Pulmonary Rehabilitation in Bronchiectasis

2026.4.4

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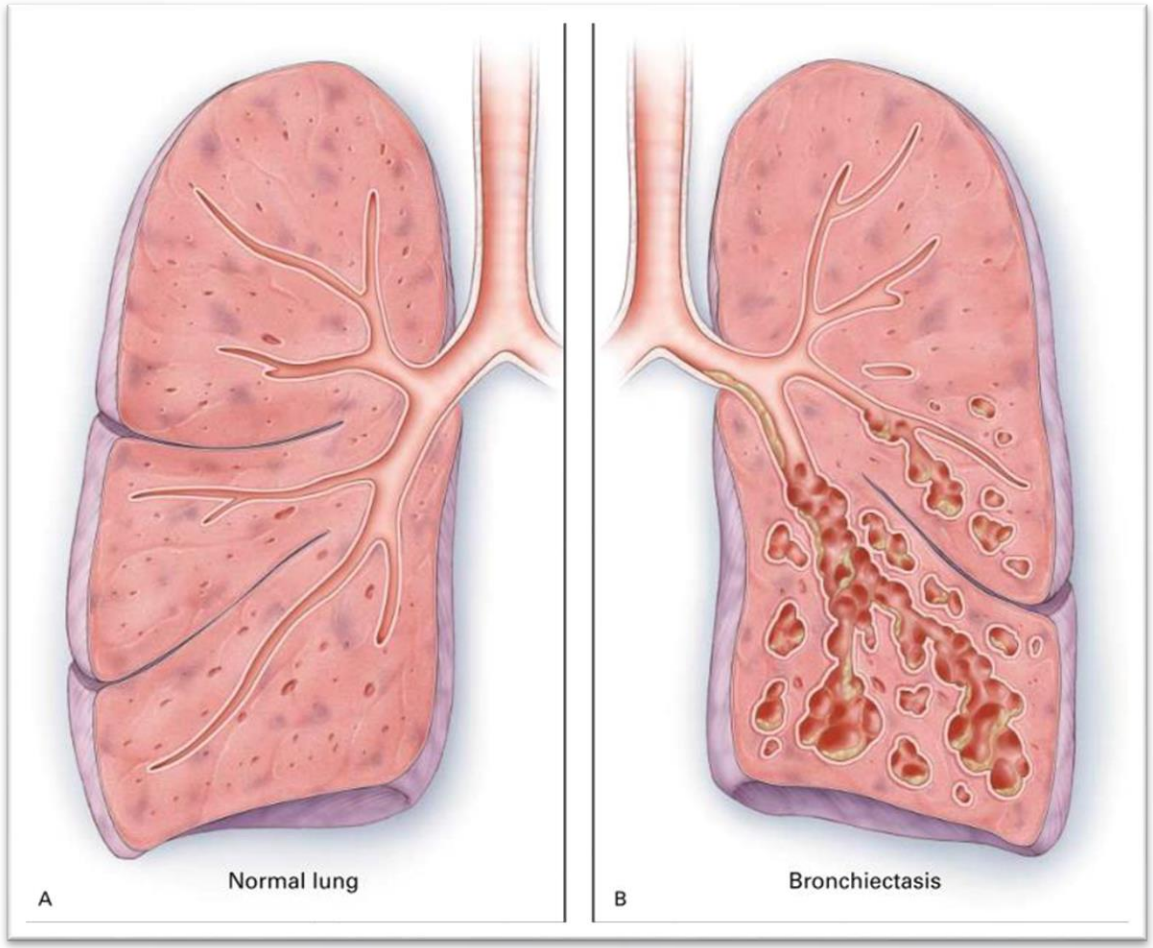
Bronchiectasis

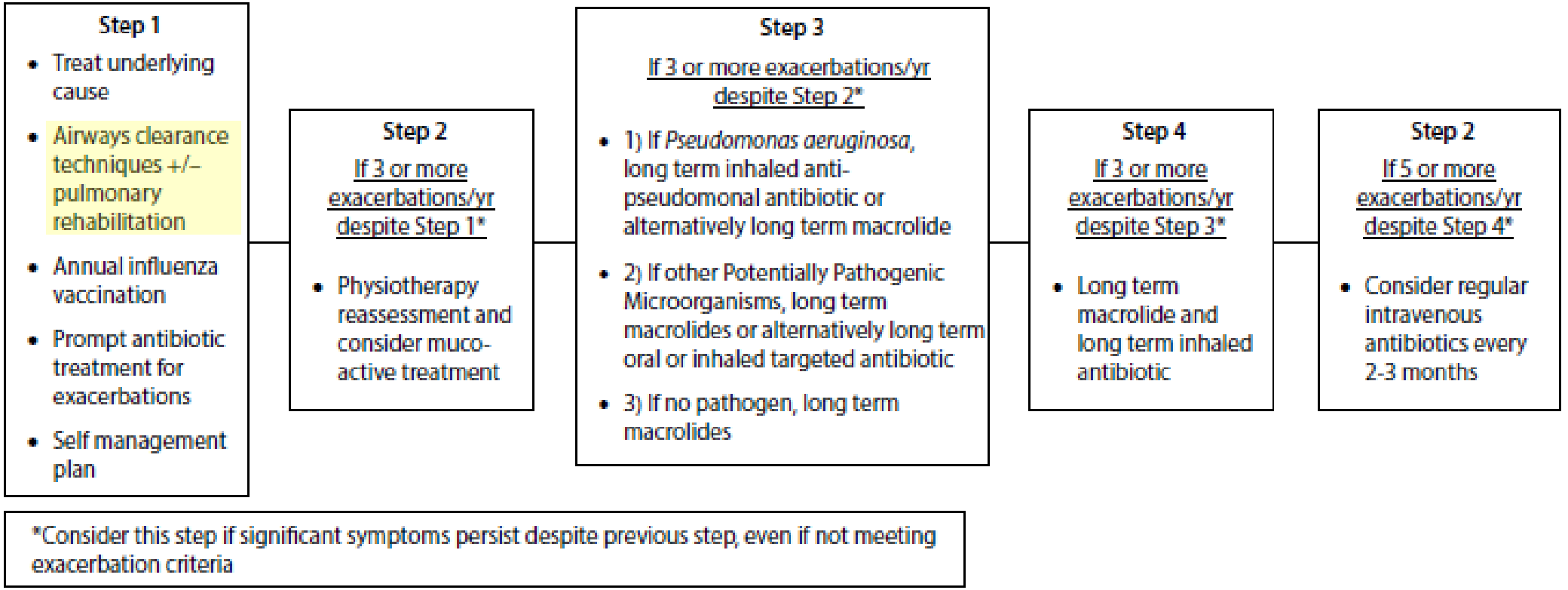


- Bronchiectasis is a chronic airway disorder characterized by permanent dilation of the bronchi.
- Clinical presentations vary widely, from asymptomatic cases to patients with chronic cough, sputum, recurrent infection and exacerbations.
- Prevalence is 464 cases per 100,000 population in South Korea.
- Bronchiectasis is associated with increased economic burden, hospital admission, and mortality rate.

N Engl J Med. 2002;346(18):1383-93, Eur Respir J . 2019 Aug 29;54(2):1900194., Eur Respir J. 2017;50(3)

Vicious vortex

Bronchiectasis treatment



Antibiotics are used to treat exacerbations that present with an acute deterioration (usually over several days) with worsening local symtoms (cough, increased sputum volume or change of viscosity, increased sputum purulence with or without increasing wheeze, breathlessness, haemoptysis) and/or systemic upset. The flow diagram refers to three or more annual exacerbations.

Figure 2 Stepwise management.

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PICO QUESTION 1- AIRWAY CLEARANCE
Should airway clearance techniques be used (compared to no airway clearance techniques) in adults with bronchiectasis?

Recommendation

- We recommend that patients with bronchiectasis should be taught airway clearance techniques (strong recommendation for the intervention, very low certainty of evidence)

Remarks

- Airway clearance techniques (ACTs) are best taught by a respiratory physiotherapy with appropriate experience.
- There is no evidence that one technique is superior to another and, therefore, treatment should be personalized.
- Airway clearance devices may be used to support manual ACTs.
- Previous ERS guidelines limited ACTs to patients with chronic productive cough. The current recommendation acknowledges that some patients with a dry cough, particularly those with mucus plugging on chest CT, may benefit from ACTs. Instruction in ACTs may also assist patients during periods of increased symptoms, such as exacerbations.

Airway Clearance Techniques

Manual Techniques
(전통적 물리치료)

중력·물리적 자극으로 점액 이동 유도

- Postural Drainage (체위 배액법)
- Percussion & Vibration (타격 및 진동)

Breathing Strategies
(호흡 조절 기법)

자가 조절 호흡 패턴으로 객담 배출

- Active Cycle of Breathing Technique (ACBT)
- Autogenic Drainage (AD)
- Forced Expiratory Technique (FET)

Mechanical Devices
(기구 이용 기법)

기구를 통한 기도 개방 및 진동 유발

- Positive Expiratory Pressure (PEP)
- Oscillating PEP (O-PEP)
- High-Frequency Chest Wall Oscillation (HFCWO)
- Intrapulmonary Percussive Ventilation (IPV)

Eur Respir J. 2023 Jul 20;62(1):2202053.

