Inspiratory Muscle Training

호흡재활에서의 역할

이세원

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COPD: Definition

"a **preventable and treatable** disease with some significant **extrapulmonary** effects that may contribute to the severity in individual patients. Its pulmonary component is characterised by

airflow limitation that is not fully reversible.

The airflow limitation is usually **progressive** and associated with **abnormal inflammatory response of the lung to noxious particles or gases**"

Global Strategy for the Diagnosis, Management, and Prevention of Chronic Obstructive Pulmonary Disease, Global Initiative for Chronic Obstructive Lung Disease (GOLD) **2010**. Available from www.goldcopd.com

1975년
Atrovent

1981년
Ventolin

2000년
Seretide
Symbicort

2005
Spiriva
Handihaler

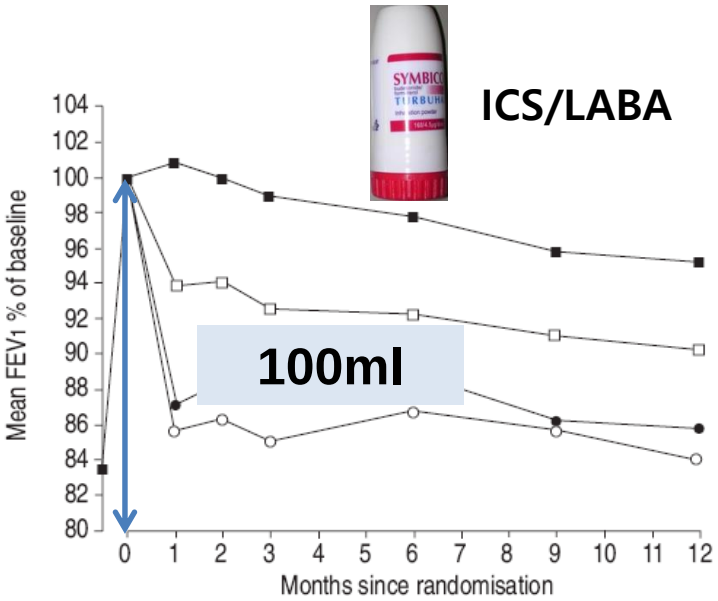
2010년
Onbrez

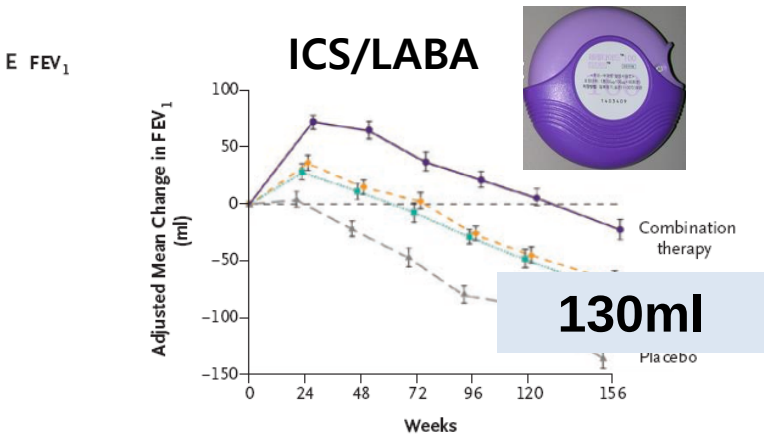
2011년
Spiriva
Respimat

2014년
Flutiform

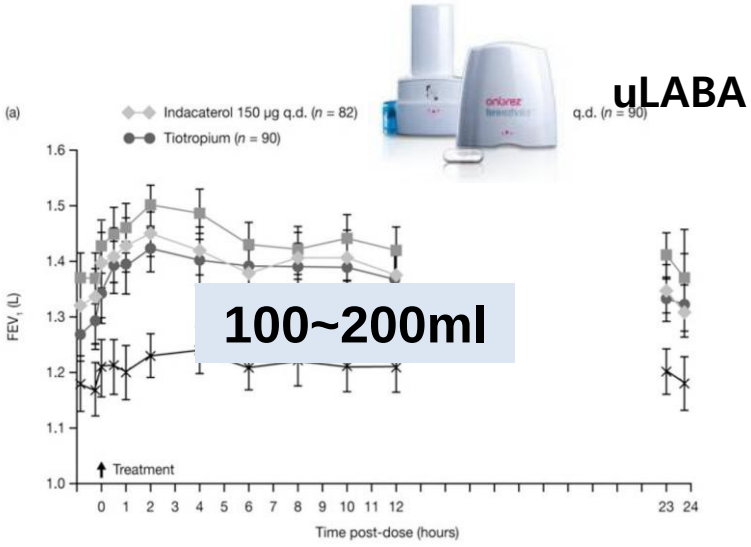
2015년
Anoro
Eklira
Duaklir
Xoterna
Relvar

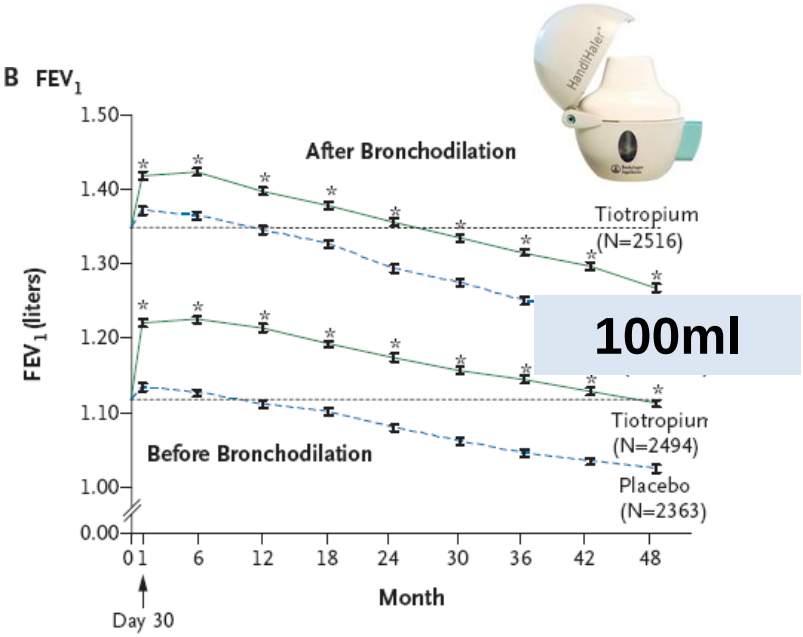
2016년
symbicort rapihaler
Vahalvar respimat
Incruz

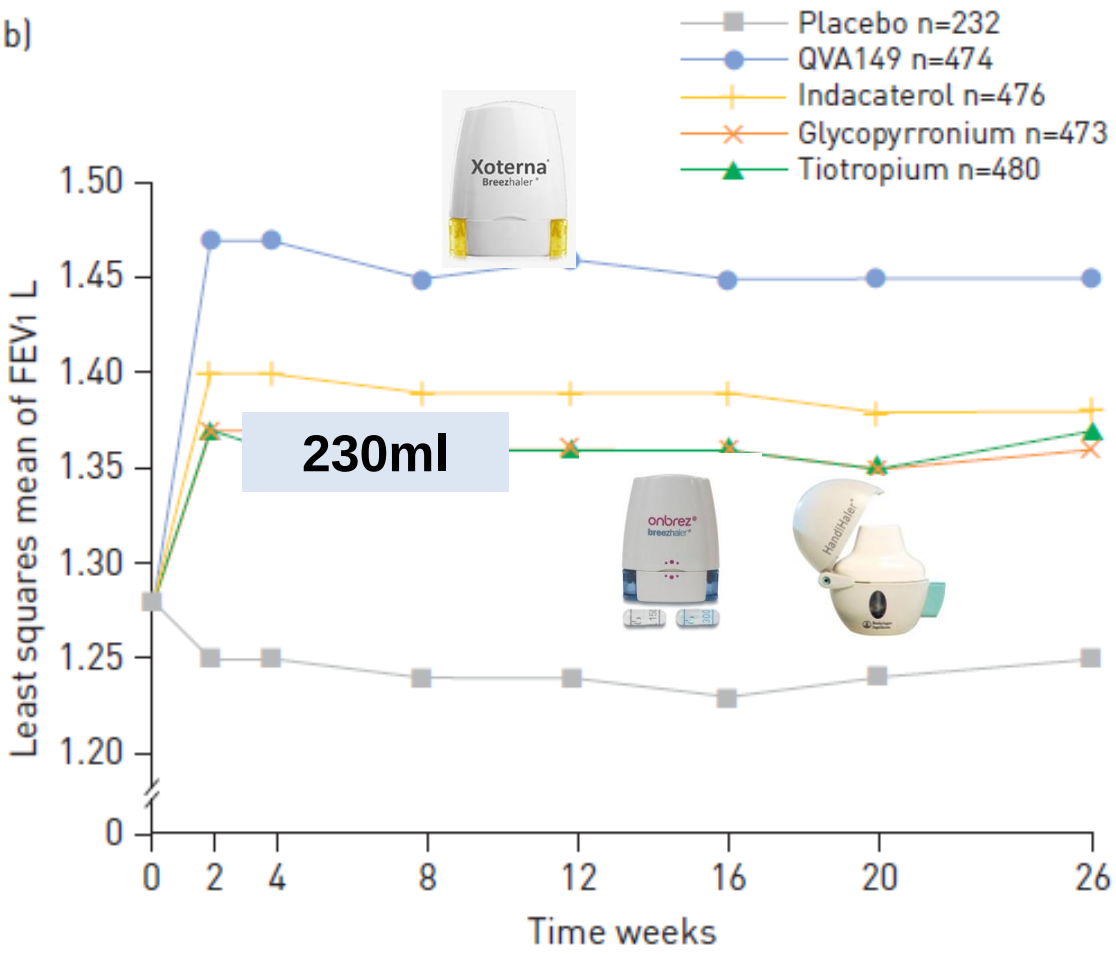




No. of Patients							
Placebo	1524	1248	1128	1049	979	906	819
Salmeterol	1521	1317	1218	1127	1054	1012	934
Fluticasone	1534	1346	1230	1157	1078	1006	908
Combination therapy	1533	1375	1281	1180	1139	1073	975







LAMA+LABA

LAMA or LABA

Placebo

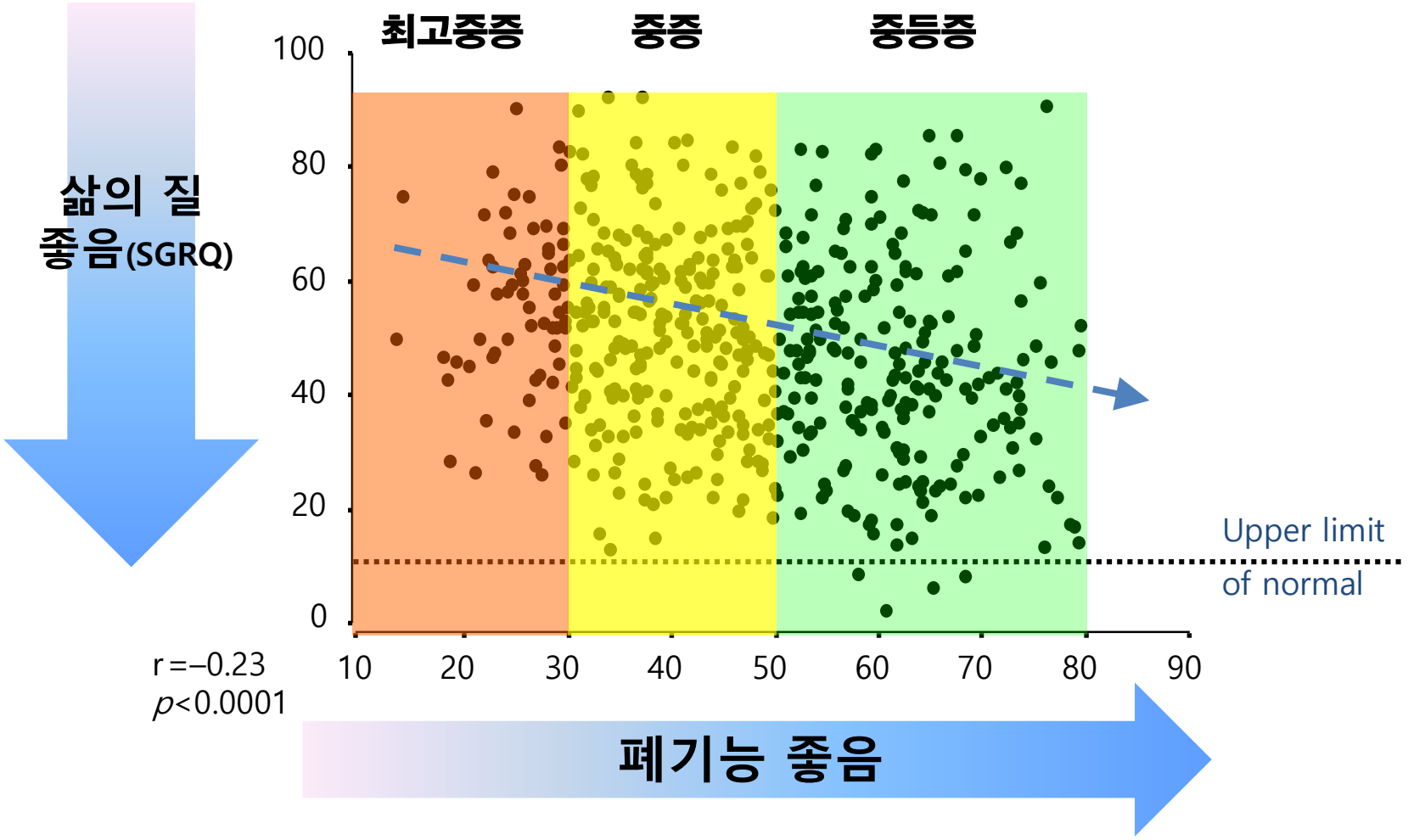
Eur Respir J 2013; 42: 1484–1494

COPD를 흡입제로 완치시킬 수 없다

metry	(BTPS)	PRED	PRE-RX BEST	%PRED
FVC	Liters	3.68	3.39	92
FEV1	Liters	2.44	0.99	40
FEV1/FVC	%	69	29	
FEF25-75%	L/sec	2.28	0.20	9
IsoFEF25-75	L/sec	2.28	0.20	9
FEF75-85%	L/sec	0.37	0.10	28
PEF	L/sec	7.17	2.36	33
FET100%	Sec		20.98	
FIVC	Liters	3.68	2.54	69

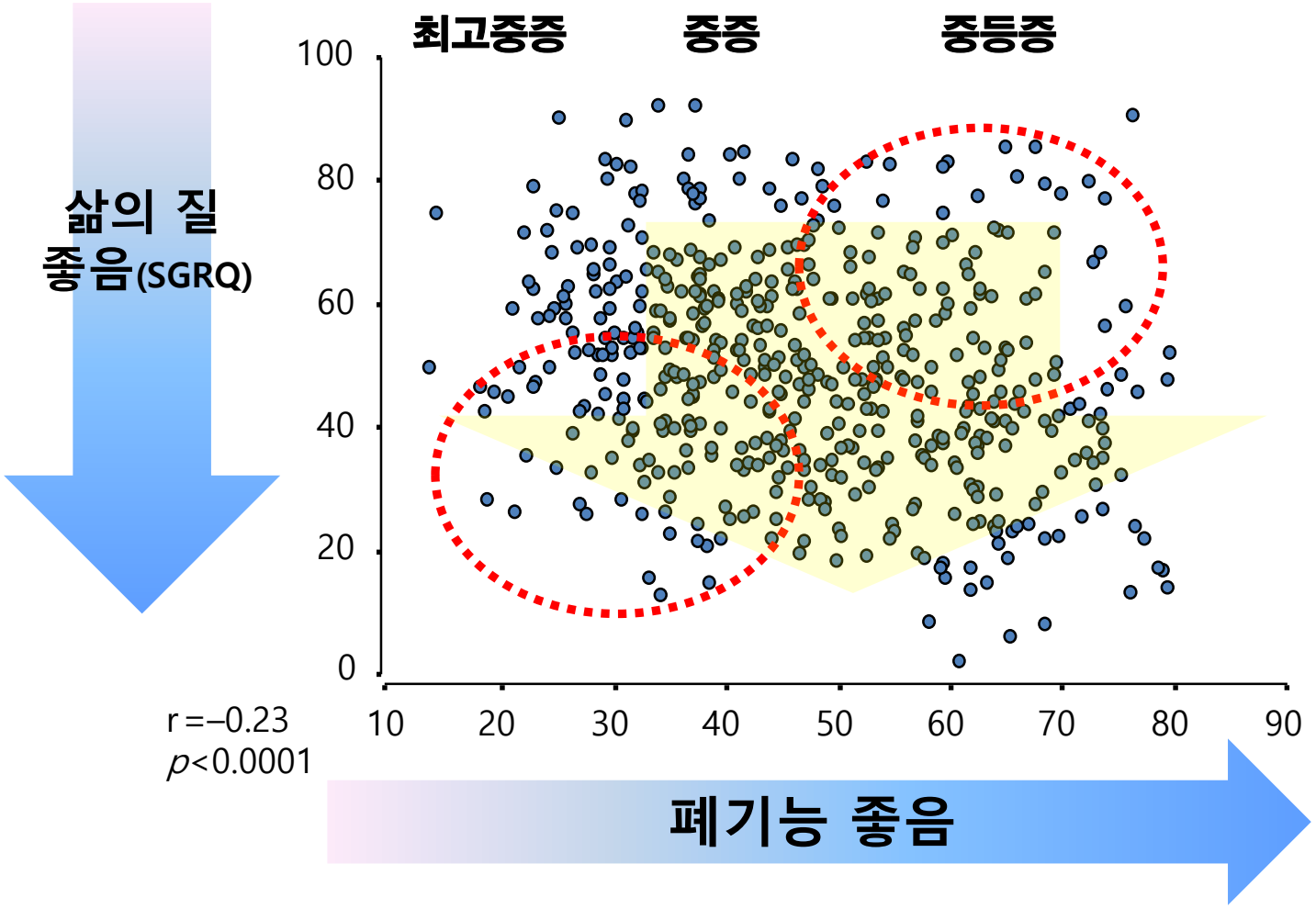
1450ml

건강 상태 (삶의 질)과 폐기능



Am Rev Respir Dis 1992;145:1321–1327

건강 상태 (삶의 질)과 폐기능: 약한 관련



Am Rev Respir Dis 1992;145:1321–1327

COPD의 예후에 중요한 지표

폐기능

나이

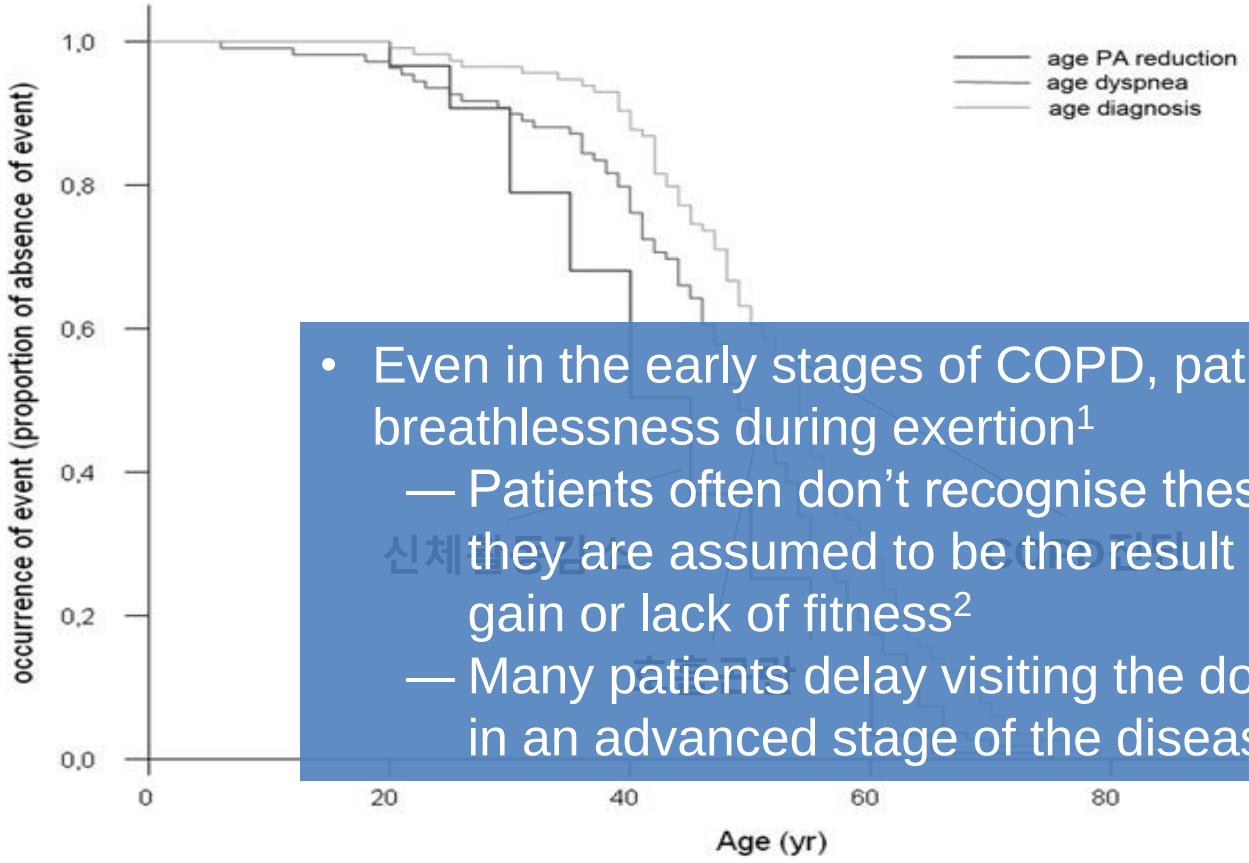
체질량 (체중)

증상: 호흡곤란

운동능력: 6분 보행거리 (m)

N Engl J Med 2004;350:1005-12.

