (Activity & Energy Expenditure)	SF-36 (Short-Form Health Survey)
BMI	HADO index (sr-Health, sr-physical Activity, Dyspnea, airflow Obstruction)	Cardiopulmonary Exercise Test	Work done during 6MWT or ISWT (km·kg)	EQ-5D (EuroQol-5 Dimension Questionnaire)

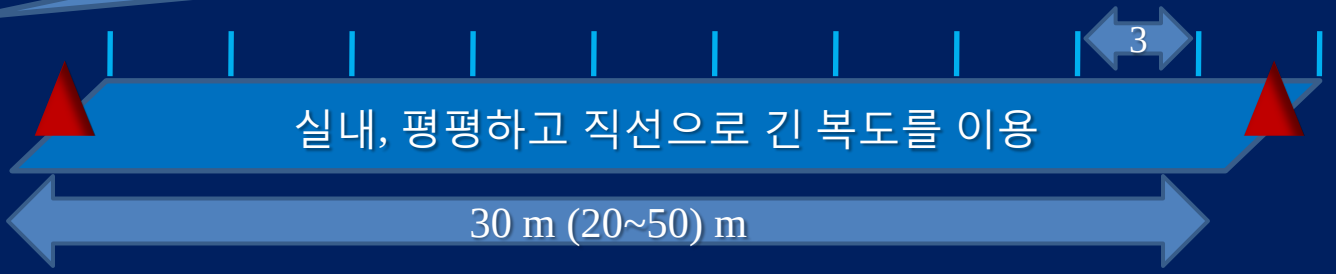


Chest 2012;142:738, *Chest* 2012;141:406, *Respirology* 2010;15:1157

Six-Minute Walk Test (6MWT)

시작 전 의자에 앉아 10분간 안정하고 HR, BP, SpO_2를 측정

환자를 일어서게 한 다음 dyspnea와 fatigue를 평가 (Borg scale)



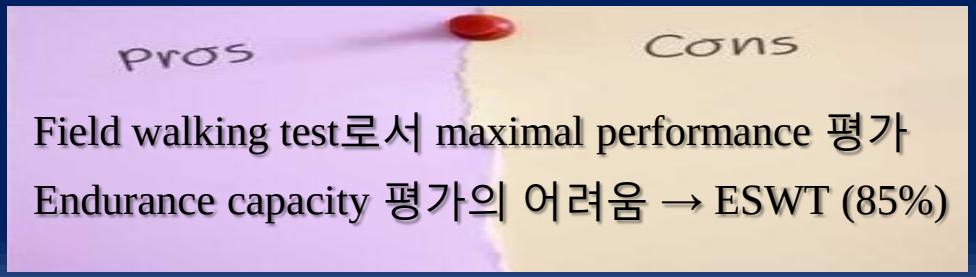
6분 동안 **가능한 많이** 걷도록 지시
필요에 따라 걷는 속도 조절 가능
힘들면 쉬는 것도 가능
일정한 간격으로 시간을 알려주고 보행을 격려

근골격계 문제로 인한 보행 제한
심혈관계: 지난 1개월간 UA or MI, rHR >120, sBP >180, dBP >100

Am J Respir Crit Care Med 2002;166:111

Incremental Shuttle Walk Test (ISWT)

녹음된 metronome signal에 따라 pace를 조절하도록 지시
매 분마다 0.17 m/s씩 속도가 빨라짐
최대 12 stages까지 진행 가능
Dyspnea나 fatigue로 pace를 유지할 수 없으면 중단



Respiration 2009;77:121, *COPD* 2007;4:217

Cardiopulmonary Exercise Test

Maximal Incremental Protocol

P/E, PFT, Borg scale

↓

Resting (3 min)

↓

Unloaded pedaling (3 min)

↓

↑ 20 (5~25) W/min (10 min)
until volitional exhaustion

↓

Recovery (10 min)

	Cycle	Treadmill
$V_{O_2}max$	Lower	Higher
Work rate measurement	Yes	No
Artifacts & noise	Less	More
Weight bearing	Less	More
Safety	More	Less
More appropriate for	Patients	Normal subjects