Manual Techniques

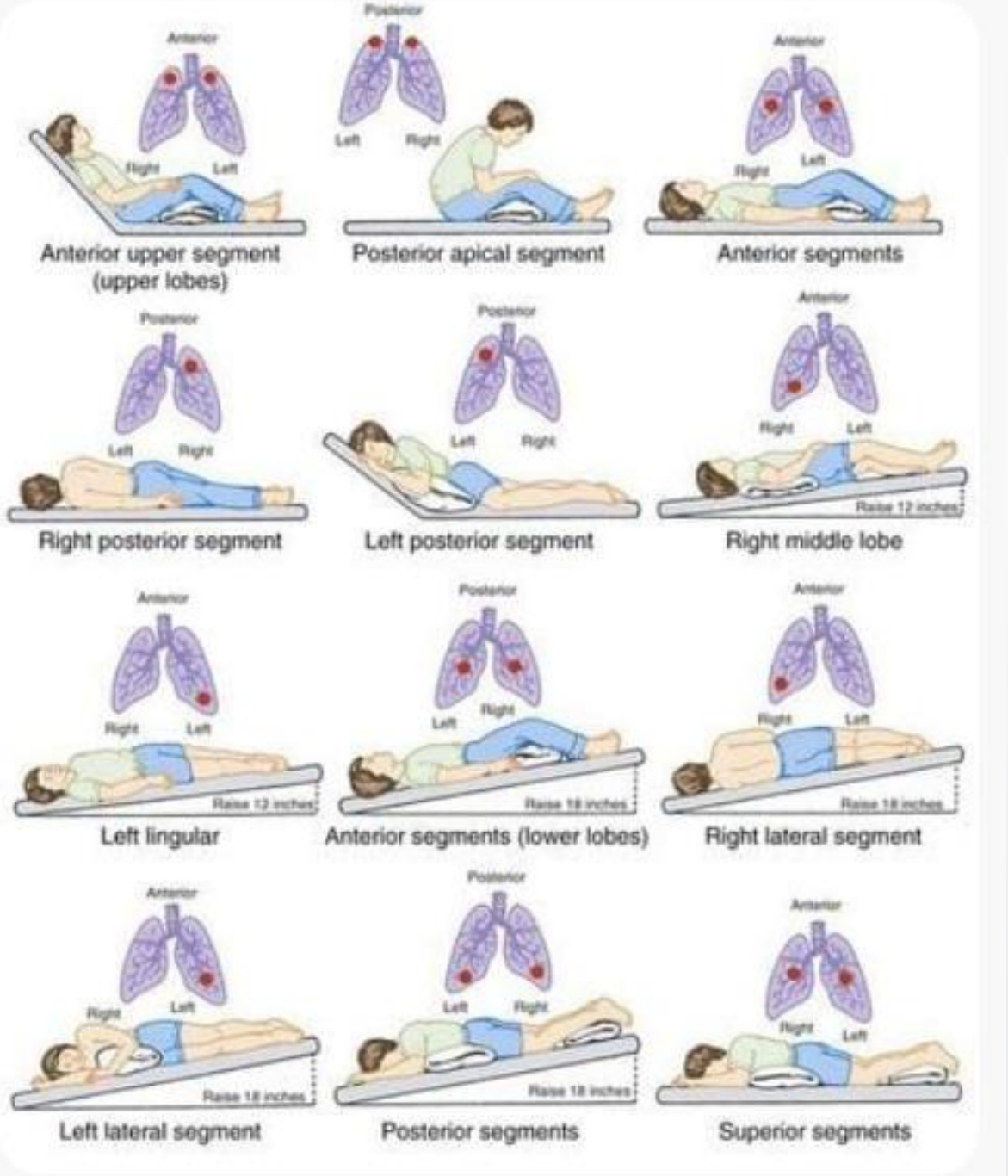
Postural Drainage
(체위 배액법)

▶ 작용 원리

- 중력을 이용하여 특정 폐 구역의 점액이 중심 기도로 흐르도록 유도하는 기법

▶ 특징

- 병변 부위에 따라 특정 체위 선택
- 15~20분간 자세 유지
- 중력 방향으로 점액이 큰 기도로 이동
- 이후 기침 또는 FET로 객담 배출
- 식후 1~2시간 후 시행 권장



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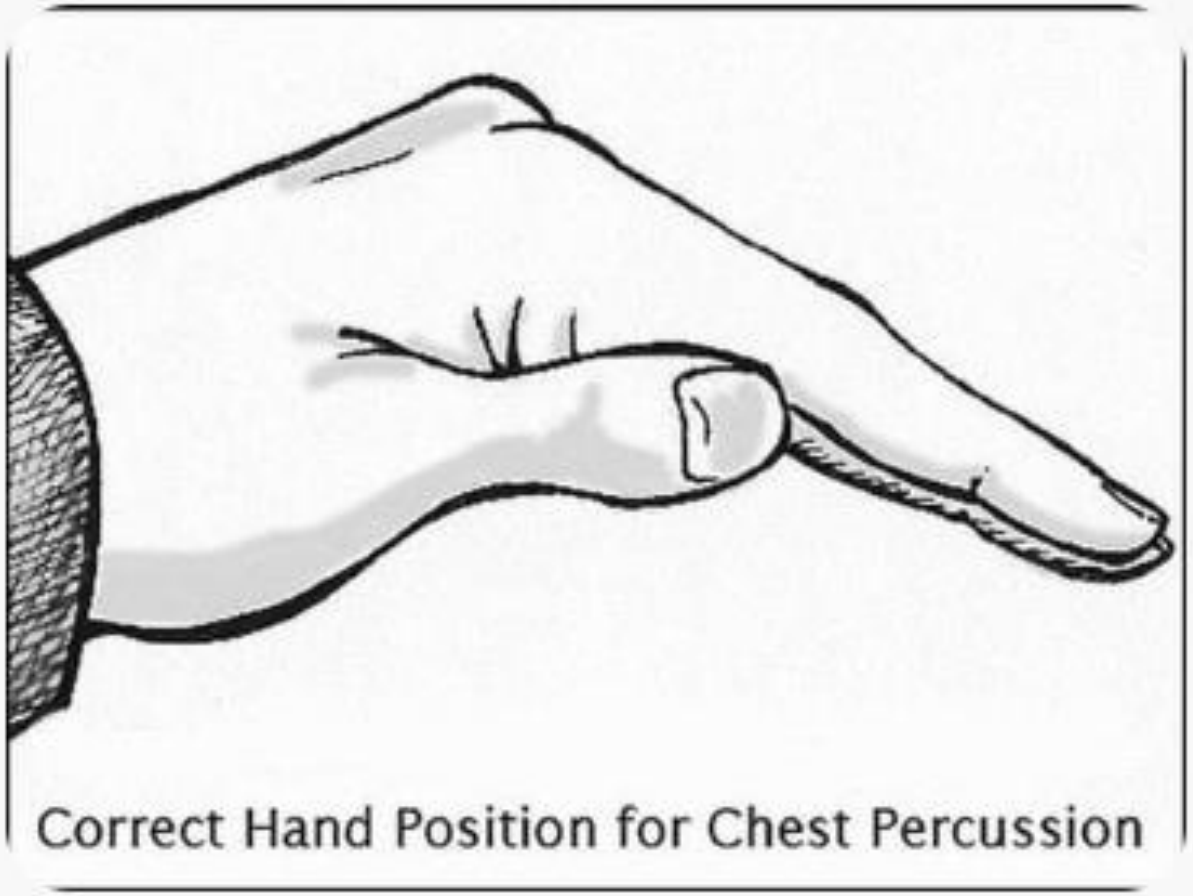
Manual Techniques



Correct Hand Position for Chest Percussion

Percussion & Vibration (타격 및 진동)

▶ 작용 원리

흉벽에 반복적인 percussion 또는 vibration을 가해 기도 벽에 달라붙은 점액을 분리시키는 기법

▶ 특징

- 손을 컵 모양으로 만들어 흉벽 두드림 (Cupped-hand percussion)
- 호기 중 흉벽에 손떨림으로 진동 전달 (Vibration)
- 체위 배액과 병행하면 효과 증대
- 골다공증·늑골 골절·혈소판감소증 시 주의
- 기계 진동기(mechanical vibrator) 사용 가능

Breathing Strategies

ACBT (Active Cycle of Breathing Technique)

호흡 조절 (Breathing Control)

방법: 어깨와 가슴의 긴장을 풀고 입술 오므리기 호흡(Pursed-lip breathing) 시행.

특징: 편안하게 코로 들이마시고 입으로 천천히 내뱉으며 호흡 리듬을 안정시킴.

흉곽 확장 운동 (Thoracic Expansion)

방법: 코로 깊게 숨을 들이마신 후, 2~3초간 멈췄다가 입으로 가볍게 내뱉음 (3~5회 반복).

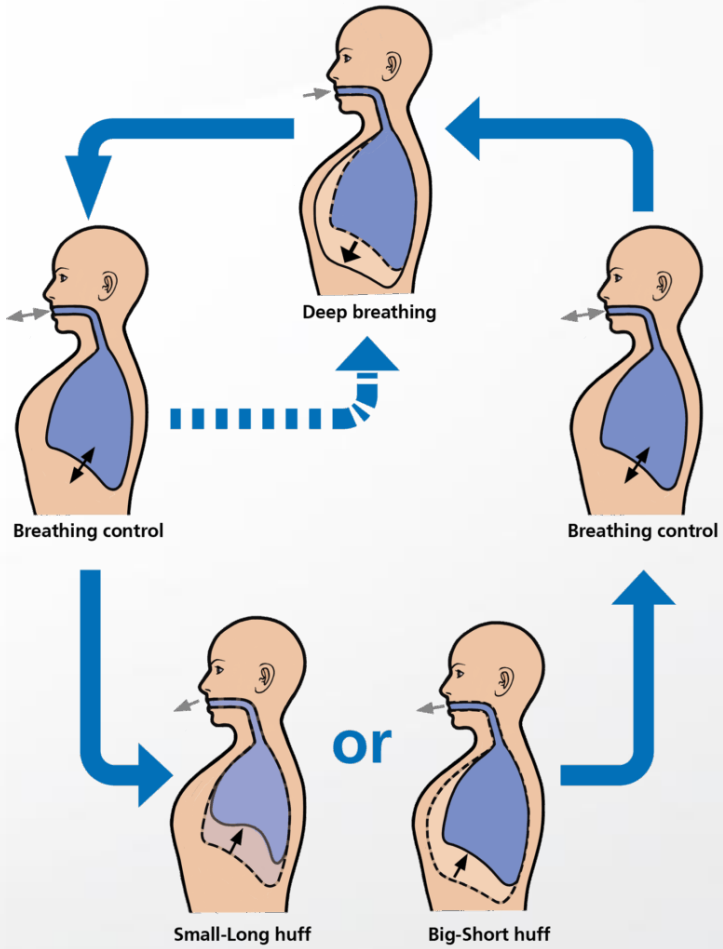
특징: 폐 용적을 넓히고 공기를 가래 뒤쪽까지 전달하여 가래를 이동시킴.