신체 활동 감소는 호흡곤란 COPD 진단에 앞서 나타난다



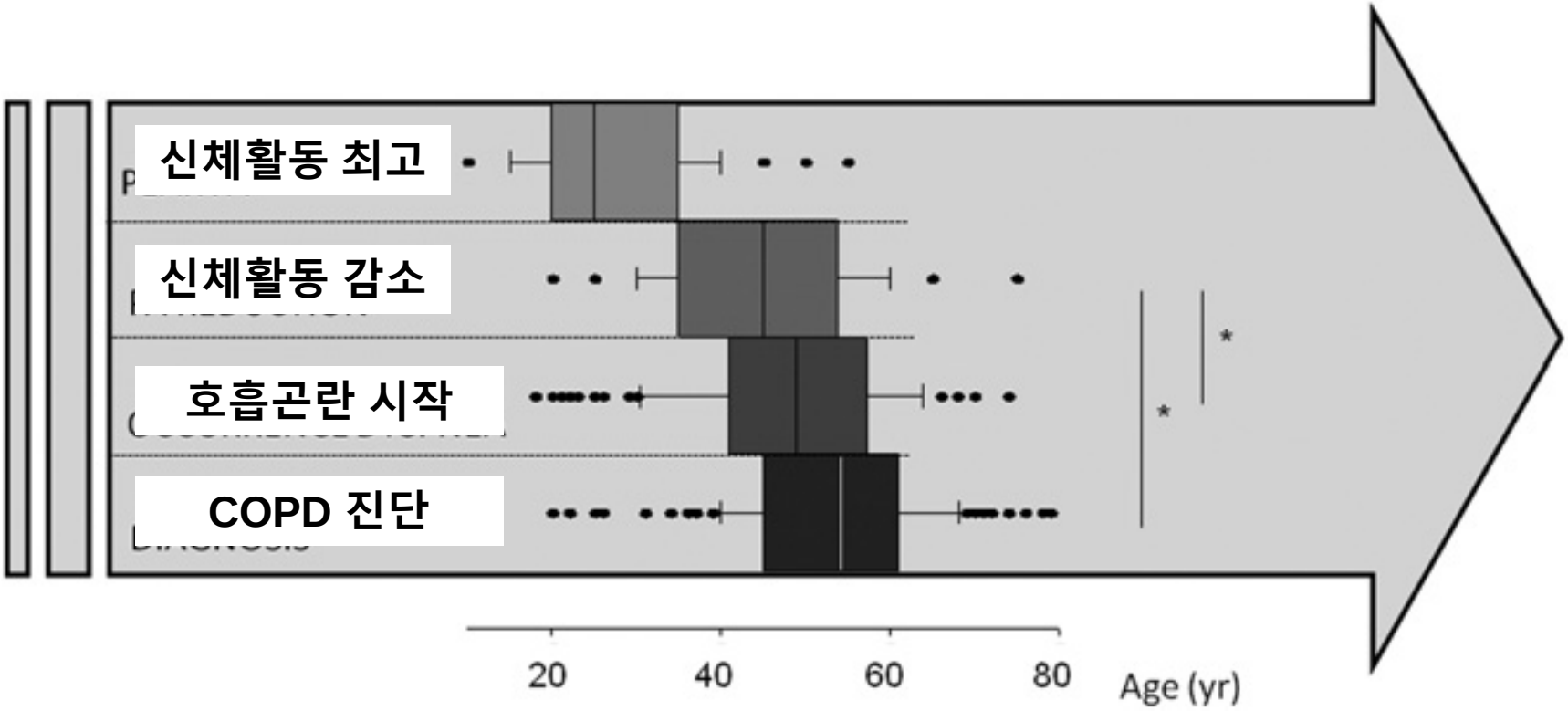
- Even in the early stages of COPD, patients experience breathlessness during exertion[1]
  - Patients often don't recognise these early symptoms; they are assumed to be the result of ageing, weight gain or lack of fitness[2]
  - Many patients delay visiting the doctor until they are in an advanced stage of the disease[2]

호흡재활에 참여한 **COPD 120**명 설문 조사 연구

1. O'Donnell 2014; 2. Price 2011;
3. Watz 2009; 4. Troosters 2010

Arch Phys Med Rehabil 2011;92: 1611-7.

신체 활동 감소는 호흡곤란 COPD 진단에 앞서 나타난다

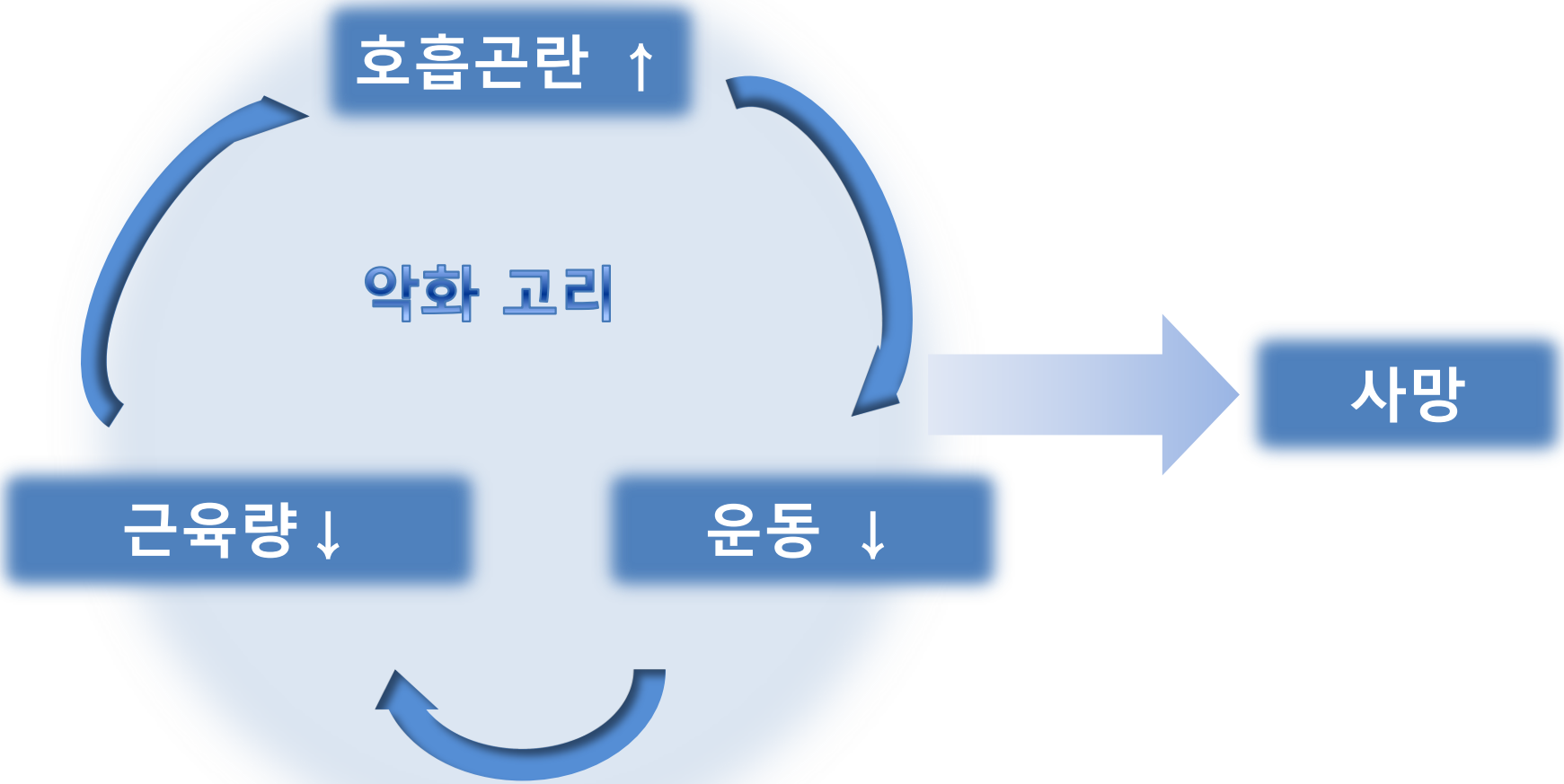


호흡재활에 참여한 **COPD 120**명 설문 조사 연구

1. O'Donnell 2014; 2. Price 2011;
3. Watz 2009; 4. Troosters 2010

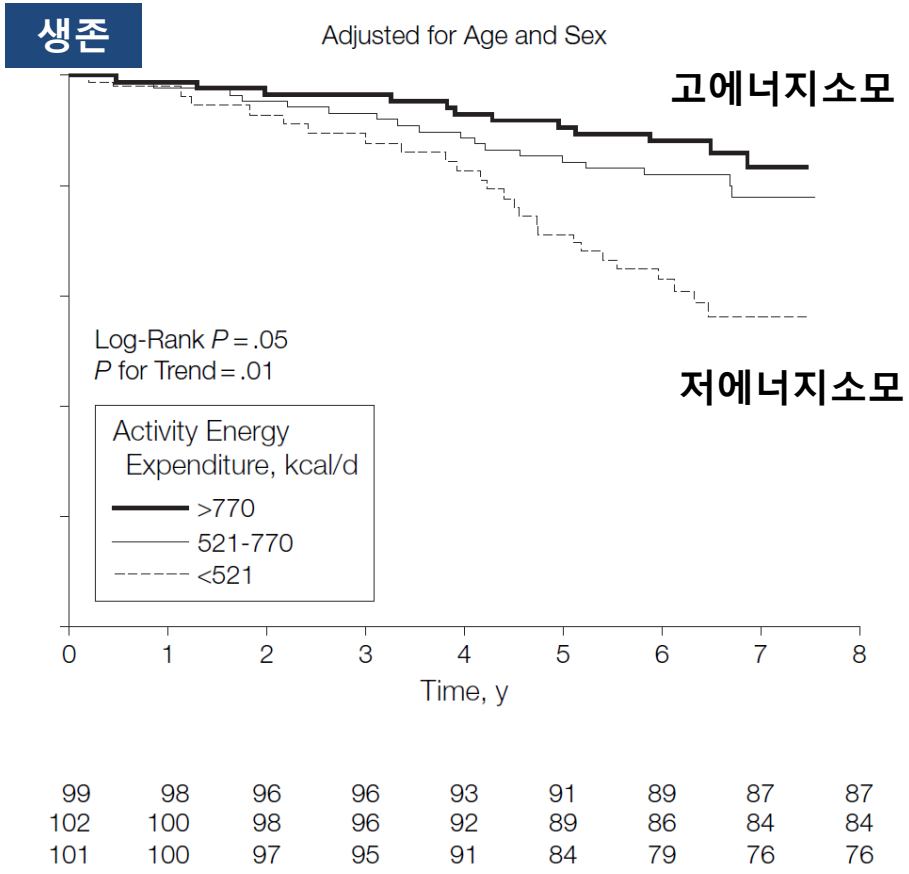
Arch Phys Med Rehabil 2011;92:
1611-7.

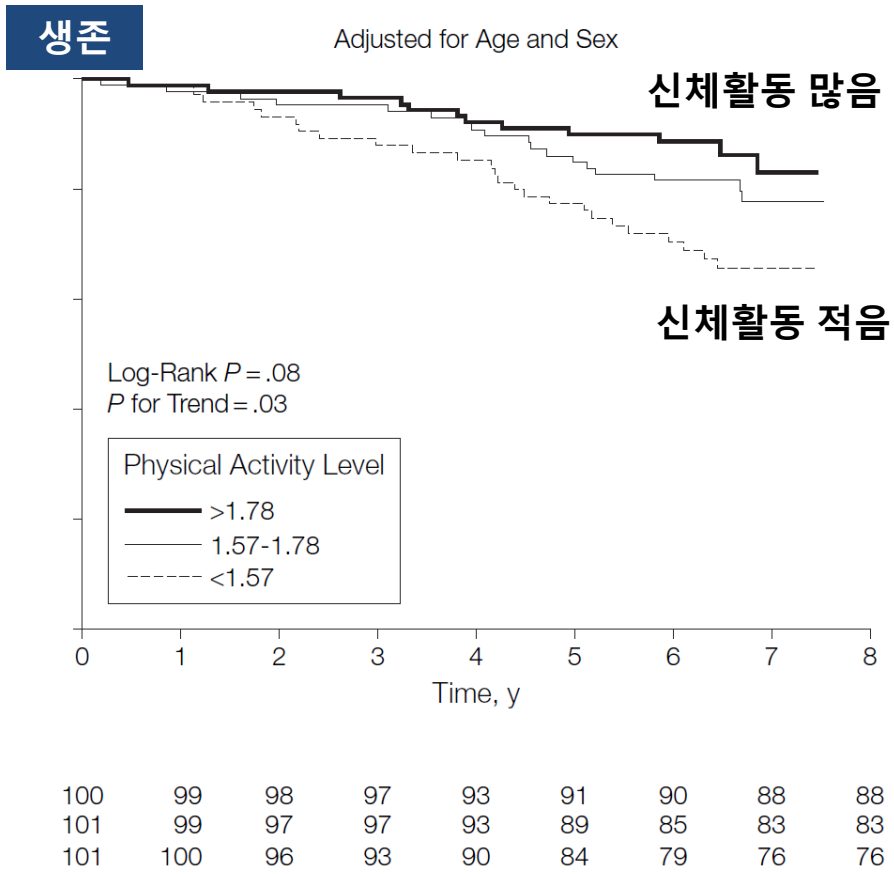
COPD 환자의 악화 고리



활동적인 노인이 오래 산다

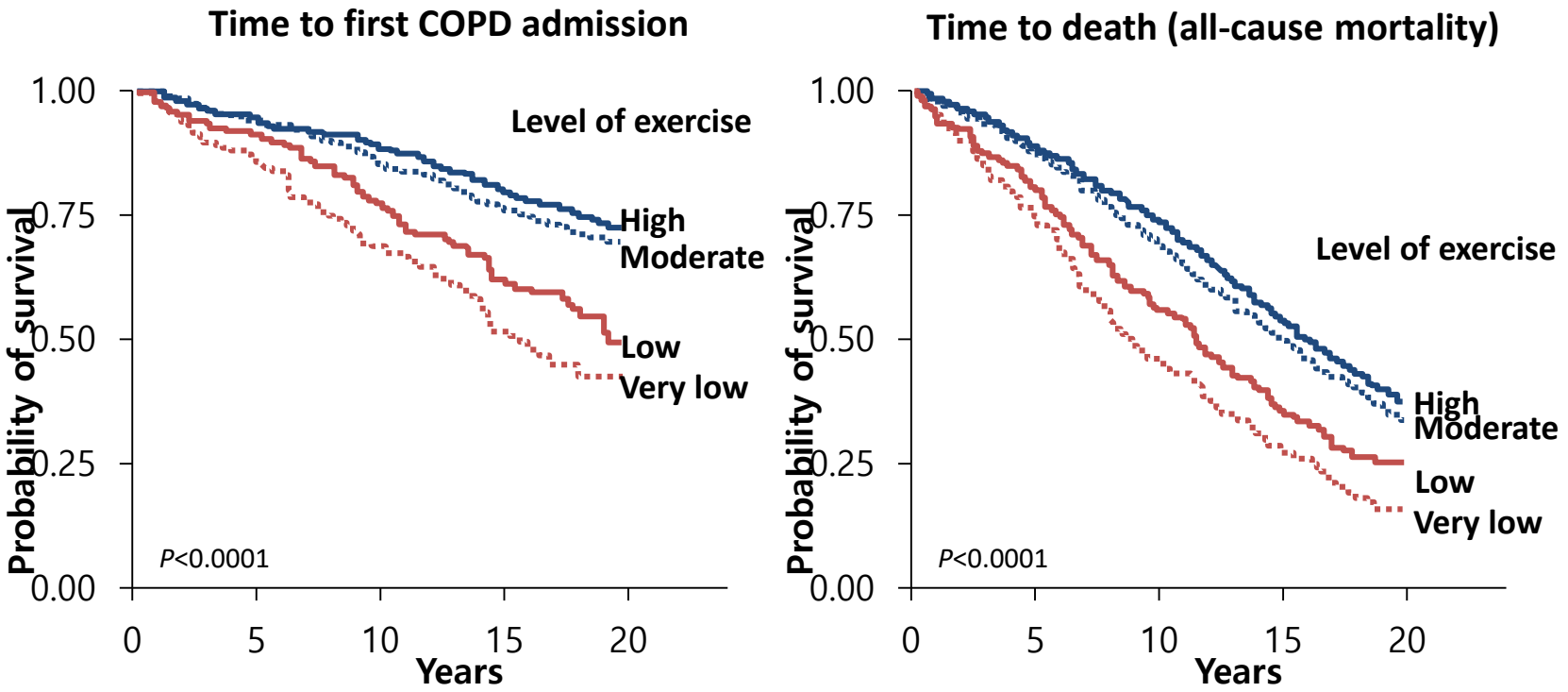
- 302명의 Community 70-82세 노인 관찰 연구
- 6.15년 관찰 기간 동안 18.73% 사망





JAMA. 2006;296:171-179

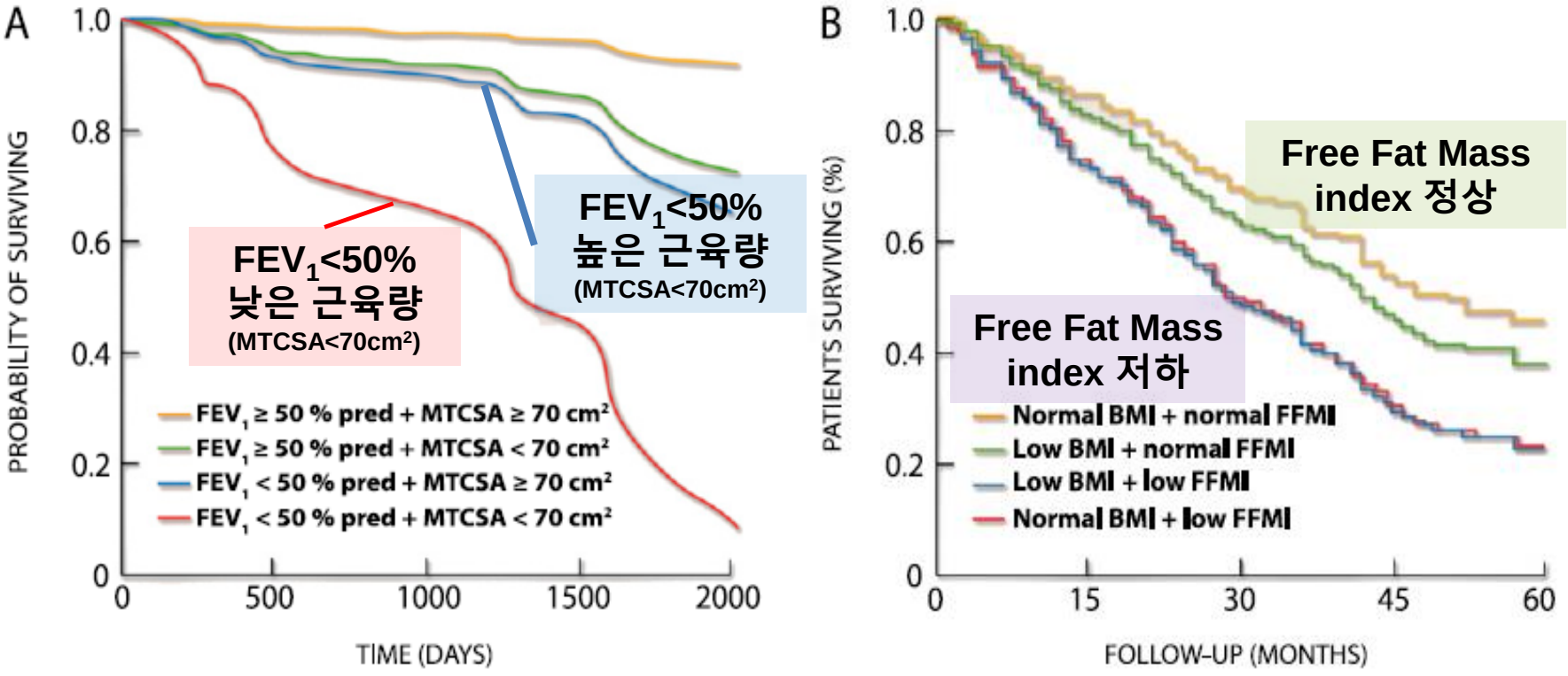
운동량이 많으면 입원율 사망률 감소



Physical inactivity is an important predictor of the risk of developing several chronic diseases, including COPD
In patients with COPD, regular exercise lowers the risk of both hospital admissions and mortality
Patients with COPD should be encouraged to maintain or increase their levels of regular physical activity

