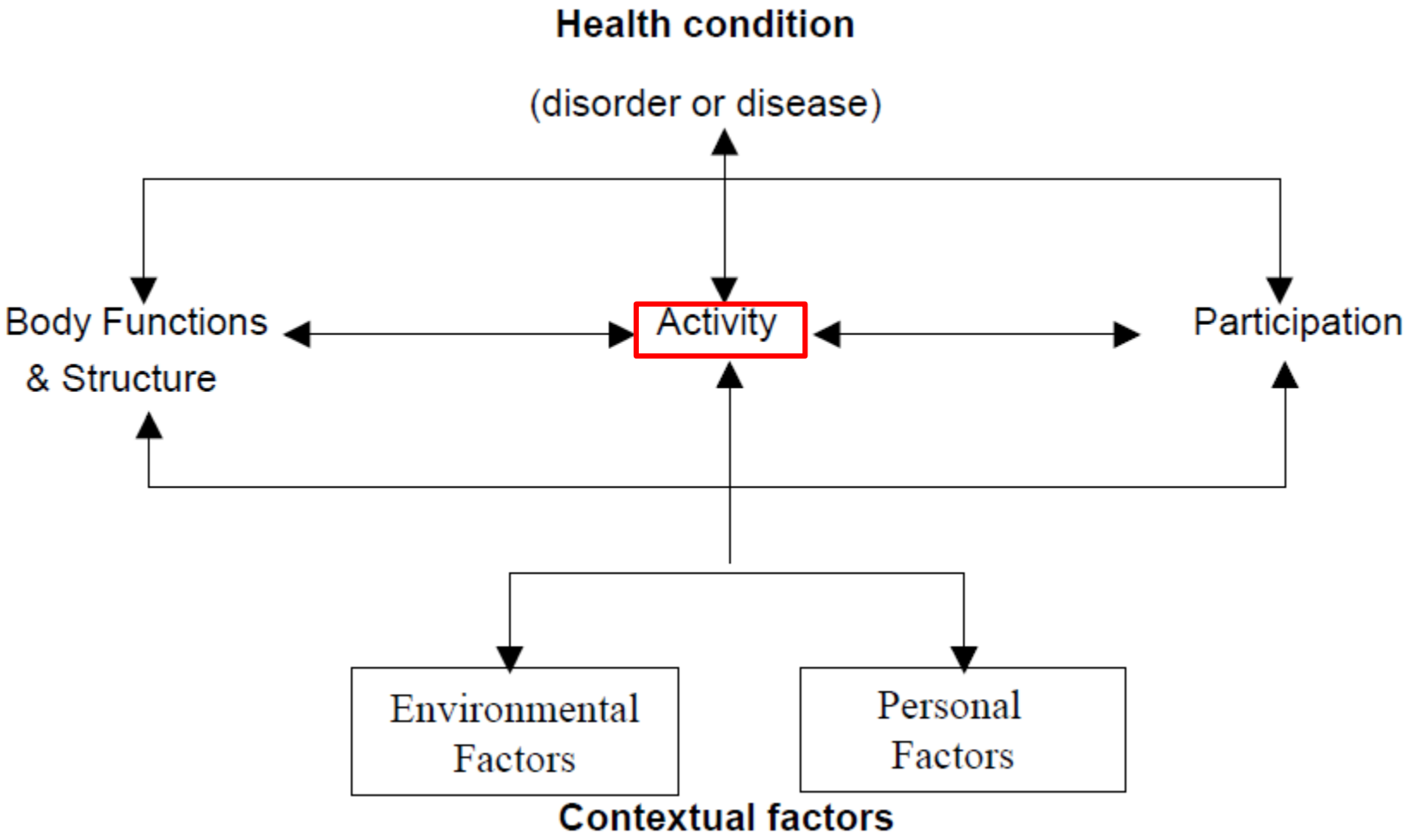
호흡재활환자평가:
Functional vs Exercise capacity-Which Test should We Focus on

울산대학교병원 호흡기내과 나승원

Functioning, Disability and Health



ICF, The International Classification of Functioning, Disability and Health
WHO Geneva 2002

Patient with chronic respiratory diseases Centered Outcomes

- To assess effectiveness of PR (Pulmonary Rehabilitation)

평가 영역	평가 항목	평가 방법	
운동 능력	보행 거리 산소소모량	6분보행검사 셔틀보행검사 운동부하검사	Exercise capacity
증상	호흡곤란중증도	mMRC, CAT	
	피로도	수정 Borg척도(Modified Borg Scale)	
건강관련 삶의 질	신체기능	CRQ	
	정서 또는 감정상태	SGRQ	Patient Reported Outcome (PRO)
	증상	CAT	

- Physical activities
  - 보행측정기(Pedometers), 활동 측정기(Activity monitors)
- 기능적 상태 질문지(functional status questionnaires)
  - ADL (activity of daily life), PFSDQ (Pulmonary Functional Status and Dyspnea Questionnaire), PFSDQ-M (Pulmonary Functional Status and Dyspnea Questionnaire-Modified), PFSS (Pulmonary Functional Status Scale)

호흡재활 지침서 제 1판 2015

Patient with chronic respiratory diseases Centered Outcomes

- Exercise Performance & Capacity (6MWD, SWT, CPET)
- Muscle Strength and Respiratory muscle function

} **Exercise capacity**

- Physical Activities
- Symptom and Quality-of-Life Measurements
- Functional Status
- Depression and Anxiety

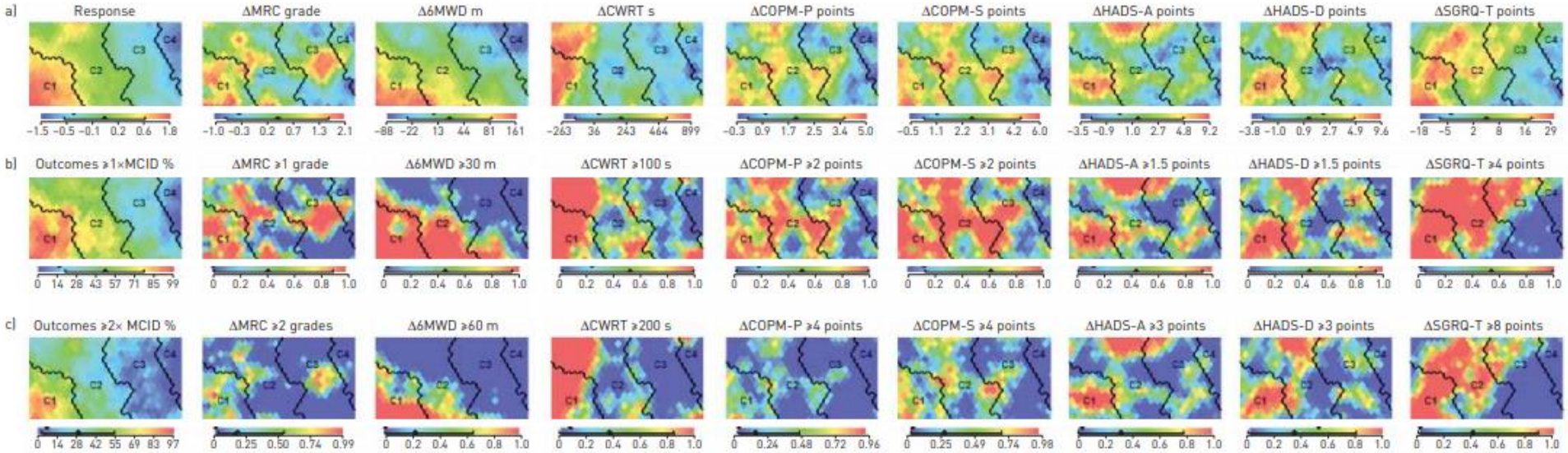
} **Patient Reported outcome (PRO)**

→ 호흡곤란으로 수행 힘들었던 것을 가능하게 개인별 목표 설정,
개별화된 운동치료를 중심으로 다학제 호흡재활 프로그램 적용

→ If insufficient progress is made, should alter the rehabilitation program

PR responses are not always in Sync

Outcome	All patients	Very good responder	Good responder	Moderate responder	Poor responder
Patients n (%)	2068 (100)	378 (18.3)	742 (35.9)	731 (35.4)	217 (10.5)
ΔMRC dyspnoea grade	−0.4±1.1	−1.3±1.2	−0.5±1.0$^{\#}$	−0.2±1.0$^{\#,\P}$	0.2±1.0$^{\#,\P,+}$
−1 grade % patients	40.9	73.4	46.1$^{\#}$	27.9$^{\#,\P}$	17.8$^{\#,\P}$
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]