Measurements (non-invasive)	
Symptoms	Dyspnea, fatigue, chest pain
Cardiovascular	HR, BP, ECG
Ventilatory	V_E, V_T, f_R
External work	WR
Metabolic gas exchange	**V_{O_2}**, V_{CO_2}, RER, AT
Pulmonary gas exchange	Sp_{O_2}, $P_{ET_{O_2}}$, $P_{ET_{CO_2}}$

Am J Respir Crit Care Med 2003;167:211

Exercise Training

- Endurance Training
  - High vs Low Intensity
  - Interval Training
- Resistance/Strength Training
- Respiratory Muscle Training
- Neuromuscular Electrical Stimulation

Am J Respir Crit Care Med 2013;188:e13

Endurance Training

Exercise modality

Exercise frequency

3-5 times / week
> minimum 6 weeks

Exercise Intensity

- ≥ 60% maximal work rate
- for 20~60 min per session

maximize

Physiologic Benefits

- Exercise tolerance
- Muscle function
- Bioenergetics

Am J Respir Crit Care Med 2013;188:e13

High vs Low Intensity Exercise

	High Intensity	Low Intensity
Definition	V_{O_2}max 60~80%	V_{O_2}max 40~60%
Merits	Greater improvement in exercise capacity Greater physiologic benefits	More tolerable Greater improvement in dyspnea a/w daily activities & health status
Demerits	Less tolerable Need to observe	Smaller improvement in exercise capacity
Indication	Mild dyspnea Highly motivated patients	Severe dyspnea

Chronic Respiratory Disease 2004;1:143

Setting of Exercise Intensity

- Metabolic Equivalent of Task (MET, 대사상당량)
- 1 MET = 1 kcal/kg·h = 4.184 kJ/kg·h
- 1 MET = 3.5 ml/kg/min (안정 상태에서 1분 동안 소비되는 산소량)
- ? MET = V_{O_2}max (ml/kg/min) / 3.5

  Ex) V_{O_2}max가 21 ml/kg/ml이면 6 MET에 해당

  60% intensity training시 3.6 MET로 설정

등급	MET	속도(km/h)	100m 당 소요시간
1	≤ 3.4	1.6	3 min 45 sec
2	3.5~4.4	2.9	2 min 4 sec
3	4.5~5.4	4.2	1 min 25 sec
4	5.5~6.4	5.4	1 min 7 sec
5	≥ 6.5	6.4	56 sec

Gordon NF, Breathing Disorders: Your Complete Exercise Guide 1993

Interval Training

High intensity → Low intensity or Resting → High intensity

Practical recommendations

- 30 s exercise → 30 s rest or 20 s exercise → 40 s rest
- Initial 80~% of PWR, 15~20 min duration
- Increase ~150% of PWR, 45~60 min duration
- Target Borg scale 4~6 / 10

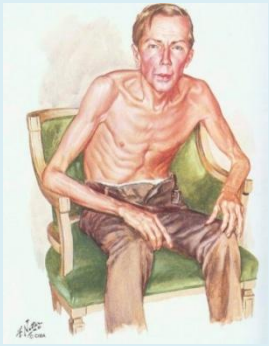
Outcomes c/w continuous training

- ↑ Exercise capacity, HR-QoL – similar improvement
- ↓ Dyspnea & dynamic hyperinflation in COPD III-IV
- Long-term effects or adherence – not investigated

0	Nothing at all
0.5	Extremely Slight (just noticeable)
1	Very Slight
2	Slight
3	Moderate
4	Somewhat Severe
5	Severe
6	
7	Very Severe
8	
9	Extremely Severe (almost maximal)
10	Maximal

