

Physical activity assessment for Pulmonary Rehabilitation

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Physical activity

- “Lack of activity destroys the good condition of every human being, while movement and methodical physical exercise save it and preserve it.”

- Plato -

- Definition
 - “Any bodily movement produced by skeletal muscles that results in energy expenditure”
- Characterized by type, intensity, duration, patterns, symptom experience

Eur Respir J 2014; 44: 1521–1537

- **Physical Inactivity** : If one of the following criteria is not met in healthy individual
 - 1) 30 min of moderate-intensity physical activity on ≥ 5 days/week
 - 2) 20 min of vigorous-intensity physical activity on ≥ 3 days/week
 - 3) accumulated in shorter bouts, moderate (10 min x 3) or vigorous (10 min x 2) exercise

ACSM guidelines on PA to protect against health risks
Circulation 2007; 116: 1081–1093.

Level of Physical activity in patient with COPD

- Physical inactivity appears to be more common in patients with COPD compared with age-matched healthy individuals or even patients with other chronic diseases (e.g., CAD, RA)
 - Spend significantly less time walking, walk at a lower intensity
 - Reduce their physical activity early in the course of the disease
- Daily symptoms (i.e., dyspnea and fatigue) are associated with lower physical activity levels in patients with COPD
- Impaired health status is weakly-to-moderately related to physical activity in patients with COPD
- Exacerbations clearly reduce physical activity levels in patients with COPD

Am J Respir Crit Care Med (2015) 192, 924–933

Eur Respir J (2014) 44, 1521–1537

Level of Physical activity in patient with COPD

- Physical activity substantially decreases over time in patients with COPD and to a greater extent than in non-COPD subjects
- A sustained low level of physical activity over time
→ accelerated progression of exercise intolerance and muscle depletion
- Physical inactivity independently predicts poor outcomes
 - A higher risk of an exacerbation-related hospitalization
 - A higher risk of all-cause mortality in patients with COPD

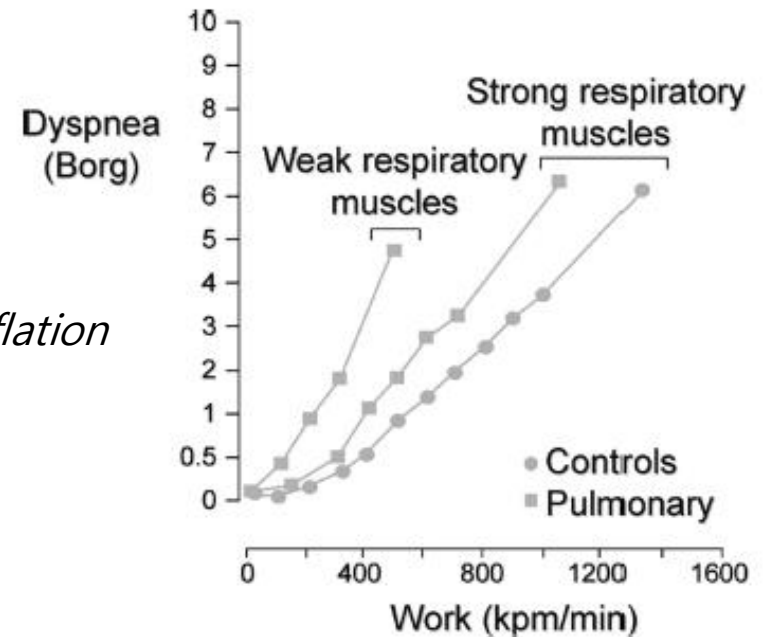
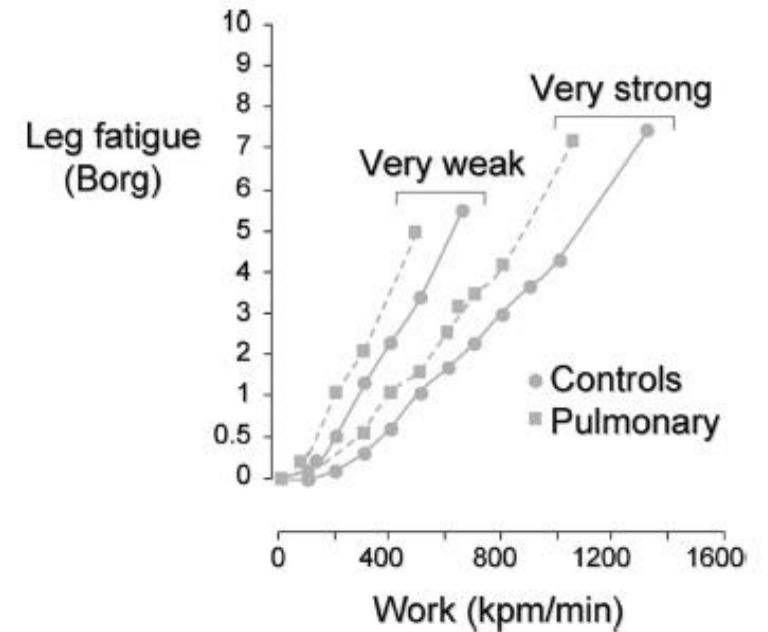
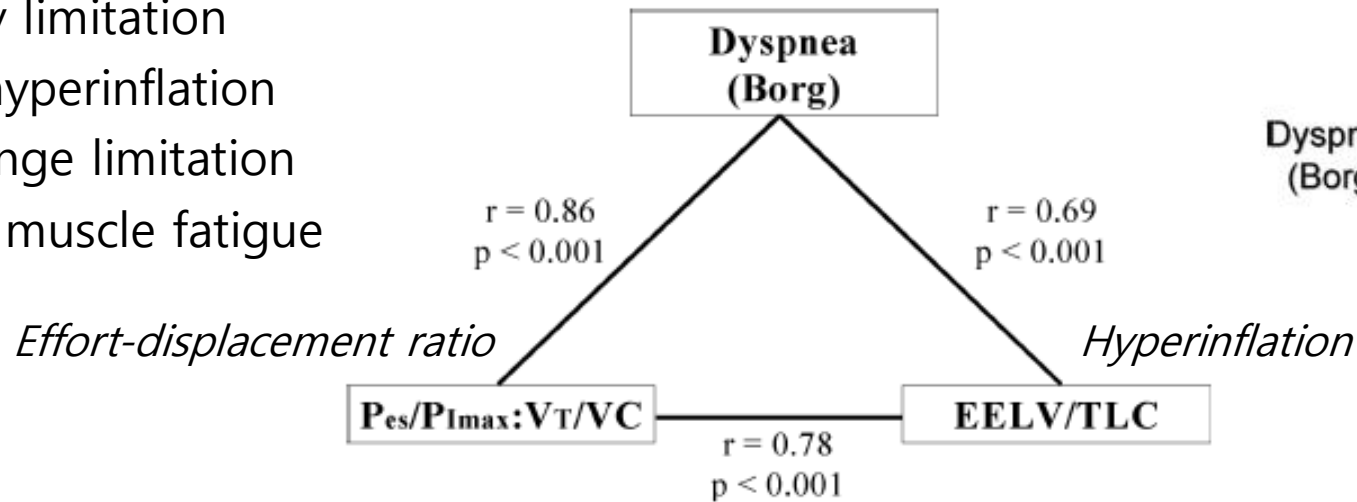
Studies on Physical inactivity

- ▲ Physical activity levels \propto ▼ Magnitude of lung function decline, ▼ COPD incidence

Author	Design	Subjects	Subjects characteristics	PA assessment	Outcomes	Main results
JAKES	Population based cohort UK	N=512,283 Mean 3.7 years follow-up	45% male Age: 59±9 years FEV1: 3.0±0.7 L(M), 2.2±0.5 L(F)	Standardized questionnaire	FEV1 decline mL/year	<ul style="list-style-type: none"> • Climbing more stairs is associated with slower FEV1 decline in females • Participation in vigorous leisure time activities is associated with slower FEV1 decline in females • No association found in males
PELKO NEN	Cohort of rural men with a high PA level Finland	N=5,186 25 years follow-up	100% male Age: 54±5 years FEV 0.75 : 2.9±0.6 L	Validated questionnaire	FEV0.75 decline mL/year	<ul style="list-style-type: none"> • Decline in FEV0.75 over 25 years was -44.4, -40.5 and -36.5 mL/year for low, medium and high physical activity
CHENG	Convenience sample from a clinic USA	N=55,707 Mean 1.6 years follow-up	87% male Age: 25–55 years	Self-report	FEV1 and FVC decline mL/year	<ul style="list-style-type: none"> • Males who remained in the active category during the follow-up increased FEV1 by 50 mL and FVC by 70 mL while subjects who remained in the sedentary group reduced FEV1 and FVC by 30 and 20 mL • No association found in females
GARCIA AYMERI CH	Population based cohort Denmark	N=56,568 Mean 16 years follow-up	41% male Age: 49±11 years FEV1: 2.7±0.8 L FVC: 3.4±1.0 L	Validated questionnaire	COPD incidence (FEV1/FVC <70%) FEV1 and FVC decline mL/year	<ul style="list-style-type: none"> • Subjects with moderate-to-high physical activity show a reduced risk of developing COPD compared with the low physical activity group (OR 0.79) • Subjects with moderate and high physical activity show a reduced FEV1 decline compared with those with low physical activity (relative change of +7.4 and +10.3 mL/year for FEV1) • Subjects with moderate and high physical activity show a reduced FVC decline compared with those with low physical activity