강제 호기 기법 (FET / Huffing)

방법: 성문을 연 상태에서 '하-' 하고 짧고 강하게 숨을 내뱉음 (huffing).

특징: 기도가 허탈(Collapse)되지 않게 유지하면서 점액을 상부 기도로 밀어 올려 배출함.

반복 (Repeat)



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기관지확장증 치료
능동적 가래배출법
안내

Breathing Strategies

Autogenic Drainage (AD)

분리 단계 (Unsticking)

방법: 숨을 최대한 내뱉은 상태에서 아주 적은 양만 들이마시는 저용적 호흡 반복.

특징: 폐 깊숙한 곳(말초 기도)에 달라붙어 있는 가래를 떼어냄.

수집 단계 (Collecting)

방법: 중간 정도의 깊이로 숨을 마시고 내뱉는 중용적 호흡 반복.

특징: 말초에서 떨어진 가래를 중간 크기의 기도로 모음.

배출 단계 (Evacuating)

방법: 깊게 숨을 마시고 강하게 내뱉는 고용적 호흡과 함께 Huffing 시행.

특징: 큰 기도로 모인 가래를 최종적으로 입 밖으로 배출.

반복 (Repeat)

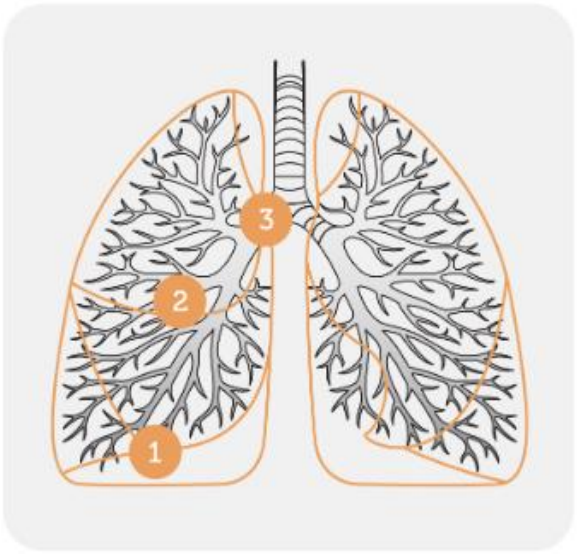


Fig. 3 Sitting posture

Eur Respir J. 2023 Jul 20;62(1):2202053.
https://bronchiectasis.com.au/physiotherapy/techniques/autogenic-drainage


기관지확장증 치료
능동적 가래배출법

Mechanical Devices

PEP (Positive Expiratory Pressure)

▶ 작용 원리

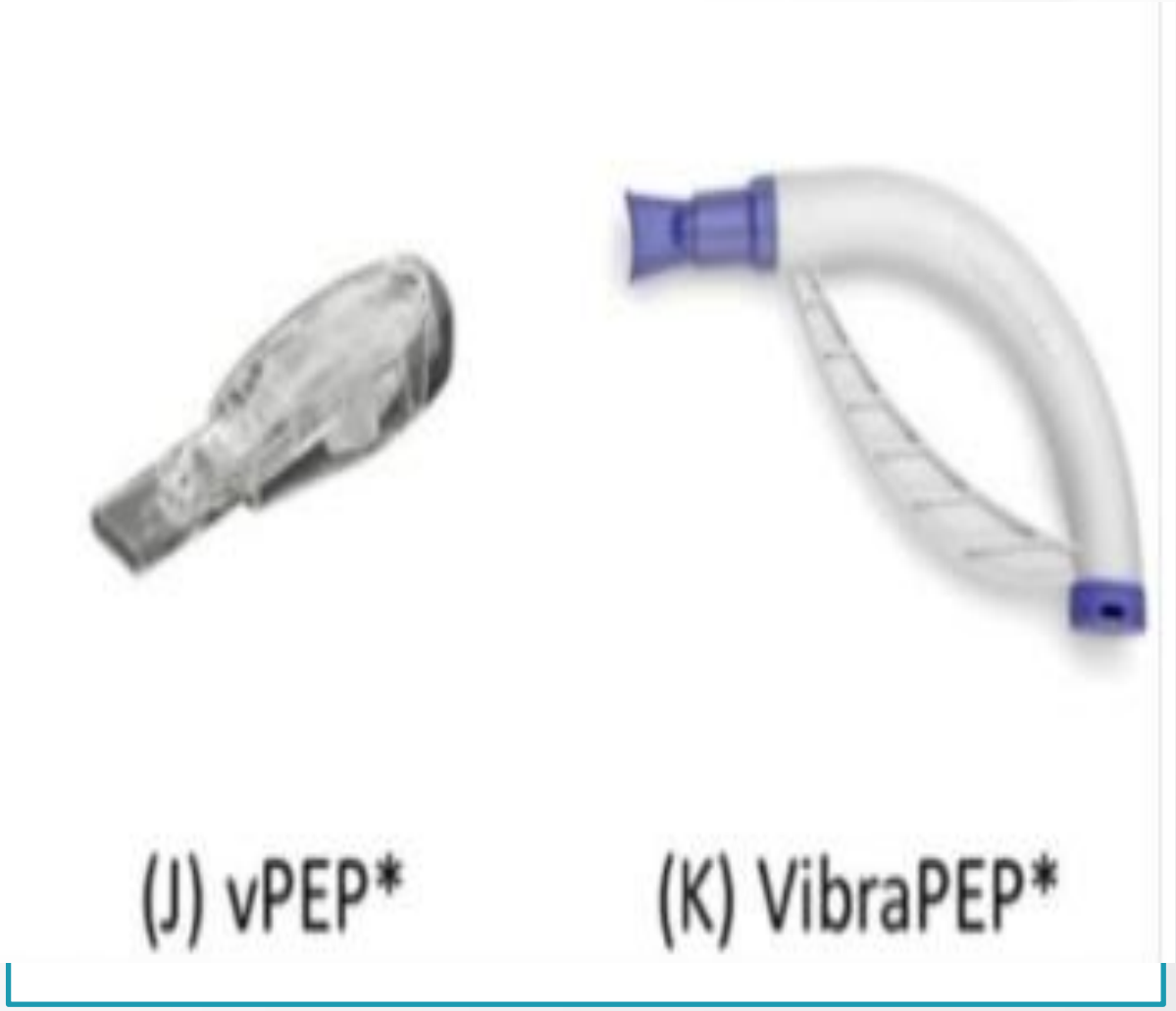
호기 시 저항(10–20 cmH_2O)을 가해 측부 환기 증가, 분비물을 말초에서 중심기도로 이동

▶ 대표 기기

- Pari PEP
- TheraPEP
- Aerosal PEP

▶ 특징

- 마스크 또는 마우스피스로 10~20 cmH_2O 저항
- 10~15회 호기 후 Huff/기침
- 하루 2회, 10~20분 시행
- 기도 역동적 허탈이 잦은 환자에게 적합



OPEP (Oscillating PEP)

▶ 작용 원리

PEP + 진동(oscillation)으로 점액 점도 감소,
섬모 기능 촉진, 분비물 이동 용이

▶ 대표 기기

- Flutter VRP1
- Acapella (Choice / Duet)
- Aerobika • RC-Cornet

▶ 주요 단계 / 특징

- 6~10초 호기 중 기도에 고주파 진동 전달
- 점액의 점도↓ · 탄성↑ → 이동 용이
- 하루 2~4회 시행; 휴대 편리

Mechanical Devices

HFCWO (고주파 흉벽 진동)

▶ 작용 원리

진동 조끼(Vest)를 착용 후 공기 펄스로 흉벽 전체에 5~25 Hz의 고주파 진동을 가하여 점액을 분리·이동

▶ 특징

- 인플레이터블 조끼 착용 후 컴프레서 연결
- 주파수·압력 개별 조절 (5~25 Hz)
- 20~30분간 시행, 중간에 기침·Huff
- 자세 독립적; 물리치료사 불필요

Mechanical Devices

IPV (Intrapulmonary Percussive Ventilation)

▶ 작용 원리

구강을 통해 고주파(100~300 cycles/min) 소형 공기 흐름을 기도로 직접 전달하여 미세 기도까지 점액을 분리

▶ 특징

- 마우스피스로 고주파 공기 펄스 전달
- 기도 내압 진동 + 가습 효과 동시 발생
- 자연 호흡 유지하며 치료 가능
- 기계환기 중 환자에게도 적용 가능
- 무기폐 예방·치료에도 활용

Airway Clearance Techniques

R Recommendations (Grade D)

- 모든 기관지확장증 환자에게 권고
- ACBT (Active Cycle of Breathing Techniques)
- Oscillating PEP device (Flutter, Acapella)
- Postural Drainage, Huff (FET)

G Good Practice Points

- 호흡 물리치료사가 교육
- 흡입제·운동 등 보조요법 함께 안내
- CT 기반으로 병변 위치·자세 결정 후 ACT 선택
- 대안 고려: AD · PEP · HFCWO · IPV