Am J Respir Crit Care Med 2013;188:e13, *Eur Respir Rev* 2013;22:178

Other Exercise Training



Peripheral m. weakness & dysfunction

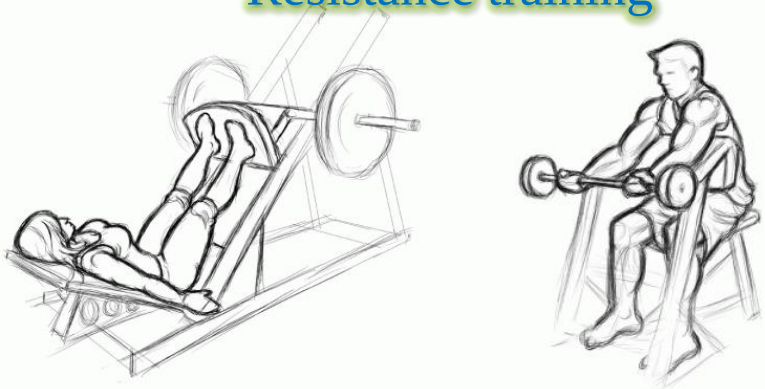
↓

Poor symptoms & exercise intolerance

↓

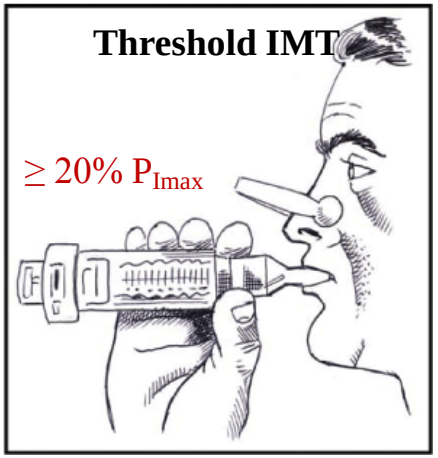
Endurance + Resistance Trainin

Resistance training



- 60~80% of one repetition maximum
- 1~3 sets of 8~12 repetitions, 2~3 days / week
- Improves m. strength & exercise capacity

Inspiratory muscle training



- Improves inspiratory m. strength & endurance
- Reduces dyspnea during daily activities
- Additional benefits?

Am J Respir Crit Care Med 2013;188:e13, *Eur Respir Rev* 2013;22:178

	ACSM	AACVPR	ATS
Mode of Aerobic exercise	Walking or Cycling	Walking, Cycling, Stepping Arm ergometry, Rowing...	Cycling or Walking
Frequency	>3~5 d/wk	>3~5 d/wk	>3~5 d/wk
Duration	20~60 min/d	20~90 min a session If debilitated, initial sessions can be shorter, with more frequent breaks	> 30 min Interval training if the patient cannot achieve time and/or intensity
Intensity	For mild COPD: RPE 5~6/10 (moderate) RPE 7~8/10 (vigorous) For moderate to severe COPD: 60~80% of peak work rate or RPE 3~5/10	High intensity (60~80% of peak work rate) Interval training is effective for those who cannot sustain continuous high intensity exercise	60% of peak work rate RPE 4~6/10 High intensity exercise yields greater physiological effect Lower intensity exercise is able to improve symptoms & HR-QoL.
Strength training	Train each muscle group 2~4 sets (rest intervals 2~3 min) 2~3 times per week at least 48-h apart Intensity 60~80% of 1 RM For increase m. endurance 15~25 reps at ≤ 50% 1 RM For older or deconditioned 10~15 reps at RPE 5~6/10	Hand and ankle weights, free weights, and machine weights Elastic resistance, using body weight (eg, stairs or squats) Intensity: begin with lower resistance and higher reps to work on muscle endurance	2~4 sets of 6~12 reps at 50~85% of 1 RM intensity

RPE, Rating of Perceived Exertion; RM, Repetition Maximum

J Cardiopulm Rehabil Prev 2013;33:314

Outcome Assessment

MCID: Minimal Clinically Important Differences

Symptom	Susceptibility to c	
Borg scale (unit)	++	
Visual analog scale (unit)		10~20
Exercise capacity		
6MWD (m)	++	26 ± 2 (severe COPD)
ISWT (m)	++	47.5
ESWT (s)	+++	45~85
Peak work rate (W)	+	4 ± 1 (severe COPD)
V_{O_2}max (ml/kg/min)	+	
HR-QoL		
SGRQ total score (unit)	++	4
CRQ domain score (unit)	++	0.5 (10 for total score)