Exercise intolerance in COPD

- Maximal oxygen consumption (VO₂max)
 - The best measure of exercise capacity
 - $VO_2 = CO \times (A-V)O_2$ (\propto workload)
- Exercise intolerance in COPD results from
 - Symptom perception
 - Ventilatory limitation
 - Dynamic hyperinflation
 - Gas exchange limitation
 - Peripheral muscle fatigue



Assessment for Pulmonary rehabilitation

필수 평가 항목	가능하다면 시행하는 평가 항목
병력	심폐운동부하검사, 셔틀보행검사
신체검사	호흡근 근력(최대흡기압, 최대호기압) 평가
폐기능검사(Pulmonary Function Test)	사지 근력 평가
흉부 방사선 촬영	일상생활동작 수행 평가
심전도	삶의 질 평가
전혈구계산(CBC)	정신의학적 평가
산소포화도(안정시, 보행시)	심장초음파, 홀터 검사
증상 평가(호흡곤란 정도, 피로감)	영양평가
운동 능력 평가(6분보행검사)	



1. Symptom assessment

- (1) 호흡 곤란
 - 예후를 결정, 운동제한이나 삶의 질에 관여하는 중요한 인자임
 - Modified Borg Scale

표 5-2. 수정 Borg척도⁷

등급	증상	증상
0	Nothing at all	전혀 아님
0.5	Very, very slight (just noticeable)	매우 매우 약간
1	Very slight	매우 약간
2	Slight (light)	약간(경미)
3	Moderate	중간 정도
4	Somewhat severe	꽤 심함
5	Severe (heavy)	심함
6		
7	Very severe	매우 심함
8		
9		
10	Very, very severe (maximal)	매우 매우 심함

Borg Scale	Perceived Exertion	Modified Borg Scale	
		0.0	Nothing at all
		0.5	Very, very weak
		1.0	Very weak
		1.5	
		2.0	Weak (light)
6		2.5	
7	Very, very light	3.0	Moderate
8		3.5	
9	Very light	4.0	Somewhat strong
10		4.5	
11	Fairly light	5.0	Strong (heavy effort)
12		5.5	
13	Somewhat hard	6.0	
14		6.5	
15	Hard	7.0	Very strong
16		7.5	
17	Very hard	8.0	
18		8.5	
19	Very, very hard	9.0	
20		9.5	
		10	Very, very strong
		>10	Maximal

- VAS

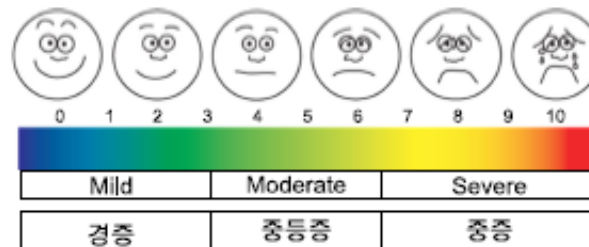


그림 5-1. 10 cm 가로선 VAS

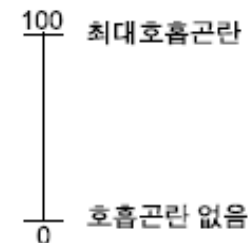


그림 5-2. 10 cm 세로선 VAS

1. Symptom assessment

- (1) 호흡 곤란
 - Modified Medical Research Council (mMRC)

호흡곤란 점수	호흡곤란 내용
0	힘든 운동을 할 때만 숨이 차다.
1	평지를 빨리 걸거나, 약간 오르막길을 걸을 때 숨이 차다.
2	평지를 걸을 때 숨이 차서 동년배보다 천천히 걸거나, 자신의 속도로 걸어도 숨이 차서 멈추어 쉬어야 한다.
3	평지를 약 100 m 정도 걸거나, 몇 분 동안 걸으면 숨이 차서 멈추어 쉬어야 한다.
4	숨이 너무 차서 집을 나설 수 없거나, 옷을 입거나 벗을 때도 숨이 차다.

- Chronic Respiratory Disease Questionnaire (CRQ)
- St. George's Respiratory Questionnaire (SGRQ)



1. Symptom assessment

- (2) 피로감
 - 운동 중 Modified Borg scale, VAS를 이용하여 실시간 피로감 평가
 - Brief Fatigue Inventory (BFI)
 - 암환자의 피로감을 측정, 삶의 질 평가 도구
 - 0-10점, 9개 항목 평균 점수가 7점 이상이면 임상적으로 의미 있는 피로감으로 진단
 - SF-36 (Medical Outcome Study Short Form)
 - CRQ



1. Symptom assessment

- (3) 기타 – 삶의 질
 - COPD assessment test (CAT)
 - GOLD에서 정의하는 모든 COPD 환자를 대상으로 개발됨
 - 기침, 객담, 호흡곤란, 가슴조임, 일상생활 동작, 자신감, 수면 등 8가지 항목
 - 한국어판 사용 가능
 - 3~6개월에 한번씩 작성 권고

나는 전혀 기침을 하지 않는다.	0 - 1 - 2 - 3 - 4 - 5	나는 항상 기침을 한다.	
나는 가슴에 전혀 가래가 없다.	0 - 1 - 2 - 3 - 4 - 5	나는 가슴에 가래가 가득 차있다.	
나는 전혀 가슴이 답답함을 느끼지 않는다.	0 - 1 - 2 - 3 - 4 - 5	나는 가슴이 아주 답답함을 느낀다.	
나는 언덕이나 계단을 오를 때 전혀 숨이 차지 않는다.	0 - 1 - 2 - 3 - 4 - 5	나는 언덕이나 계단을 오를 때 아주 숨이 차다.	
나는 집에서 활동하는데 전혀 제약을 받지 않는다.	0 - 1 - 2 - 3 - 4 - 5	나는 집에서 활동하는데 많은 제약을 받는다.	
폐질환에도 불구하고 나는 외출하는데 자신이 있다.	0 - 1 - 2 - 3 - 4 - 5	폐질환으로 인하여 나는 외출하는데 전혀 자신이 없다.	
나는 잠을 깊이 잔다.	0 - 1 - 2 - 3 - 4 - 5	폐질환으로 인하여 나는 잠을 깊이 자지 못한다.	
나는 기운이 왕성하다.	0 - 1 - 2 - 3 - 4 - 5	나는 전혀 기운이 없다	
총점			

CAT 점수	임상 양상	관리, 고려사항
>30	매우 높음 외출, 가사일 불가능, 목욕이나 샤워에 오랜 시간	전문의에 치료 의뢰 추가적인 약물 치료 호흡재활기관에 의뢰 악화 최소화 필요
>20	높음 집안 생활에서도 숨이 참, 말할 때 숨이 참, 두려움, 공포 심	
10~20	중간 1주일에 며칠은 괜찮지만 거의 매일 가래 동반된 기침, 1년에 한 두 번 악화, 몸을 숙이면 숨이 참, 가사일 천천히 하거나 중간에 쉬 필요	악화인자 검토(흡연) 호흡재활기관에 의뢰 악화 최소화 필요
<10	낮음 1주일에 며칠은 기침, 운동할 때, 무거운 짐 들 때 숨이 참, 언덕 오르거나 평지 천천히 가야 함	금연 매년 독감 접종 악화요인 노출 감소

2. Physical activity assessment

- Spirometry
 - Recommended by the GOLD for the diagnosis of COPD
 - Poorly predict disability and QOL in patients with COPD
 - Correlate only weakly with dyspnea, exercise capacity, and health status

→ *Quantification of the degree of functional impairment is important*
- Purpose of physical activity assessment
 - To identify the individual's exercise capacity
 - To identify factors limiting exercise performance (dyspnea, subjective fatigue, MSK limitation)
 - To identify response to an intervention
 - To prescribe exercise intensity for pulmonary rehabilitation