빈도 & 시간

- 최소 10분 ~ 최대 30분
- 1일 2회
- 개인 맞춤 조절

추적 관찰 & 재평가

- 초기 교육 후 3개월 내
- 연 1회 정기 평가
- 악화 빈도 증가 시 technique재검토

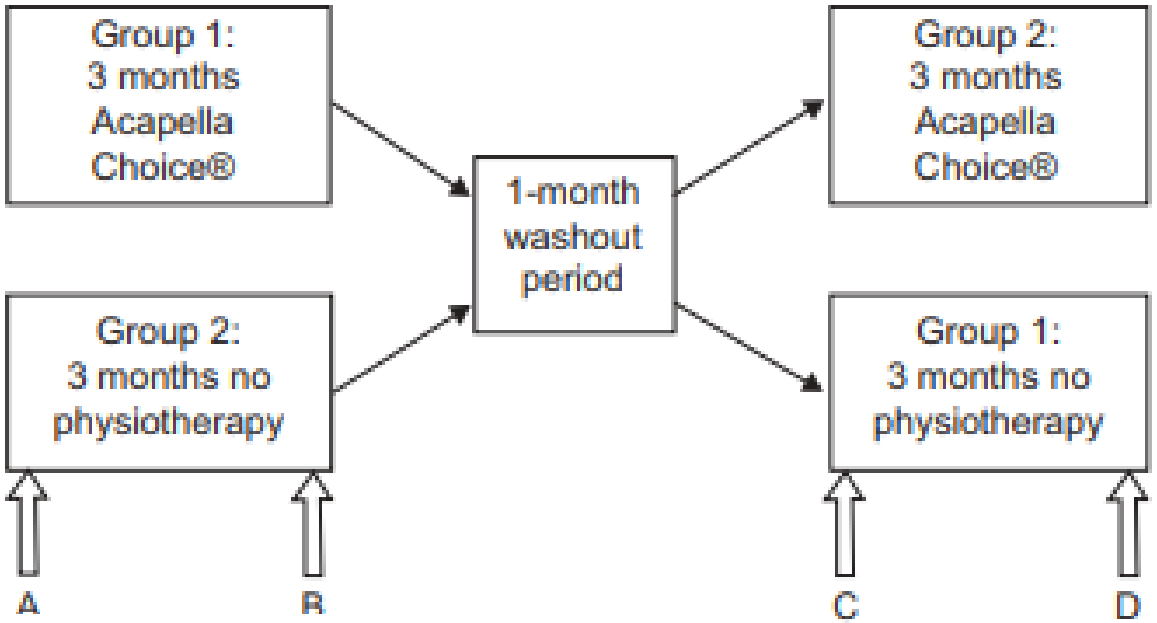
운동과의 관계

- 신체 활동은 적극 권장
- PR 병행 시 ACT 효과 극대화

Eur Respir J 2009; 34: 1086–1092
DOI: 10.1183/09031936.00055509

A randomised crossover trial of chest physiotherapy in non-cystic fibrosis bronchiectasis

M.P. Murray*, J.L. Pentland# and A.T. Hill*



Intervention

- Twice-daily using Acapella® for 3 months
- Each session: ~20–30 minutes

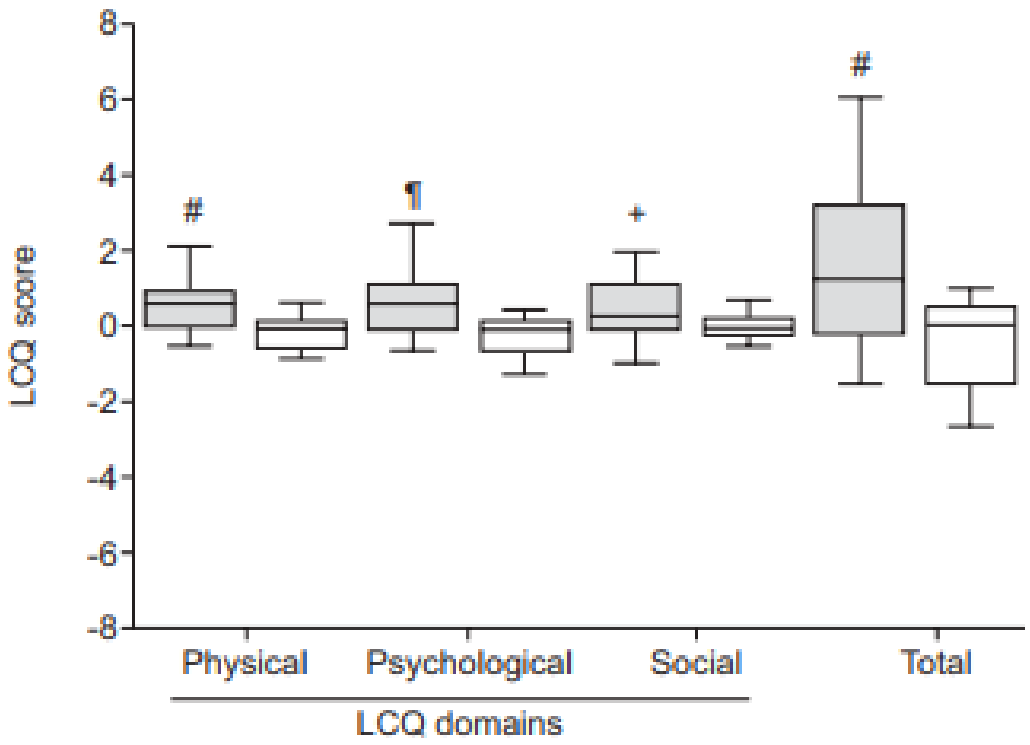
TABLE 1 Patient characteristics

Study participants#	20
Male	12 (60)
Age yrs	73 (72–77)
Ex-smokers	8 (40)
Chronic cardiac disease	3 (15)
Neurological disease	1 (5)
Chronic renal impairment	1 (5)
Diabetes mellitus	0
Inhaled corticosteroid therapy	12 (60)
Systemic corticosteroid therapy	0
Long-term antibiotic therapy	2 (10)
Infective exacerbations requiring antibiotic treatment in preceding 12 months	2 (1.5–3)
Lobes affected with bronchiectasis on HRCT	4 (3–4.75)
Varicose or cystic dilatation affecting ⩾1 lobe	15 (75)
Chronically colonised with pathogenic organisms in sputum when stable	14 (70)
Pseudomonas aeruginosa	6 (42.9)
Haemophilus influenzae	5 (35.7)
Staphylococcus aureus	2 (14.3)
Moraxella catarrhalis	1 (7.1)
Aetiology of bronchiectasis	
Post-infective	10 (50)
Idiopathic	8 (40)
Inactive allergic bronchopulmonary aspergillosis	1 (5)
Inflammatory bowel disease	1 (5)

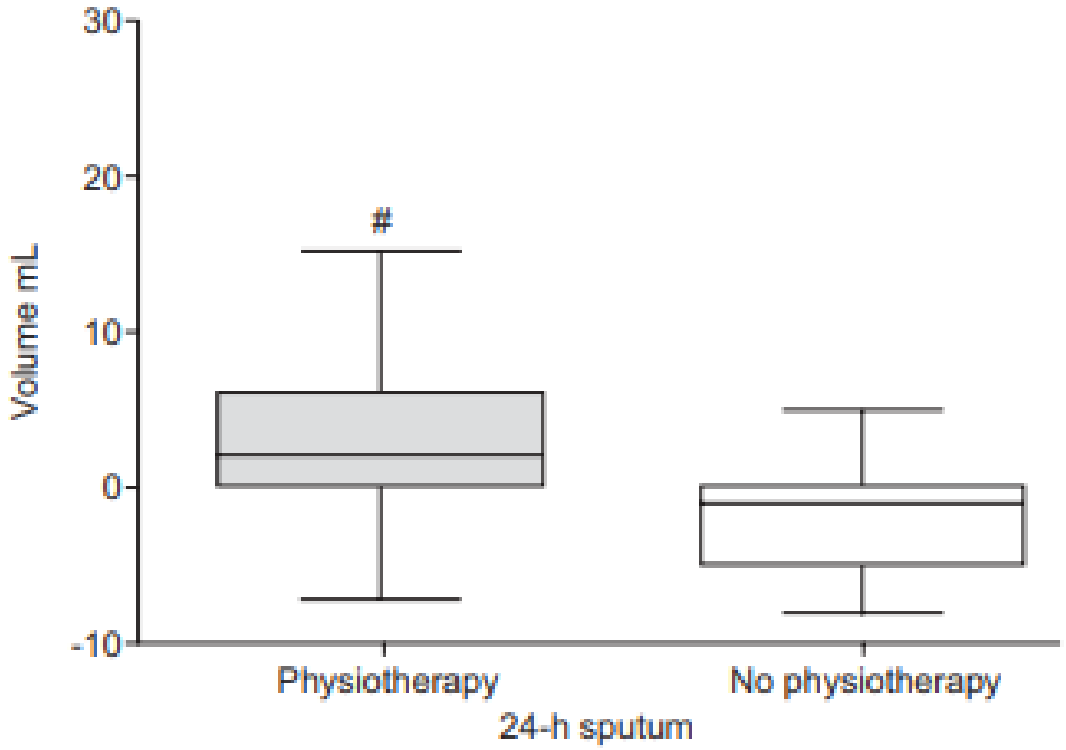
Data are presented as n, n (%) or median (interquartile range). HRCT: high-resolution computed tomography. #: all outpatients.