Garcia-Aymerich J, et al. Thorax 2006; 61: 772–778

근육량이 생존율과 연관



ATS documents 2014

신체 활동은 흡연자에서 폐기능 감소 줄여 COPD 진행을 막음

폐기능 감소

		Active Smokers (n = 3,654)§		Former Smokers (n = 1,393)§	
	n§	Coefficient (95% CI)	*P* Value	Coefficient (95% CI)	*P* Value
Physical activity					
Low (reference)	1,035	−20.3		−9.9	
Moderate	2,418	2.6 (−1.0 to 6.2)	0.159	−2.0 (−8.7 to 4.6)	0.550
High	3,166	4.8 (1.3 to 8.3)	0.008	2.4 (−4.8 to 5.1)	0.672
P for linear trend			0.006		0.852

신체 활동을 늘리면,

COPD 이환율 사망률 악화 감소

COPD 발병위험도

	All Subjects (n = 5,780)†		Former Smokers (n = 1,243)†		Active Smokers (n = 3,079)†	
	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Physical activity						
Low	1.00		1.00		1.00	
Moderate	0.78 (0.63–0.98)	0.031	1.00 (0.52–1.95)	0.994	0.76 (0.59–0.99)	0.038
High	0.81 (0.65–1.01)	0.065	1.20 (0.63–2.27)	0.584	0.77 (0.60–0.99)	0.047
Physical activity						
Low	1.00		1.00		1.00	
Moderate and High	0.80 (0.65–0.98)	0.030	1.11 (0.60–2.05)	0.740	0.77 (0.61–0.97)	0.027

Am J Respir Crit Care Med Vol 175. pp 458–463, 2007

COPD에서 호흡재활의 효과

Evidence A

운동능력 향상

호흡곤란 개선

삶의 질 개선

입원 횟수 및 일수 감소

COPD 관련 걱정 우울 감소

Evidence B

생존율 향상

호흡재활 보험고시 (2016)

소요시간

60분

수가

45,590원 (현재)

33,850원 (2016)

소요장비

호흡재활 보험고시 (2016)

대상

만성폐쇄성폐질환

기관지확장증

천식

폐동맥고혈압

간질성폐질환

결핵성폐질환

폐암 및 폐암의 수술 전후

폐이식 폐용적감소수술

제한성폐질환

(전후척추측만증)

*호흡곤란, 일상생활 어려움

소요인력

의사 간호사 물리치료사

내용

호흡재활 전문의사
환자의 운동능력과 호흡곤란 정도,
기저질환 및 동반질환을 고려
개인별 맞춤 운동프로그램
유산소 운동 :
- 최대운동능력의 60% 이상의 강도
- 20~60분의 운동
- 주 3~5회시행
- 고강도 운동이 불가능한 환자에서는 저강도 운동

근력 운동 :
- 최대 근력의 60~70%의 강도
- 1세트 10회 이상
- 세트 2~3회 시행

Inspiratory Muscle Training: 이론적 배경

Respiratory muscle weakness is observed in COPD patients and contributes to hypercapnia, dyspnea, nocturnal oxygen desaturation and reduced walking distance.

During exercise it has been shown that diaphragm work is increased in COPD.

COPD patients use a larger proportion of the maximal inspiratory pressure (PI max) than healthy subjects.

This pattern of breathing is closely related to the dyspnea sensation during exercise and might potentially induce respiratory muscle fatigue

Pulmonary rehabilitation in the treatment of chronic obstructive pulmonary disease. Am Fam Physician. 2010; 82(6): 655-660.
Maximal transrespiratory pressures in obstructive lung disease. Bull Eur Physiopathol Respir. 1980; 16: 479-490.
Diaphragm strength in chronic obstructive pulmonary disease. Am J Respir Crit Care Med. 1996; 154: 1310-1317.

Inspiratory Muscle Training: 효과?

Recommendation	*Strength of evidence*
Lower-extremity exercise training should be a mandatory component of pulmonary rehabilitation.	Strong evidence; strong recommendation
Low- and high-intensity exercise training produces clinical benefits for patients with COPD.	Strong evidence; strong recommendation
Lower-extremity exercise training performed at a high level of intensity produces greater physiologic benefits than lower-intensity training.	Moderate evidence; strong recommendation
Unsupported upper-extremity endurance training should be included in pulmonary rehabilitation exercise programs.	Strong evidence; strong recommendation
Including a strength training component in a	Strong evidence; strong
component of pulmonary rehabilitation.	; strong recommendation

There is no evidence to support the routine use of inspiratory muscle training as an essential component of pulmonary rehabilitation.

Am Fam Physician. 2010;82(6):655-660

IMT device type: MTL vs. TFRL

Mechanical Threshold Loading (MTL)

A

Original model

POWERbreathe™
MEDIC
(10-90cmH2O)

B

New model

POWERbreathe™
MEDIC PLUS
(1,3,9 -78cmH2O)

Tapered Flow Resistive Loading (TFRL)

C

POWERbreathe™
K3
(3 -200cmH2O)

D

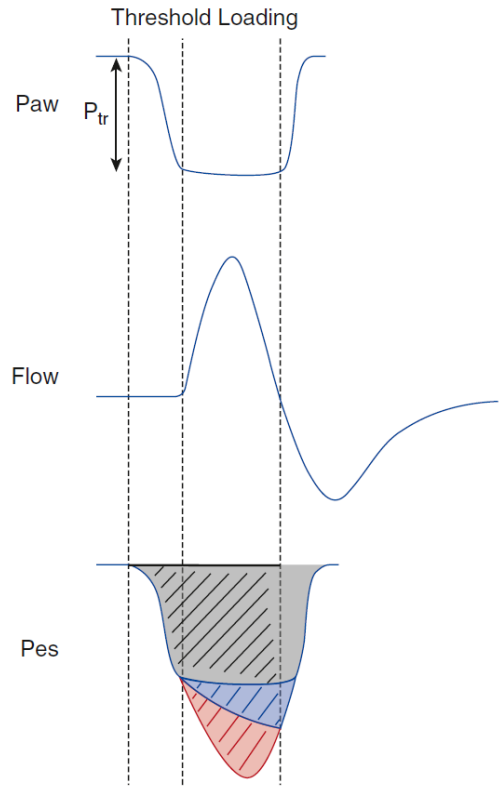
POWERbreathe™
KH2 PC software
(3 -200cmH2O)

IMT device type: MTL vs. TFRL

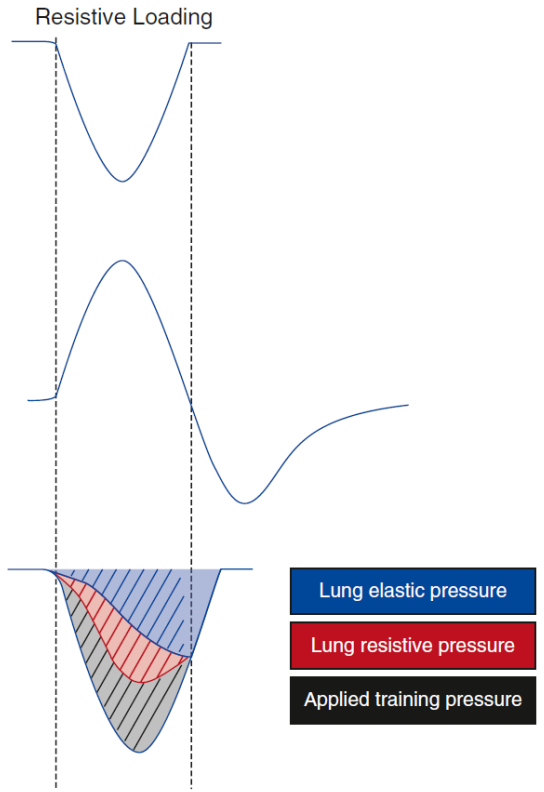
Mechanical Threshold Loading (MTL)	Tapered Flow Resistive Loading (TFRL)
41~90 cmH_2O,	Tapered resistance
Constant load	Electronically controlled
고강도 training 프로그램을 견딜 수 있는 사람	Dynamically adjusted valve
9만 7천원 (3가지 종류)	130만원

IMT device type: MTL vs. TFRL

Mechanical Threshold Loading (MTL)

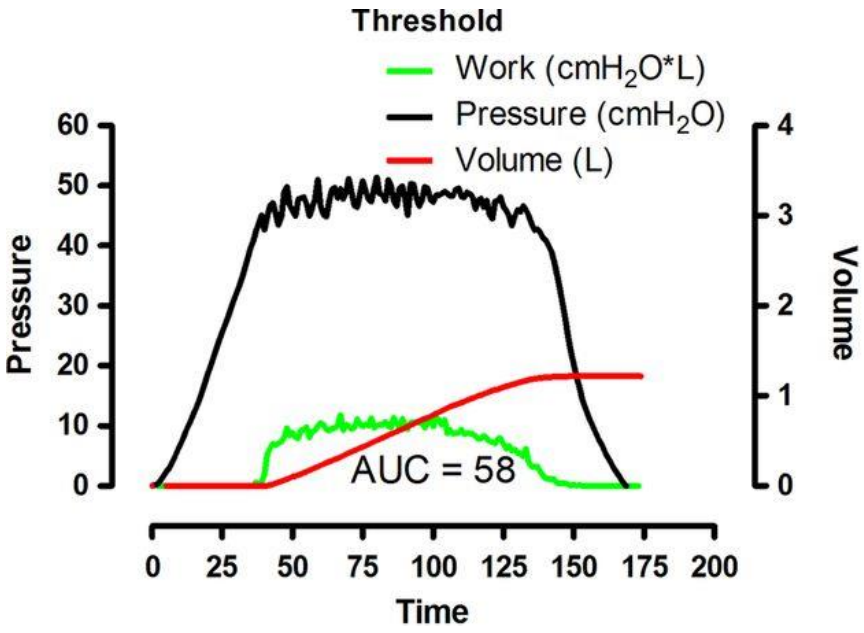


Tapered Flow Resistive Loading (TFRL)

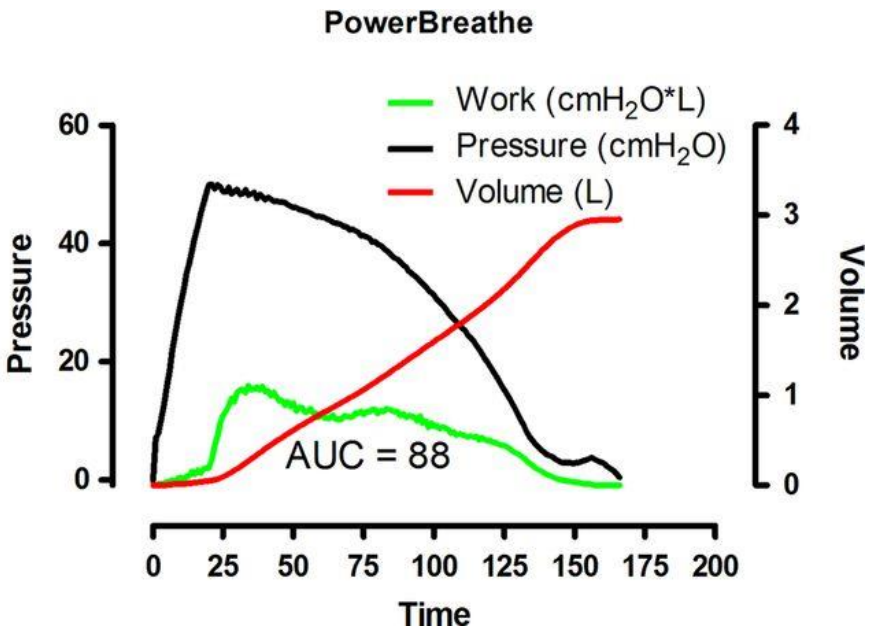


IMT device type: MTL vs. TFRL

Mechanical Threshold Loading (MTL)



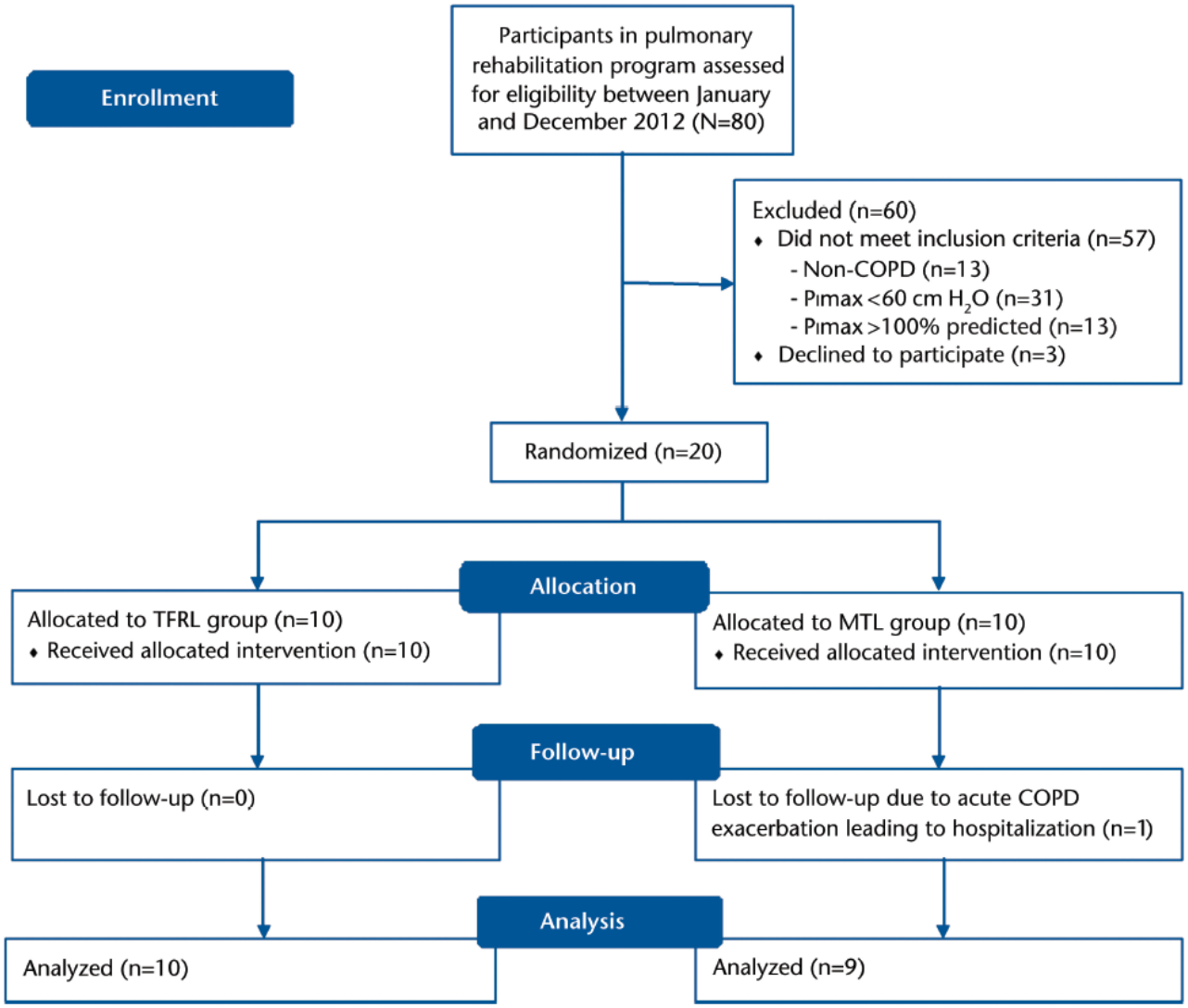
Tapered Flow Resistive Loading (TFRL)




POWER®
breathe
the world's no.1 breathing trainer™

Efficacy of a Novel Method for Inspiratory Muscle Training in People With Chronic Obstructive Pulmonary Disease

Daniel Lar
Alison Mc



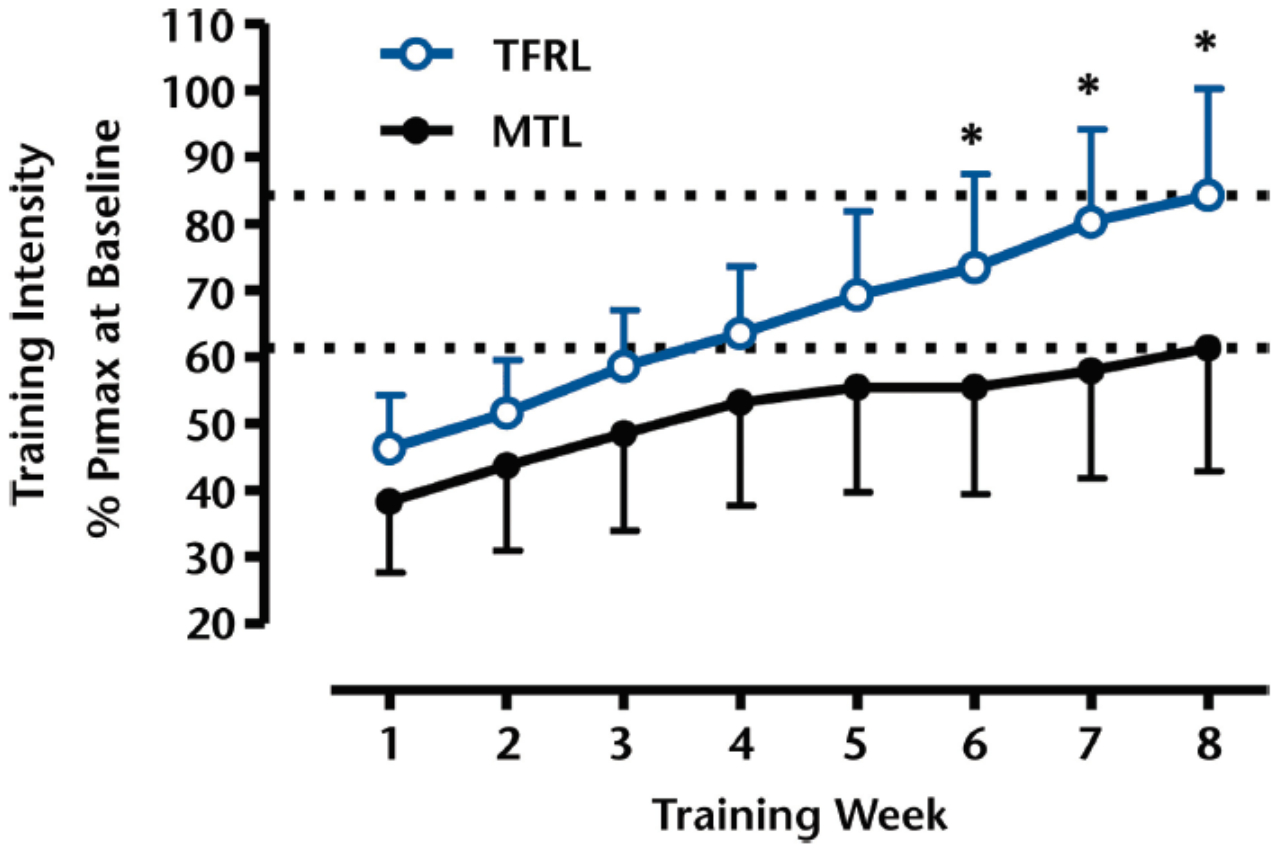
Efficacy of a Novel Method for Inspiratory Muscle Training in People With Chronic Obstructive Pulmonary Disease

Daniel Langer, Noppawan Charususin, Cristina Jácome, Mariana Hoffman, Alison McConnell, Marc Decramer, Rik Gosselink

Measure	TFRL Group (n=10)			MTL Group (n=9)			*P*
	Preintervention	Postintervention	Change	Preintervention	Postintervention	Change	
Tlim (s)	219±71	751±168	+532±204[b]	193±124	361±309	+187±233[b]	.02
Breaths (n)	32±12	95±34	+64±27[b]	32±18	52±33	+21±33[b]	.03
Total work (J)	132±73	539±235	+407±230[b]	157±188	331±466	+193±245[b]	.03
Avg Ti (s)	2.7±1.3	1.6±0.6	−1.1±0.8[b]	2.3±1.1	2.0±0.8	−0.2±0.3	.02
Ti/Ttot (%)	37±6	21±8	−16±6[b]	37±7	33±11	−5±5[b]	.02
Avg peak V_T/Ti (L/s)	2.1±0.5	3.4±0.7	+1.4±0.6[b]	1.9±0.5	1.9±0.8	+0.1±0.3	.001
Avg power (W)	1.9±0.6	4.2±1.5	+2.3±1.0[b]	2.0±0.9	2.5±1.7	+0.5±1.2	.004
Avg inspiratory volume (L)	1.8±0.7	2.2±0.6	+0.4±0.2[b]	1.6±0.7	1.7±1	+0.1±0.1	.25
Avg work (J)	4.7±3.5	6.4±3.9	+1.7±1.0[b]	4.6±3.7	5.3±5.2	+0.7±1.1	.27