⩾−1.5 points % patients	44.8	69.9	52.1$^{\#}$	34.6 $^{\#,\P}$	9.1$^{\#,\P,+}$
⩾−3.0 points % patients	33.3	58.2	39.8$^{\#}$	21.3 $^{\#,\P}$	6.4 $^{\#,\P,+}$
ΔSGRQ-T points	−5.3±12.6	−16.0±12.7	−7.9±10.2$^{\#}$	−0.4±10.7 $^{\#,\P}$	5.3±9.0$^{\#,\P,+}$
⩾−4 points % patients	53.6	84.1	66.5$^{\#}$	36.1$^{\#,\P}$	14.9$^{\#,\P,+}$
⩾−8 points % patients	39.7	74.1	49.5 $^{\#}$	22.3$^{\#,\P}$	4.8$^{\#,\P,+}$

*MCID, Minimal Clinically Important Difference

European Respiratory Journal 2015; 46: 1625-1635

A good outcome measure

- Simple Standard Operating Procedure
- Valid and Reliable
- Sensitive to change
- Interpretable (e.g. MCID) and understandable
- Preferable usable accross chronic respiratory diseases

Symptom assessment

Symptom	Type and Name of Measure	References	Psychometric Properties			Purpose	Time Frame
			Reliable	Valid	Responsive		
Dyspnea	Short-term						
	Borg	17, 534, 535, 759	✓	✓	✓	Discriminative and evaluative	Current
	VAS	536–540	✓	✓	✓	Discriminative and evaluative	Current
	Situational						
	MRC	541–543	✓	✓	✓	Discriminative	Are you ever
	BDI	540, 544–546	✓	✓	✓	Discriminative	Current
	SOBQ	18, 547	✓	✓	✓	Discriminative and evaluative	Last few weeks
	Impact						
	CRQ (dyspnea subscale)	17, 538, 548	✓	✓	✓	Discriminative and evaluative	Last 2 wk
	PFSDQ	549	✓	✓	✓	Discriminative and evaluative	Today, most days, current
	PFSDQ-M (dyspnea subscale)	550	✓	✓	✓	Discriminative and evaluative	Today, most days, current
Fatigue	Short-term						
	Borg	534, 551	✓	✓	✓	Discriminative and evaluative	Current
	VAS	539	✓	✓	✓	Discriminative and evaluative	Current
	Impact						
	CRQ (fatigue subscale)	17, 538, 548	✓	✓	✓	Discriminative and evaluative	Last 2 wk
	PFSDQ-M (fatigue subscale)	550	✓	✓	✓	Discriminative and evaluative	Today, most days, current
	FACIT-fatigue	552, 553	✓	✓	✓	Discriminative and evaluative	Previous 7 d
	MFI	554, 555	✓	✓	NR	Discriminative	Previous few days
	CIS	760	✓	✓	✓	Discriminative and evaluative	Last 2 wk
Multiple symptoms	CAT	526, 527	✓	✓	✓	Discriminative and evaluative	Current
	SGRQ symptoms domain	17, 515	✓	✓	✓	Discriminative and evaluative	Previous 3 or 12 mo

Am J Respir Crit Care Med 2013; 188(8): e13–e64

Symptoms and Quality of Life after PR

Table 2 Response to pulmonary rehabilitation (PR): n=261. Data expressed as mean (95% CIs).

Outcome	MCID	Change with PR	p Value
MRC		−0.7 (−0.8 to −0.5)	<0.001
ISW (m)	38	63 (55 to 72)	<0.001
SGRQ Total	-4.0	−5.3 (−6.7 to −3.4)	<0.001
SGRQ Symptoms		−4.6 (−6.4 to −2.7)	<0.001
SGRQ Activities		−3.7 (−5.8 to −1.7)	<0.001
SGRQ Impact		−6.2 (−7.9 to −4.5)	<0.001
CRQ Total	10	14.1 (11.9 to 16.4)	<0.001
CRQ Dyspnoea	2.5	4.3 (3.5 to 5.1)	<0.001
CRQ Fatigue	2	3.0 (2.5 to 3.6)	<0.001
CRQ Emotion	3.5	3.9 (3.0 to 4.9)	<0.001
CRQ Mastery	2	2.9 (2.2 to 3.5)	<0.001
CAT	-2.0	−1.9 (−2.7 to −1.1)	<0.001
CCQ Total	-0.4	−0.5 (−0.6 to −0.3)	<0.001
CCQ Symptoms		−0.1 (−0.2 to −0.1)	<0.001
CCQ Functional		−0.2 (−0.1 to −0.3)	<0.001
CCQ Mental		−0.1 (−0.1 to −0.1)	<0.001

CAT, COPD Assessment Test; CCQ, Clinical COPD Questionnaire; CRQ, Chronic Respiratory Questionnaire; ISW, incremental shuttle walk; MRC, Medical Research Council Dyspnoea Score; SGRQ, St George's Respiratory Disease Questionnaire.