Symptom
Exercise capacity
HR-QoL

Respiration 2009;77:121, *Eur Respir J* 2011;37:784, *Am J Respir Crit Care Med* 2014;189:250

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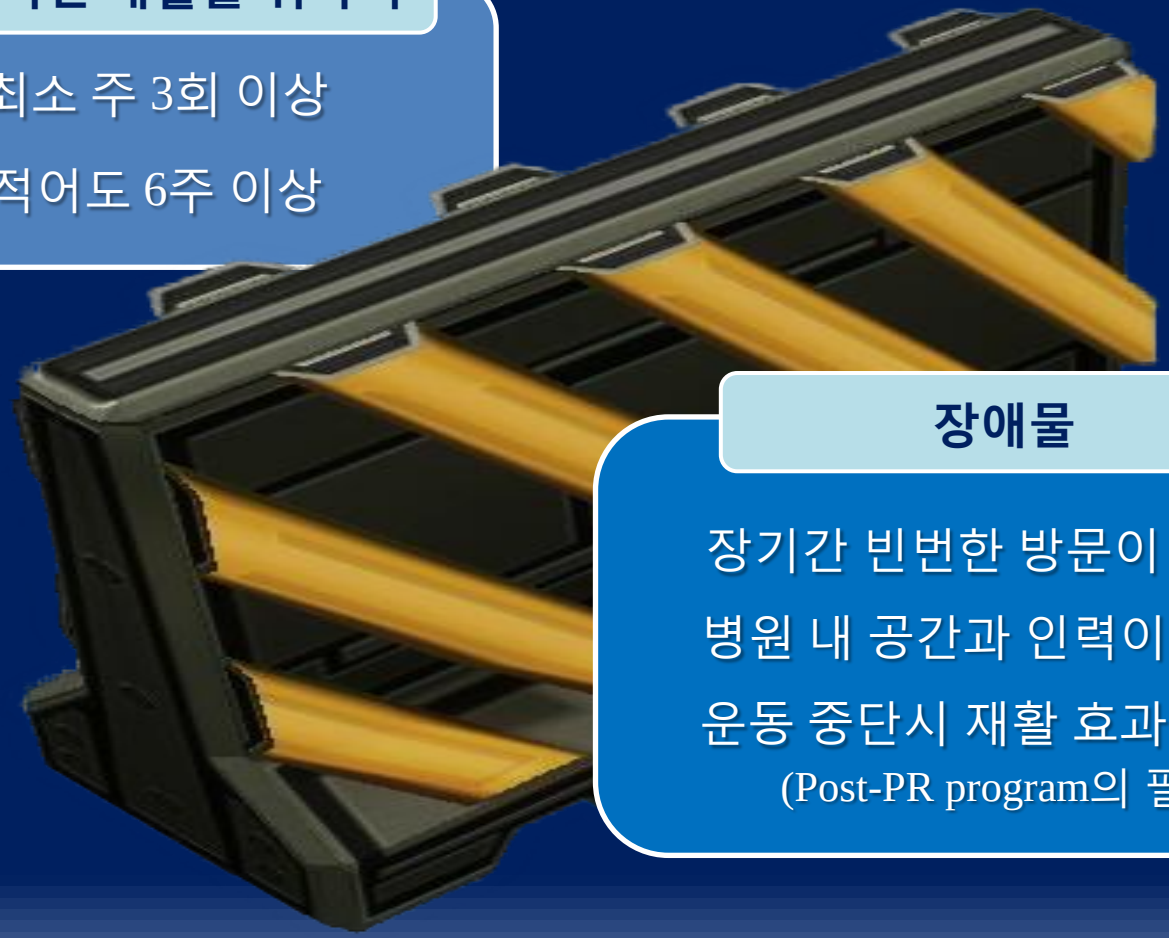
Barriers of Hospital-based PR