Efficacy of a Novel Method for Inspiratory Muscle Training in People With Chronic Obstructive Pulmonary Disease

Daniel Langer, Noppawan Charususin, Cristina Jácome, Mariana Hoffman, Alison McConnell, Marc Decramer, Rik Gosselink



Phys Ther. 2015;95:1264–1273

Inspiratory Muscle Training in Patients with Chronic Obstructive Pulmonary Disease

Structural Adaptation and Physiologic Outcomes

Alba Ramírez-Sarmiento, Mauricio Orozco-Levi, Rosa Güell, Esther Barreiro, Nuria Hernandez, Susana Mota, Merce Sangenis, Joan M. Broquetas, Pere Casan, and Joaquim Gea

Servei de Pneumologia, Hospital del Mar; Grup de Recerca de Pneumologia, Unitat de Recerca Respiratòria i Ambiental; Institut Municipal d'Investigació Mèdica; Ciencies Experimentals i de la Salut–Universitat Pompeu Fabra; and Servei de Pneumologia, Hospital de la Santa Creu i Sant Pau, Universitat Autònoma de Barcelona, Barcelona, Spain

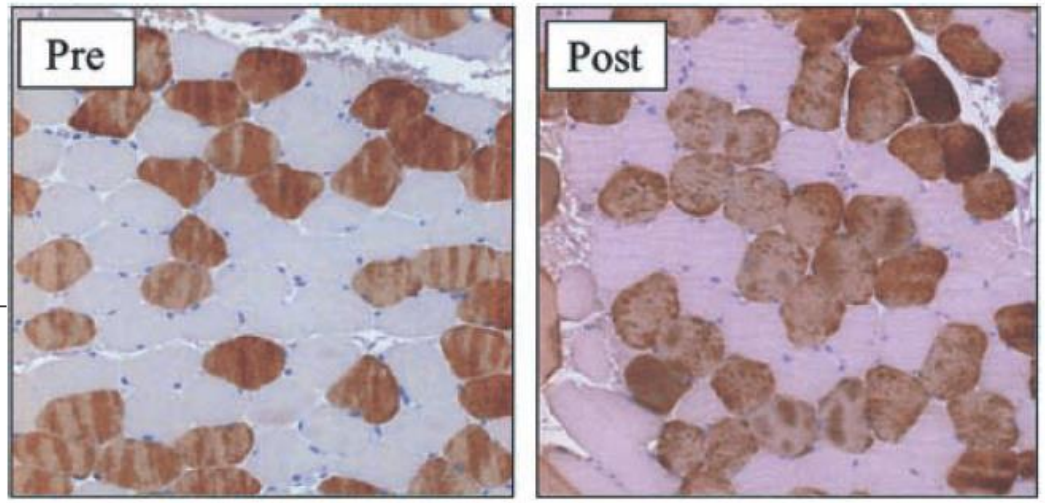
TABLE 1. GENERAL CHARACTERISTICS OF STUDY POPULATION

	Sham Training Group	Inspiratory Training Group
n	7	7
Age, yr	66 ± 6	65 ± 5
Body mass index, kg/m^2	26 ± 4	29 ± 4
Cholesterol, mg%	229 ± 37	235 ± 50
Serum proteins, gr%	7.5 ± 3	7 ± 0.8
Albumin, gr%	4.5 ± 0.2	4.3 ± 0.4
Prothrombin consumption time, s	105 ± 12	104 ± 7

Am J Respir Crit Care Med Vol 166. pp 1491–1497, 2002

IMT의 효과: PI_{max}

	Sham Training Group		Inspiratory Training Group	
	Pre	Post	Pre	Post
PI_{max}, cm H_2O	77 ± 9	79 ± 10	77 ± 22	99 ± 22*
PI_{max}, % pred	74 ± 7	76 ± 7	69 ± 19	90 ± 20*
Pes_{max}, cm H_2O	−55 ± 17	−58 ± 16	−49 ± 16	−74 ± 19*
Pdi_{max}, cm H_2O	91 ± 24	90 ± 13	74 ± 19	110 ± 23*
	0.06 ± 0.03	0.04 ± 0.04	0.07 ± 0.02	0.04 ± 0.01
	.06 ± 0.03	0.04 ± 0.04		
Pth_{max}, cm H_2O	−39 ± 21	−41 ± 20	−30 ± 19	−39 ± 22*
Tth_{80}, min	9.3 ± 4	9.2 ± 2	11 ± 6	22 ± 6*
Expiratory muscle strength				
PE_{max}, cm H_2O				144 ± 30
PE_{max}, % pred				81 ± 16
Six minute walking test				
Distance, m				433 ± 81
Incremental cycle test				
Work rate, $Watt_{max}$				86 ± 23
VO_{2max}, ml/kg/min				15 ± 5



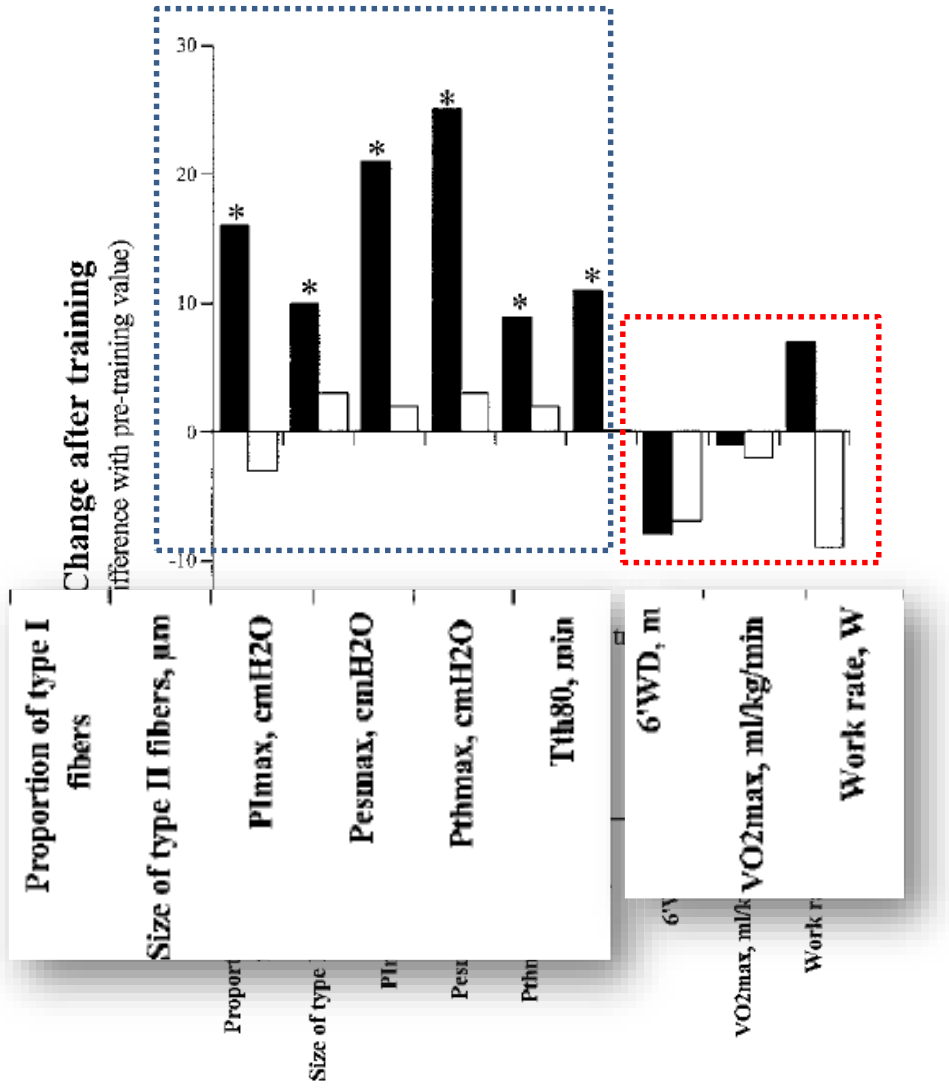
Am J Respir Crit Care Med Vol 166. pp 1491–1497, 2002

IMT의 효과: 폐기능

	Sham Training Group		Inspiratory Training Group	
	Pre	Post	Pre	Post
N	7	7	7	7
FEV_1, l	836 ± 184	913 ± 185	974 ± 312	997 ± 341
FEV_1, % pred	27 ± 7	29 ± 7	33 ± 8	34 ± 11
TLC, l	6.8 ± 7.8	6.7 ± 8.9	6.3 ± 1.5	6.2 ± 1.3
TLC, % pred	115 ± 7	115 ± 17	112 ± 22	111 ± 19
RV, % pred	190 ± 18	179 ± 32	177 ± 46	179 ± 52
Pa_{O_2}, torr	68 ± 5	66 ± 5	68 ± 7	72 ± 10
Pa_{CO_2}, torr	47 ± 5	46 ± 4	43 ± 7	44 ± 4

Am J Respir Crit Care Med Vol 166. pp 1491–1497, 2002

IMT의 효과: 운동능력



Am J Respir Crit Care Med Vol 166. pp 1491–1497, 2002

Comparison of Specific Expiratory, Inspiratory, and Combined Muscle Training Programs in COPD*

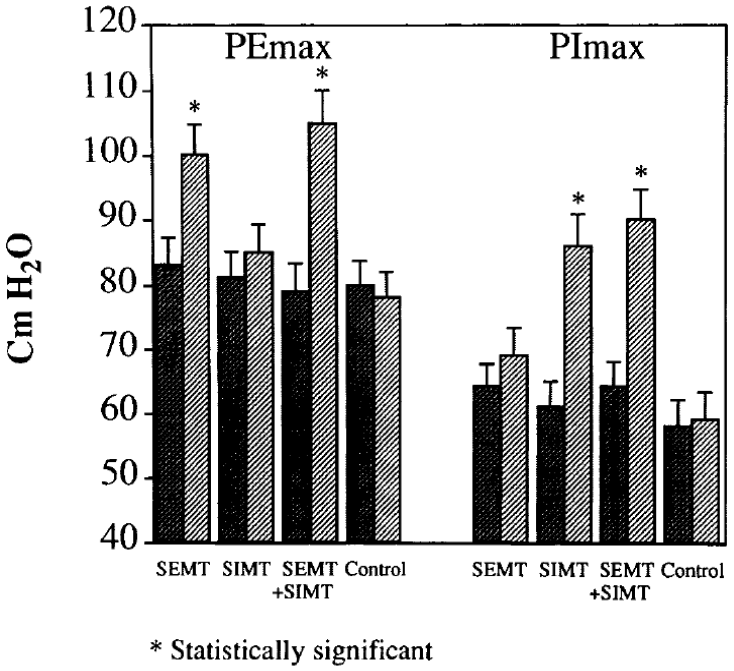
Paltiel Weiner, MD; Rasmi Magadle, MD; Marinella Beckerman, MD; Margalit Weiner, PhD; and Noa Berar-Yanay, MD

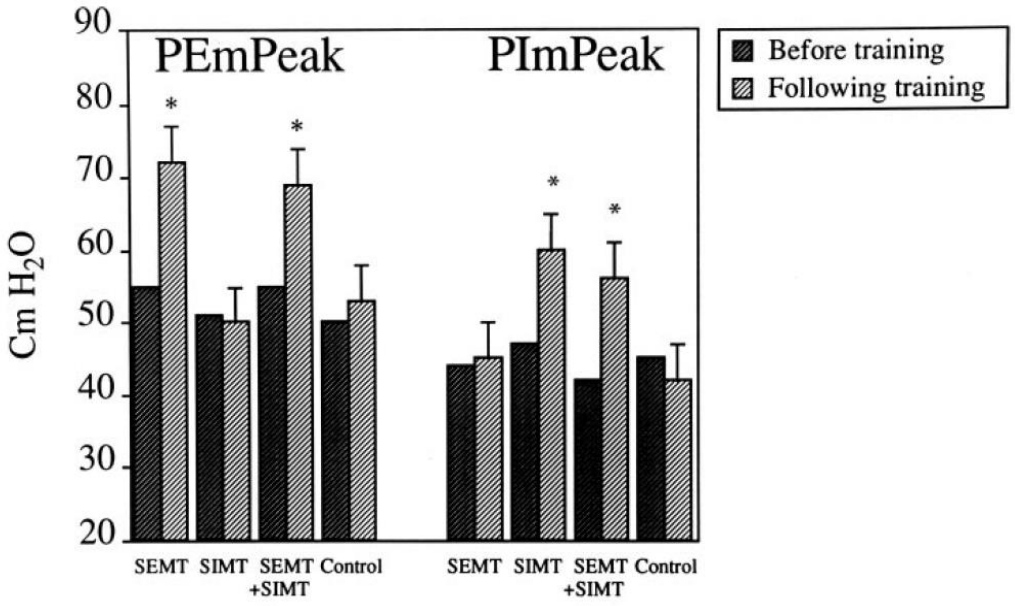
Table 1—*Characteristics of Patients With COPD

Characteristics	SEMT Group (n = 8)	SIMT Group (n = 8)	SEMT + SIMT Group (n = 8)	Control Group (n = 8)
Age, yr	65.4 ± 3.3	63.1 ± 3.1	62.7 ± 3.0	61.8 ± 3.2
Sex				
Male	7	6	6	7
Female	1	2	2	1
Weight, kg	73.4 ± 2.8	73.5 ± 3.3	71.4 ± 3.0	74.5 ± 3.4
Height, m	1.70 ± 3.5	1.68 ± 3.0	1.69 ± 3.5	1.72 ± 3.8
FVC				
L	2.55 ± 1.2	2.51 ± 1.1	2.47 ± 0.9	2.51 ± 1.3
% predicted	71 ± 4.4	73 ± 4.3	71 ± 4.0	68 ± 4.1
FEV_1				
L	1.21 ± 0.4	1.33 ± 0.5	1.33 ± 0.6	1.34 ± 0.5
% predicted	43 ± 2.6	44 ± 3.2	45 ± 3.0	43 ± 2.9
6MW, m	270 ± 41	276 ± 44	297 ± 47	293 ± 40
$P_{I}max$, cm H_2O	64 ± 4.7	61 ± 4.5	64 ± 4.2	58 ± 3.9
PImpeak, cm H_2O	44 ± 2.6	48 ± 2.7	42 ± 2.6	46 ± 2.7
$P_{E}max$, cm H_2O	83 ± 4.7	81 ± 4.0	79 ± 4.4	80 ± 4.1
PEmpeak, cm H_2O	55 ± 2.9	51 ± 2.4	55 ± 2.9	50 ± 2.5

CHEST 2003; 124:1357–1364

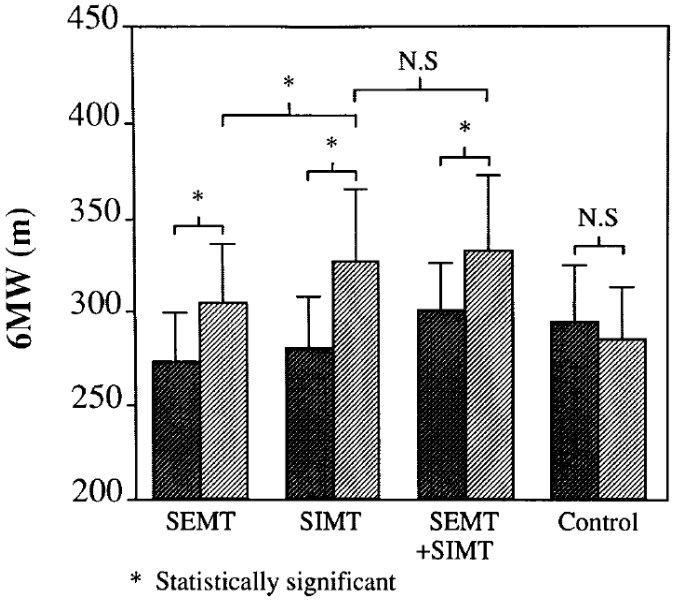
흡기근 vs. 호기근: 훈련한 효과가 결과로 나옴

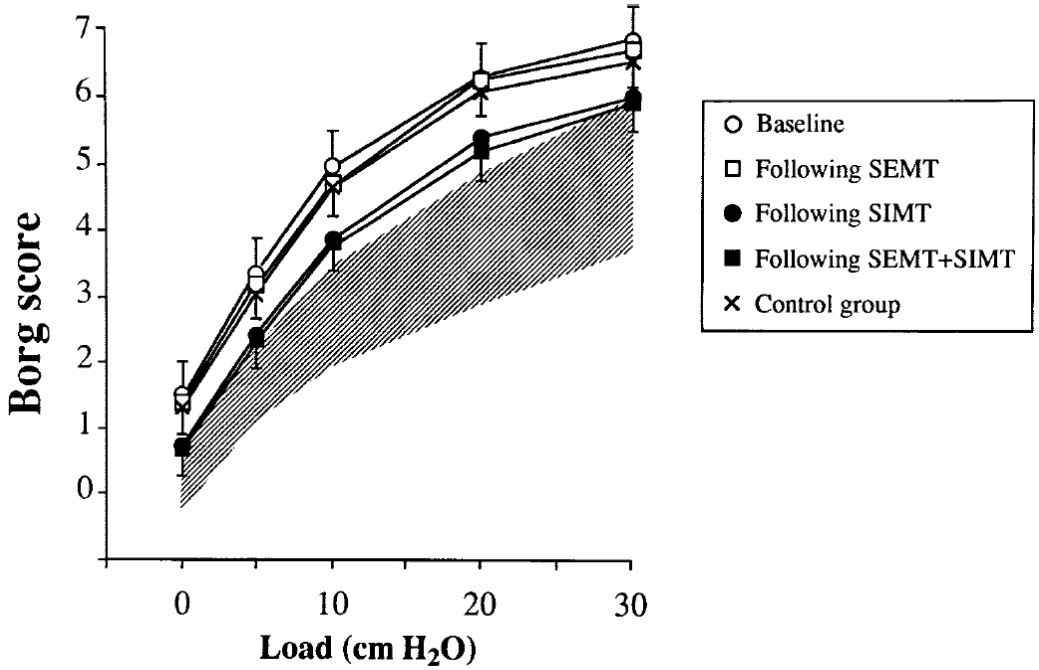




CHEST 2003; 124:1357–1364

흡기근 훈련의 효과가 더 우수





CHEST 2003; 124:1357–1364

The Effects of 1 Year of Specific Inspiratory Muscle Training in Patients With COPD*

Marinella Beckerman, MD; Rasmi Magadle, MD; Margalit Weiner, PhD; and Paltiel Weiner, MD

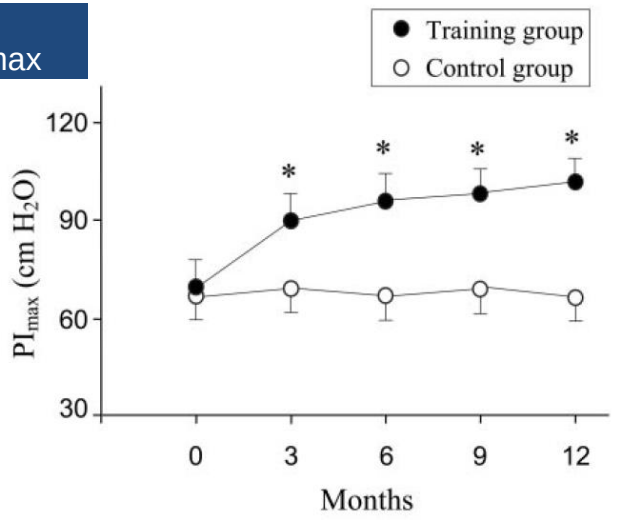
Characteristics	IMT (n = 21)	Control (n = 21)
Age, yr	67.7 ± 3.6	66.9 ± 3.3
Male/female gender	17/4	15/6
Weight, kg	76.8 ± 3.2	74.3 ± 3.4
Height, m	1.69 ± 3.2	1.69 ± 3.4
FVC, L	2.31 ± 1.0	2.34 ± 0.9
% predicted	65 ± 4.4	68 ± 4.6
FEV_1, L	1.21 ± 0.4	1.26 ± 0.4
% predicted	42 ± 2.6	43 ± 2.5
Six-minute walk distance, m	256 ± 41	268 ± 43
Pɪmax, cm H_2O	71 ± 4.9	67 ± 4.9
Current smokers	4	2
Ex-smokers	16	17
Previous admissions		
Patients	12	14
Total	22	20