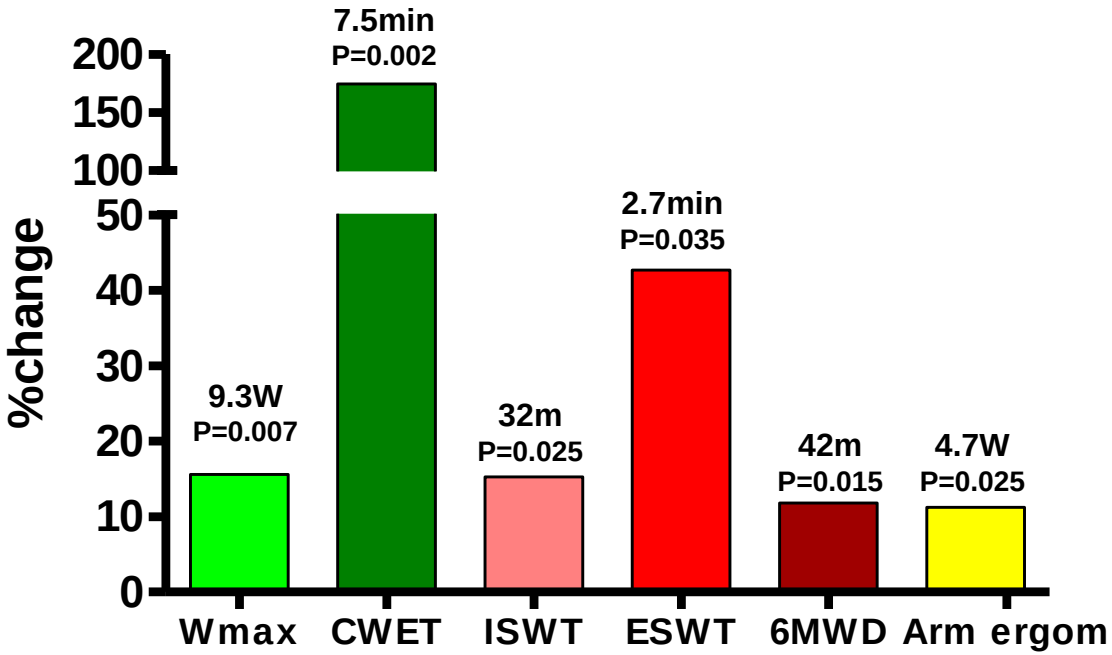
Kon Thorax 2014

Responsiveness of exercise tests to PR

Puente-Maestu et al. Eur Respir J 2016; 47: 429–460

	Variable	COPD	PAH	ILD	Cystic fibrosis/ bronchiectasis
IET	$V'O_{2peak}$	Mean ↑ of 11%	Mean ↑ of 1–1.5 mL·min^{-1}·kg^{-1}	Mean ↑ of 1.2 mL·min^{-1}·kg^{-1}	Limited evidence suggests that it is responsive
	WR_{peak}	Mean ↑ of 6.8 W	No		Limited evidence suggests that it is responsive
	V'_E-V'_{CO_2} indices				Yes
CWRET	tLIM	Yes; several studies; usually large effects Most studies show ↑ > MCID (105 s) Limited comparative evidence suggests that it is more responsive than other tests	Limited evidence suggests that it is responsive	Limited evidence suggests that it is responsive	Limited evidence suggests that it is responsive
	Isotime IC	Yes		Limited comparative evidence suggests that it is more responsive than other tests	
	Isotime dyspnoea	Yes			
ISWT	Time or distance	Yes Mean ↑ of 38 m	No available information	Limited evidence suggests that it is responsive	No available information
ESWT	Time or distance	Yes Several studies report ↑ of 100–400 s	No available information	Limited evidence suggests that it is responsive	Limited evidence suggests that it is responsive
6MWT	Distance	Mean ↑ of 44 m	Improvements of 50–80 m	Yes Mean ↑ of 39 m	

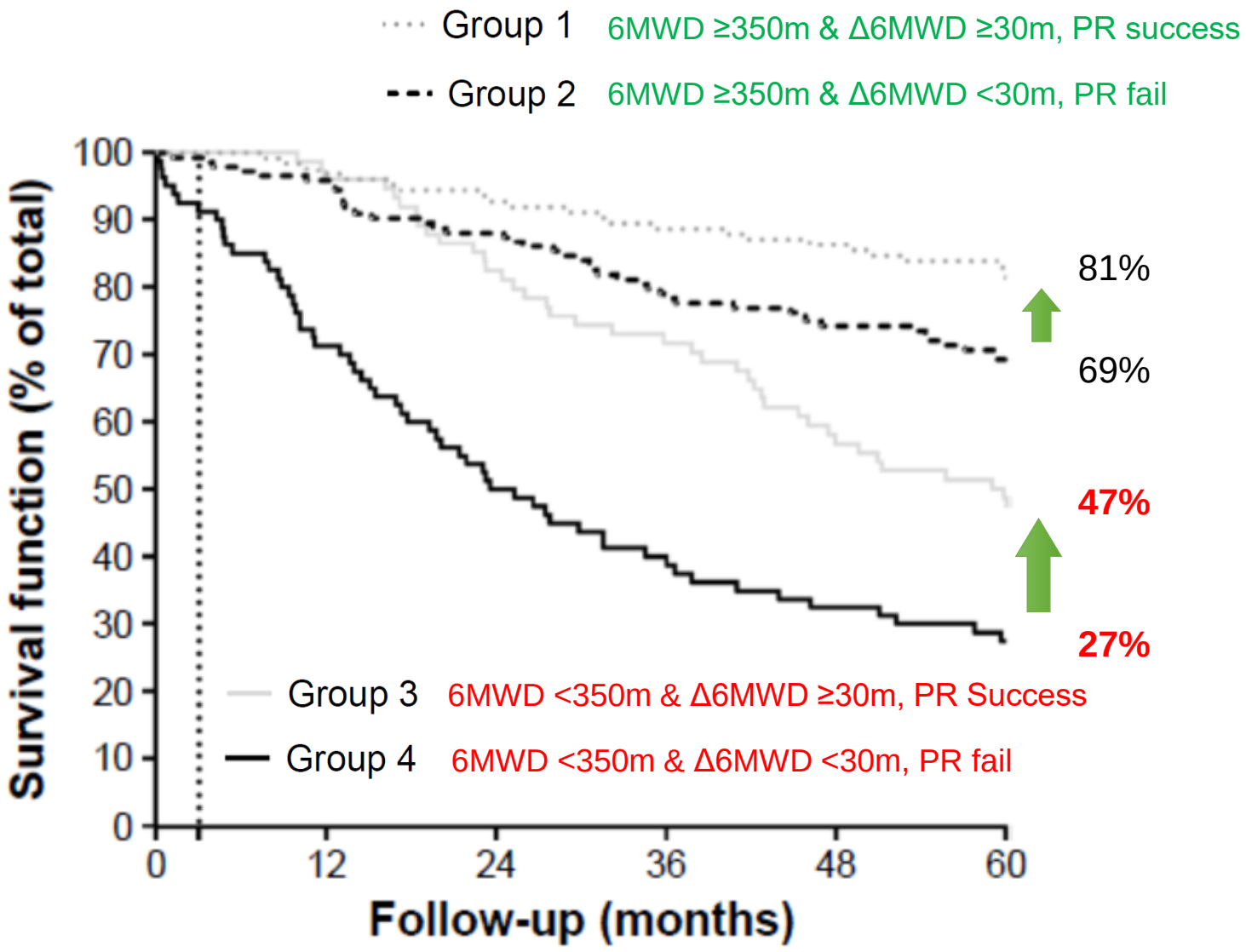
Responsiveness of exercise tests to PR



- After PR most exercise tests are responsive.
- The change appears larger in an endurance (cycling) test.
- Endurance tests are easily understood by patients.

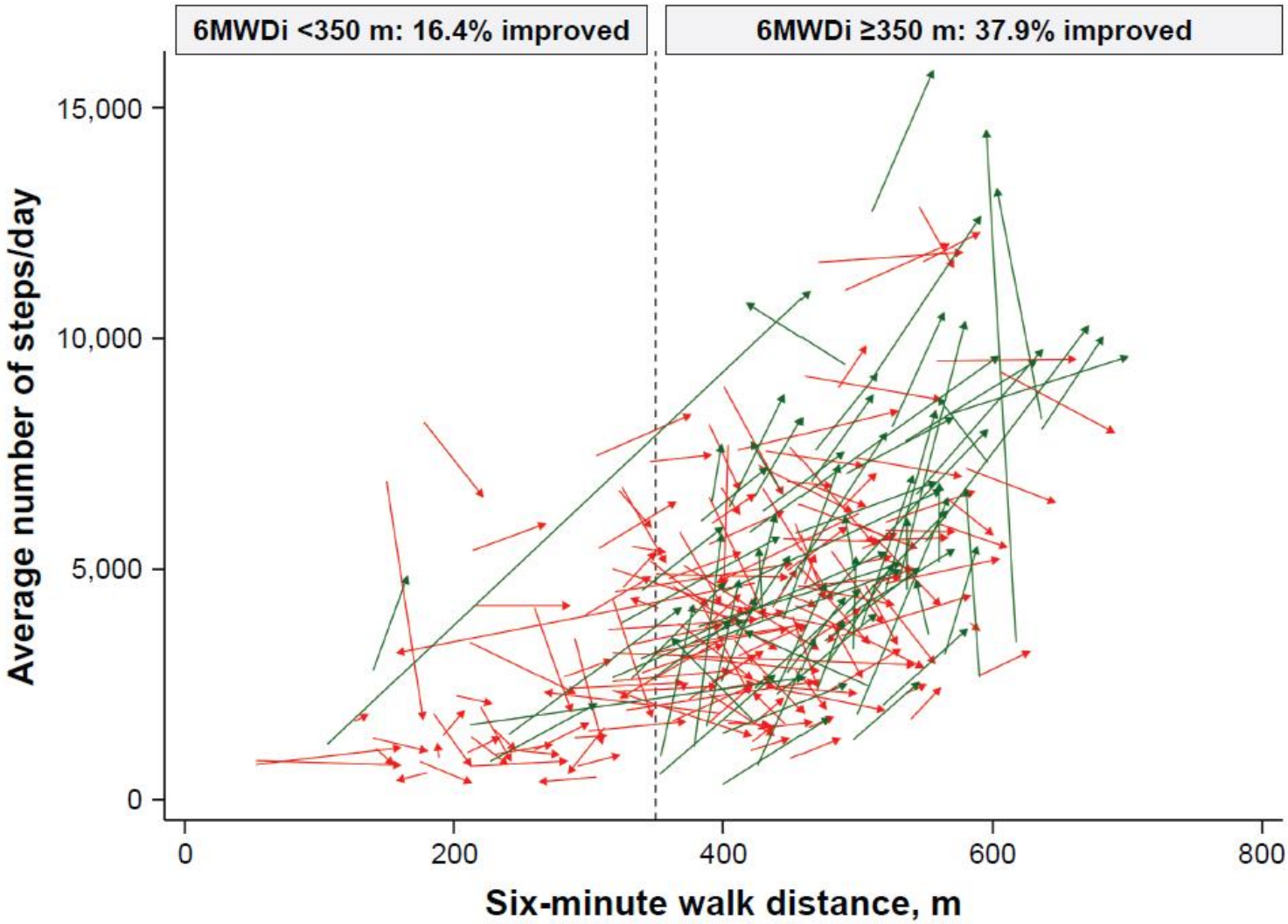
Mador et al. Journal of Cardiopulmonary Rehabilitation and Prevention 2016;36:132-139