2. Physical activity assessment

- Questionnaires
- Motion sensors

- Walk distance tests
 - 6- or 12- minute walk tests (6MWT, 12MWT)
 - Incremental and endurance shuttle walk tests (ISWT, ESWT)
- Incremental maximal exercise test
- Submaximal exercise test
 - No consensus about which test is the most appropriate for use in patients with COPD
 - Reflect different physiological parameters → difficult to compare results across studies



2.1. Questionnaires

- Commonly used in epidemiological studies and large clinical trials
- Prone to inaccuracy when used on an individual level

- PFSDQ (Pulmonary functional status and dyspnea questionnaire)
 - 164-item, measuring dyspnea intensity with activities + changes in functional ability related to 79 activities of daily living
- PFSDQ-M (modified)
- PFSS (Pulmonary functional status scale)

2.2. Motion sensors

- Pedometers (step counters)
 - Most accurate at step counting / less accurate in distance estimates
 - Motivational tool to increase PA
 - May underestimate the number of steps and energy expenditure during walking at slow speed (COPD)
- Accelerometers (detection of body acceleration)
 - More sensitive to detection of PA differences in inactive and slowly moving individuals
 - More accurate and sensitive to light activity
 - Various type → difficult to compare studies using different devices



2.3. 6-minute walk test

- 안전함, 시행이 용이함, 최소한의 자원 필요, 일상에서의 신체활동을 가장 정확하게 반영

TABLE 1. INDICATIONS FOR THE SIX-MINUTE WALK TEST

Pretreatment and posttreatment comparisons

Lung transplantation (9, 10)

Lung resection (11)

Lung volume reduction surgery (12, 13)

Pulmonary rehabilitation (14, 15)

COPD (16–18)

Pulmonary hypertension

Heart failure (19, 20)

Functional status (single measurement)

COPD (21, 22)

Cystic fibrosis (23, 24)

Heart failure (25–27)

Peripheral vascular disease (28, 29)

Fibromyalgia (30)

Older patients (31)

Predictor of morbidity and mortality

Heart failure (32, 33)

COPD (34, 35)

Primary pulmonary hypertension (10, 36)

- Contraindications for 6MWT
 - Absolute Clx : UA during the previous month
MI during previous month
 - Relative Clx : resting HR \geq 120, SBP/DBP \geq 180/100
- Reasons for immediately stopping a 6MWT
 - chest pain
 - intolerable dyspnea
 - leg cramps
 - staggering
 - Diaphoresis
 - pale or ashen appearance

2.3. 6-minute walk test

- Location
 - Indoors, a long, flat, straight, enclosed corridor with a hard surface
 - Must be 30m in length, marked every 3m
 - Turnaround points should be marked with a cone, starting line should be marked on the floor
 - ** use of treadmill for 6MWT is not recommended
- Required equipment
 - Timer(stopwatch), lap counter, two small cones, chair, worksheet, O₂, sphygmomanometer, AED
- Patient preparation
 - Comfortable clothing, appropriate shoes for walking, usual walking aids(cane, walker), medical regimen, should not exercise vigorously within 2hrs of beginning the test
- Measurements
 - Pre-test: Patient should sit at rest in a chair(for at least 10min)/ BP, HR, SpO₂, Borg scale
 - Post-test: Borg scale for dyspnea and fatigue, SpO₂, HR

2.3. 6-minute walk test

- 6 minute walk distance (6MWD)
 - Associated with outcomes such as ADL, exacerbations, death
 - 6MWD < 350m : increased risk of hospitalization and mortality rates in COPD
 - Minimal clinical important difference (MCID)
 - Stable, severe COPD : 54m (95% CI, 37-71m)
 - Severe COPD : MID 26 ± 2 m
 - Moderate to severe COPD: 35m (10% change of the baseline 6MWD)

Am J Respir Crit Care Med 1997;155:1278–1282

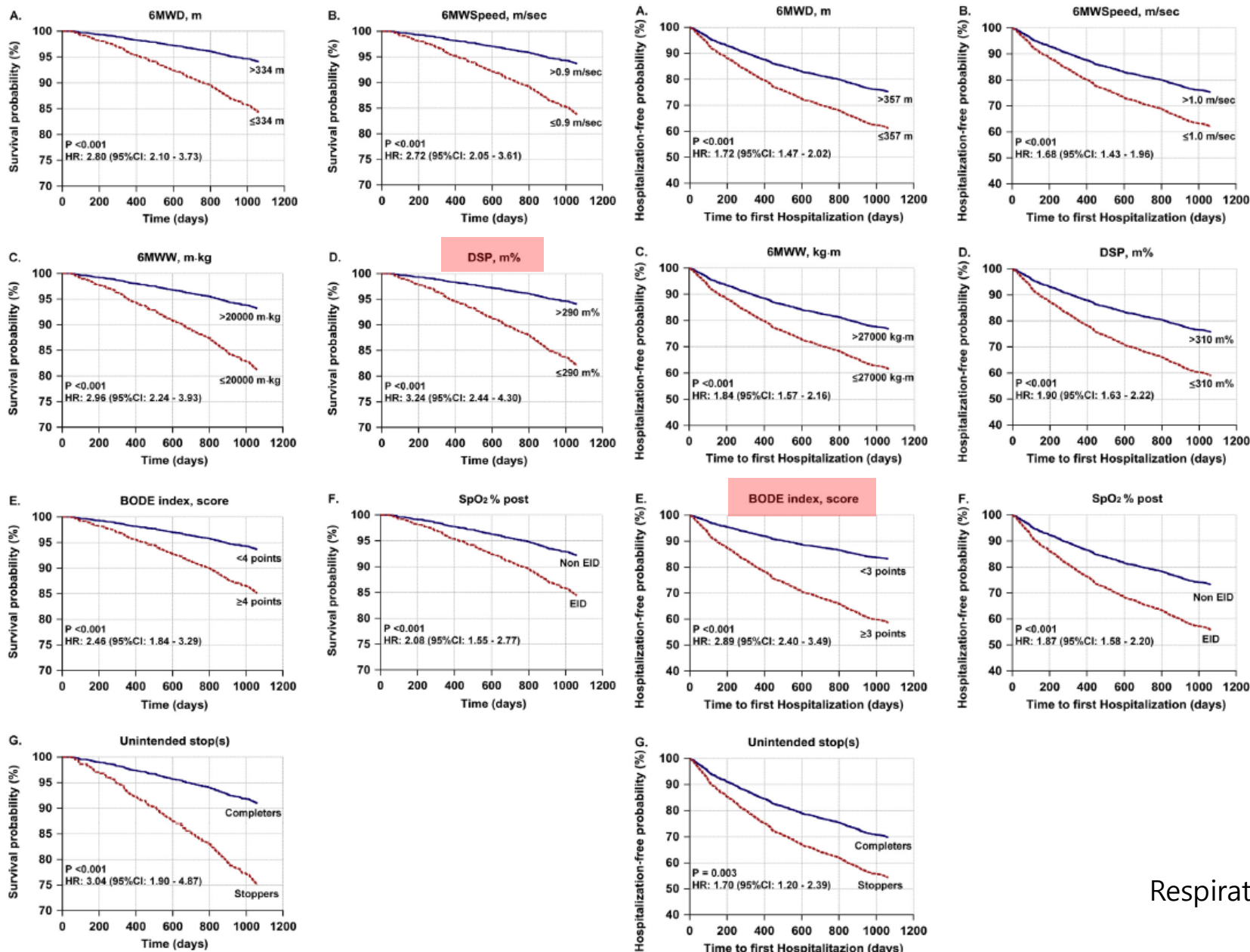
Eur Respir J 2011; 37: 784–790.