Treatment effect

Changes in Cough



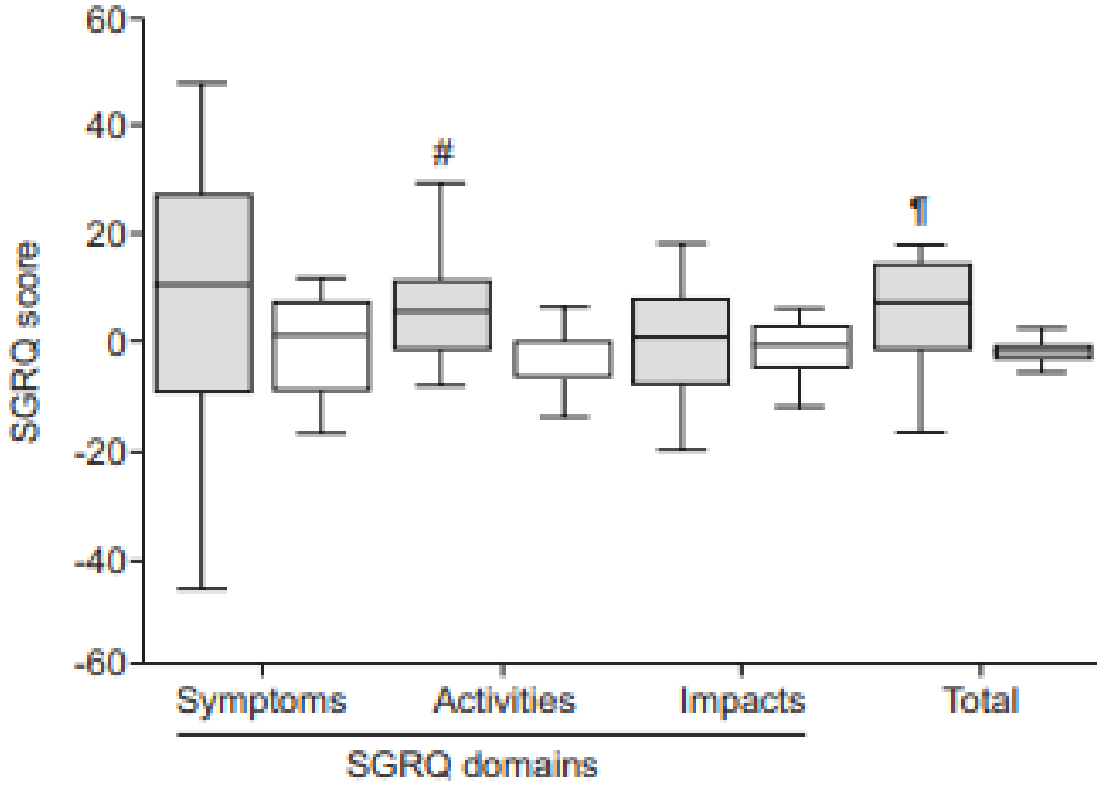
Changes in Sputum



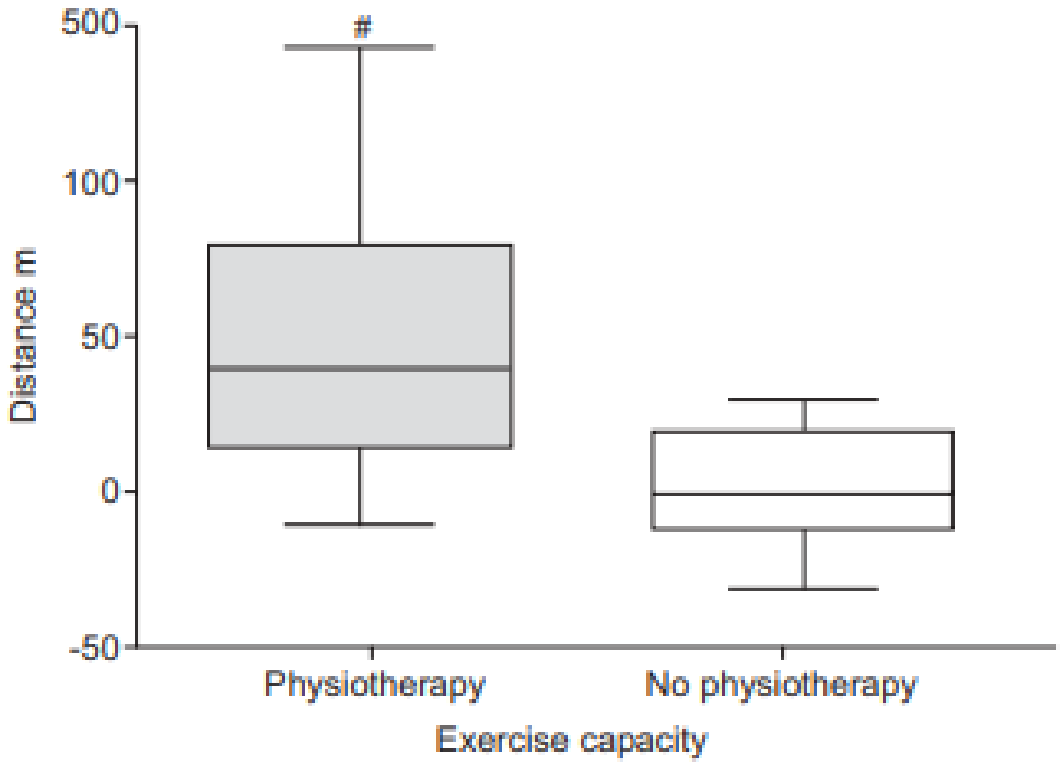
Murray MP et al. Eur Respir J. 2009;34(5):1086-1092.

Treatment effect

Changes in SGRQ



Changes in Exercise capacity



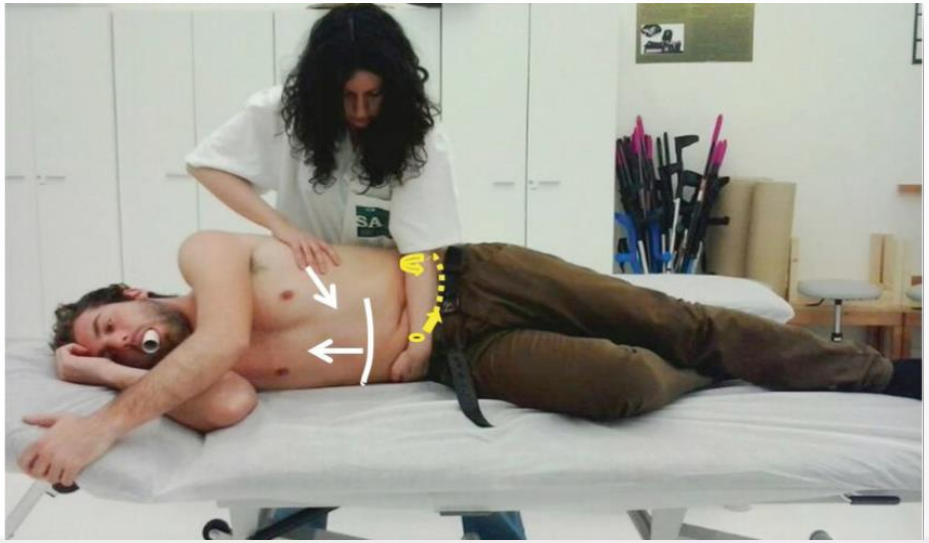
Murray MP et al. Eur Respir J. 2009;34(5):1086-1092.

Long-term benefits of airway clearance in bronchiectasis: a randomised placebo-controlled trial

Gerard Muñoz[1,2], Javier de Gracia[3,4,5], Maria Buxó[6], Antonio Alvarez[3,4] and Montserrat Vendrell[1,3]

Intervention

- ELTGOL vs placebo (stretching exercises)
- Performed twice daily for 12 months
- ELTGOL: slow, prolonged expiration with open glottis in lateral position to facilitate mucus clearance



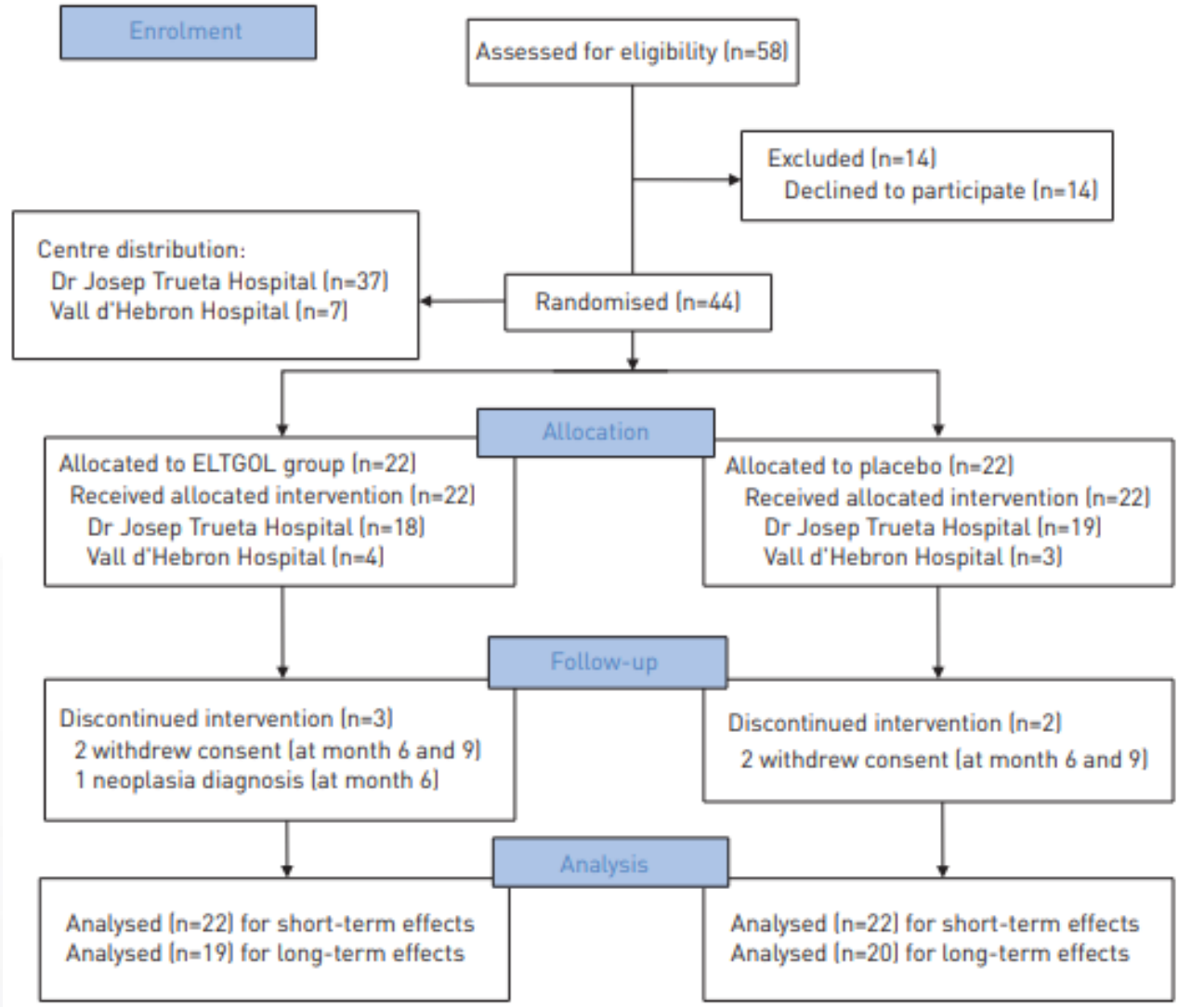


FIGURE 1 Trial profile.