6MWD and 5-year survival in COPD after PR



Camillo et al. International Journal of COPD 2016:11

Physical activity changes after PR in patients with COPD



Osadnik et al. International Journal of COPD 2018:13 3515–27

Six-Minute Walk Test (6MWT)

- Ceiling effect – smaller change in the near normal
- Is susceptible to a significant training effect
- Standardization really improves reproducibility
  - ✓ Encouragement, hallway length (30m), walking course, etc.
- 낮은 보험수가
- Safe when the test is stopped if SpO_2 < 80%
- Assess exercise hypoxemia and need for O_2 therapy

Holland AE et al. European Resp J 2014;44:1428-46, Singh SJ et al. European Resp J 2014;44:1447-78

6분 보행검사 결과지

	검사전	검사중(최저)min	6분 보행검사직후	SP02회복시간
시간		2 분 00 초		7 분 00 초
혈압	110 / 60		109 / 63	106 / 53
맥박	73 회	99 회	78 회	72 회
산소포화도	93 %	86 %	88 %	90 %
호흡곤란	0 (Borg scale)		7 (Borg scale)	
피로도	5 (Borg scale)		7 (Borg scale)	

◎ 6분전 검사중단 혹은 휴식 예 이유: 숨이너무가쁘고,한걸음도걸기힘들다함.

◎ 검사후 증상: 기타: 총 보행시간 3분 30초

◎ 6분간 보행거리: 왕복횟수(2) X 60m + 마지막 왕복시 보행거리(0)

= 120 m

	검사전	검사중(최저)min	6분 보행검사직후	SP02회복시간
시간		4 분 00 초		8 분 00 초
혈압	98 / 54		102 / 60	90 / 55
맥박	70 회	99 회	102 회	68 회
산소포화도	91 %	72 %	73 %	91 %
호흡곤란	0 (Borg scale)		2 (Borg scale)	
피로도	1 (Borg scale)		1 (Borg scale)	

◎ 6분전 검사중단 혹은 휴식 아니요 이유:

◎ 검사후 증상: 기타:

◎ 6분간 보행거리: 왕복횟수(6) X 60m + 마지막 왕복시 보행거리(0)

= 360 m

6분 보

◎ 날짜 2018-11-05

◎ Sex/Age 남 / 73

◎ 의뢰과 호흡기내과

◎ 검사중 산소공급여부 : 아니오

◎ 산소 유속 L/min

	검사전
시간	
혈압	134 / 71
맥박	91 회
산소포화도	97 %
호흡곤란	1 (Borg scal
피로도	0 (Borg scal

◎ 6분전 검사중단 혹은 휴식 아니

◎ 검사후 증상:

◎ 6분간 보행거리 : 왕복횟수(6

= 390 m

6분 보행검사 결과 기록지

◎ 날짜 2019-07-29 환자 ID 0928887 이름

◎ Sex/Age 남 / 74 키 174 cm 몸무게 65 kg

◎ 의뢰과 호흡기내과 Physician 나승원 Technician 이근석

◎ 검사중 산소공급여부 : 아니오

◎ 산소 유속 L/min ◎ 산소 공급장치

	검사전	검사중(최저)min	6분 보행검사직후	SP02회복시간
시간		4 분 00 초		7 분 00 초
혈압	107 / 65		146 / 75	141 / 75
맥박	110 회	140 회	139 회	127 회
산소포화도	96 %	88 %	88 %	92 %
호흡곤란	0.5 (Borg scale)		3 (Borg scale)	
피로도	0.5 (Borg scale)		0.5 (Borg scale)	

◎ 6분전 검사중단 혹은 휴식 아니요 이유:

◎ 검사후 증상: 기타:

◎ 6분간 보행거리 : 왕복횟수(9) X 60m + 마지막 왕복시 보행거리(50.25)

= 590.25 m

6분 보행검사 표준화

TABLE 6 Standardised encouragement for the 6-min walk test

1 min	You are doing well. You have 5 minutes to go.
2 min	Keep up the good work. You have 4 minutes to go.
3 min	You are doing well. You are halfway.
4 min	Keep up the good work. You have only 2 minutes left.
5 min	You are doing well. You have only 1 minute to go.
6 min	Please stop where you are.
If the patient stops during the test, every 30 s once S_{pO_2} is ⩾85%	Please resume walking whenever you feel able.

S_{pO_2}: arterial oxygen saturation measured by pulse oximetry.

Holland AE et al. European Resp J 2014;44:1428-46

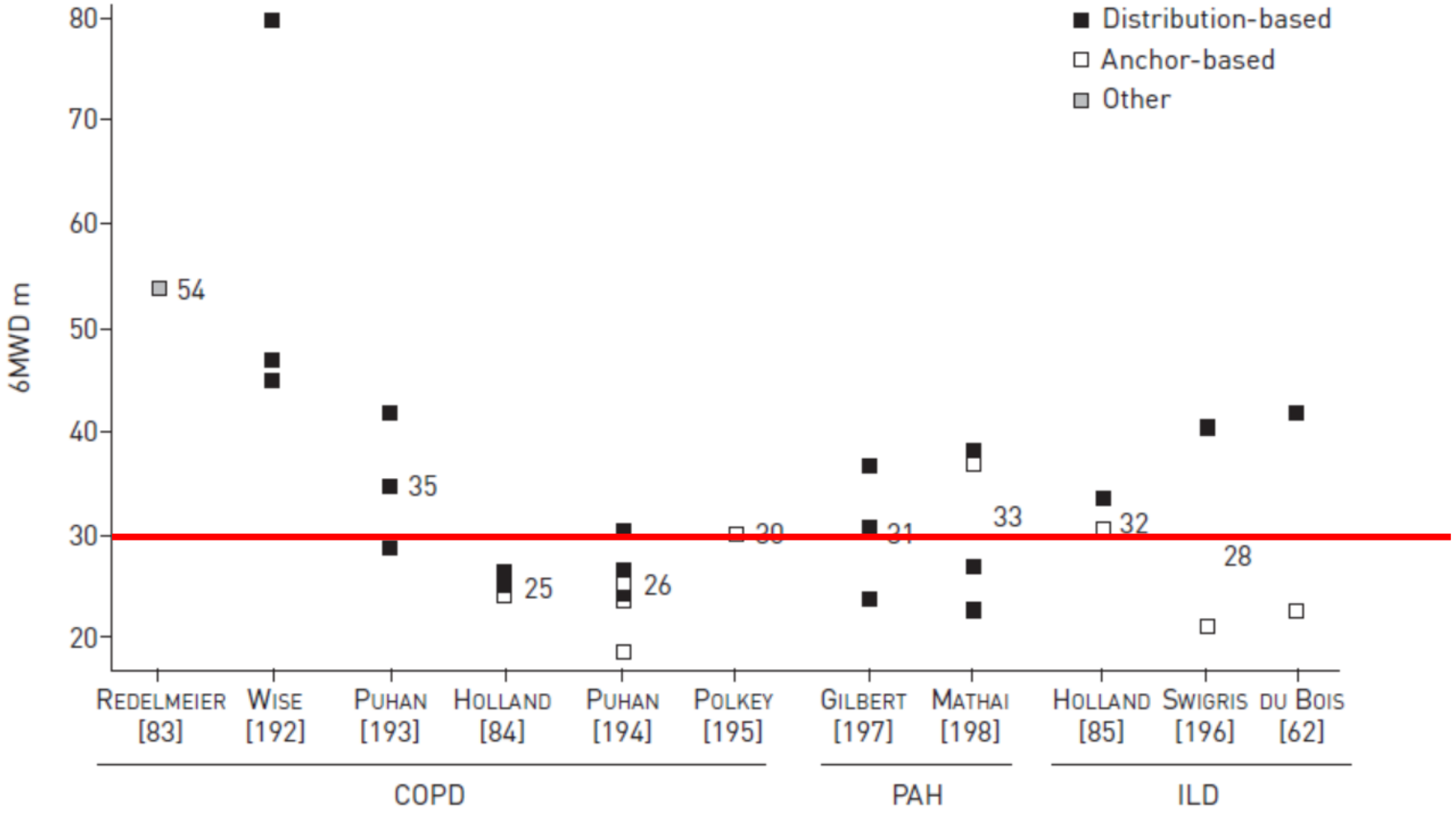
- 1분 후, “잘하고 계십니다. 5분 남았습니다.”
- 2분 후, “계속하세요. 4분 남았습니다.”
- 3분 후, “잘하고 계십니다. 반 정도 남았습니다.”
- 4분 후, “계속하세요. 2분 밖에 안 남았습니다.”
- 5분 후, “잘하고 계십니다. 1분 밖에 안남았습니다.”
- 15초 전, “잠시 후 제가 그만이라고 하면 그 자리에 멈추세요. 제가 그 곳으로 가겠습니다.”
- 6분 후, “그만.” 이라고 말하고 피검자에게 간다. 피검자가 지쳐 보이면 의자를 가져간다.
- 멈추어 선 지점에 물건을 놓아 표시한다. 이외에 **다른 독려의 말이나 몸짓은 하지 않는다.**