Eur Respir J 2008; 32: 637–643

- Average walking speed (6MWSpeed, m/s)
- 6-min walk work (6MWW, m kg)
- Distance-saturation product (DSP, meters%) : 6MWD X the lowest SpO₂%
- Exercise induced oxygen desaturation (EID, SpO₂ < 88% in the 6MWT)



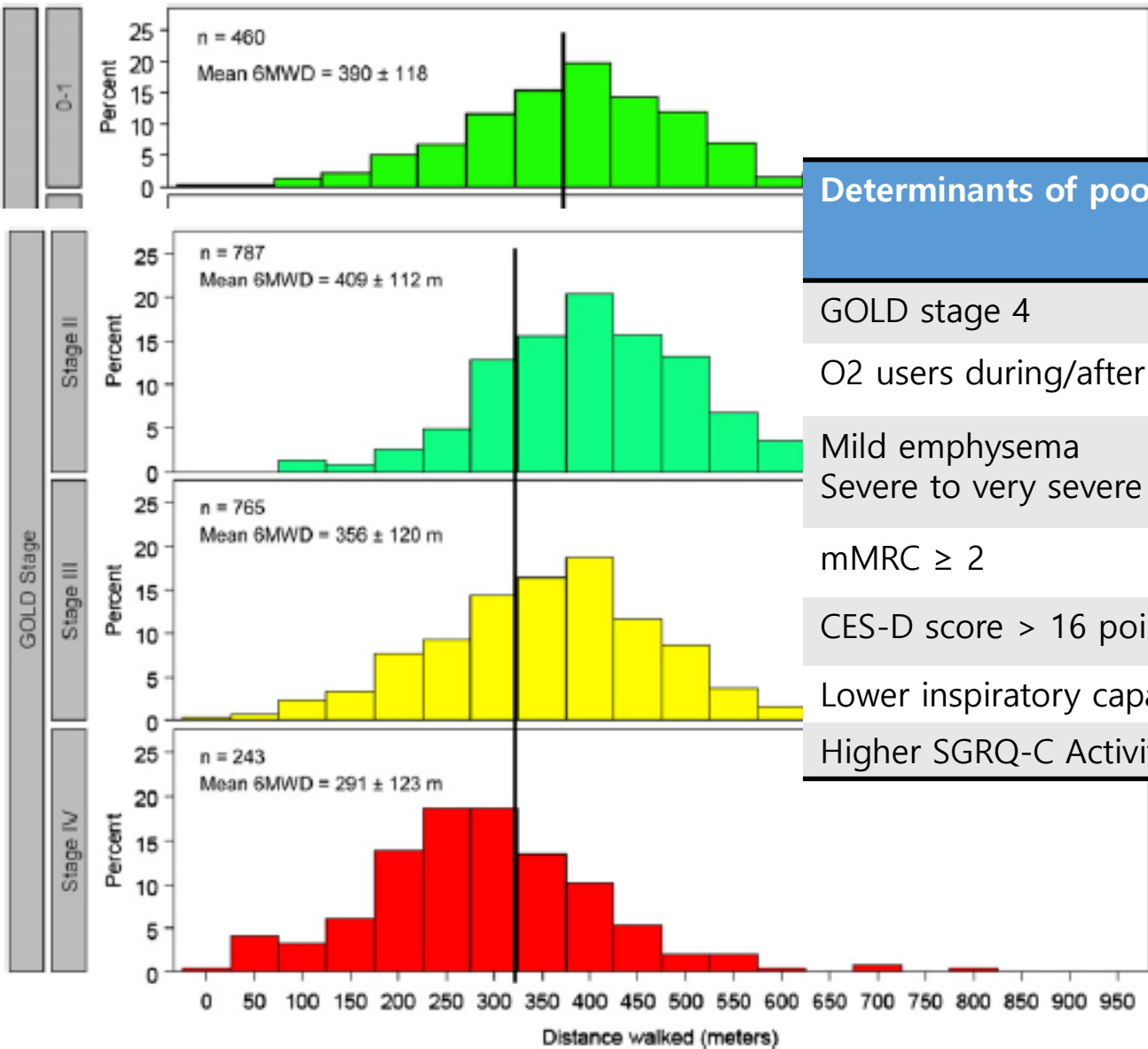
Prognostic value of variables derived from the six-minute walk test in patients with COPD: Results from the ECLIPSE study



- 6MWD
- 6MWSpeed
- 6MWW
- **DSP** (distance saturation product) as the strongest predictor of mortality
- **BODE index** as the most sensitive tool for assessing the risk of hospitalization
- SpO₂%post
- Unintended steps



Determinants of poor 6-min walking distance in patients with COPD: The ECLIPSE cohort[☆]

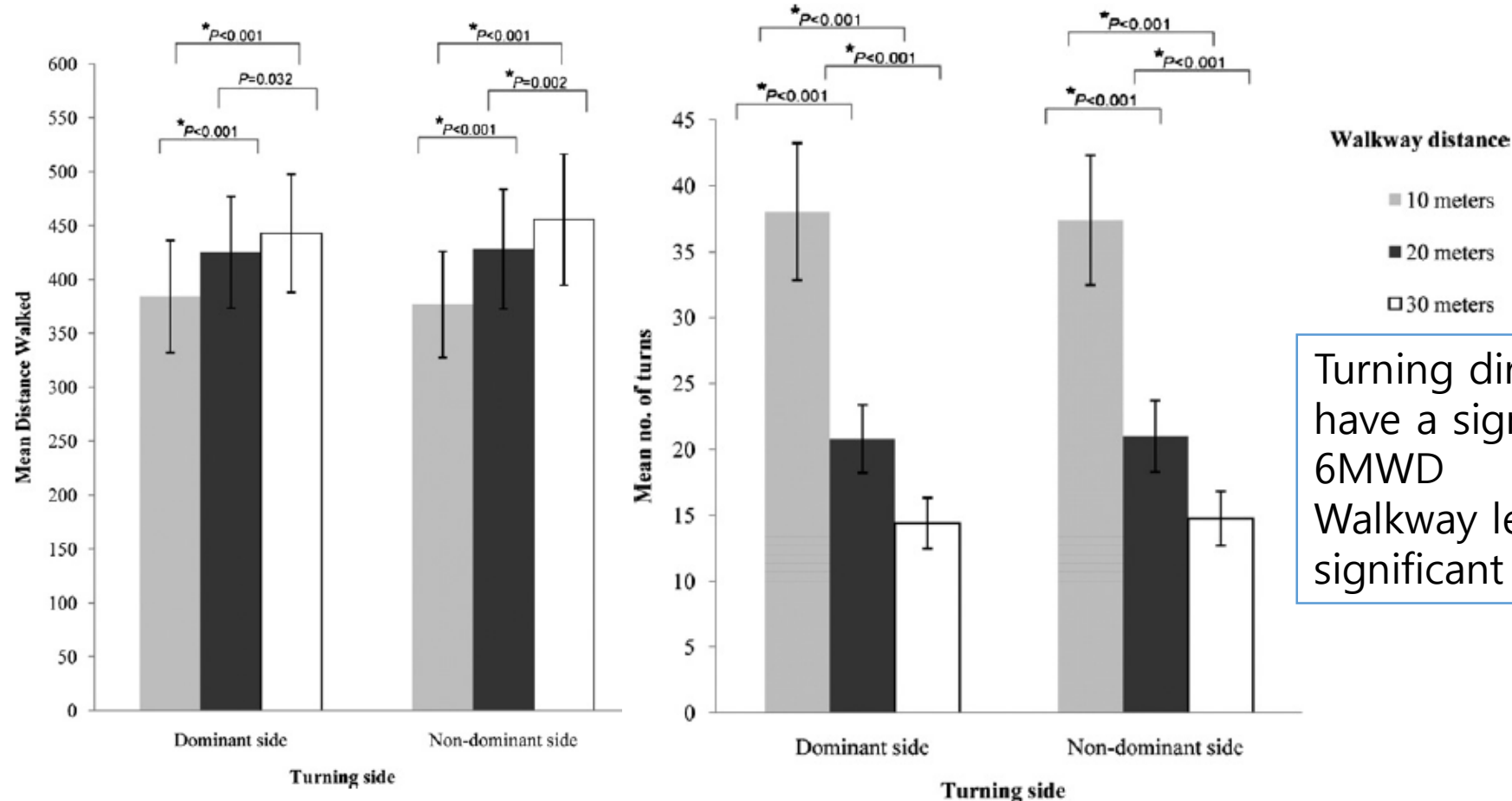


Determinants of poor 6MWD		OR	95% CI	P-value
GOLD stage 4	GOLD stage 2	1.91	1.20-3.03	P=0.006
O2 users during/after the 6MWT	non-users	2.16	1.34-3.47	p=0.002
Mild emphysema	Trivial emphysema	1.56	1.07-2.27	P=0.020
Severe to very severe emphysema	emphysema	1.89	1.29-2.78	P=0.001
mMRC ≥ 2	mMRC < 2	2.24	1.70-2.95	p < 0.001
CES-D score > 16 points	CES-D ≤ 16	1.51	1.14-1.99	P=0.004
Lower inspiratory capacity		0.97	0.96-0.99	p < 0.001
Higher SGRQ-C Activity domain		1.03	1.02-1.03	p < 0.001



Effect of walkway length and turning direction on the distance covered in the 6-minute walk test among adults over 50 years of age: a cross-sectional study

Shamay S. Ng*, Phoebe C. Yu, Fenny P. To, Josiben S. Chung, Tracy H. Cheung



Turning direction was not found to have a significant effect on the 6MWD
 Walkway length had the expected significant effect

Clinical characteristics of COPD patients with early-onset desaturation in the 6-minute walk test



I. García-Talavera^{a,*}, J.M. Figueira-Gonçalves^a, N. Gurbani^a, L. Pérez-Méndez^{b,c},

Table 2 Characteristic of early and non early desaturators patients.