Change in Sputum

TABLE 2 Sputum volume obtained during the study

	Sputum volume mL		p-value
	ELTGOL group	Placebo group	
Baseline 24-h	20 (15–40)	15 (15–20)	0.061
Visit 2 overall 24-h	40 (23.75–60)	12.5 (0–20)	<0.001
During intervention	12.27±11.93	0	
24 h later	30 (20–45)	12.5 (0–20)	<0.001
Difference between visit 2 and baseline*	17.5 (10–26.25)	−5 (−11.25–0)	<0.001
Month 12 overall 24-h	35 (30–50)	15 (10–20)	<0.001
During intervention	10.83±5.21	0	
24 h later	25 (20–40)	15 (10–20)	0.001
Difference between month 12 and baseline#	10 (−5–25)	0 (−10–3.75)	0.015
Difference between month 12 and visit 2¶	−5 (−30–5)	5 (5–10)	0.019

Data are presented as mean±SD and median (interquartile range); differences are expressed as median (95% confidence interval). Unpaired t-test values of the differences in the overall 24-h sputum volume between visit 2 and baseline*, month 12 and baseline#, month 12 and visit 2¶ in the ELTGOL group (p=0.001, p=0.026, p=0.09, respectively) and in the placebo group (p=0.008, p=0.106, p=0.261, respectively).

Treatment Effects

TABLE 3 Quality of life, pulmonary function, dyspnoea scale, exercise capacity and inflammatory markers between the groups at the beginning and the end of the study

	ELTGOL			Placebo			p-value#
	Baseline	Month 12	Between-group differences	Baseline	Month 12	Between-group differences	
SGRQ total score	40.2±13.7	33.7±15.7	−6.8 (−15.1–1.5)+	35.0±9.9	47.6±12.8	11.4 (6.9–15.9)+	<0.001
LCQ total score	14.5±3.4	16.2±3.2	1.96 (0.2–3.8)+	15.7±2	13.7±2.1	−2 (−2.8– −1.2)+	<0.001
Exacerbations	2 (1–3.25)	1 (0–2)	−0.8 (−1.5– −0.1)¶	1(0.75–2.25)	2 (1–3)	0.35 (−0.5–0.35)¶	0.042
FEV1% predicted	58.1±22.9	57.9±25	−0.4 (−3.5–2.8)+	64.6±21.1	61.3±21	−2.5 (−4.7– −0.2)+	0.262
FEV1 L	1.6±0.8	1.6±0.8	−0.004 (−0.1–0.03)+	1.5±0.4	1.5±0.4	−0.1 (−0.2–0.004)+	0.407
mMRC	1 (0–1.25)	1 (0–1)	0 (−0.5–0)¶	1 (1–1.25)	1 (1–2)	0.5 (0–0.5)¶	0.127
6MWT m	417.8±67	423.5±84.9	2.3 (−16.7–21.2)+	382.9±76.9	377.8±57.3	−2.6 (−29.3–24.1)+	0.746
ESR mm	22.3±26.5	17.1±17.5	9 (7–23)+	25.5±22.3	23.9±17.6	24 (7.3–34.5)+	0.863
Leukocytes $\times 10^3$ μL^{-1}	6.9±2	7.5±2	0.03 (−0.8–0.9)+	7.5±2.2	7.7±2.7	0.6 (−0.2–1.3)+	0.641
Neutrophils %	59.7±8.7	60±8.9	−1.6 (−6.6–3.3)+	58.5±8.4	57.9±12.1	−1.4 (−6–3.2)+	0.945
CRP mg·dL^{-1}	0.7±0.9	1.7±2.7	0.7 (−0.7–2.2)+	0.6±0.5	0.7±0.6	0.06 (−0.3–0.4)+	0.619
Fibrinogen mg·dL^{-1}	425.5±69	468.6±1000.5	43.9 (−31.3–119)+	449.6±930.5	492.6±125.2	59.3 (−13.8–132.3)+	0.756

Data are presented as median (interquartile range) or mean±SD, unless otherwise stated. #: unpaired t-test comparing difference between baseline and month 12 between the two groups (ELTGOL *versus* placebo); ¶: data are presented as median difference (95% confidence interval); +: data are presented as mean difference (95% confidence interval). SGRQ: St George's Respiratory Questionnaire; LCQ: Leicester Cough Questionnaire; FEV1: forced expiratory volume in 1 s; mMRC: modified Medical Research Council; 6MWT: 6-min walk test; ESR: erythrocyte sedimentation rate; CRP: C-reactive protein.

Contents

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PICO QUESTION 8 - Pulmonary rehabilitation
Should pulmonary rehabilitation be used (compared to no pulmonary rehabilitation) in adults with bronchiectasis?

Recommendation

- We recommend that patients with breathlessness and/or impaired exercise capacity should be offered pulmonary rehabilitation (strong recommendation for the intervention, very low certainty of evidence)

Remarks

- The educational component of pulmonary rehabilitation (PR) should ideally be bronchiectasis specific and include discussion of airway clearance strategies.
- Patients with bronchiectasis should be encouraged to undertake regular physical activity, given its multiple health benefits.

Pulmonary Rehabilitation

R Recommendations (Grade B)

- mMRC ≥ 1 환자에게 PR 권고
- PR + Inspiratory Muscle Training (IMT) 병행 고려
- IMT 병행 시 훈련 효과 및 유지 기간 연장

G Good Practice Points

- PR 운동교육 자격을 갖춘 전문 의료진이 시행
- 기관지확장증 맞춤 교육 :
  - Airway clearance techniques
  - 질환의 병태생리 (pathophysiology)
  - 흡입치료 (inhaled therapy)

운동능력 평가

- 6-Minute Walk Test (6MWT)
- Incremental Shuttle Walk Test (ISWT)

PR 효과 (Evidence)

- 운동능력 향상(ISWT, 6MWD)
- 삶의 질 향상(SGRQ, LCQ)
- 연간 악화 빈도 감소
- 첫 악화까지 기간 연장

시행 원칙

- PR 후 지속 운동 프로그램 권장
- 집단 운동 시 교차 감염 모니터링

Lung (2022) 200:409–417
https://doi.org/10.1007/s00408-022-00540-3

Effects of Pulmonary Rehabilitation on Systemic Inflammation and Exercise Capacity in Bronchiectasis: A Randomized Controlled Trial

Amanda Souza Araújo[1,2] · Mara Rúbia Figueiredo[1,2] · Isabella Lomonaco[3] · Fernando Lundgren[4] · Rafael Me
Eanes Delgado Barros Pereira[3]

Received: 22 December 2021 / Accepted: 20 April 2022 / Published online: 11 May 2022

Intervention:

- Pulmonary rehabilitation (PR) group
  - 3 sessions/week for 12 weeks
  - Included
    - ✓ Aerobic training
    - ✓ Muscle strengthening
    - ✓ Inspiratory muscle training
    - ✓ Education
- Control group:
    - ✓ Usual care + airway clearance techniques + breathing exercises