효과적인 재활을 위하여

최소 주 3회 이상

적어도 6주 이상



장애물

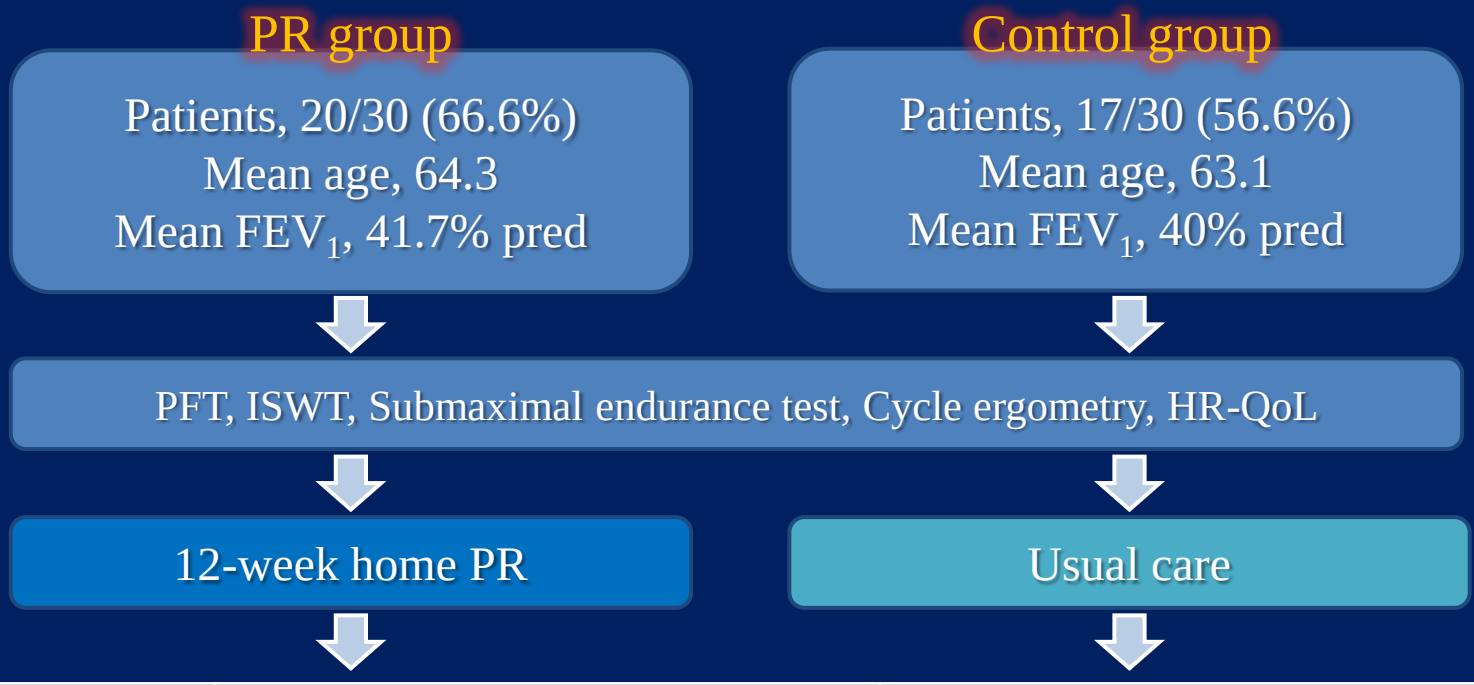
장기간 빈번한 방문이 어려움

병원 내 공간과 인력이 필요함

운동 중단시 재활 효과의 감소

(Post-PR program의 필요)

Location of PR – Home-based



Submaximal Endurance test	PR group			Control group		
	Baseline	12 weeks	*P* value	Baseline	12 weeks	*P* value
Time (min)	17.1±12.3	36±24.5	0.01	24.2±16.7	26.6±16.6	NS
Distance (m)	1247±980	2650±2056	0.01	1829±1447	2017±1452	NS
Dyspnea (BDI/TDI) & HR-QoL (CRQ) were also improved after PR						