Variables, units	Early (n = 32)	Non early (n = 74)	p-value
Baseline			
Age, years, median (P ₂₅ -P ₇₅)	68 (63-76)	68 (60-75)	0.620
BMI (kg/m ²), mean ± SD	29 ± 5	25 ± 6	0.002
Haemoglobin g/dl, mean ± SD	14.2 ± 2.0	14.4 ± 1.7	0.667
Smoking pack-year index, median (P ₂₅ -P ₇₅)	40 (10-68)	40 (14-53)	0.939
Dyspnoea, mMRC scale, median (P ₂₅ -P ₇₅)	2 (1-3)	2 (1-3)	0.997
Pulmonary function parameters			
6-min walk distance (m), mean ± SD	371 ± 105	435 ± 117	0.011
Time to SpO ₂ (<90%, median (P ₂₅ -P ₇₅))	40 (35-46)	110 (90-150)	<0.0001
Initial SpO ₂ (%), mean ± SD	93 ± 1	94 ± 2	0.002
Nadir SpO ₂ (%), mean ± SD	83 ± 5	86 ± 3	0.001
Initial to nadir SpO ₂ (%), mean ± SD	11 ± 5	8 ± 4	0.023
FEV ₁ /FVC (% predicted), mean ± SD	47 ± 12	41 ± 11	0.007
FEV ₁ litres (% predicted), mean ± SD	1.2 ± 0.577 (48 ± 17)	1.2 ± 0.654 (45 ± 19)	0.421
FVC litres (% predicted), mean ± SD	2.5 ± 0.673 (76 ± 19)	2.8 ± 0.795 (81 ± 19)	0.196
IC litres (% predicted), mean ± SD	2.2 ± 0.703 (88 ± 22)	2.3 ± 0.695 (87 ± 23)	0.913
RV/TLC, mean ± SD	142 ± 35	142 ± 32	0.979
DLCO (% predicted), mean ± SD	51 ± 18	55 ± 21	0.346

Estimation of peak work rate based on 6MWT

- Wmax
 - Parameter to prescribe the intensity of endurance cycling training
 - higher than 60% of the Wmax are considered sufficient to elicit physiologic training effects.
 - Poor to moderate agreement between measured and estimated peak VO2 (ICC 0.14-0.66)

Table 1. Regression equations predicting peak work rate including 6-min walk distance in patients with COPD

Authors	Wpeak regression equation	ICC
Hill et al. (#1) (14)	$(0.122 \times 6MWD) + (72.683 \times \text{height}) - 117.109$	0.58(0.56-0.61)
Hill et al. (#2) (14)	$17.393 + (1.442 \times 6MWW \text{ [km}\cdot\text{kg}^{-1}\text{)})$	0.59 (0.57-0.62)
Luxton et al. (16)	$103.217 + (30.50 \times \text{gender}) + (-1.613 \times \text{age}) + (0.002 \times 6MWW \text{ [m}\cdot\text{kg}^{-1}\text{)})$	0.68 (0.66-0.70)
Cavalheri et al. (13)	$-27.9717 + [3.7792 \times (6MWD \times \text{FFM})]$	0.74 (0.72-0.76)
Kozu et al. (#1) (15)	$(0.168 \times 6MWD) - 4.085$	0.59 (0.57-0.62)
Kozu et al. (#2) (15)	$(2.310 \times 6MWW \text{ [km}\cdot\text{kg}^{-1}\text{)}) + 8.820$	0.73 (0.71-0.74)

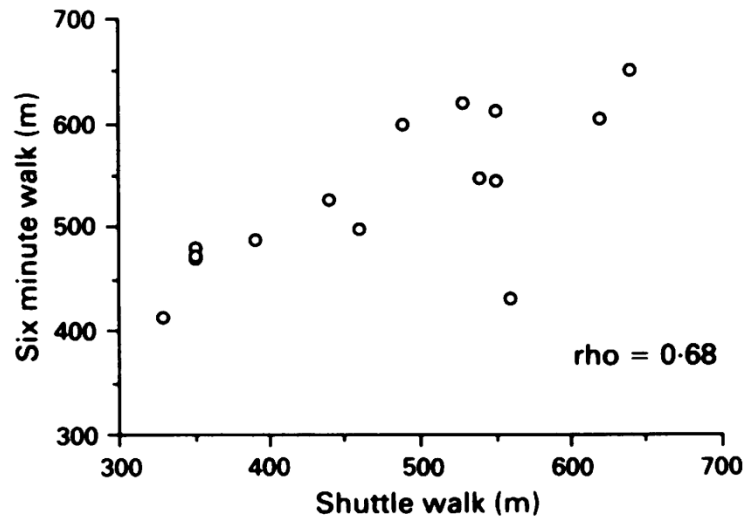
FEV₁ = forced expiratory volume in 1 second; FFM = fat free mass; 6MWD = 6-min walk distance; 6MWW = 6-min walk-work (6MWD in meters multiplied by body weight in kilograms). Height in meters; 6MWD in meters; gender is given a value of 1 for male and 0 for female.

JCRP 2015;35:431-438

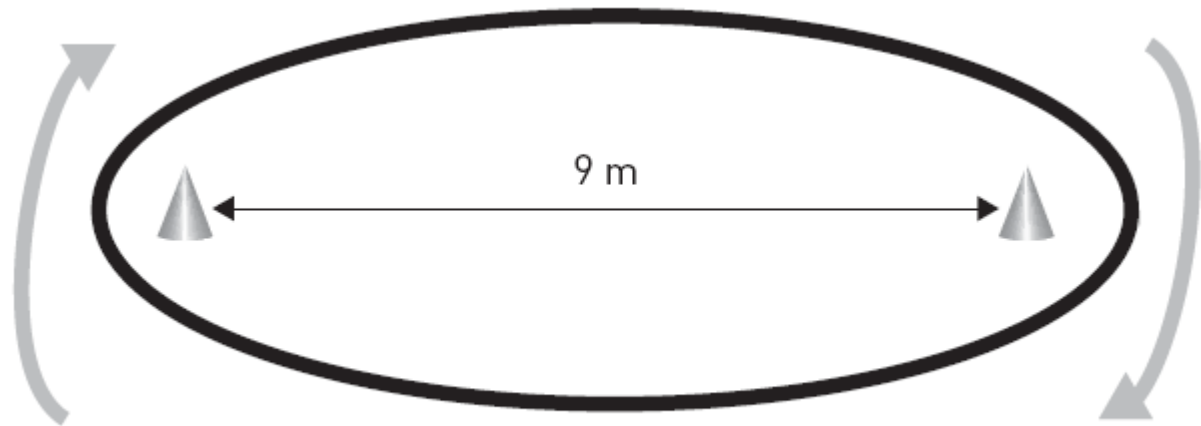
COPD, 2012; 9:281-288

2.4. Shuttle walk test

- 점증부하검사 (Incremental test, ISWT)
 - 10미터 거리의 평지를 미리 녹음된 신호음에 보행 속도를 맞추어 왕복 보행
 - 매 분마다 신호음 속도가 빨라짐(12-level, 0.5~2.37m/s) → 증상이 한계에 이를 때 까지 속도 증가
 - 검사 중단: 호흡곤란($SpO_2 < 85\%$), $HR > 85\%$ predicted max, 보행 속도를 신호음에 맞춰 유지 불가
 - 보행거리가 최대산소섭취량과 상관관계 있음 → 최대운동능력 평가
 - MCID 47.5 meter



Thorax 1992;47:1019-1024



Course layout for the ISWT/ESWT

: Cones are inset 0.5m from either end to avoid abrupt changes in direction.