CHEST 2005; 128:3177–3182

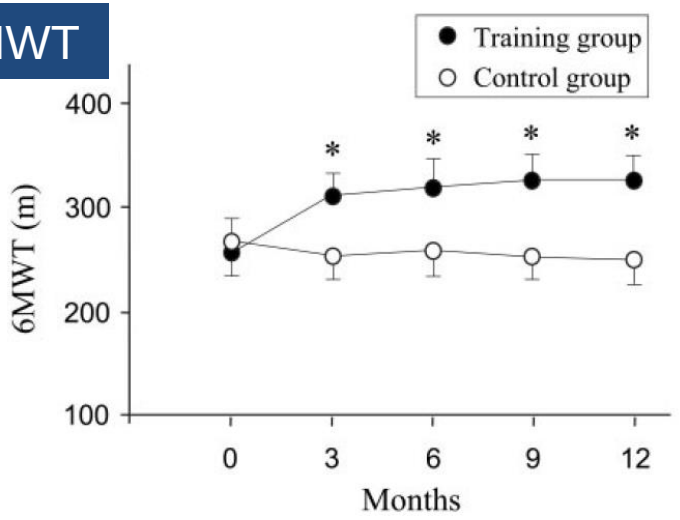
The Effects of 1 Year of Specific Inspiratory Muscle Training in Patients With COPD*

Marinella Beckerman, MD; Rasmi Magadle, MD; Margalit Weiner, PhD; and Paltiel Weiner, MD

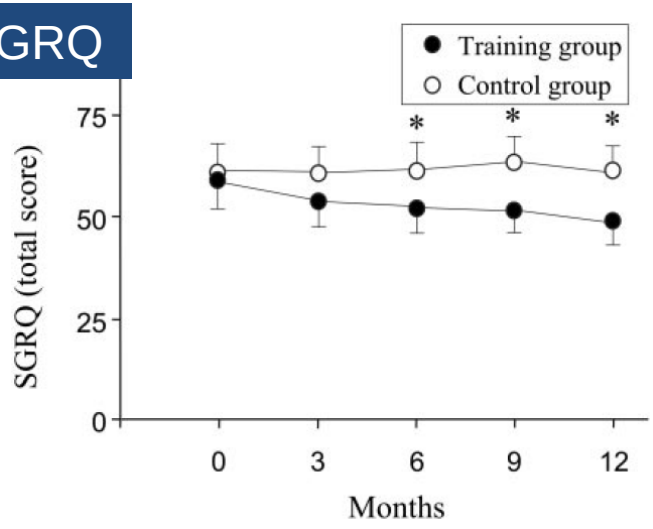
PI_{max}



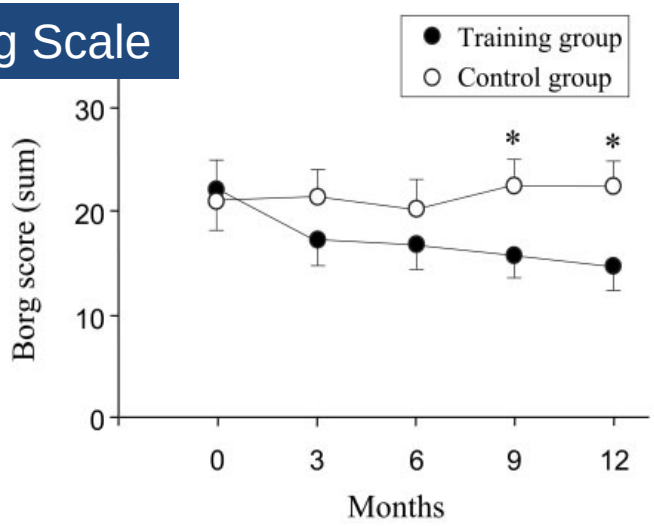
6MWT



SGRQ



Borg Scale



CHEST 2005; 128:3177–3182

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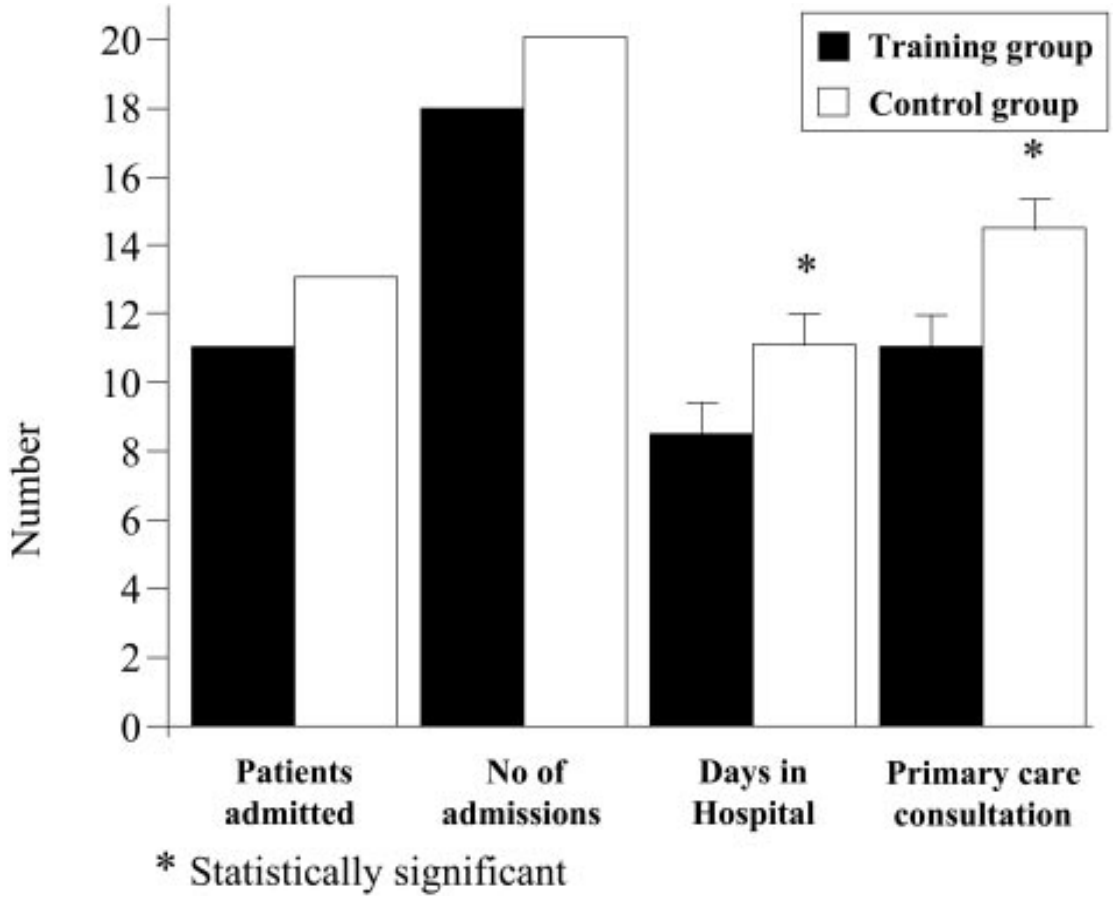

CHEST 2005; 128:3177–3182

Inspiratory Muscle Training in Patients With COPD*

Effect on Dyspnea, Exercise Performance, and Quality of Life

Hildegard Sánchez Riera, MD; Teodoro Montemayor Rubio, MD; Francisco Ortega Ruiz, MD; Pilar Cejudo Ramos, MD; Daniel Del Castillo Otero, MD; Teresa Elias Hernandez, MD; and Jose Castillo Gomez, MD

Characteristics	Group T (n = 10)	Group C (n = 10)	p Value
Sex			NS
M	9	9	
F	1	1	
Age, yr	67 ± 4	67.6 ± 5	NS
FVC, % predicted	63.6 ± 16	64.2 ± 15	NS
FEV_1, % predicted	38.3 ± 13	41.3 ± 11	NS
Pimax, cm H_2O	44.5 ± 14	50.3 ± 13	NS

*Values given as mean ± SD. M = male; F = female; NS = not significant.

CHEST 2001; 120:748–756

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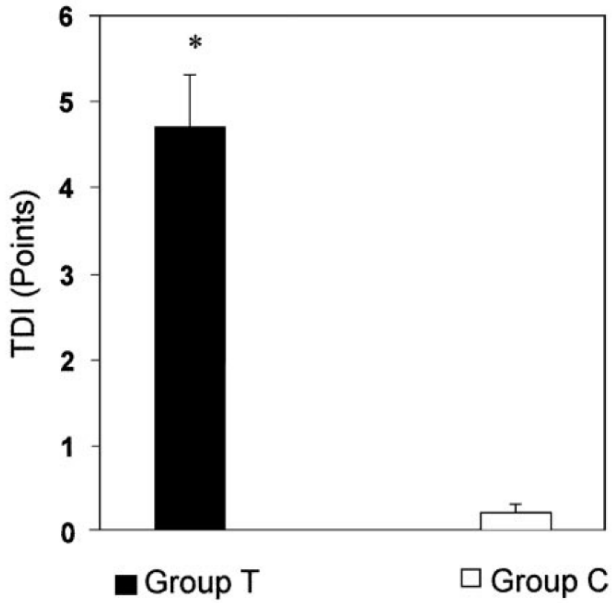
Hildegard Sánchez Riera, MD; Teodoro Montemayor Rubio, MD; Francisco Ortega Ruiz, MD; Pilar Cejudo Ramos, MD; Daniel Del Castillo Otero, MD; Teresa Elias Hernandez, MD; and Jo MD

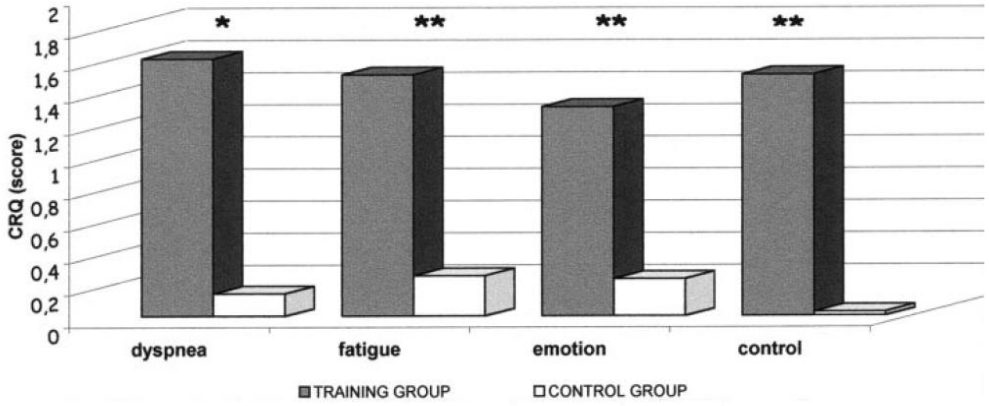
Exercise Capacity

Dyspnea



Variable	Group T		Group C	
	Baseline	After 6 mo	Baseline	After 6 mo
SWT, m	448 ± 121	541 ± 112†‡	551 ± 174	493 ± 140
Borg score	8.1 ± 1.04	8.3 ± 0.78	7.6 ± 1.43	8.3 ± 1.41

Quality of Life



CHEST 2001; 120:748–756

Impact of inspiratory muscle training in patients with COPD: what is the evidence?

R. Gosselink*,#, J. De Vos*,#, S.P. van den Heuvel¶, J. Segers*,#, M. Decramer*,# and G. Kwakkel+

Present search: 129 studies

Previous meta-analysis: 14 included studies

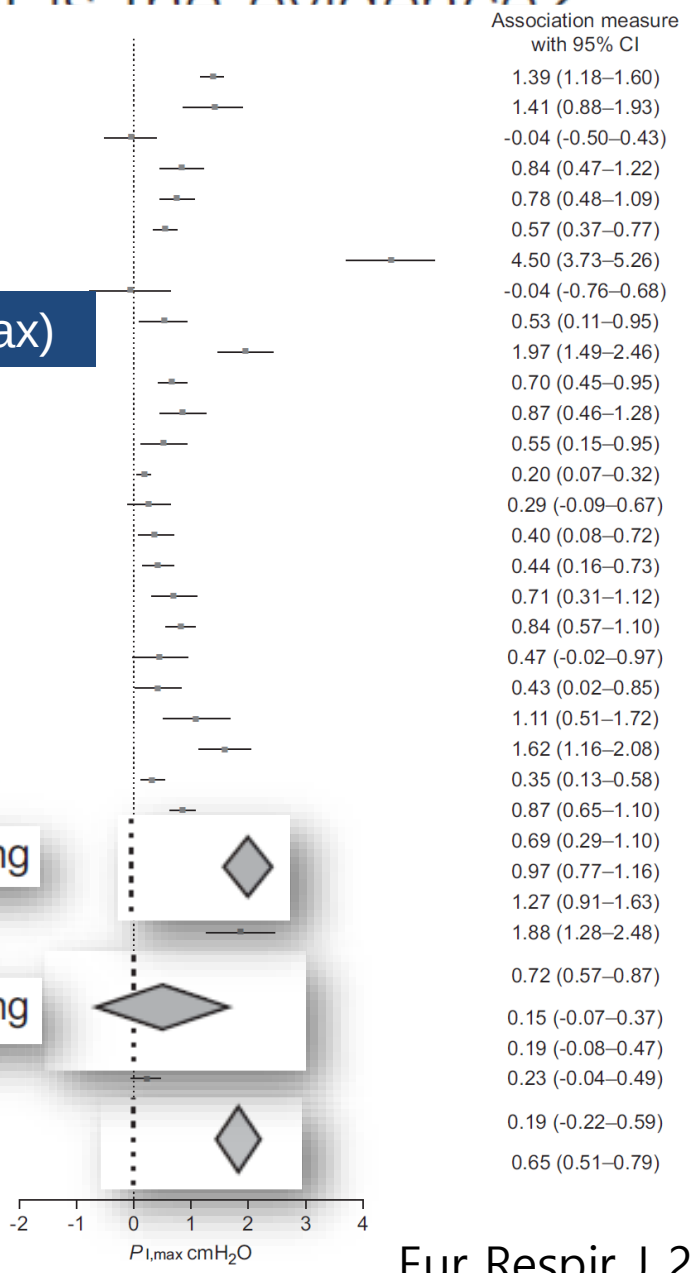
Outcome measures	Subjects n	Q-statistic	I^2	SES	95% CI	p-value (z-statistic)	Natural units
$P_{I,max}$	32	57.8	46	0.73	0.53–0.93	0.001	+13 cmH_2O
RMET	14	47.3	73	1.05	0.62–1.49	0.001	+261 s
ITL	11	16.8	3	0.98	0.72–1.25	0.001	+13 cmH_2O
MVV	4	1.2	0	0.23	-0.27–0.72	0.373	+3 $L \cdot min^{-1}$
Functional exercise capacity	22	14.3	0	0.28	0.12–0.44	0.001	6MWD: +32 m 12MWD: +85 m
Endurance exercise capacity	3	4.6	57	0.72	-0.12–1.55	0.087	+198 s
$V'_{O_2,max}$ $L \cdot min^{-1}$	9	6.0	0	-0.13	-0.38–0.11	0.293	-0.04 $L \cdot min^{-1}$
$V'_{O_2,max}$ $mL \cdot min^{-1} \cdot kg^{-1}$	5	5.0	20	0.3	-0.02–0.63	0.067	+1.3 $mL \cdot min^{-1} \cdot kg^{-1}$
$V'_{E,max}$	9	5.5	0	-0.04	-0.3–0.2	0.696	-0.7 $L \cdot min^{-1}$
W_{max}	10	5.1	0	0.07	-0.16–0.3	0.562	+1.7 W
Dyspnoea Borg score	14	15.6	17	-0.45	-0.66– -0.24	0.001	-0.9
Dyspnoea TDI	4	6.3	52	1.58	0.86–2.3	0.001	+2.8
Dyspnoea CRQ-Dyspnoea	9	16.6	52	0.34	-0.03–0.71	0.068	+1.1
Quality of life CRQ	9	10.4	20	0.34	0.09–0.60	0.007	+3.8
CRQ fatigue	10	8.2	0	0.27	0.03–0.50	0.024	+0.9
CRQ emotion	10	7.6	0	0.19	-0.04–0.42	0.107	+0.5
CRQ mastery	10	8.5	0	0.09	-0.14–0.33	0.432	-0.005

Eur Respir J 2011; 37: 416–425

Impact of inspiratory muscle training in patients with COPD: what is the evidence?

R. Gosselink*,#, J. De V
M. Decramer*,# and G.

Maximal Inspiratory Strength (PI max)



SES inspiratory muscle strength training

SES inspiratory muscle endurance training

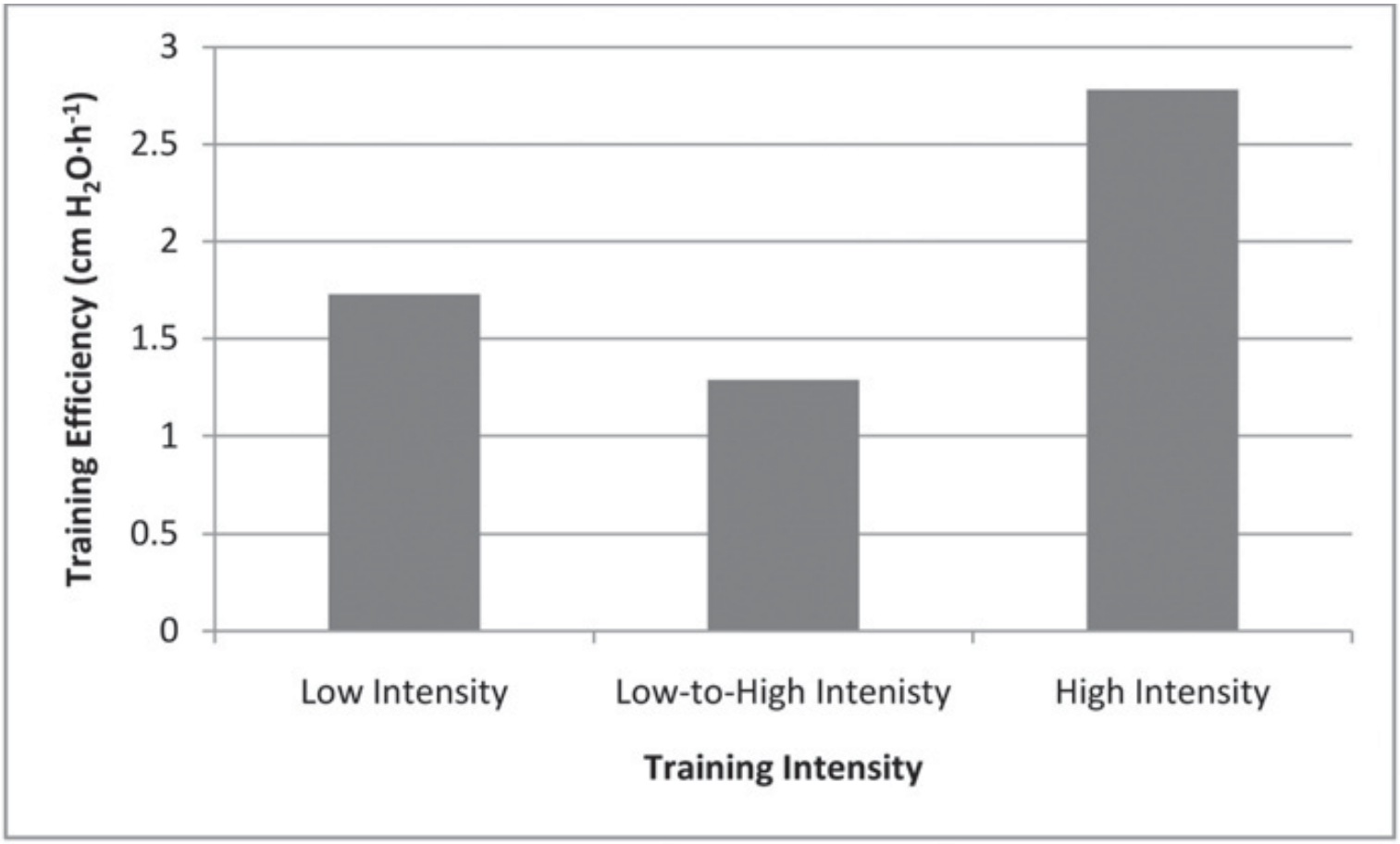
Total SES

Eur Respir J 2011; 37: 416–425

IMT training type

Strength	Endurance
<200 repetitions / session Higher load	>200 repetitions / session Lower load

Training Efficiency: Systematic Review

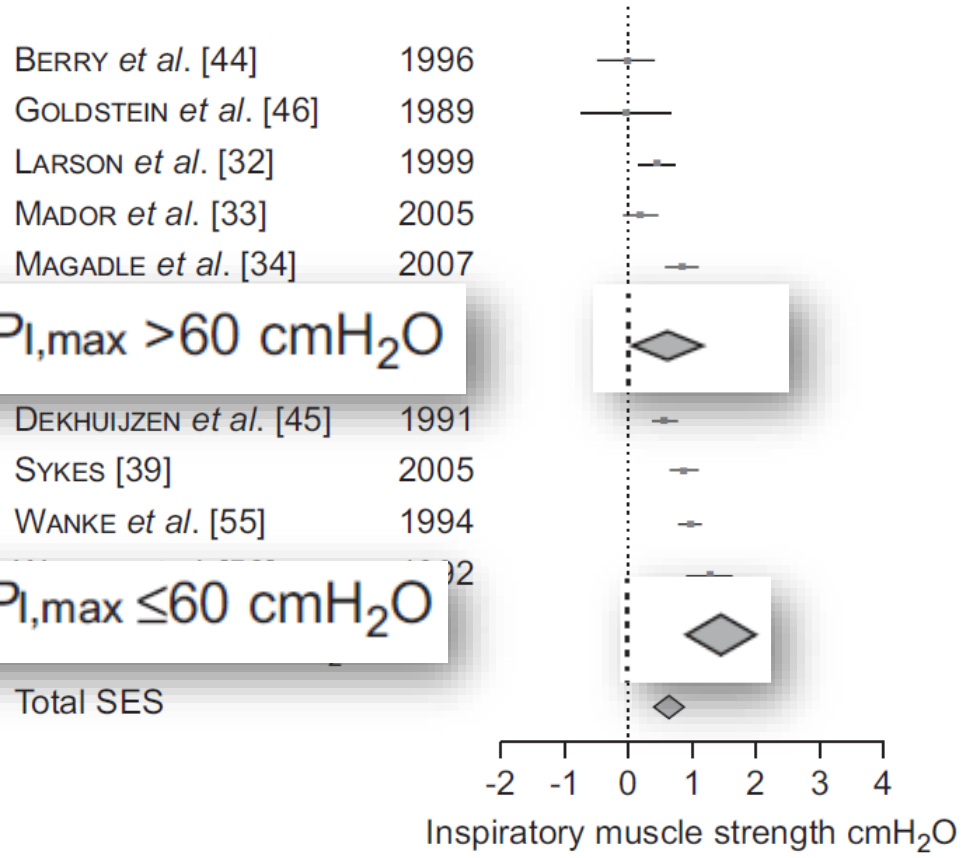


Cardiopulmonary Physical Therapy Journal 2009

Impact of inspiratory muscle training in patients with COPD: what is the evidence?