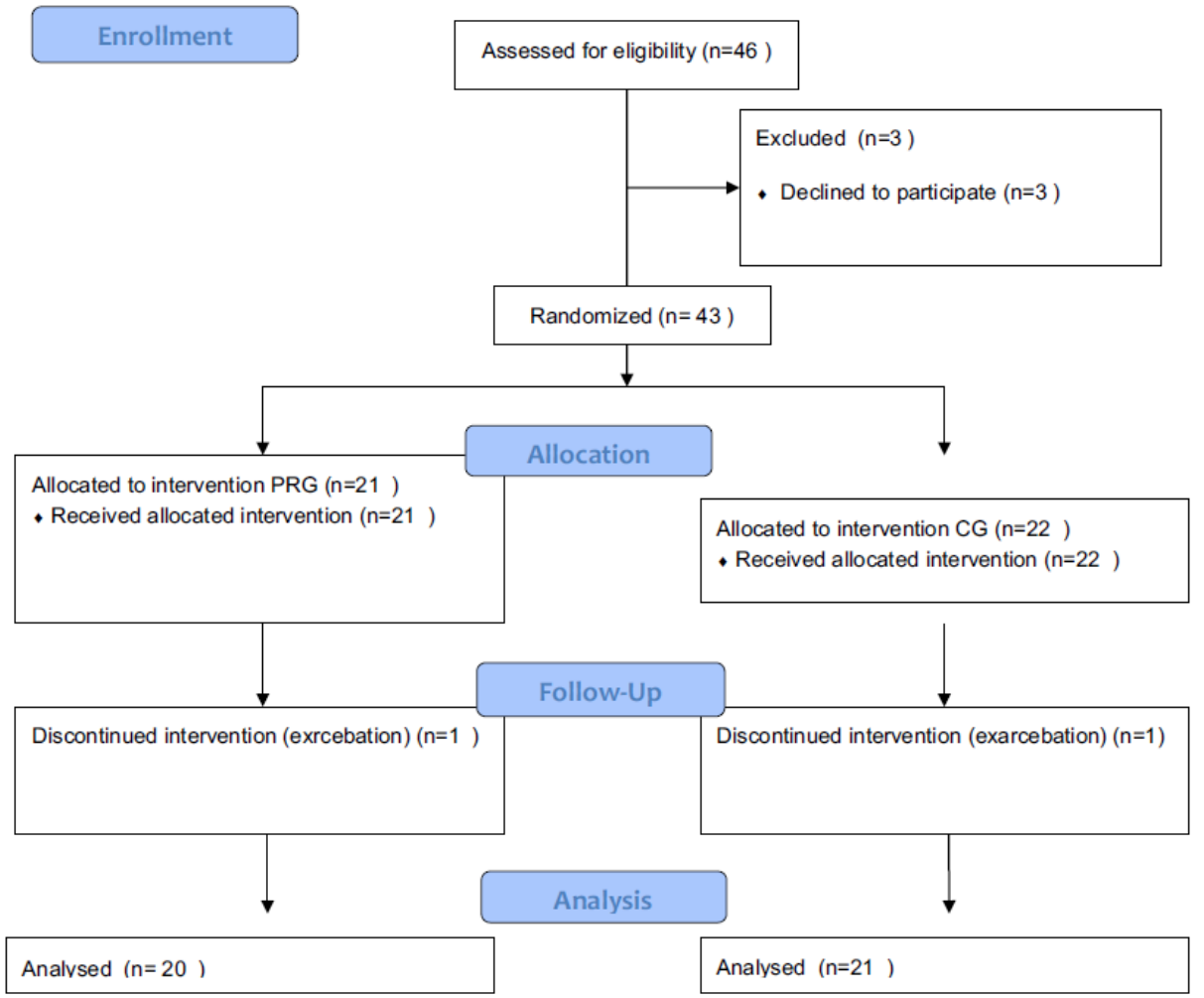

Fig. 1 Flow diagram of the randomized controlled trial of 12 weeks of pulmonary rehabilitation in bronchiectasis. *PRG* pulmonary rehabilitation group, *CG* control group

Treatment Effects

Table 3 Evaluation of dyspnea, exercise capacity, respiratory muscle strength, systemic inflammation, fatigue and quality of life, between the groups at the beginning and the end of the study

Variables	PR Group			Control Group			p*
	Baseline	Post 3 months	Within-groups difference[a](IC95%)	Baseline	Post 3 months	Within-groups difference[a](IC95%)	
mMRC	2.2 ± 1.2	1.4 ± 1.1	− 0.8 (− 1–0.6)	2.1 ± 1.1	2.4 ± 0.9	0.3 (0.03–0.6)	< 0.01
PImax (cmH_2O)	70 ± 17.2	91.8 ± 21.5	21.8 (14–29.5)	80 ± 25.4	78.6 ± 23.5	− 1.4 (− 6.1–3.2)	< 0.01
PEmax (cmH_2O)	63.5 ± 18.9	82.3 ± 21.8	18.8 (13.9–23.6)	74.8 ± 22.4	74.3 ± 23.4	− 0.5 (− 8.1–7.1)	< 0.01
Fibrinogen (mg/dl)	372.8 ± 71.0	280 ± 52.7	− 92.8 (− 112.6 –73)	393.4 ± 75.5	346.4 ± 73.5	− 47.1 (− 56.1–38)	< 0.01
6MWT (m)	493.1 ± 79.1	547.1 ± 81.1	54 (40.3–67.7)	486.1 ± 72.1	498.1 ± 71.5	12 (1.6–22.3)	< 0.01
6MWT (%)	82.5 ± 9.2	91.9 ± 10.5	9.4 (7–11.9)	82.3 ± 12.3	84.4 ± 11.8	2.1 (0.5–3.7)	< 0.01
SGRQ total	47.6 ± 16.2	40.1 ± 16.2	− 7.6 (− 10.3–4.8)	46.5 ± 17.1	49.6 ± 16.1	3.2 (0.6–5.7)	< 0.01
Fatigue	4.9 ± 1.7	3.5 ± 1.1	− 1 (− 1.1–0.4)	5 ± 1.5	5.3 ± 1.4	0.3 (0.05–0.5)	< 0.01

Data are presented as mean ± SD

PR pulmonary rehabilitation, *mMRC* modified Medical Research Council, 6*MWT* 6-min walk test, *SGRQ* St George's Respiratory Questionnaire, 6*MST* 6-min step test, *PImax* inspiratory pressure, *PEmax* expiratory pressure

[a]Data are presented as mean difference (95% confidence interval) between baseline and 3-month

*t-test comparing difference (3 months − baseline) between the two groups (PR versus control)

Lee et al. Respiratory Research 2014, 15:44
http://respiratory-research.com/content/15/1/44

RESPIRATORY RESEARCH

RESEARCH Open Access

The short and long term effects of exercise training in non-cystic fibrosis bronchiectasis – a randomised controlled trial

Annemarie L Lee[1,2,3*], Catherine J Hill[2,4], Nola Cecins[5,6], Sue Jenkins[5,6,7], Christine F McDonald[2,4], Angela T Burge[1], Linda Rautela[2,4], Robert G Stirling[1,8], Philip J Thompson[5,6,7] and Anne E Holland[1,2,9]

Study design:

- Multi-center, randomized, single-blind controlled trial

Participants:

- Adults (>18 years) with non-CF bronchiectasis confirmed by HRCT, clinically stable with ≥2 exacerbations in the previous 2 years

Intervention:

- 8-week supervised exercise training (2 sessions/week)
- review and optimization of airway clearance therapy
- home exercise program (3–5 sessions/week)

Control group:

- Usual care with general advice on physical activity (no supervised training)

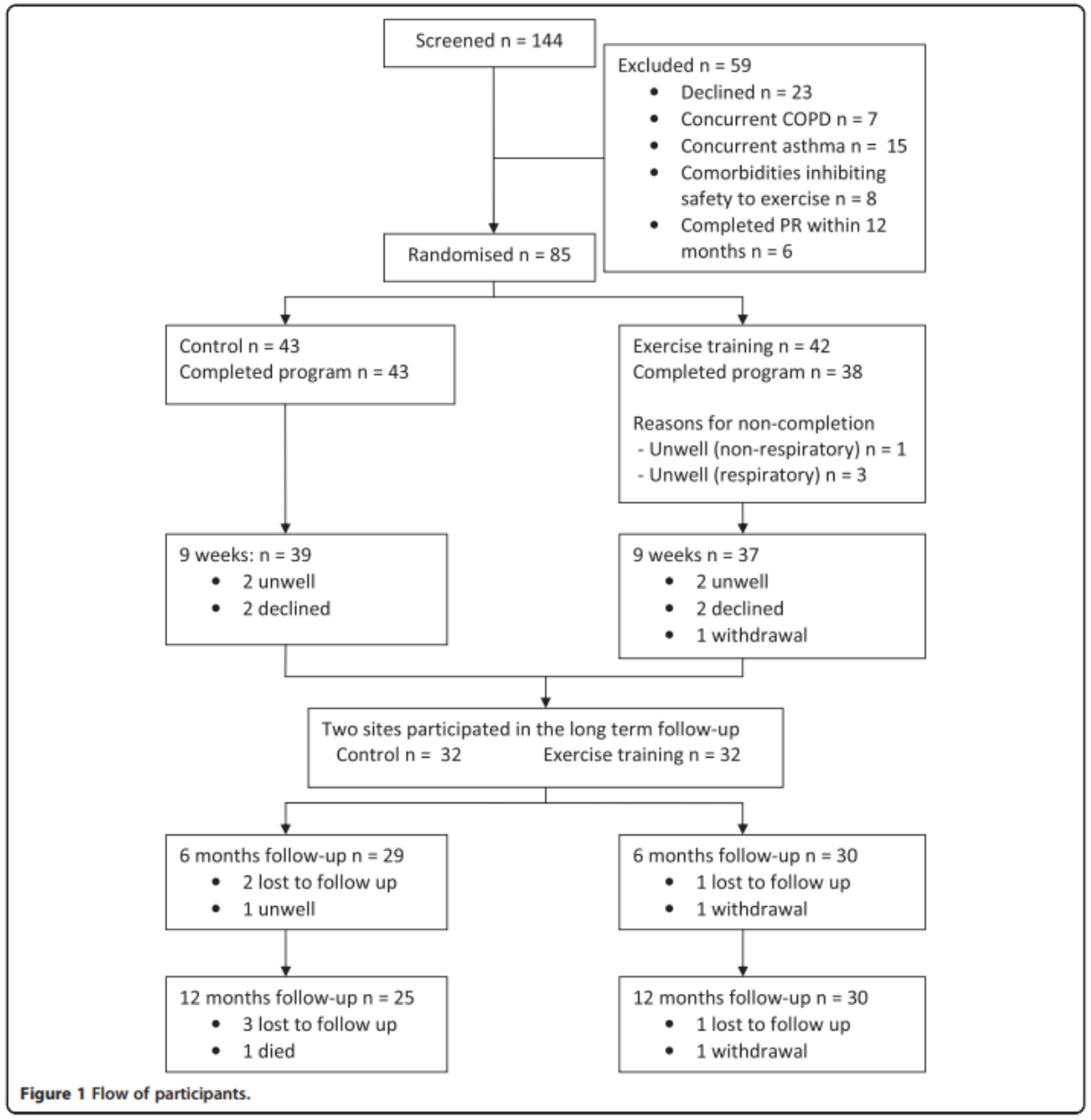

Figure 1 Flow of participants.