2.4. Shuttle walk test

- 일정부하검사 (Endurance test, ESWT)
 - 일정한 속도로 걸으면서 지구력을 평가하는 검사
 - 점증부하검사(ISWT)를 통해 최대운동능력을 평가 → **85%** 속도 계산하여 10미터 왕복 보행
 - 변화를 감지하는데 적절 → 추적검사에 용이, 환자의 기능적 상태를 보다 잘 반영함
 - MCID 45~85 second

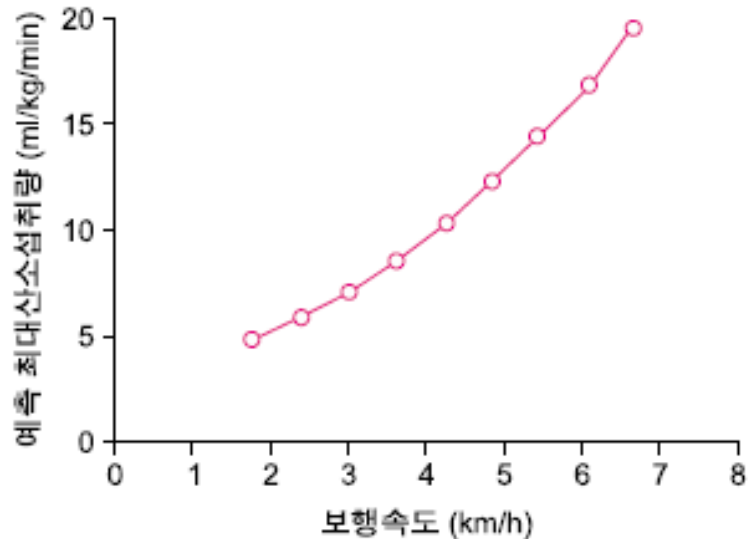


그림 1. 일정부하 셔틀보행검사의 단계 선택방법

Table 3 Patients' responses at the end of the endurance shuttle walk tests

	Time (min)	HR (beats/min)	Borg ratings	
			BS	PE
75% ESWT	13.1 (2.3)	117 (5)	3.9 (0.4)	13.5 (0.6)
85% ESWT	10.2 (2.5)	121 (6)	4.5 (0.6)	13.6 (0.9)
95% ESWT	5.3 (1.7)*	126 (8)†	5.0 (0.5)	14.3 (0.7)

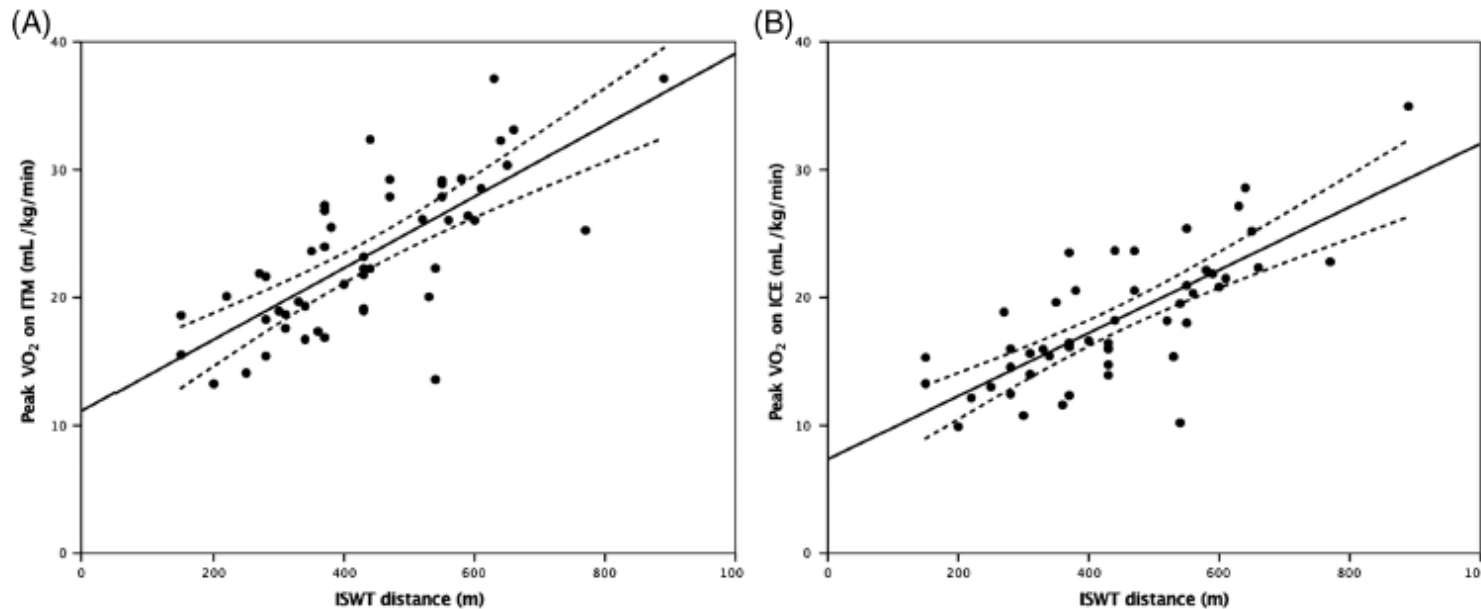
Thorax 1999;54:213-222

Variables influence the walking distance in the ISWT

- The walked distance correlated with
 - age ($r=-0.76$), height ($r=0.49$) and BMI ($r=-0.23$) ($p<0.001$ for all)
 - but not with weight ($r=0.06$, $p=0.315$)
- Gender, age and BMI were independent contributors to the ISWT in healthy subjects, explaining 71% ($p < 0.0001$) of the variability.
- $ISWT_{pred} = 1449.701 - (11.735 \times \text{age}) + (241.897 \times \text{gender}) - (5.686 \times \text{BMI})$
 - male gender=1 and female gender=0

Correlation between ISWT distance with VO_{2peak}

- The ISWT distance showed a strong correlation with VO_{2peak} on ITM ($r = 0.74, P < 0.001$) and ICE ($r = 0.75, P < 0.001$)



A comparison between VO_{2pk} measured on ITM (A) and ICE (B) with the ISWT distance.

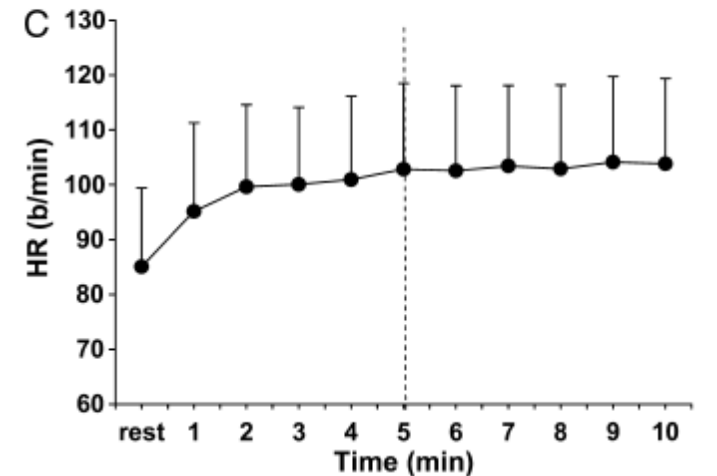
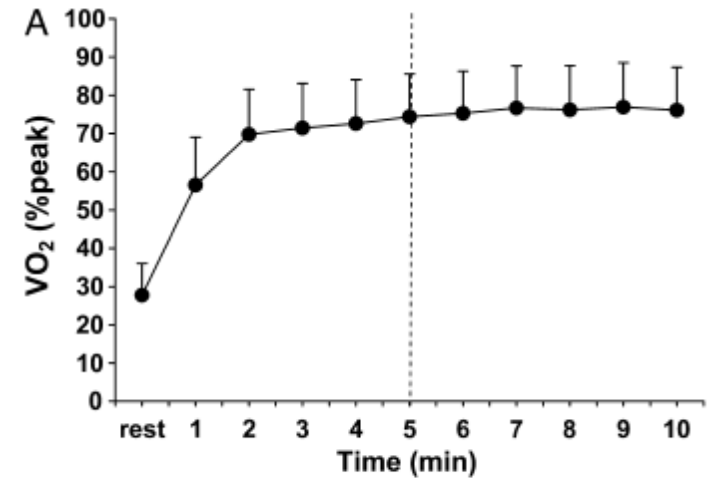
Respirology (2019)

Prescription of walking exercise intensity from ISWT

- Walking exercise training has been recommended to be prescribed
 - at 60%~75% of the peak speed achieved on the ISWT in people with COPD.