Chest 2000;118:106

Location of PR – Home vs Hospital

The largest multicenter RCT, Moderate to severe COPD patients, 8 week PR program, 1 year F/U

CRQ

Within-Group Differences from Baseline (95% CI)

	Outpatient Rehabilitation (n = 109)				Home Rehabilitation (n = 107)			
	3 mo	*P* Value	1 y	*P* Value	3 mo	*P* Value	1 y	*P* Value
Dyspnea	0.78 (0.60 to 0.96)	<0.001	0.46 (0.28 to 0.64)	<0.001	0.82 (0.64 to 1.01)	<0.001	0.62 (0.43 to 0.80)	<0.001
Mastery	0.51 (0.35 to 0.67)	<0.001	0.30 (0.13 to 0.48)	<0.001	0.49 (0.32 to 0.66)	<0.001	0.39 (0.23 to 0.57)	<0.001
Fatigue	0.46 (0.26 to 0.65)						0.25 (0.06 to 0.44)	0.010
Emotion	0.38 (0.24 to 0.53)						0.28 (0.14 to 0.43)	<0.001

Home-based PR was not inferior to improve symptom, exercise capacity & HR-QoL.

The benefits last for 1 year.

Exercise capacity &

					tation (n = 89)			
	3 mo						1 y	*P* Value
6-minute walking distance, *m*	11 (2 to 20)						0 (−13 to 12)	0.62
Cycling endurance time, *s*	237 (166 to 308)	<0.001	95 (20 to 170)	0.013	246 (173 to 320)	<0.001	122 (46 to 199)	0.002
SGRQ score								
Total	−6.3 (−8.4 to −4.3)	<0.001	−3.5 (−5.7 to −1.3)	<0.001	−7.7 (−9.8 to −5.6)	<0.001	−4.5 (−6.7 to −2.2)	<0.001
Symptoms	−3.1 (−6.5 to 0.3)	0.077	−6.3 (−10.5 to −2.9)	0.001	−9.2 (−12.6 to −5.6)	<0.001	−6.9 (−10.7 to −3.0)	<0.001
Activity	−5.7 (−8.6 to −2.7)	<0.001	−0.3 (−3.4 to 2.7)	0.83	−5.9 (−8.9 to −2.8)	<0.001	−1.6 (−4.7 to 1.5)	0.31
Impact	−7.9 (−10.2 to −5.5)	<0.001	−4.3 (−6.8 to −1.9)	<0.001	−8.1 (−10.5 to −5.6)	<0.001	−5.0 (−7.5 to −2.5)	<0.001

Ann Intern Med 2008;149:869

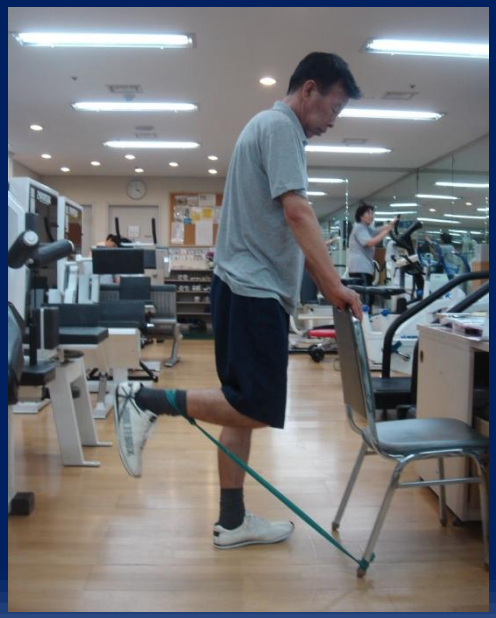
Home-based PR Program

운동강도 및 스케쥴 결정 / 교육

V_{O_2}max 60%
Set walking speed
Resistance training
Inspiratory muscle training

재택호흡재활 (8~12주)

정기적 방문 →운동강도조절
(Submaximal endurance test)