TABLE 2 Effect of methodological variations on 6-min walking distance (6MWD)

Variation in methodology	Studies n	First author [ref.]	Effect on 6MWD
Hallway *versus* treadmill	2	Stevens [14]	13–20% less on treadmill
		de Almeida [15]	
Indoors *versus* outdoors	1	Brooks [16]	4 m (1%) more outside
Circular *versus* straight track	2	Bansal [17]	13–19 m (3–5%) more on circular track
		Sciurba [18]	
Track length	2	Sciurba [18]	No statistically significant difference in 6MWD from tracks of 15–121 m
		Beekman [19]	50 m more on 30-m track compared to 10-m track
Wheeled walking aid *versus* no aid	6	Gupta [20]	Weighted mean 6.2% more with wheeled walker
		Honeyman [21]	Range 2–46 m more with wheeled walker
		Probst [22]	83 m more with modern draisine compared to wheeled walker
		Roomi [23]	
		Solway [24]	
		Vaes [25]	
With *versus* without oxygen	4	Davidson [26]	12–59 m more with oxygen
		Fujimoto [27]	
		Rooyackers [28]	
		Jolly [29]	
Oxygen *versus* compressed air	2	Jolly [29]	17–109 m more with oxygen
		McDonald [30]	
Carry oxygen *versus* oxygen in wheeled cart	1	Crisafulli [31]	23 m more with wheeled cart
Patient carries oxygen *versus* tester carries oxygen	1	Woodcock [32]	24 m *versus* 35 m improvement
Encouragement	1	Guyatt [33]	30.5 m more with encouragement
Instructions	1	Weir [34]	53 m further when asked to walk as "fast" as possible, rather than as "far" as possible

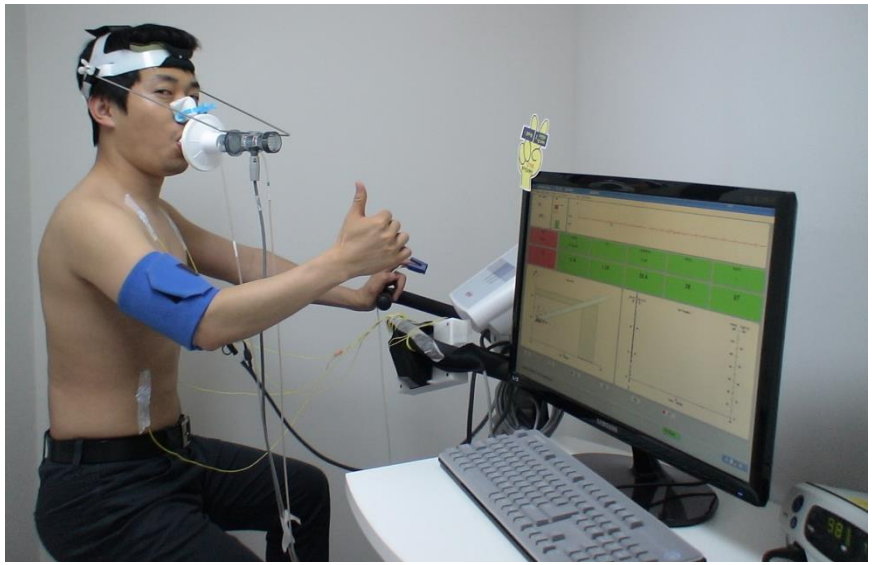
Holland AE et al. European Resp J 2014;44:1428-46

MCID of 30m for adult patients with chronic respiratory disease



Singh SJ et al. European Resp J 2014;44:1447-78

Cardiopulmonary exercise test

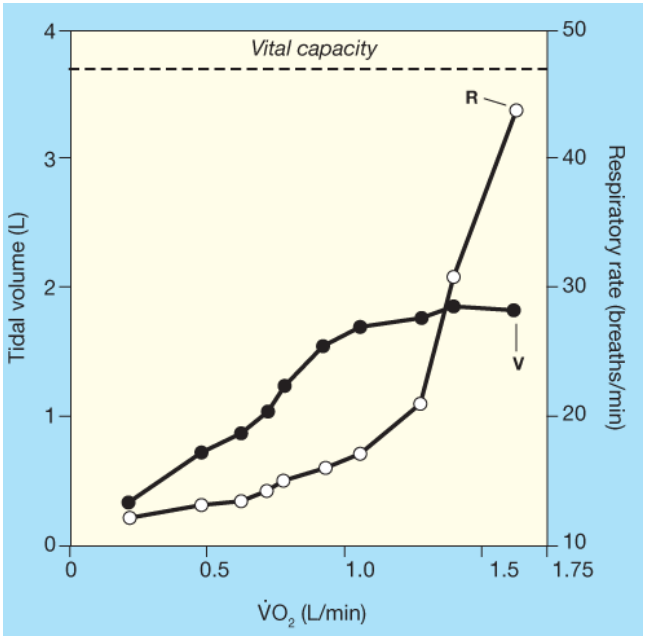


- **측정**
  - O_2 섭취량, CO_2 생성량, 분당환기량
  - SaO_2, 동맥혈검사
  - 심전도, 혈압
- 운동능력평가
  - 최대산소섭취량, VO_2max = (HRmax X SVmax) X (CaO_2max – CvO_2max)
  - 적응증
    - 폐암, 폐기종 수술 (>15ml/kg/min)
    - COPD, IPF, …
      - ✓ 검사소견보다 심한 호흡곤란
    - 운동처방계획
    - 치료 반응/추적
- 호흡곤란 감별진단
  - 폐, 심장, 혈관, 근육, 정신…