TABLE 2 Physiologic responses and symptom scores

Variables ^a	ICT	ISWT	10-min Walking Exercise ^b (70% Peak ISWT Speed)
Walking speed, km/hr	–	5.2 (0.7)	3.6 (0.5)
METs	–	–	3.5 (0.7)
$\dot{V}O_2$, liters/min	1.19 (0.27)	1.22 (0.30)	0.92 (0.23)
$\dot{V}O_2/\dot{V}O_{2peak}$, %	–	–	76 (11) ^c
\dot{V}_E , liters/min	48.3 (12.5)	45.4 (12.5) ^d	34.6 (9.8)
$\dot{V}_E/\dot{V}_{Epeak}$, %	–	–	78 (13)
$\dot{V}CO_2$, liters/min	1.17 (0.34)	1.06 (0.34) ^d	0.74 (0.21)
\dot{V}_E/MVV , %	99 (29)	94 (31) ^d	73 (28)
HR, beats/min	115 (20)	116 (19)	103 (16)
SpO ₂ , %	94.2 (5.6)	91.7 (5.9) ^d	92.9 (5.5)
Dyspnea score, CR 0–10	5 (2)	3 (2) ^d	2 (2)
RPE, CR 0–10	6 (2)	2 (2) ^d	2 (2)



Field walking tests in chronic respiratory disease

	Correlation	Learning effect	Influenced by	Associated outcome	MID
6MWD (meter) : <i>self-paced timed walking test</i>	VO _{2peak} Peak work capacity(r=0.59- 0.93) Physical activity(r=0.40-0.85) Resp. function(r=0.10-0.59)	(+)	Course layout, track length, encouragement, walking aids, supplement O2	Risk of mortality (COPD, ILD), hospitalization Sensitive to change of rehab (mod to high)	25~33m (chronic resp. disease)
ISWT (meter) : <i>externally paced walking test</i>	VO _{2peak} and work rate on CPET(r=0.75-0.88)	(+)	Supplement O2	Risk of mortality (COPD) Sensitive to change of rehab (mod to high), bronchodilator	47.5m
ESWT (second)		?	Supplement O2	Sensitive to change of rehab (mod to high)	65s or 85m after bronchodilation (preliminary) 180s after PR

2.5. Incremental maximal exercise test

- Treadmill, ergometer, 증상이 한계에 이를 때 까지 운동 강도 증가
→ 최대 운동능력 측정
- Gold standard assessment of exercise capacity
 - VO_{2pk} during maximal CPET with expired gas analysis
 - 반응평가: 심전도, 혈압, 맥박, 산소포화도/증상(호흡곤란, 피로도): Borg척도
 - More accurate quantification of the work rate / Less space required
- MID : 4 ± 1 watt (severe COPD, Eur Respir J 2011; 37: 784–790)



	자전거 에르고미터	트레드밀
최대산소섭취량	보다 낮음	보다 높음
운동량 측정	가능	불가능
혈액가스분석	보다 용이함	보다 어려움
소음(noise)과 허상(artifacts)	보다 적음	보다 많음
안전성	보다 안전	
체중부하	보다 적음	보다 많음
하지근육 훈련정도	보다 적음	보다 많음
적합한 대상자	환자	정상인

2.5. Incremental maximal exercise test

TABLE 4 Absolute and relative contraindications for field walking tests

Absolute	Relative
Acute myocardial infarction (3–5 days)	Left main coronary stenosis or its equivalent
Unstable angina	Moderate stenotic valvular heart disease
Uncontrolled arrhythmias causing symptoms or haemodynamic compromise	Severe untreated arterial hypertension at rest (200 mmHg systolic, 120 mmHg diastolic)
Syncope	Tachyarrhythmias or bradyarrhythmias
Active endocarditis	High-degree atrioventricular block
Acute myocarditis or pericarditis	Hypertrophic cardiomyopathy
Symptomatic severe aortic stenosis	Significant pulmonary hypertension
Uncontrolled heart failure	Advanced or complicated pregnancy
Acute pulmonary embolus or pulmonary infarction	Electrolyte abnormalities
Thrombosis of lower extremities	Orthopaedic impairment that prevents walking
Suspected dissecting aneurysm	
Uncontrolled asthma	
Pulmonary oedema	
Room air SpO ₂ at rest ≤ 85%#	
Acute respiratory failure	
Acute noncardiopulmonary disorder that may affect exercise performance or be aggravated by exercise (<i>i.e.</i> infection, renal failure, thyrotoxicosis)	
Mental impairment leading to inability to cooperate	

Eur Respir J 2014; 44: 1428–1446

2.6. Submaximal exercise test

- Treadmill, ergometer 이용
- 최대 운동속도의 약 60-80%로 일정하게 운동 지속 → 운동지속시간 및 지구력을 측정

- 호흡재활의 효과 평가
- 일상생활동작에서 산소공급이 필요한지 평가
- 심한 폐고혈압 또는 심부전이 있거나 최대운동부하가 금기인 환자 등에도 적용 가능

- Modified Bruce treadmill test
- Single-stage submaximal treadmill walking test
- Astrand and Ryhming cycle ergometer test

2.7. Other simple lower limb functional tests

- Gait speed test
 - Easy to perform and requires simple and inexpensive equipment
 - Shorter courses (4m) are more suitable when assessing patients with severe disability
- Timed up and go(TUG) test
 - The most appropriate among these 4 tests used to assess functional mobility and to objectively detect balance impairment and risk of falling in patients with COPD
- Sit-to-stand(STS) test
 - Evaluates a common activity in daily life
 - Should be considered in situations where space is restricted
 - Screening patients with poor physical functioning
 - Strong predictor of 2yr death in COPD
- Step test
 - Easy to standardize
 - Evaluates a type of daily activity other than the ability to walk in patients with COPD
 - Incremental protocols → to prescribe intensity, speed, or workload in an exercise training

Comparison of laboratory- and field-based exercise tests for COPD: a systematic review

- Repeatability
 - Significant increase in 6MWT distance from the first to the second test
- Reproducibility
 - Good reproducibility in distances achieved in the 6MWT between the first and second tests
- Responses to interventions
 - Pulmonary rehabilitation: 6MWT, ITT, ETT, ISWT, ESWT
 - Bronchodilator: 6MWT > 12MWT, ISWT/ ECET > 6MWT, ICET, ETT / ESWT > 6MWT
- MCID in responses to interventions
 - 6MWT: 26m
 - ISWT: 48m
 - ESWT: 45~85s, or 60~115m (after bronchodilatory intervention)
 - ICET: 4watts

Systematic Review of the Association Between Field-Based Exercise Tests and Lung Function in Chronic Obstructive Pulmonary Disease

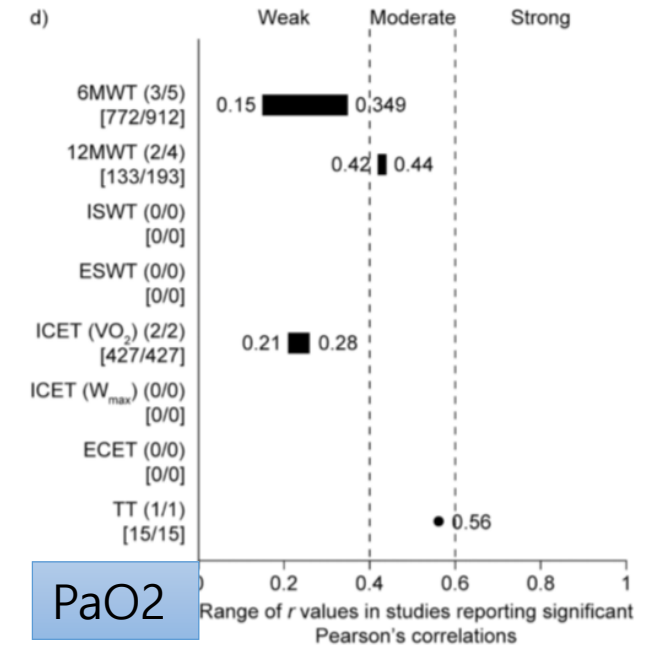
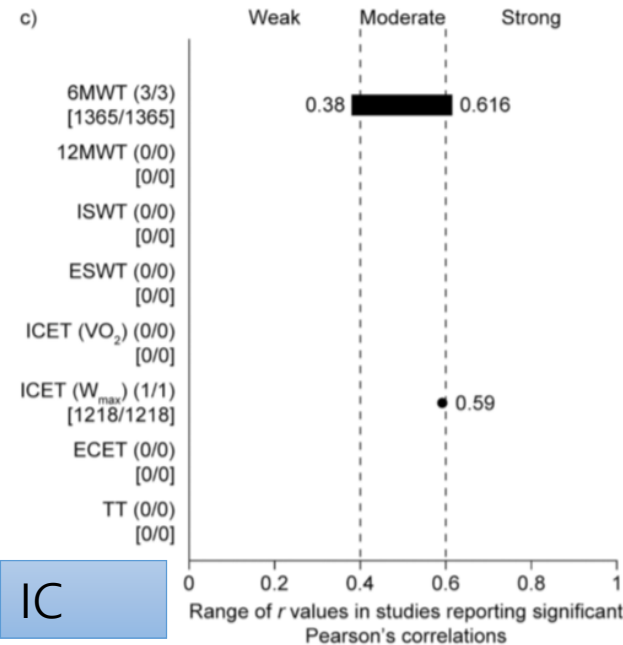
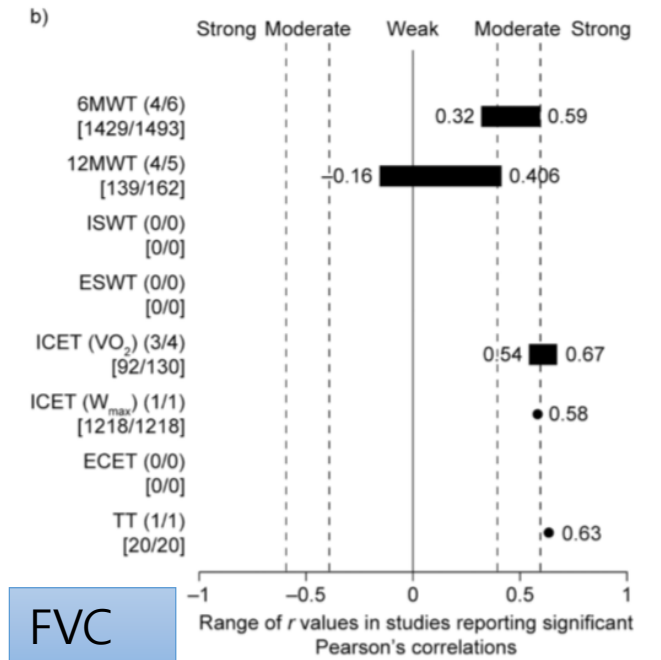
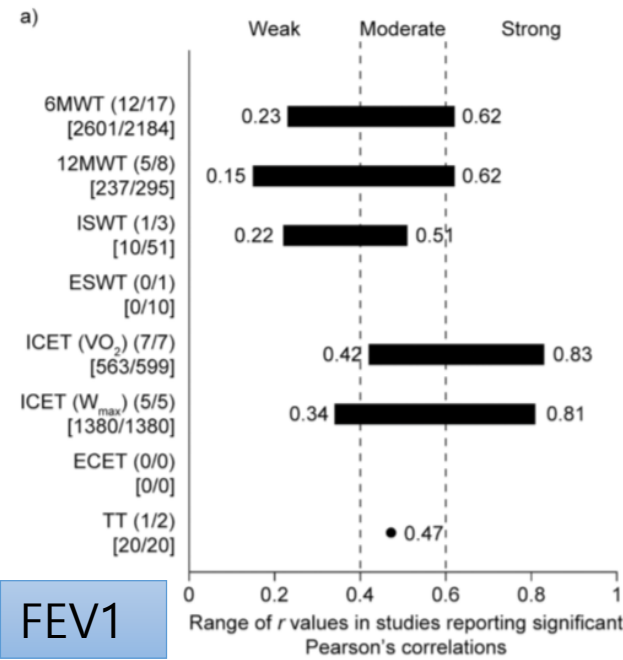
Martin Bell, PhD¹ Iain Fotheringham, BA¹ Yogesh Suresh
 Sarah Cockle, PhD² Sally J. Singh, PhD³