R. Gosselink*,#, J. De Vos*,#, S.P. van den Heuvel¶, J. Segers*,#, M. Decramer*,# and G. Kwakkel+

Inspiratory m. strength (cmH_2O)



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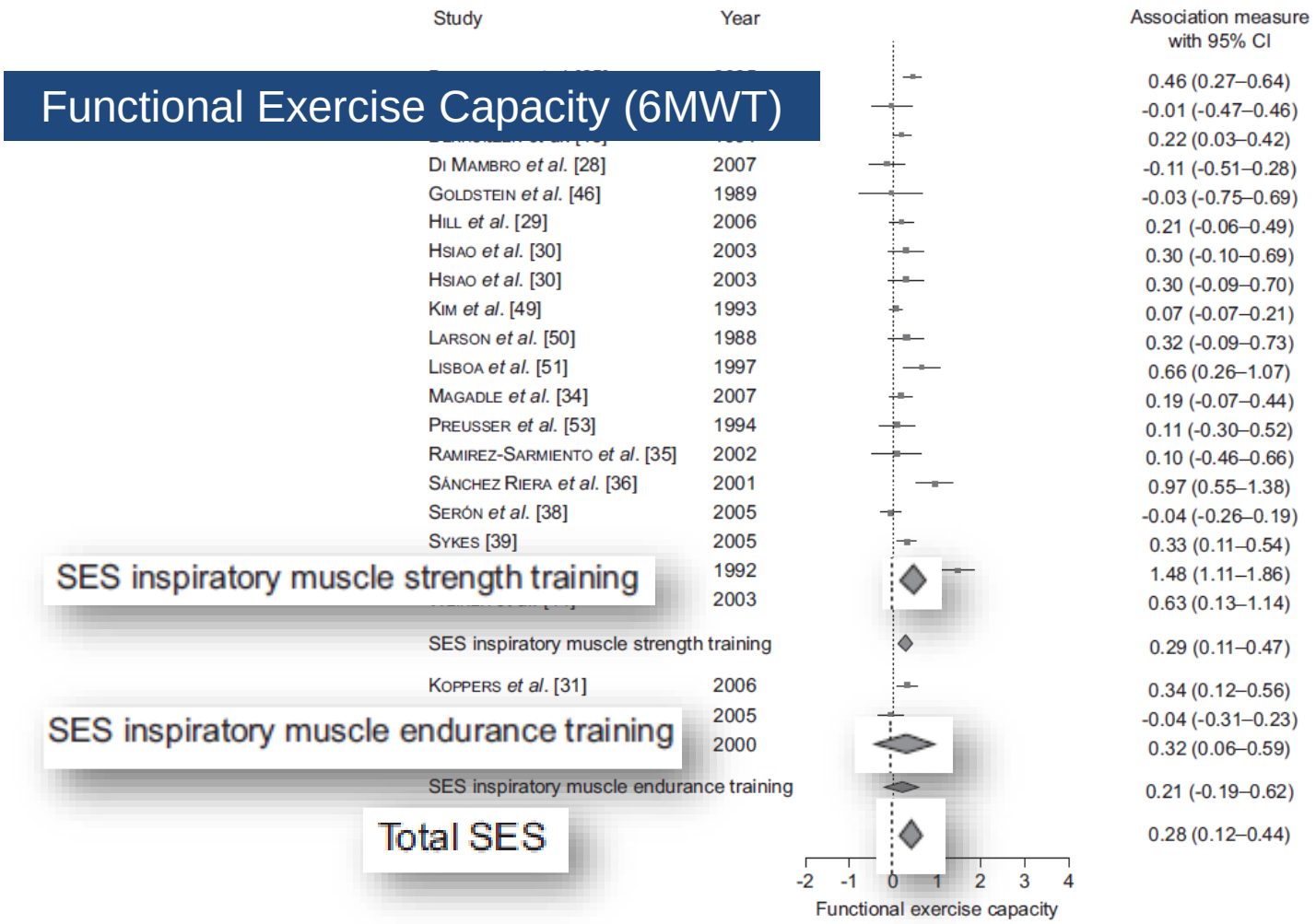

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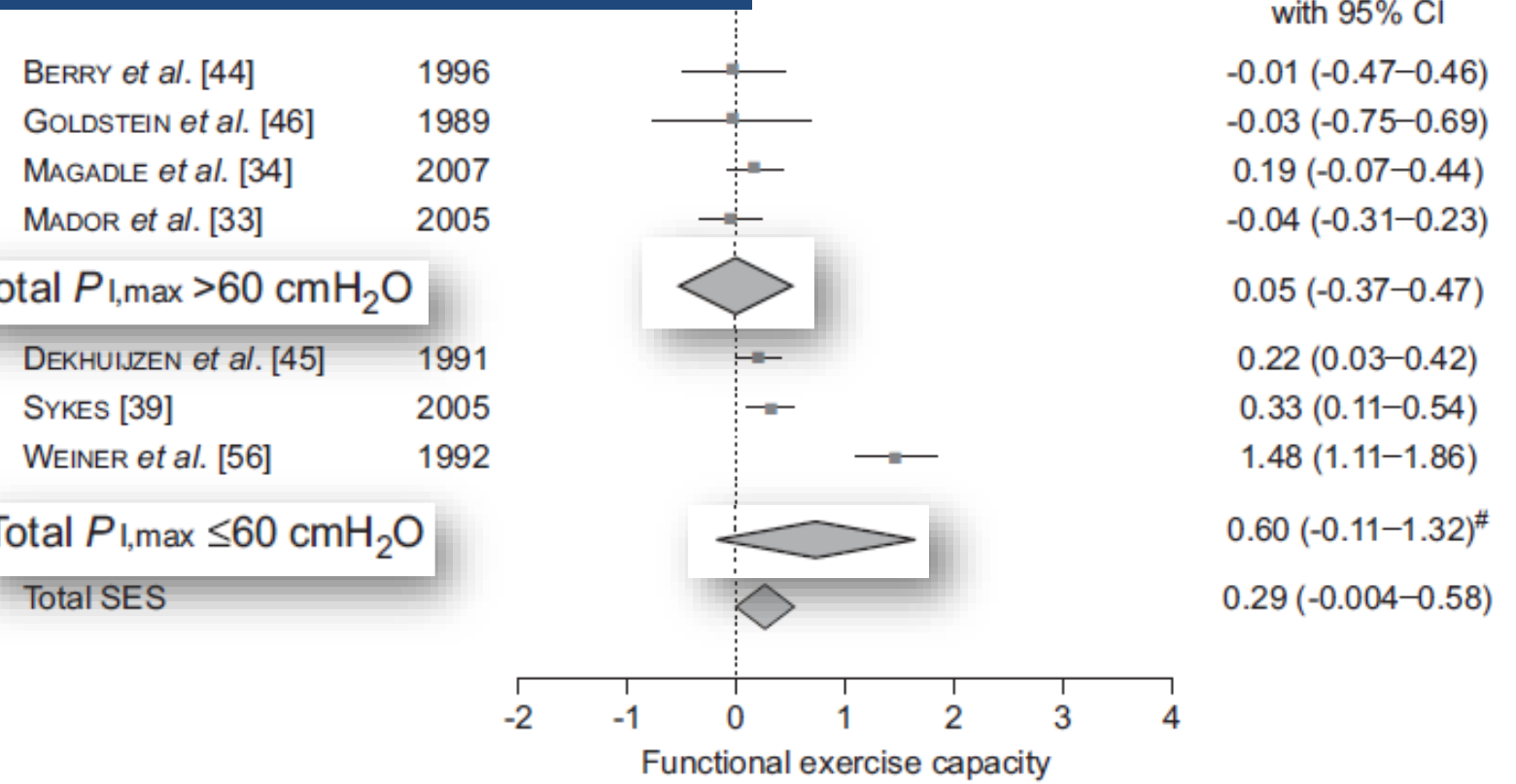
Functional Exercise Capacity (6MWT)



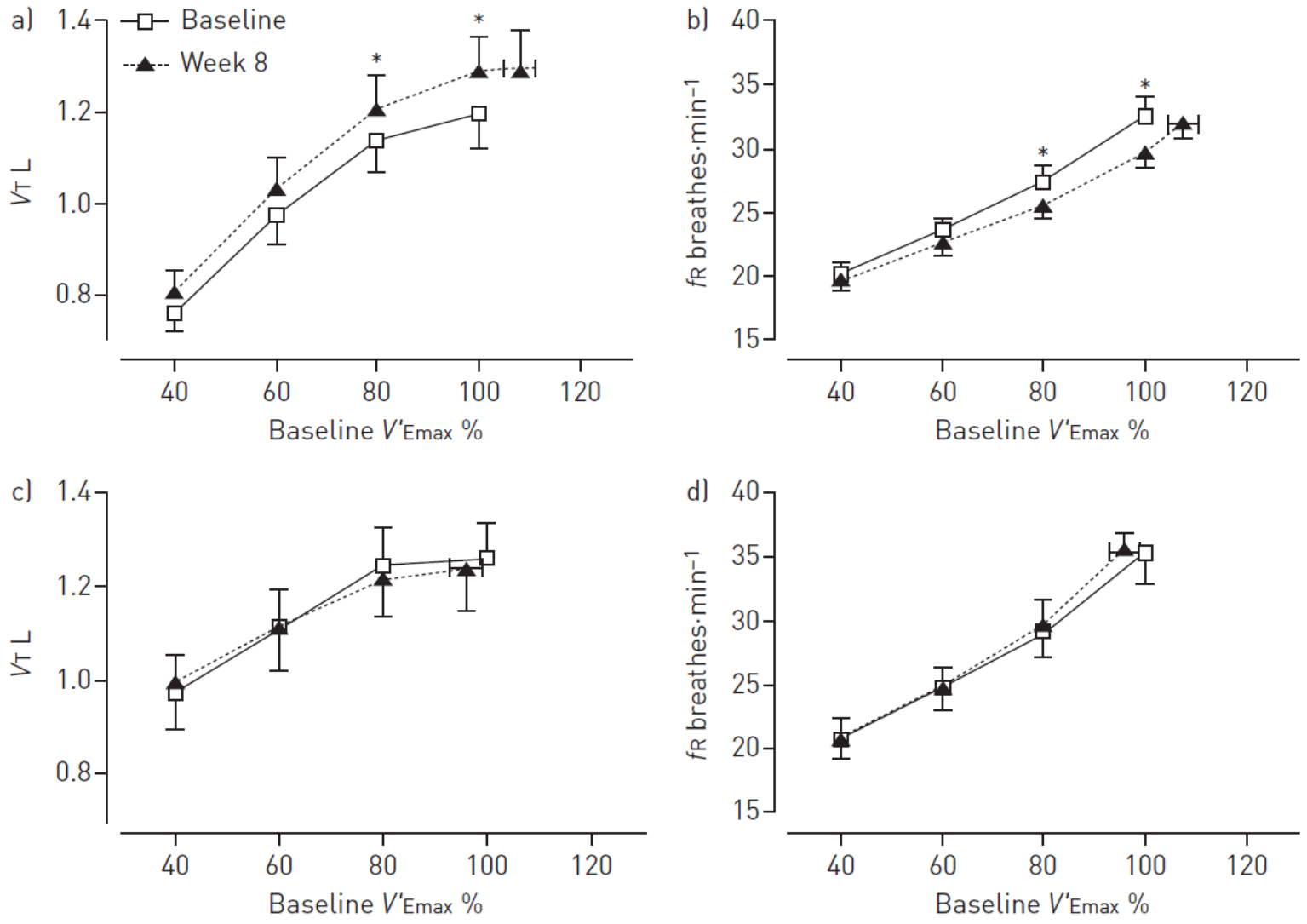
Eur Respir J 2011; 37: 416–425

TFRL 의 효과

	Baseline	12-weeks	Changes
PImax (cmH_2O)	83.7±24.1	105.9±24.8	22.3 (16.4-28.1)**
PEmax (cmH_2O)	116.5±31.4	139.2±38.0	22.7 (11.5-33.9)**
QF (kgf)	47.2±11.8	49.4±10.9	2.21 (0.05-4.35)*
WBI (kgf/kg)	0.78±0.18	0.82±0.17	0.04 (0.01-0.07)*
6MWD (m)	486.6±114.4	519.4±111.2	32.7 (17.9-47.6)**
Borg Dyspnea#	4.0 (1.0-4.0)	2.5 (1.0-3.3)	-0.73 (-1.40-(-0.05))
Borg Leg Fatigue#	2.0 (1.0-3.3)	2.0 (0.5-2.3)	-0.20 (-0.72-0.32)

Eur Respir J. Congress 2016; 48(Supp 60): PA703

TFRL 8주 시행: V_T의 향상, 호흡 횟수의 감소



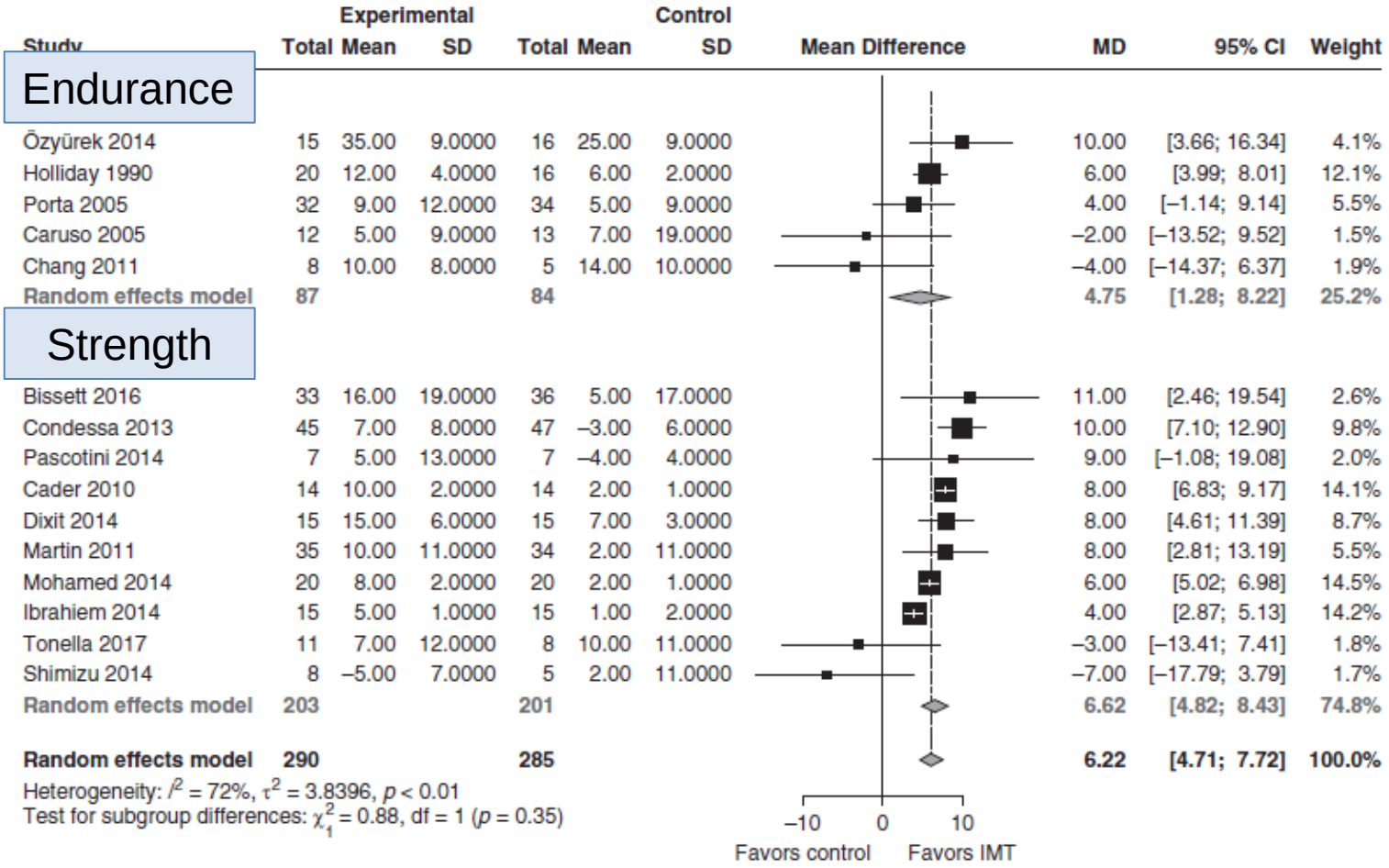
Eur Respir J 2016; 47: 1261–1264

Inspiratory Muscle Rehabilitation in Critically Ill Adults

A Systematic Review and Meta-Analysis

Stefannie Vorona[1], Umberto Sabatini[1], Sulaiman Al-Maqbali[1], Michele Bertoni[1], Martin Dres[2,3], Bernie Bissett[4,5], Frank Van Haren[5,6,7], A. Daniel Martin[8], Cristian Urrea[1], Debbie Brace[1], Matteo Parotto[9,10,11], Margaret S. Herridge[1,9,12], Neill K. J. Adhikari[9,13,14], Eddy Fan[1,9,12,15], Luana T. Melo[16], W. Darlene Reid[9,16], Laurent J. Brochard[2,9,12], Niall D. Ferguson[1,9,12,14,15], and Ewan C. Goligher[1,9,15]

Maximal inspiratory pressure



Ann Am Thorac Soc 2018 Vol 15, No 6, pp 735–744

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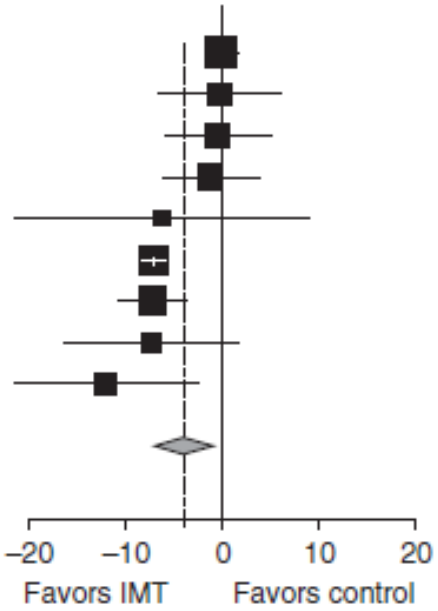
Duration of ventilation in mechanically ventilated patients

Study	Experimental Total	Mean	SD	Control Total	Mean	SD	MD	95% CI	Weight
Condessa 2013	45	9.1	4.0	47	9.2	3.3	–0.10	[–1.60; 1.40]	16.4%
Shimizu 2014	8	17.8	6.8	5	18.1	4.7	–0.30	[–6.56; 5.96]	10.5%
Chang 2011	8	6.4	4.0	5	6.9	5.3	–0.50	[–5.91; 4.91]	11.6%
Caruso 2005	12	8.6	3.6	13	9.8	8.0	–1.20	[–6.00; 3.60]	12.5%
Martin 2011	35	57.3	29.5	34	63.5	34.0	–6.20	[–21.24; 8.84]	3.7%
Mohamed 2014	20	3.3	1.6	20	10.4	2.5	–7.10	[–8.40; –5.80]	16.6%
Yosef-Brauner 2015	9	9.0	5.0	9	16.2	2.0	–7.20	[–10.72; –3.68]	14.2%
Tonella 2017	11	14.5	10.0	8	21.8	9.8	–7.30	[–16.30; 1.70]	7.4%
Holliday 1990	20	20.6	8.9	16	32.6	17.6	–12.00	[–21.46; –2.54]	7.0%
Random effects model	**168**			**157**			**–4.07**	**[–7.35; –0.80]**	**100.0%**