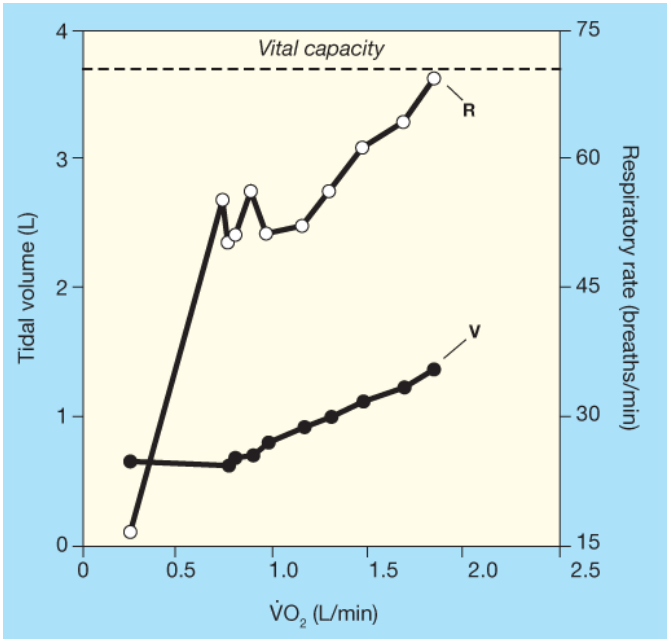
CPET in Psychogenic dyspnea

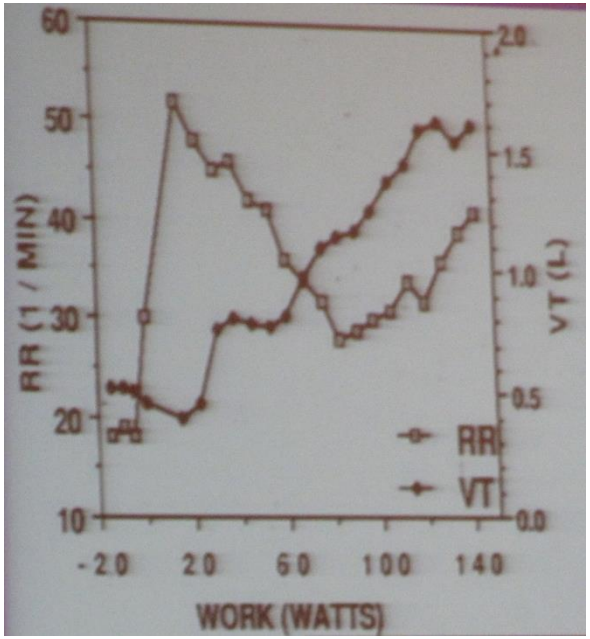
- **49세 여자**
  - 1달 전부터 계단 오르거나, 말을 길게 할 때 30분 가량 지속되는 가슴이 답답하면서 숨찬 증상이 있어 외부병원 chest CT, echocardiography 시행했으나 이상 소견 없어 호흡곤란의 원인을 찾기 위해 본원 외래 내원.

Normal respiratory pattern to exercise



Psychogenic Dyspnea





Weisman et al. Cardiologia. 1996 Jul;41(7):621-34.

2013년 미국흉부학회

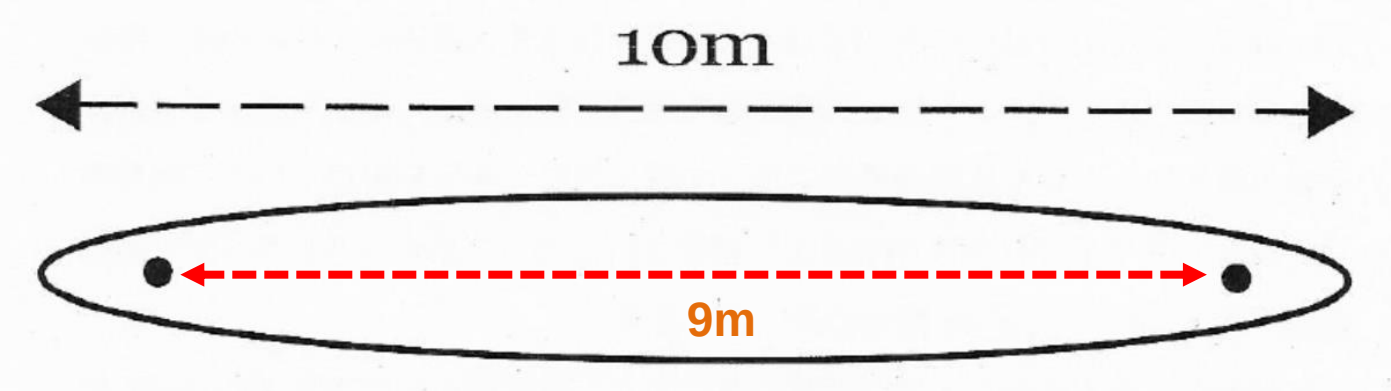
Incremental Shuttle Walking Test (ISWT)

By courtesy of pf. Senju

셔틀 워킹 테스트

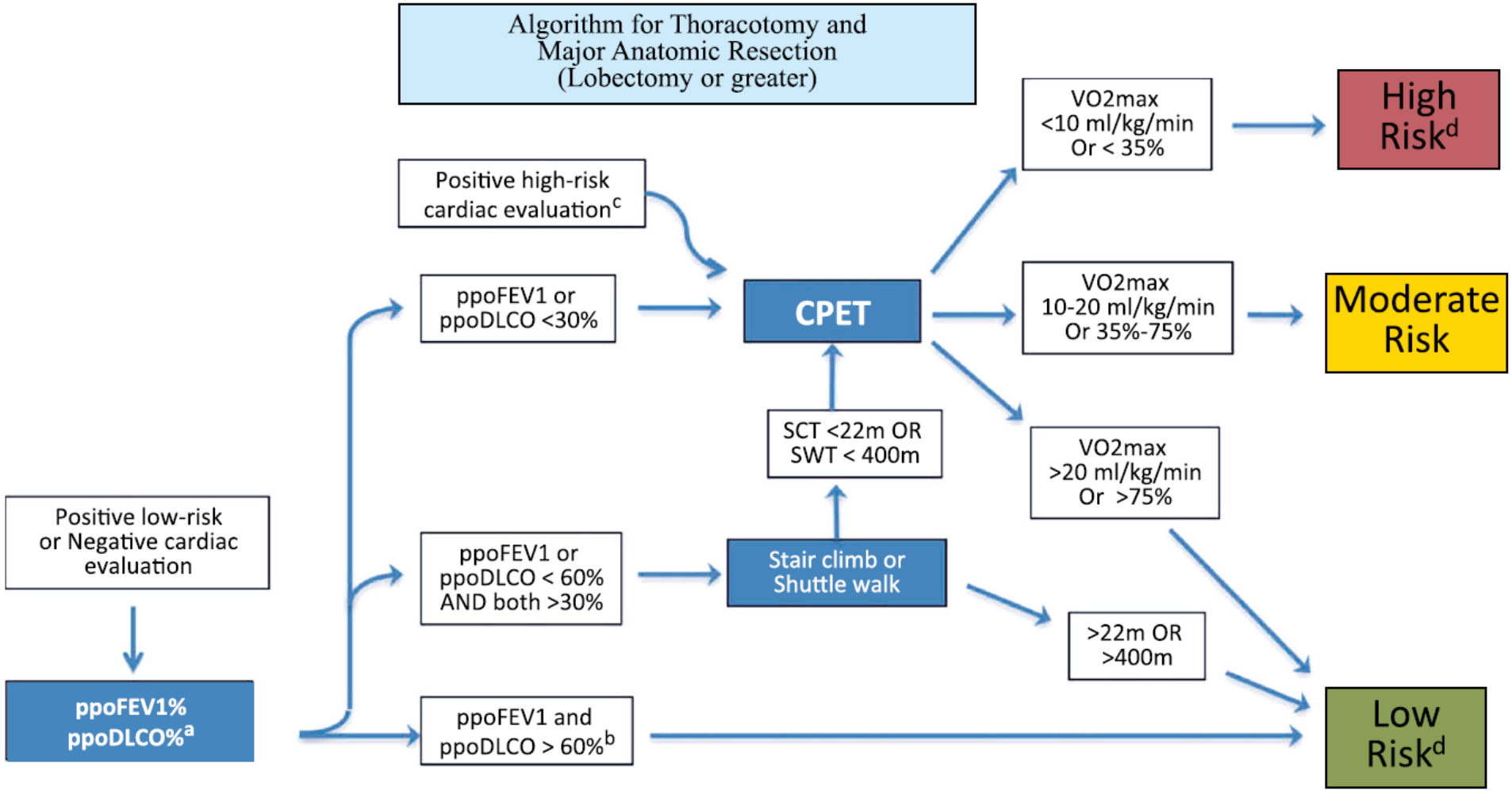
(Shuttle Walking Test: SWT)

한국어판 매뉴얼



※ 첨부되어 있는 USB의 SWT 설명 동영상을 참조하여 주십시오.