- FEV1, FVC, Inspiratory capacity, PaO2
- 6MWT, 12MWT, ISWT, ESWT, ICET, ECET, treadmill tests

FEV1

- ✓ Moderately-to-strongly correlates with 6MWT, 12MWT and ICET

Chronic Obstr Pulm Dis (Miami). 2015; 2(4): 321-342.



Systematic review of the association between exercise tests and patient-reported outcomes in patients with chronic obstructive pulmonary disease

SGRQ

- ✓ Very weakly to moderately correlates with the 6MWT
- ### Breathless PROs
- ✓ Moderately to strongly associated with 6MWT outcomes

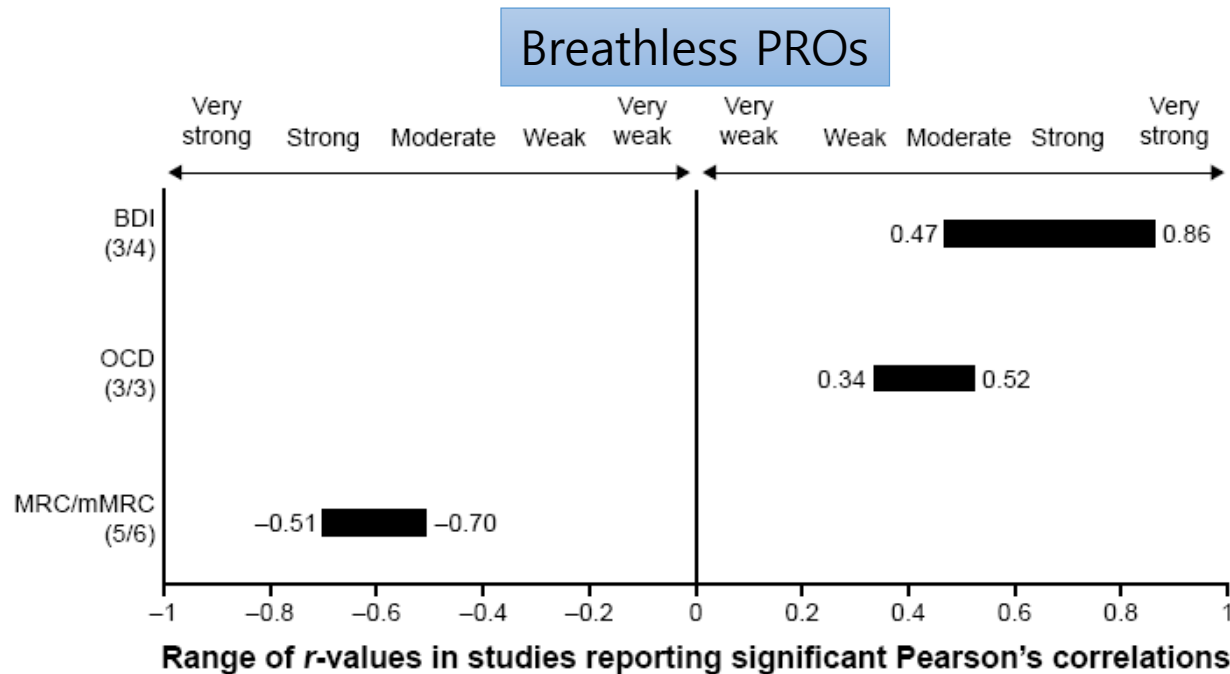


Figure 3 Pearson's correlations in studies reporting significant associations between the 6-minute walk-test outcomes and breathlessness PROs.

SGRQ

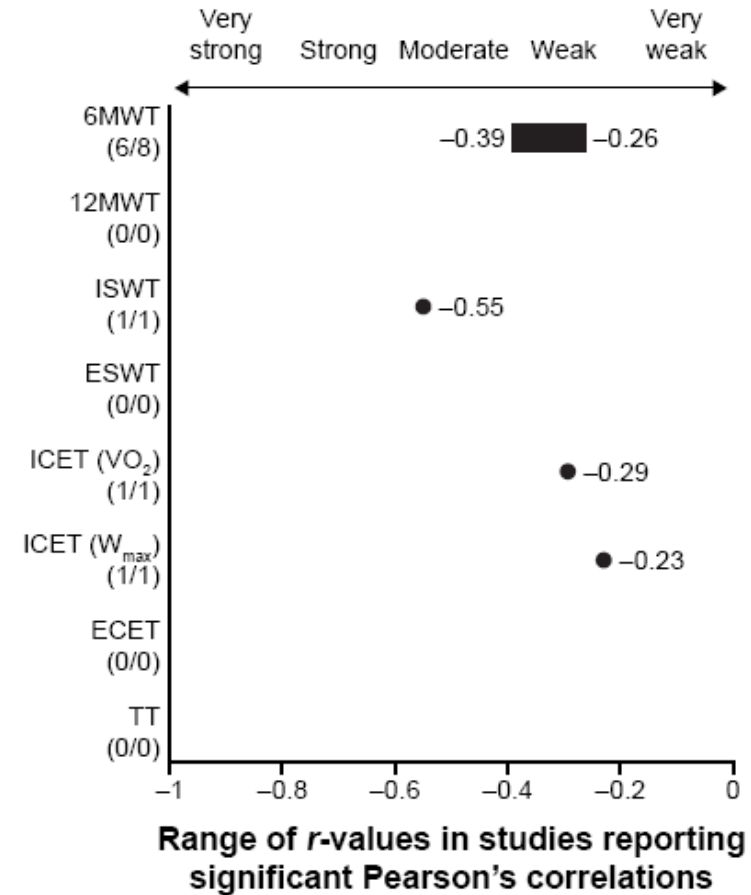


Figure 2 Pearson's correlations in studies reporting significant associations between exercise test outcomes and SGRQ.

Take home message

- Exercise intolerance in COPD
- Assessment of symptoms
 - Dyspnea, fatigue, quality of life
- Assessment of physical activity
 - Purpose
 - Questionnaires
 - Motion sensors
 - Walk distance tests
 - 6- or 12- minute walk tests (6MWT, 12MWT)
 - Incremental and endurance shuttle walk tests (ISWT, ESWT)
 - Incremental maximal exercise test
 - Submaximal exercise test





THANK YOU FOR YOUR ATTENTION!