J Korean Med Sci 2013;28:738

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PR during or after AECOPD

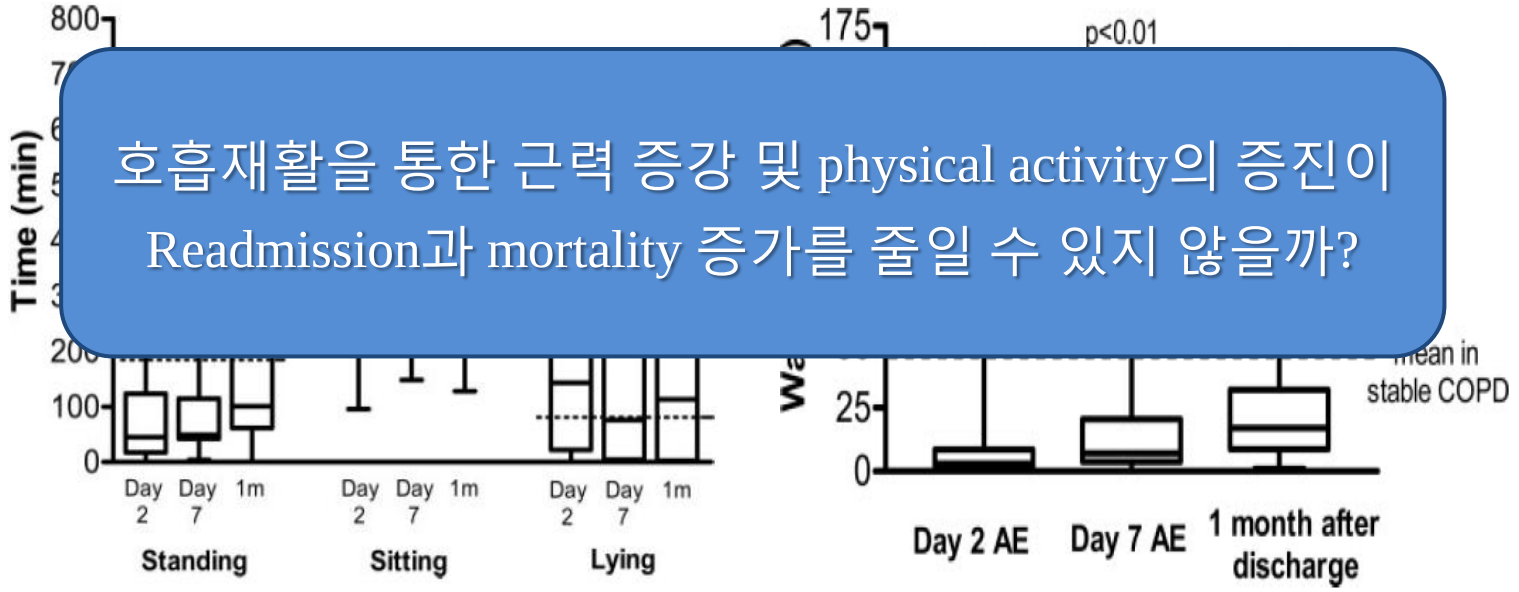
Muscle force during AECOPD

	Hospitalised COPD (34)	Stable	
Age	69	68	
FEV1 (% pred)	40†	50†	107
HGF (% pred)	86*†	104	112
QPT (% pred)	66*†	86†	103

↓ functional stuatus, HR-QoL
↑ psychological distress
↑ hospital readmission, mortality

HGF: handgrip force, QPT: quadriceps peak torque

Physical Activity during AECOPD



호흡재활을 통한 근력 증강 및 physical activity의 증진이
Readmission과 mortality 증가를 줄일 수 있지 않을까?