Preoperative evaluation



$VO_2peak = 4.19 + 0.025 \times$ 거리(SWT distance, m)

CHEST 2013; 143(5)(Suppl):e166S–e190S

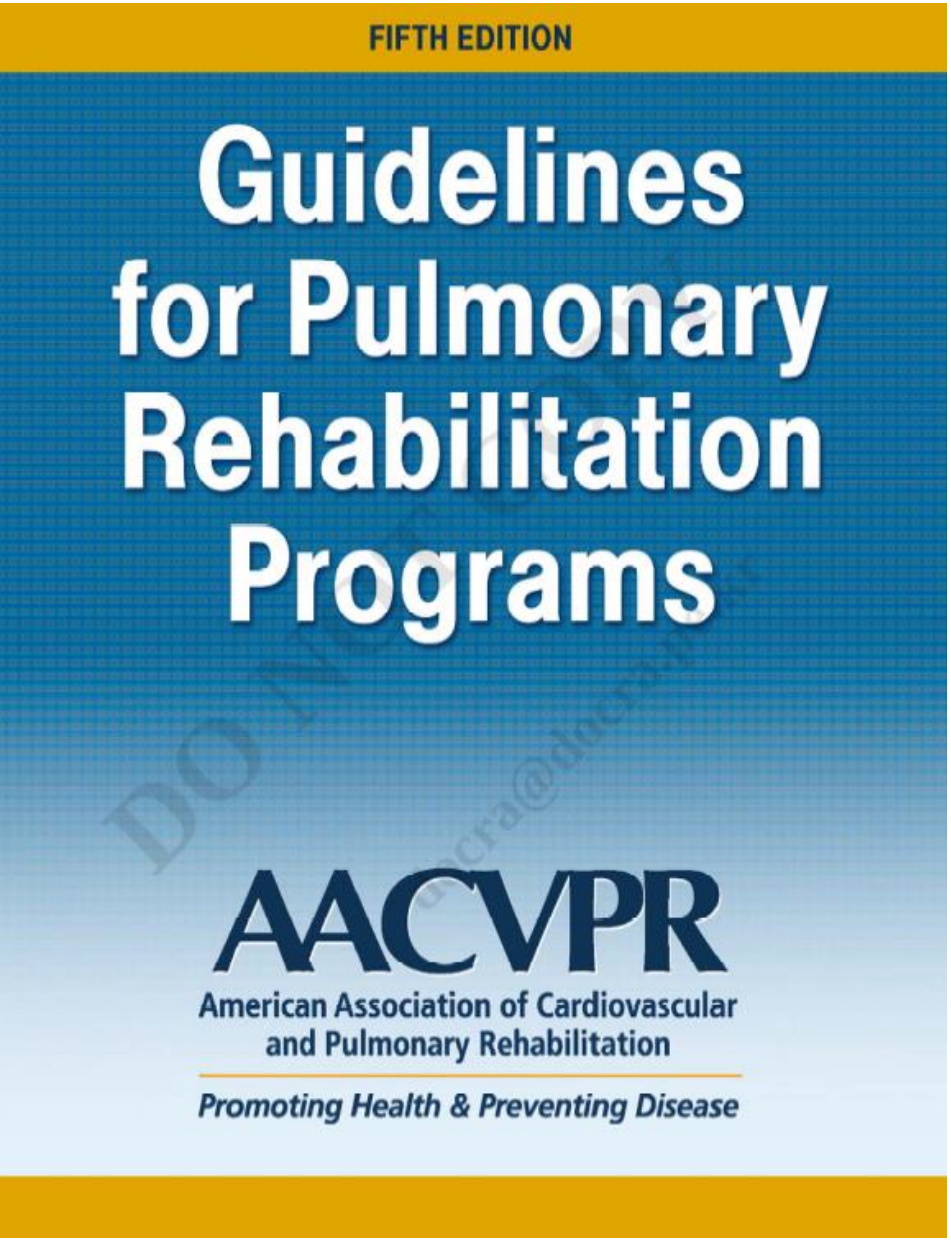
S26255 폐질환 운동재활치료 (Rehabilitation Exercise)

- **1회/일 급여 가능**
- **목적:** 호흡부전 증상 완화, 삶의 질과 운동능력의 향상, 일상생활에서 신체적, 정서적 활동 확대를 통해 건강증진 상태 유지
- **대상**
  - 만성폐쇄성폐질환, 천식, 기관지 확장증, 간질성 폐질환, 결핵성 폐질환, 폐동맥 고혈압
  - **폐암 수술 전후, 폐이식 수술 전후, 폐 용적 감소 수술 전후, 흉부 및 복부 수술 전후**
  - 척추측만증, 후만증을 포함하여 제한성 폐질환을 일으킬 수 있는 흉곽의 병변

위 대상에 해당하는 환자 군에서 호흡곤란 등의 호흡기 증상이 있거나 일상생활에 어려움이 있는 경우

- **소요인력:** 의사, 물리치료사, 간호사
- 소요시간: 60분
- 소요장비:
  - 경피적 SaO2 측정기, Treadmill, Bicycle ergometer, theraband set, dumbbell set, 산소, 도수소생기백
- 실시방법: 환자의 평가결과를 바탕으로 호흡재활전문의사가 환자의 운동능력과 호흡곤란 정도, 기저질환 및 동반질환을 고려하여 **개인별 맞춤 운동프로그램을 구체적으로 작성하여 처방하고 치료** 시행

구성요소	내용	비고
준비운동	적어도 5~10분간의 저강도(<40% VO_2max) 또는 중강도(40~60% VO_2max) 의 활동	
스트레칭	준비운동 후 적어도 10분	
본운동	20~60분간의 지구성, 저항성, 유연성 운동 등의 신체 활동으로 10분간 누적하여 실시해도 무방	FITT의 원리 적용
정리운동	적어도 5~10분간의 저강도(<40% VO_2max) 또는 중강도(40~60% VO_2max) 의 심혈관 및 근지구력 활동	정리운동 후에도 스트레칭 실시



- Physical limitations (e.g., strength, range of motion, posture, functional abilities, and activities)
- Fall risk
- Frailty
- Grip strength
- Gait and balance
- Functional assessment
- Orthopedic limitations
- Transferring abilities
- Exercise tolerance
- Exercise hypoxemia, including the need for supplemental oxygen therapy