Heterogeneity: $I^2 = 86\%$, $\tau^2 = 16.41$, $p < 0.01$

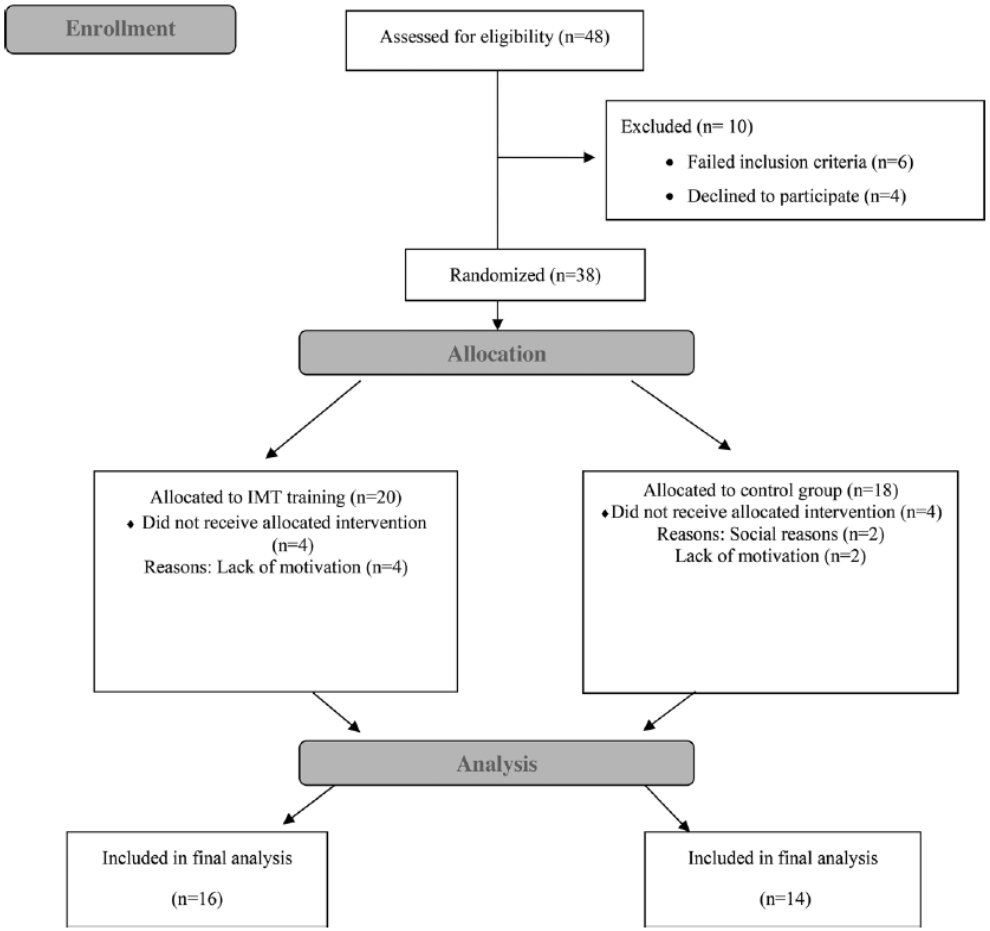


Ann Am Thorac Soc 2018 Vol 15, No 6, pp 735–744

Effect of Inspiratory Muscle Training in the Management of Patients With Asthma

A RANDOMIZED CONTROLLED TRIAL

Neslihan Duruturk, PhD, PT; Manolya Acar, MSc, PT; Mustafa Ilgaz Doğrul, MD



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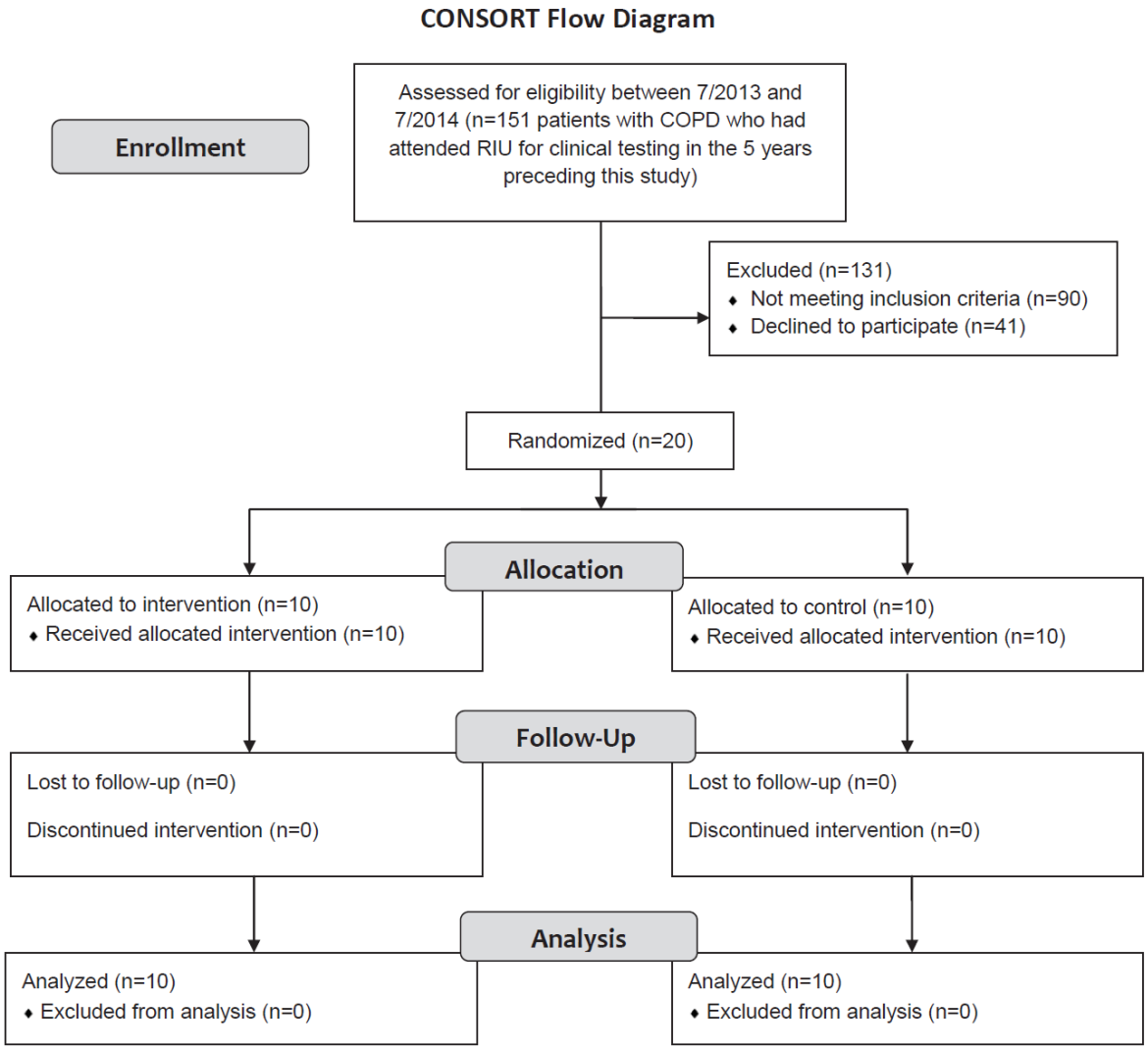
A RANDOMIZED CONTROLLED TRIAL

Neslihan Duruturk, PhD, PT; Manolya Acar, MSc, PT; Mustafa Ilgaz Doğrul, MD

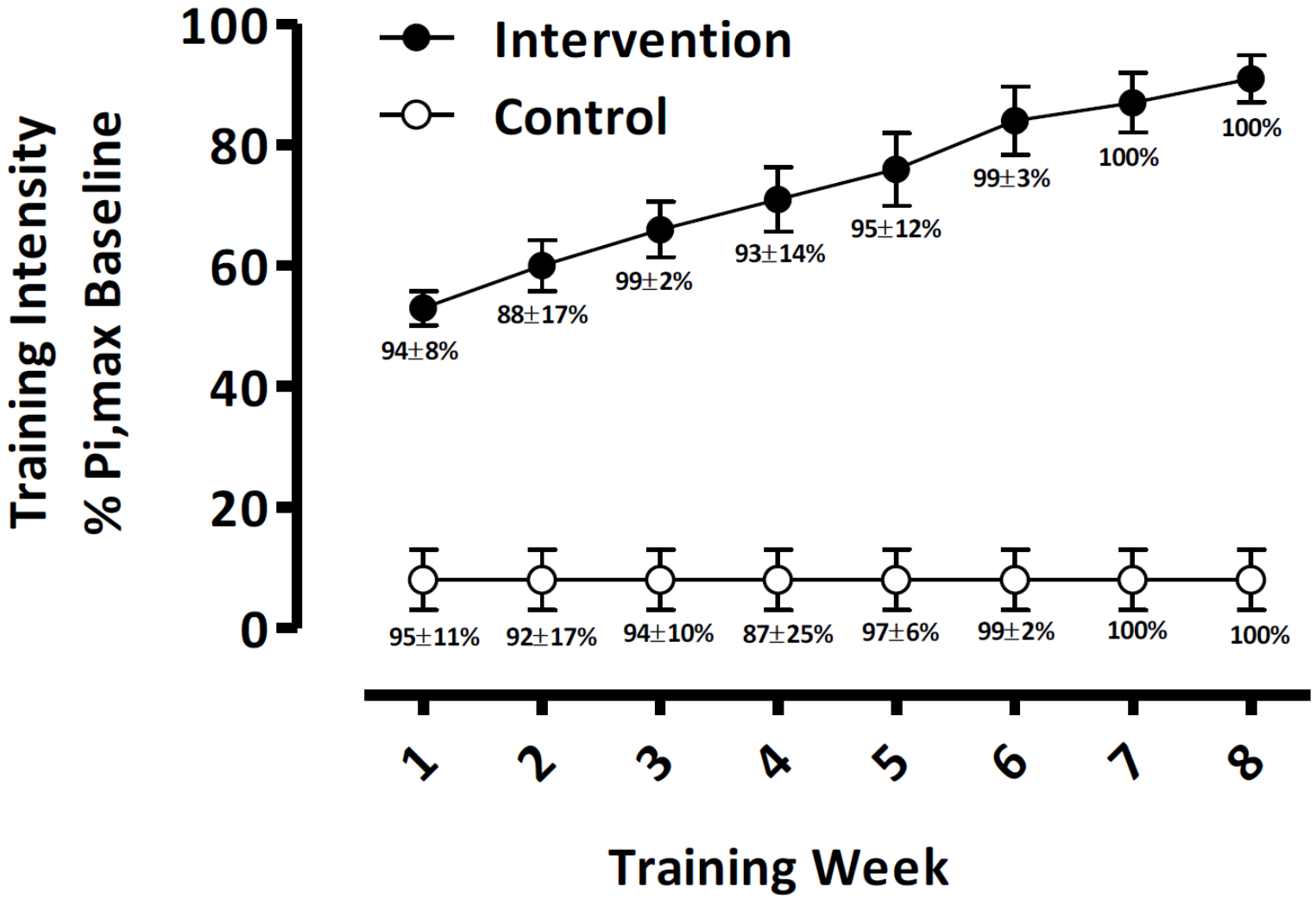
	IMT Group			Control Group			
	Baseline	6 wk	*P* Value[b]	Baseline	6 wk	*P*[b] Value	*P*[c] Value
Pulmonary function							
FEV_1, % predicted	92.95 ± 25.70	92.41 ± 21.26	.447	91.66 ± 22.03	91.21 ± 17.09	.083	.181
FEV_1, L	2.89 ± 1.29	2.65 ± 0.84	.326	2.78 ± 0.91	2.54 ± 0.83	.479	.415
FVC, % predicted	108.55 ± 21.63	108 ± 16.63	.866	96.17 ± 22.63	90.79 ± 15.35	.516	.513
FVC, L	3.82 ± 1.82	3.78 ± 1.20	.239	3.34 ± 0.95	2.94 ± 0.82	.041	.755
FEV_1/FVC	73.54 ± 12.40	73.94 ± 14.73	.195	80.50 ± 15.35	83.85 ± 14.49	.905	.342
MIP, kPa	5.11 ± 3.19	8.72 ± 4.19	<.001	4.30 ± 1.86	3.94 ± 0.78	.171	
MIP, %	59.90 ± 27.36	92.71 ± 39.77	<.001	56.39 ± 23.11	60.14 ± 18.16	.976	<.001
MEP, kPa	6.76 ± 4.13	8.17 ± 4.07	.149	5.71 ± 3.04	5.20 ± 2.42	.585	.168
MEP, %	42.79 ± 17.19	57.94 ± 27.87	.003	50.22 ± 27.64	52.21 ± 29.19	.266	.002
Exercise capa							
6MWD, m	445.70 ± 130.07	503.47 ± 92.53	.001	426.00 ± 172.95	436.79 ± 154.89		.527
Dyspnea							
mMRC score	2.10 ± 0.85	1.50 ± 0.52	<.001	2.00 ± 0.77	1.93 ± 0.73		.317
FSS score	38.95 ± 12.91	31.00 ± 10.35	.028	43.61 ± 11.10	44.00 ± 13.17	.661	.037
Quality of life							
SGRQ impact score	21.95 ± 16.67	21.90 ± 13.81	.363	28.32 ± 19.47	27.99 ± 26.65	.861	.313
SGRQ activity score	43.88 ± 22.18	34.85 ± 17.86	.057	54.09 ± 21.71	46.39 ± 26.51	.074	.372
SGRQ symptoms score	43.88 ± 22.18	34.45 ± 19.26	.088	45.79 ± 17.93	43.93 ± 24.04	.594	.034
SGRQ totals score	28.59 ± 19.48	27.24 ± 12.62	.199	37.59 ± 17.62	35.51 ± 21.80	.726	.220
Daily living activities							
LCADL self-care score	3.85 ± 4.03	3.50 ± 3.63	.556	3.11 ± 4.35	3.21 ± 3.40	.102	.129
LCADL domestic score	8.20 ± 6.07	6.69 ± 5.13	.086	8.44 ± 7.83	9.43 ± 8.02	.139	.034
LCADL physical activity score	4.05 ± 2.44	3.13 ± 2.16	.045	4.83 ± 2.57	5.00 ± 2.25	.813	.108
LCADL leisure score	2.80 ± 2.38	2.00 ± 1.79	<.001	2.33 ± 2.61	3.57 ± 2.47	.051	.014

Physiology Study



J Appl Physiol (1985). 2018 Aug 1;125(2):381-392

Physiology Study Design: Pimax의 증가



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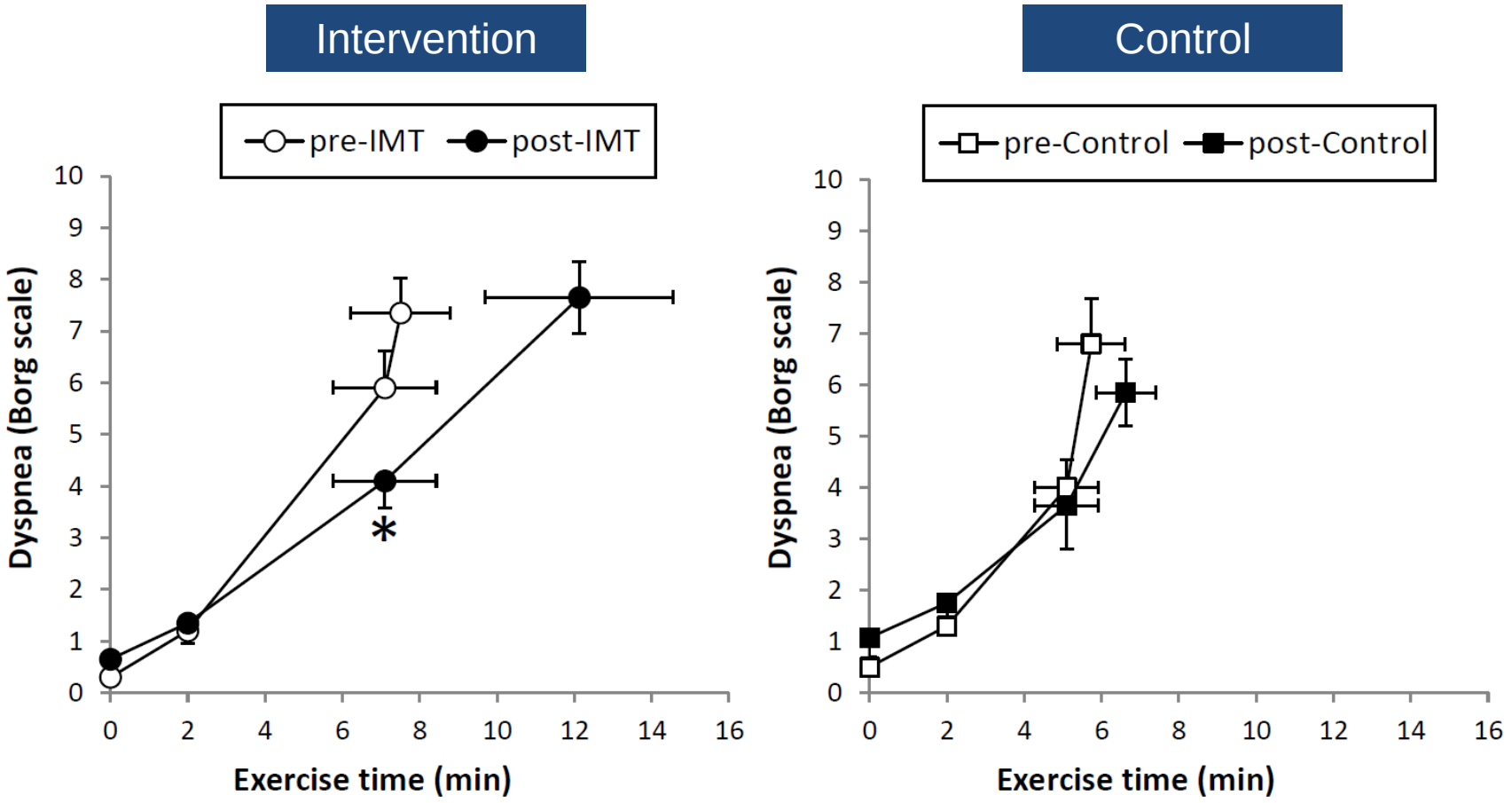
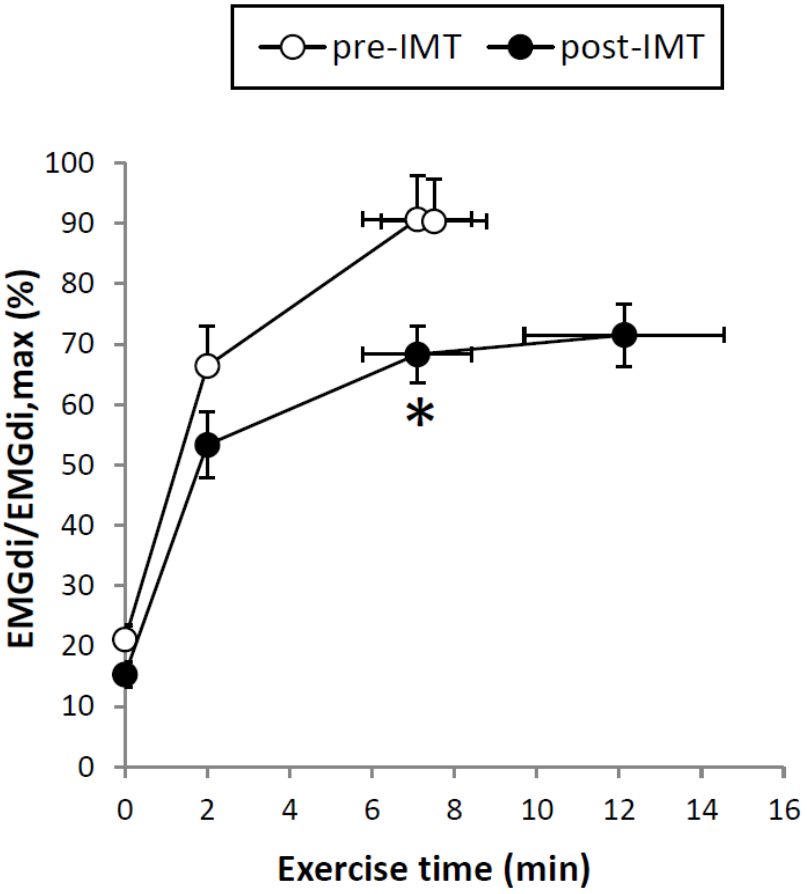
Physiology Study: 증상의 개선