Thorax 2003;58:752, *Chest* 2006;129:536

PR following AECOPD

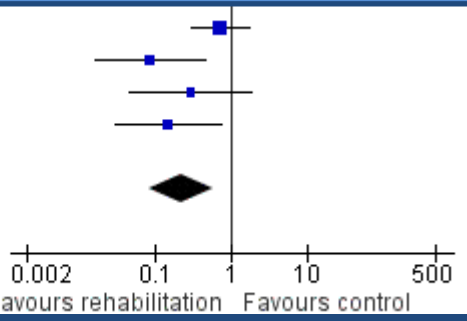
Hospital readmission (mean F/U 25 weeks, 3~

AECOPD 3주 이내에 PR 시작

Study or Subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	M-H
Behnke 2000	3	14	9	12	16.7%	
Eaton 2009	11	47	15	50	29.9%	0.71 [0.29, 1.77]
Man 2004	2	20	12	21	18.1%	0.08 [0.02, 0.45]
Murphy 2005	2	13	5	13	16.2%	0.29 [0.04, 1.90]
Seymour 2010	2	30	10	30	19.0%	0.14 [0.03, 0.72]
Total (95% CI)		**124**		**126**	**100.0%**	**0.22 [0.08, 0.58]**
Total events	20		51			

Heterogeneity: Tau² = 0.61; Chi² = 8.15, df = 4 (P = 0.09); I² = 51%

Test for overall effect: Z = 3.06 (P = 0.002)

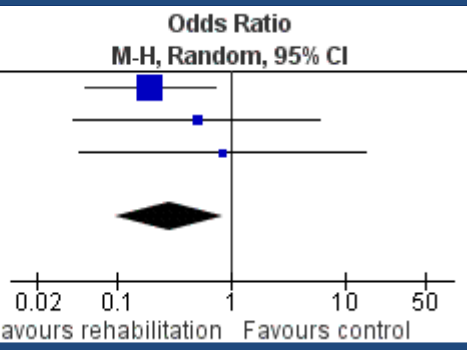


Mortality (mean F/U 107 weeks, 3~48 months)

Study or Subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Odds Ratio M-H, Random, 95% CI
Troosters 2000	6	24	12	19	67.3%	0.19 [0.05, 0.72]
Man 2004	1	20	2	21	18.8%	0.50 [0.04, 5.99]
Behnke 2000	1	14	1	12	13.9%	0.85 [0.05, 15.16]
Total (95% CI)		**58**		**52**	**100.0%**	**0.28 [0.10, 0.84]**
Total events	8		15			

Heterogeneity: Tau² = 0.00; Chi² = 1.07, df = 2 (P = 0.59); I² = 0%

Test for overall effect: Z = 2.29 (P = 0.02)



HR-QoL (SGRG): MD -9.88; 95% CI -14.40 to -5.37

Exercise capacity (6MWD): MD 77.7 m; 95% CI 12.21 to 143.20

Cochrane Database of Systematic Reviews 2011;Issue 10:CD005305

Long-term Maintenance of PR Benefits

- PR의 benefits은 6~12개월 동안 점차 감소함
- HR-QoL이 exercise capacity보다 잘 유지되는 경향을 보임
- Long PR program이 outcomes 개선을 유지하는데는 보다 효과적임

- PR 후 regular physical activity를 유지하면 benefits 감소를 지연시킴
- Monthly supervised maintenance exercise training은 유지 효과 없음
- PR 재시행시 이전과 유사한 exercise capacity와 HR-QoL 개선을 보임

Chronic Respiratory Disease 2011;8:129
Am J Respir Crit Care Med 2013;188:e13
Chest 2012;142:738

SUMMARY

Pulmonary Rehabilitation

철저한 환자 평가 → Education
Exercise training
Interdisciplinary intervention → 신체/심리상태 개선
건강증진행동 변화

- COPD 환자에서 PR이 증상과 운동능력을 향상시키고 삶의 질을 개선시킴
- Home-based PR도 증상, 운동능력, 삶의 질 개선에 동등한 효과를 보임
- AECOPD시 1개월 이내에 PR을 시작하는 것이 재입원과 사망을 줄일 수 있음

- Dyspnea나 fatigue로 인하여 continuous high intensity exercise의 적용이 어려운 환자에게 interval training이 효과적일 수 있음
- Endurance + Resistance training 병행이 근력 향상 및 운동능력 개선에 기여함
- PR 후 exercise capacity의 변화를 감지하는데 SWT(특히 ESWT)가 보다 적절함