AACVPR. Guidelines for Pulmonary Rehabilitation Programs Fifth Edition, 2019

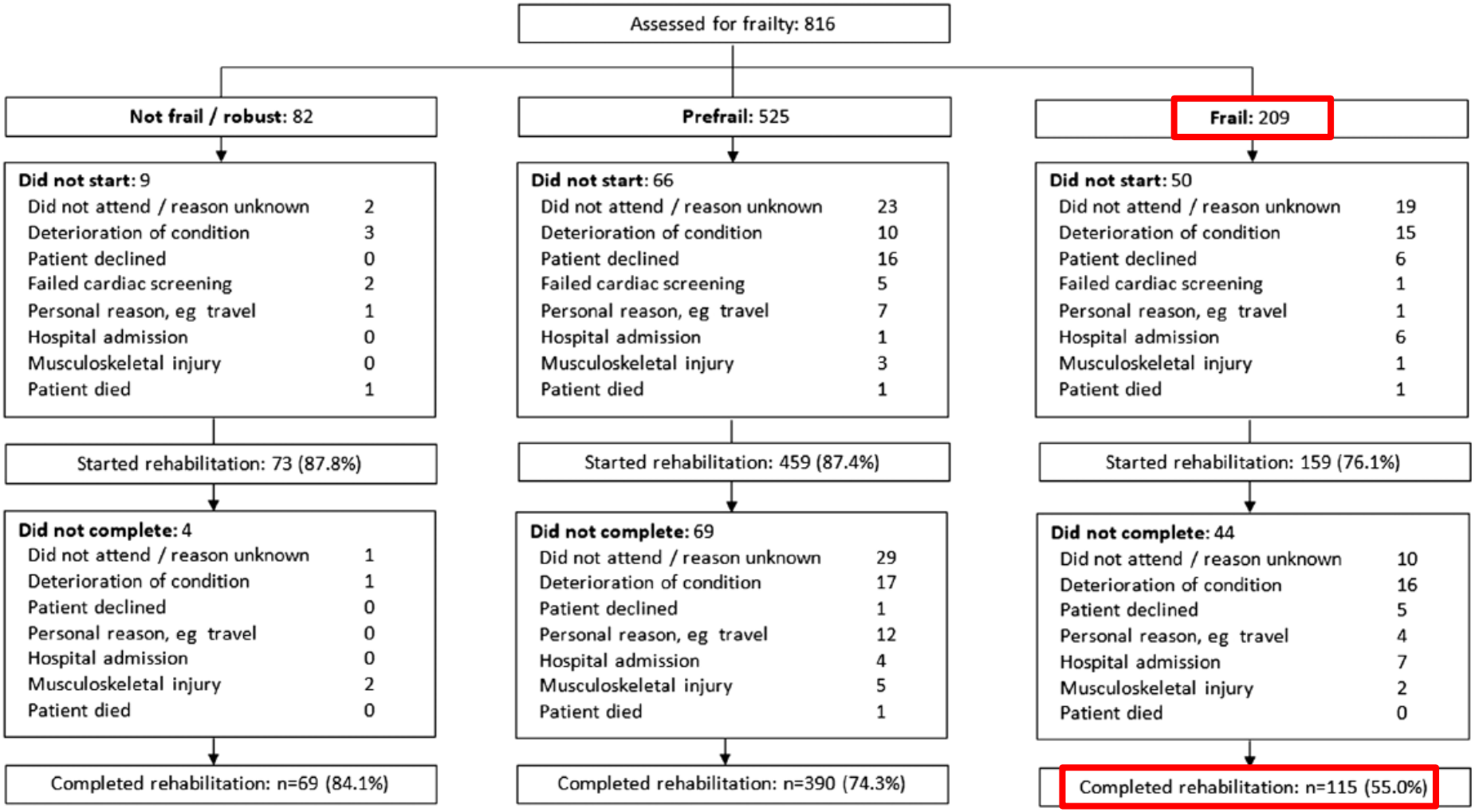
Frailty in COPD (Fried phenotype model)

1. Unintentional weight loss last year > 4.5kg
2. Exhaustion
   - I felt everything I did was an effort >3 days in the last week
   - OR I could not get going >3 days in the last week
3. Low physical activity
   - Weekly self-reported energy expenditure
   - Minnesota Leisure-time PA Questionnaire: Males <383Kcal, Female<270Kcal
4. Slowness
   - 4-m gait speed >173cm: 0.762m/s, <173cm 0.653m/s
5. Weakness
   - Handgrip dynamometry

1-2 points =prefrail
3+ points =frail

Fried et al. J Gerontol A Biol Sci Med Sci 2001;56:M146–56.

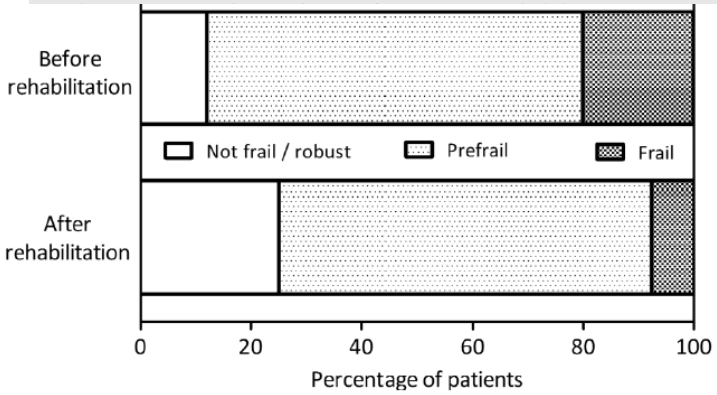
Frailty status and flow of patients through PR trial



Maddocks M, et al. Thorax 2016;71:988–995

Comparison of clinical outcomes following PR according to frailty status

	Not frail (n=69)	Prefrail (n=390)	Frail (n=115)	p Value
MRC	0.1 (−0.3 to 0.5)	−0.5 (−0.7 to −0.4)	−1.4 (−1.1 to −1.7)*†	<0.001
SMI (kg/m^2)	0.6 (0.5 to 1.1)	0.5 (0.2 to 0.7)	0.5 (0.1 to 0.8)	0.90
Handgrip (kg)	−0.2 (−1.2 to 0.9)	1.2 (0.8 to 1.5)	1.6 (1.0 to 2.3)*	0.002
Peak QMVC (kg)	2.7 (1.1 to 4.3)	1.9 (1.2 to 2.5)	1.8 (0.8 to 2.7)	0.55
Below QMVC cut-point (%)	6.4 (−1.4 to 14.1)	−21.74 (−17.7 to −25.3)	−36.6 (−24.8 to −46.9)*†	<0.001
4MGS (m/s)	0.08 (0.05 to 0.12)	0.07 (0.05 to 0.08)	0.11 (0.09 to 0.14)	0.004
ISWT (m)	17.8 (−21.7 to 57.3)	51.8 (24.4 to 79.2)	145.9 (108.6 to 183.2)*†	<0.001
CRQ dyspnoea score	3.8 (1.4 to 6.2)	4.4 (3.3 to 5.4)	6.8 (5.0 to 8.5)	0.006
CRQ fatigue score	−0.8 (−3.2 to 1.5)	3.1 (2.1 to 4.0)	6.1 (4.6 to 7.7)*†	<0.001
CRQ emotional score	−0.5 (−2.6 to 3.7)	4.0 (2.4 to 5.6)	8.6 (5.6 to 11.5)*†	<0.001
CRQ mastery score	0.7 (−1.1 to 2.4)	3.1 (2.1 to 4.1)	5.2 (3.4 to 6.9)*†	<0.001
Self-reported weekly energy expenditure (kcal)	1276.0 (714.1 to 1838.0)	606.2 (390.0 to 822.5)	767.1 (546.4 to 987.8)	0.08
Self-reported time in moderate activity (min/week)	417.5 (184.7 to 650.4)	137.0 (75.2 to 198.9)	190.3 (127.4 to 253.3)	0.006
CAT score	0.4 (−1.4 to 2.1)	−1.3 (−2.7 to 0.2)	−7.3 (−9.7 to −4.8)*†	<0.001
Katz score	0.0 (−0.1 to 0.1)	0.0 (−0.1 to 0.1)	0.1 (−0.1 to 0.3)	0.73
HADS anxiety	−0.3 (−2.0 to 1.4)	−1.0 (−1.7 to −0.3)	−2.8 (−4.4 to −1.2)*	<0.001
HADS depression	0.9 (−0.2 to 2.1)	−0.8 (−1.4 to −0.1)	−2.9 (−4.0 to −1.7)*†	<0.001



Maddocks M, et al. Thorax 2016;71:988–995

강의 요약

- **호흡재활환자평가: Functional vs Exercise capacity**
  - 호흡재활효과 판정
  - 상호보완적 - 결과가 일치하지 않을 수 있다.
    - Functional PRO (Patient Reported Outcome)
    - Exercise performance
  - 호흡재활치료결과가 만족스럽지 못할 경우 환자의 key problem 에 따라서 호흡재활프로그램을 조정
    - Muscle strength, 6MWD, Physical activities, Symptoms, psychologic morbidity, ADL performance, PImax, ...
  - To motivate patients to continue the program
    - **Endurance test**