J Appl Physiol (1985). 2018 Aug 1;125(2):381-392

Physiology Study: 횡격막 기능의 개선

Intervention



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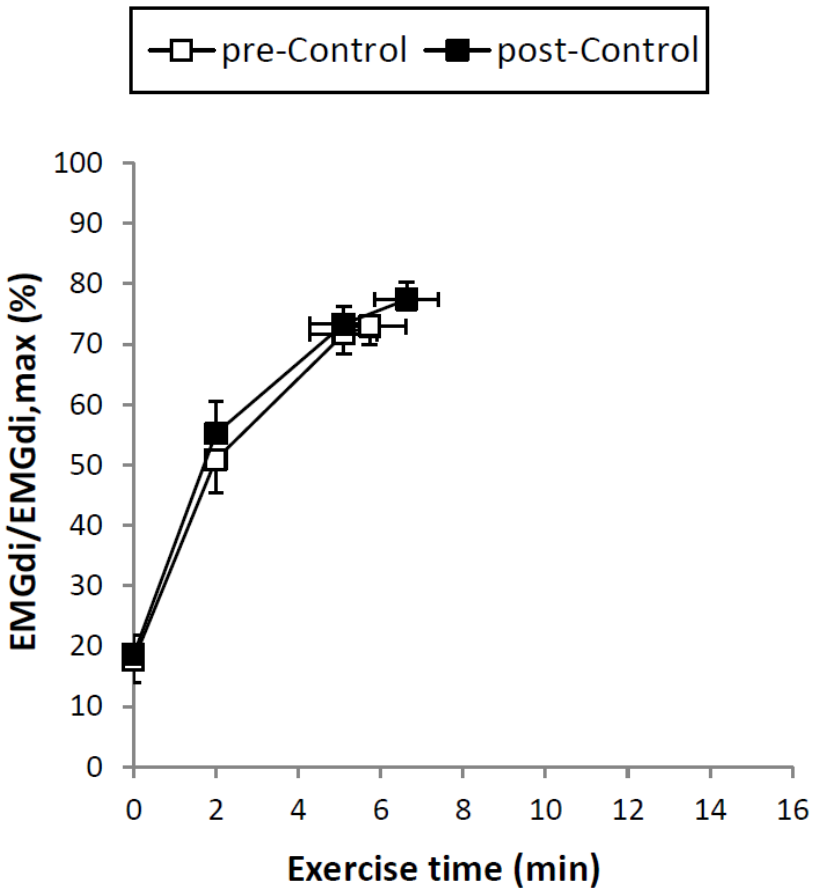
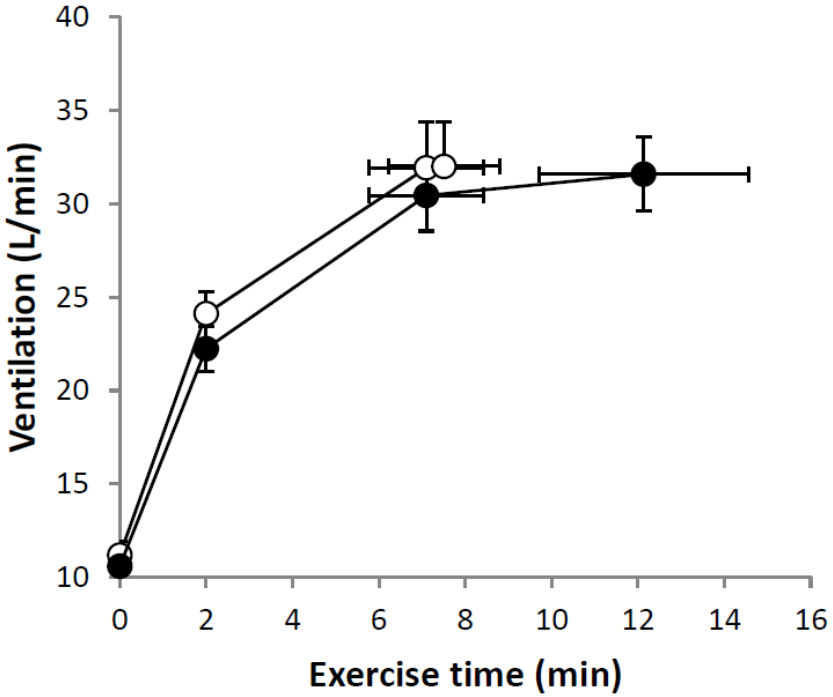


J Appl Physiol (1985). 2018 Aug 1;125(2):381-392

Physiology Study: Ventilation에서는 차이 없음

Intervention



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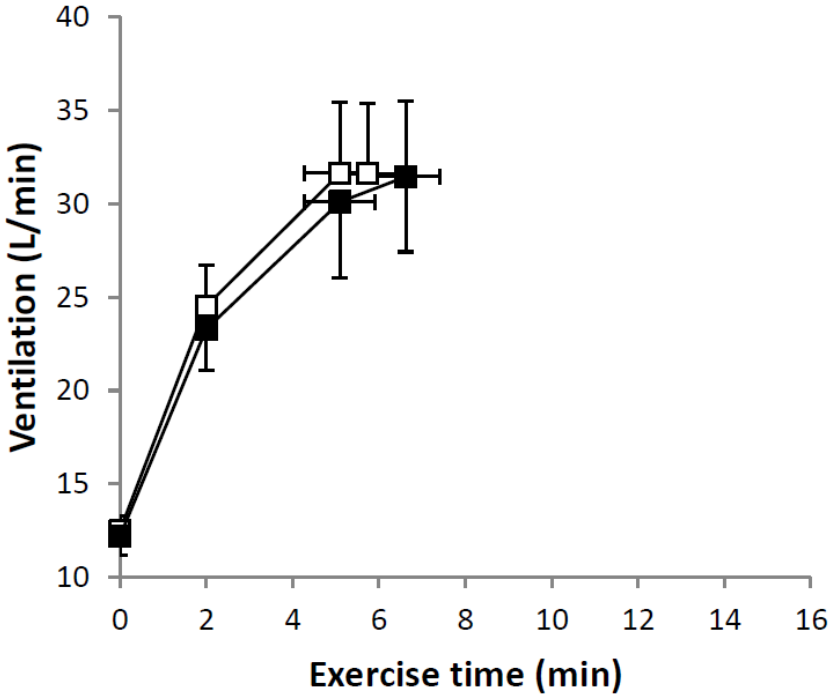

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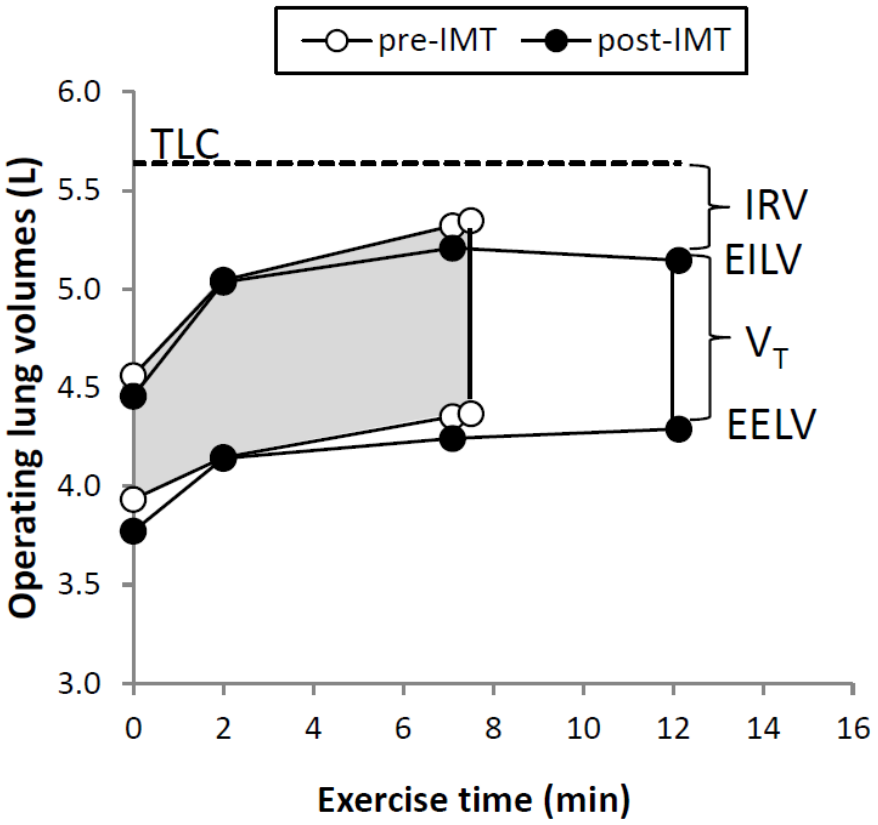
Physiology Study: Hyperinflation 개선 효과는 불확실

Intervention



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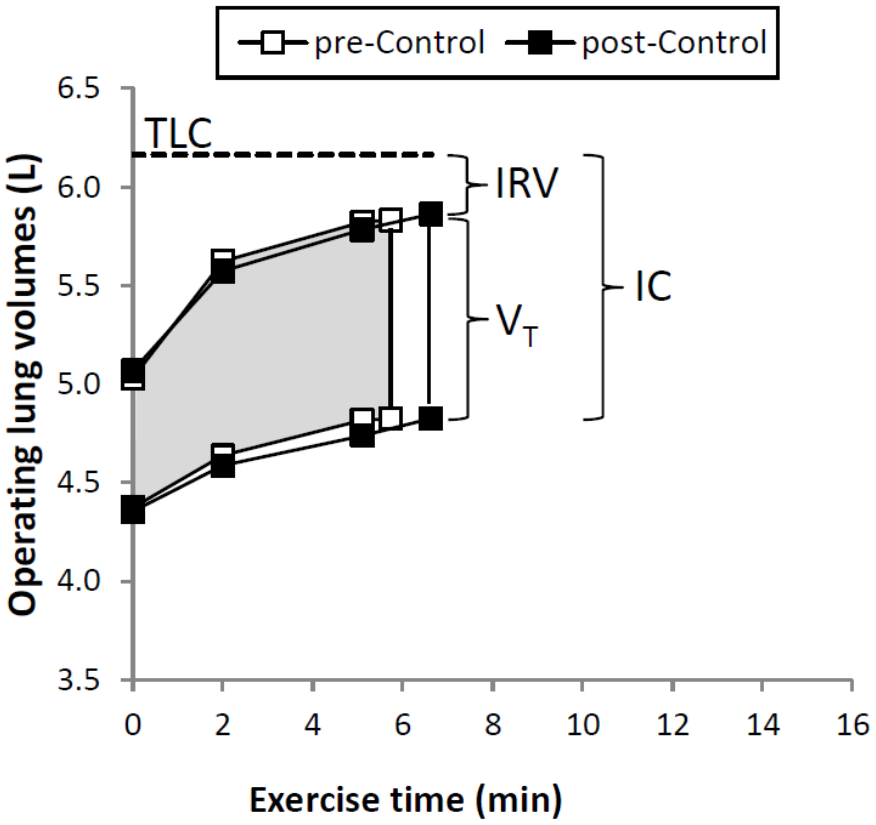

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ORIGINAL RESEARCH

Utility of ultrasound assessment of diaphragmatic function before and after pulmonary rehabilitation in COPD patients

Table 1 Baseline characteristics of the population

Characteristics	N=25
Age (years)	70.6±6.5
BMI (kg/m^2)	25.04±4.88
Gender n (%)	
Female	2 (8.0%)
Male	23 (92.0%)
Smoking history	
No smoker	1 (4%)
Current smoker	7 (28%)
Ex-smoker	17 (68%)
GOLD stages	
1	0 (0%)
2	5 (20%)
3	14 (56%)
4	6 (24%)
Charlson index	
3	5 (20%)
4	8 (32%)
5	12 (48%)

All patients attended the entire PR program and completed the **36 sessions (1 hour/session)** planned.

N=25	Pre-PR	Post-PR	*P*-value
Spirometry			
FVC%	83 (73–101)	89 (76–102)	0.020
FEV_1%	43 (34–50)	48 (39–55)	0.001
PEF%	41 (40–50)	45 (40–51)	0.024
FEV_1/FVC%	41 (34–46)	53 (47–63)	<0.001
VR%	132 (103–155)	129 (100–144)	0.002
TLC%	105 (97–115)	102 (97–112)	0.040
RV/TLC%	48 (38–52)	45 (36–50)	<0.01
Arterial blood gas			
pH	7.41 (7.40–7.42)	7.41 (7.40–7.42)	1
SaO_2%	94 (91–95)	93 (92–95)	0.008
PaO_2, mmHg	65 (59–70)	67 (60–71)	0.016
$PaCO_2$, mmHg	45 (41–49)	43 (40–45)	0.041
6MWD (m)	250 (150–350)	300 (210–400)	<0.001
CAT	26 (21–34)	24 (20–30)	<0.001
MRC	4 (3–4)	3 (2–3)	<0.001
BODE	6 (4–7)	4 (3–6)	0.001

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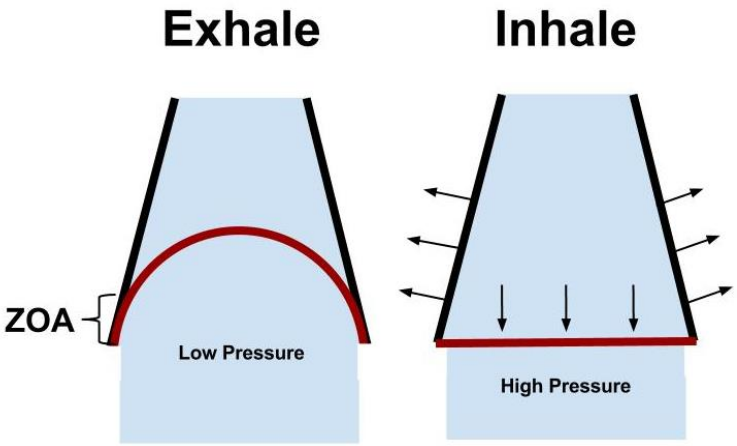
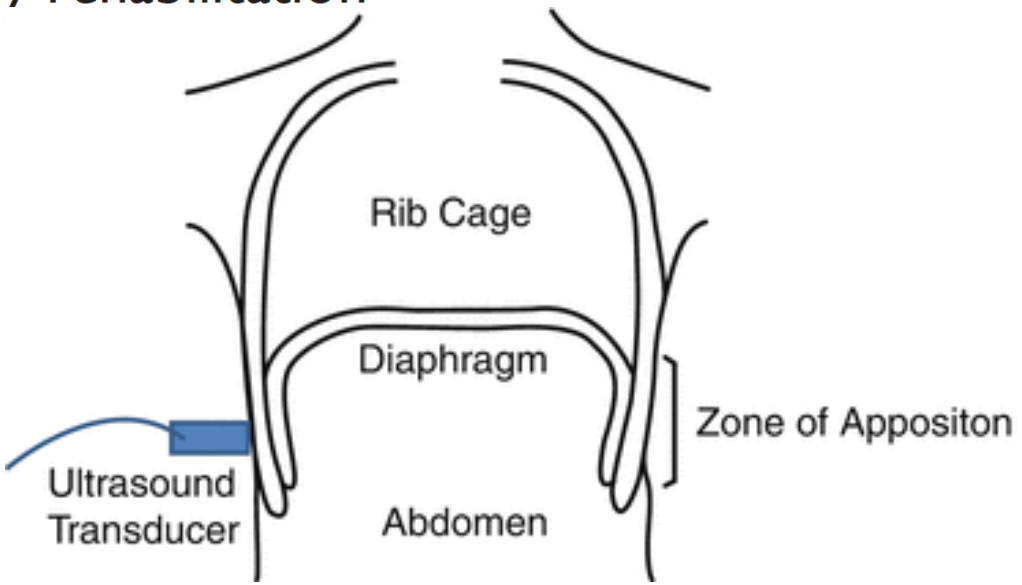
ORIGINAL RESEARCH

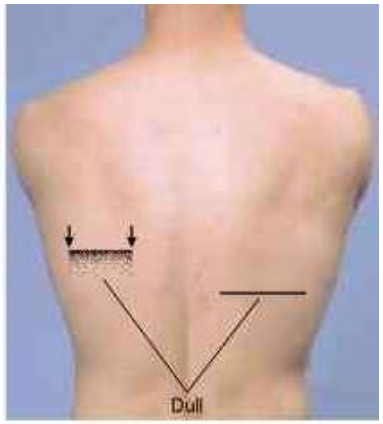
Utility of ultrasound assessment of diaphragmatic function before and after pulmonary rehabilitation in

Zone of Apposition





Diaphragm Excursion



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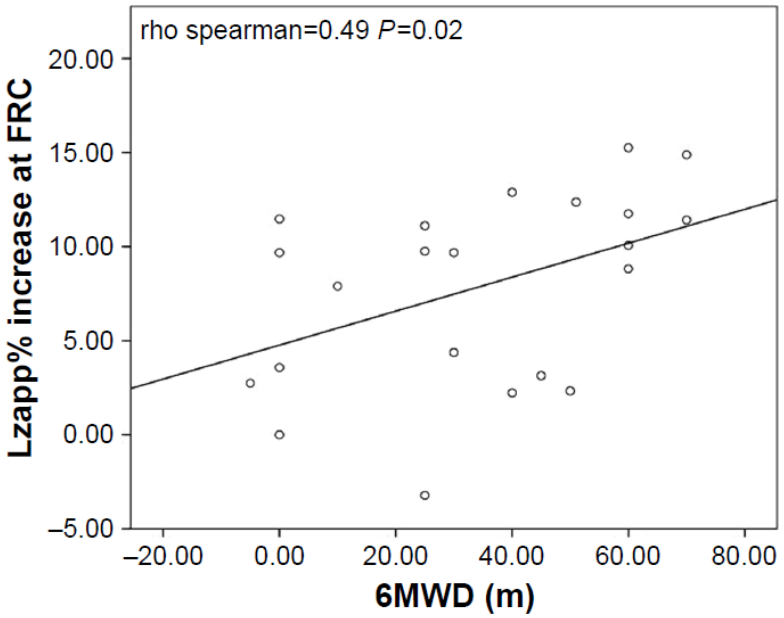
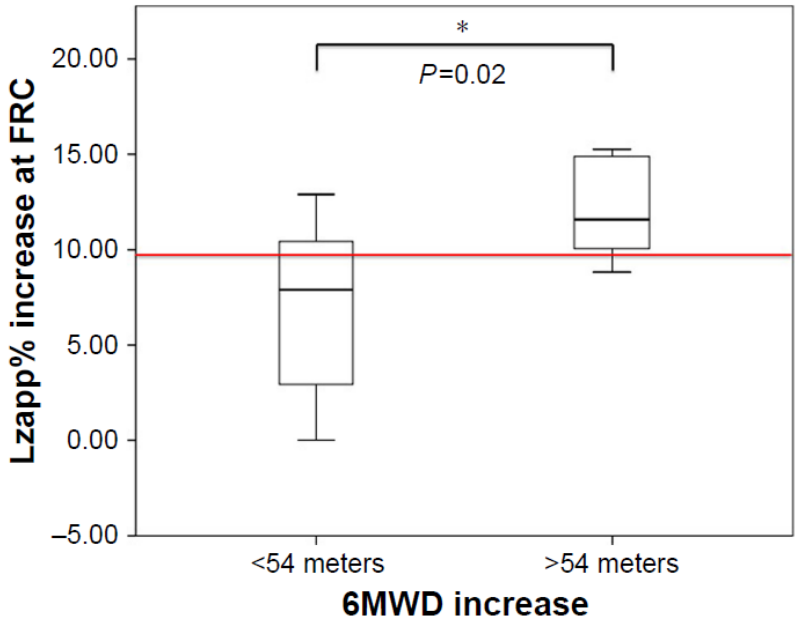
호흡재활: 횡경막 기능개선 운동 능력 비례

Table 3 Patients' ultrasonographic characteristics before and after pulmonary rehabilitation

N=25	Pre-PR	Post-PR	*P*-value
Diaphragm zapp (mm)			
Lzapp TLC	26 (18–31)	23 (19–26)	0.002
Lzapp FRC	38 (32–41)	41 (35–44)	<0.001
Szapp TLC	5 (3–6)	4 (3–5)	0.001
Szapp FRC	4 (3–4)	3 (3–4)	0.027
Diaphragmatic excursion (mm)			
Quiet breathing	23 (16–27)	27 (22–31)	<0.001
Deep breathing	36 (25–53)	50 (35–58)	<0.001
Rectus femoris area (m^2)	4 (3–4)	4 (3–5)	<0.001





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요약

- Pimax 증가 효과는 확실
  효과는 1) 근력이 약했던 사람 2) Strength (고강도) 훈련에서
  더 두드러짐.

- 운동 능력 개선 (6MWT)을 보인 일부 연구들이 있음.

- 흡기근 > 호기근
  Strength > Endurance

- Supervised Exercise 를 이 시간으로 대체하는 경우에 대해서 의문