Treatment Effects

Changes in Exercise Capacity

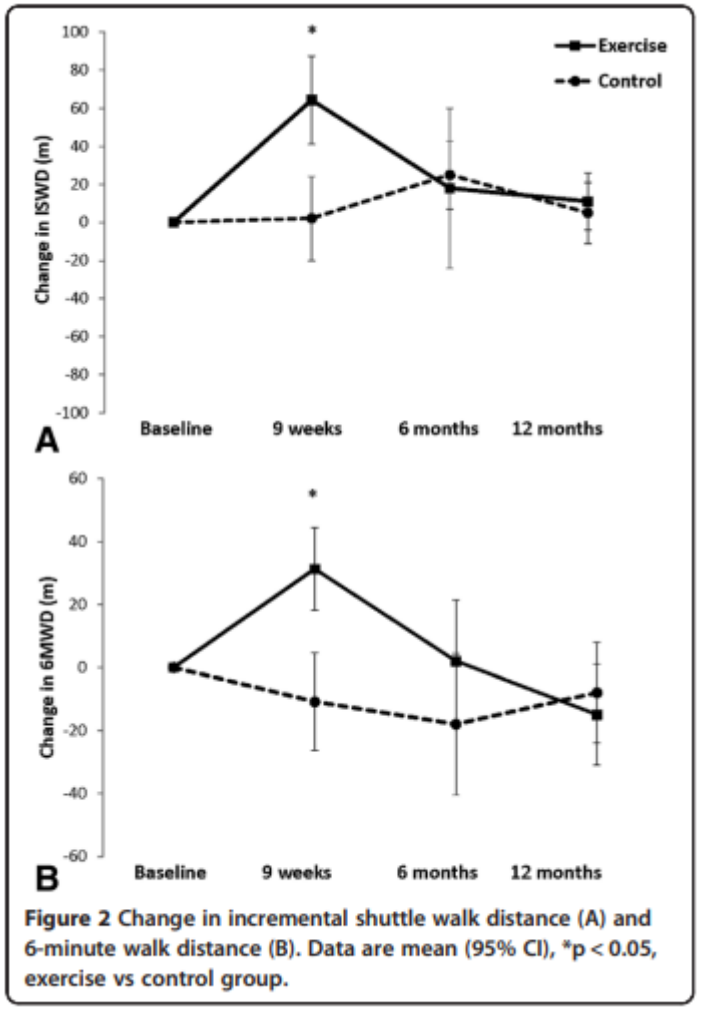

Figure 2 Change in incremental shuttle walk distance (A) and 6-minute walk distance (B). Data are mean (95% CI), *p < 0.05, exercise vs control group.

Changes in QoL

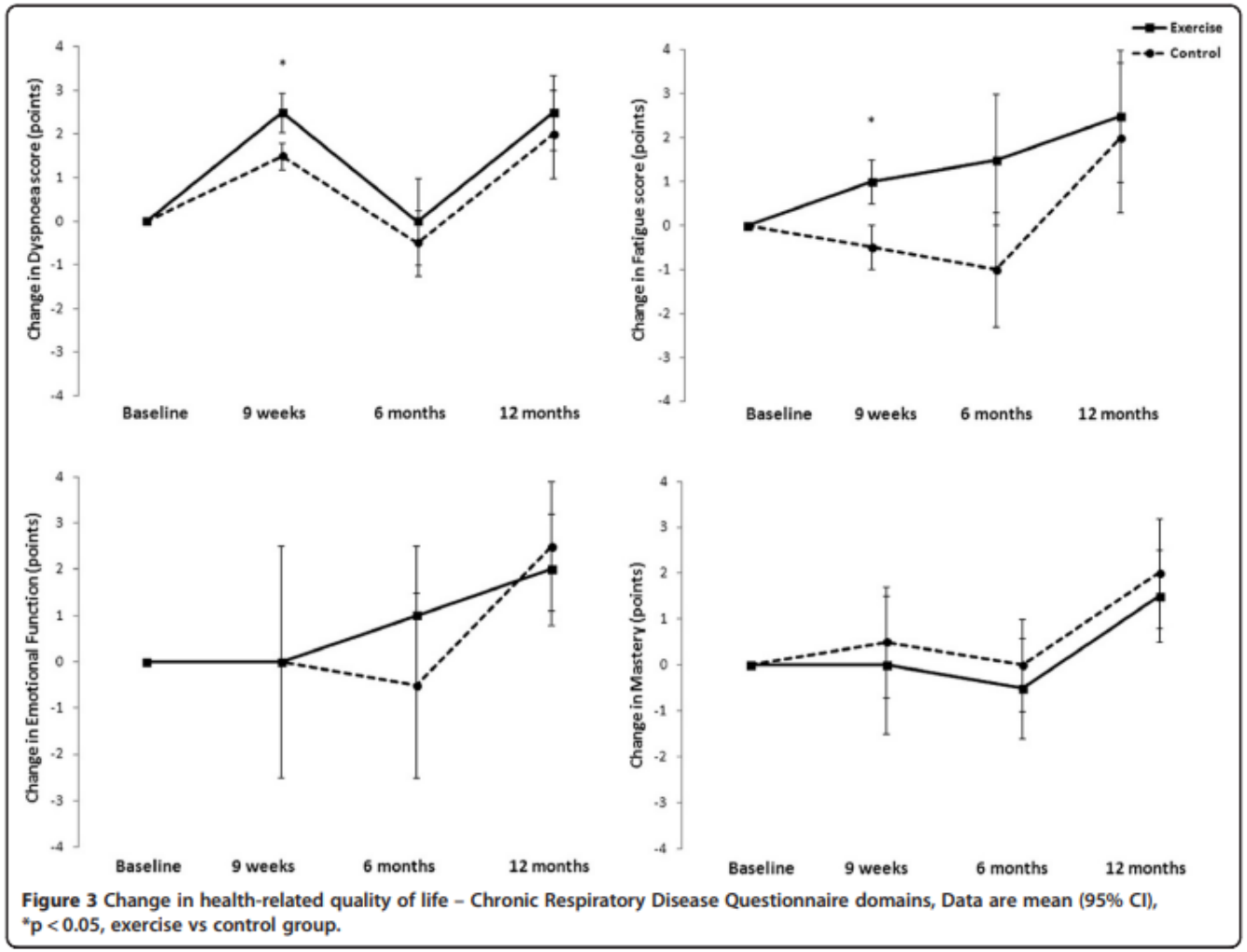

Figure 3 Change in health-related quality of life – Chronic Respiratory Disease Questionnaire domains, Data are mean (95% CI), *p < 0.05, exercise vs control group.

Lee AL et al, Respir Res . 2014 Apr 15;15(1):44.

Reduction in Exacerbation

Table 3 Number of exacerbations over 12 months (n = 55)

	Control n = 25	Exercise n = 30	p value
Exacerbations	2 (1 – 3)	1 (0 – 2)	0.012
Exacerbations requiring antibiotics	2 (0 – 4)	1 (0 – 2)	0.061
Exacerbation days	10 (2 – 13)	7 (3 – 11)	0.23
Exacerbation days with antibiotics	11 (2 – 15)	7 (2 – 13)	0.36

Data are median (IQR), p value represents difference between groups.

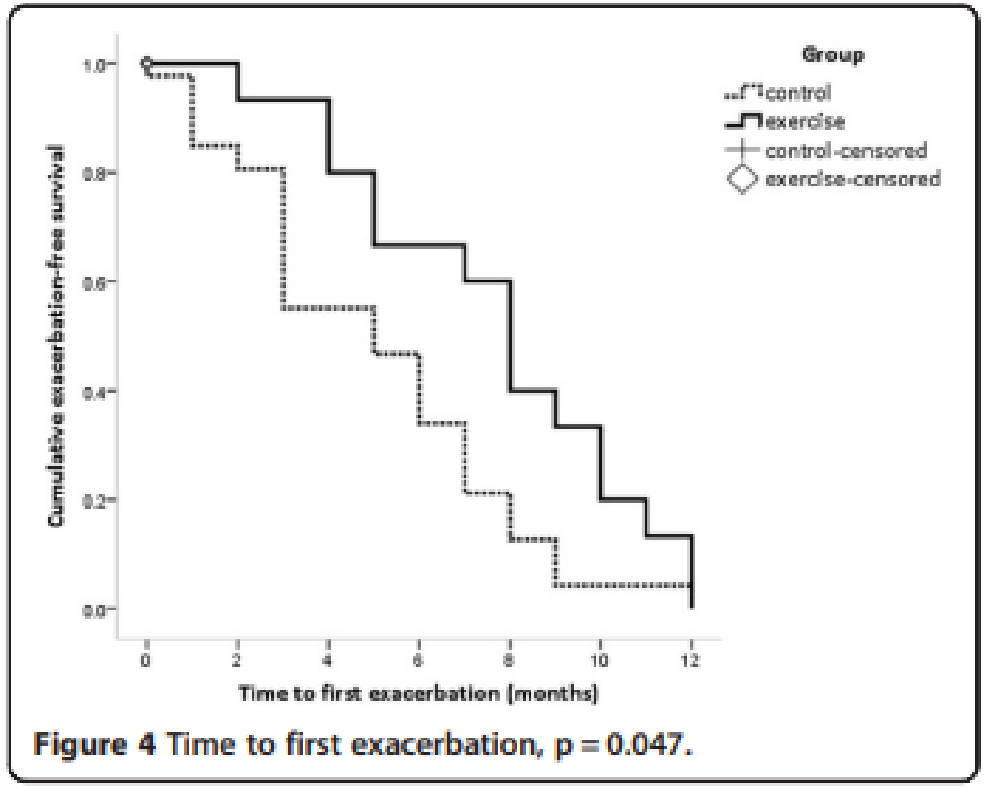

Figure 4 Time to first exacerbation, p = 0.047.

Home-based pulmonary rehabilitation in people with bronchiectasis: a randomised controlled trial

Anderson José [1], Anne E. Holland [2,3], Jessyca P.R. Selman[4], Cristiane Oliveira de Camargo[4], Diogo Simões Fonseca[5], Rodrigo A. Athanazio[6], Samia Z. Rached[6], Alberto Cukier[6], Rafael Stelmach[6] and Simone Dal Corso[4]

Intervention

- Home-based pulmonary rehabilitation
- 3 sessions/week for 8 weeks
- Aerobic training: step exercise (20 min)
- Resistance training: upper and lower limbs using elastic bands
- Weekly phone follow-up + home visit every 2 weeks

Control

- Usual care
- Advised to walk at moderate intensity

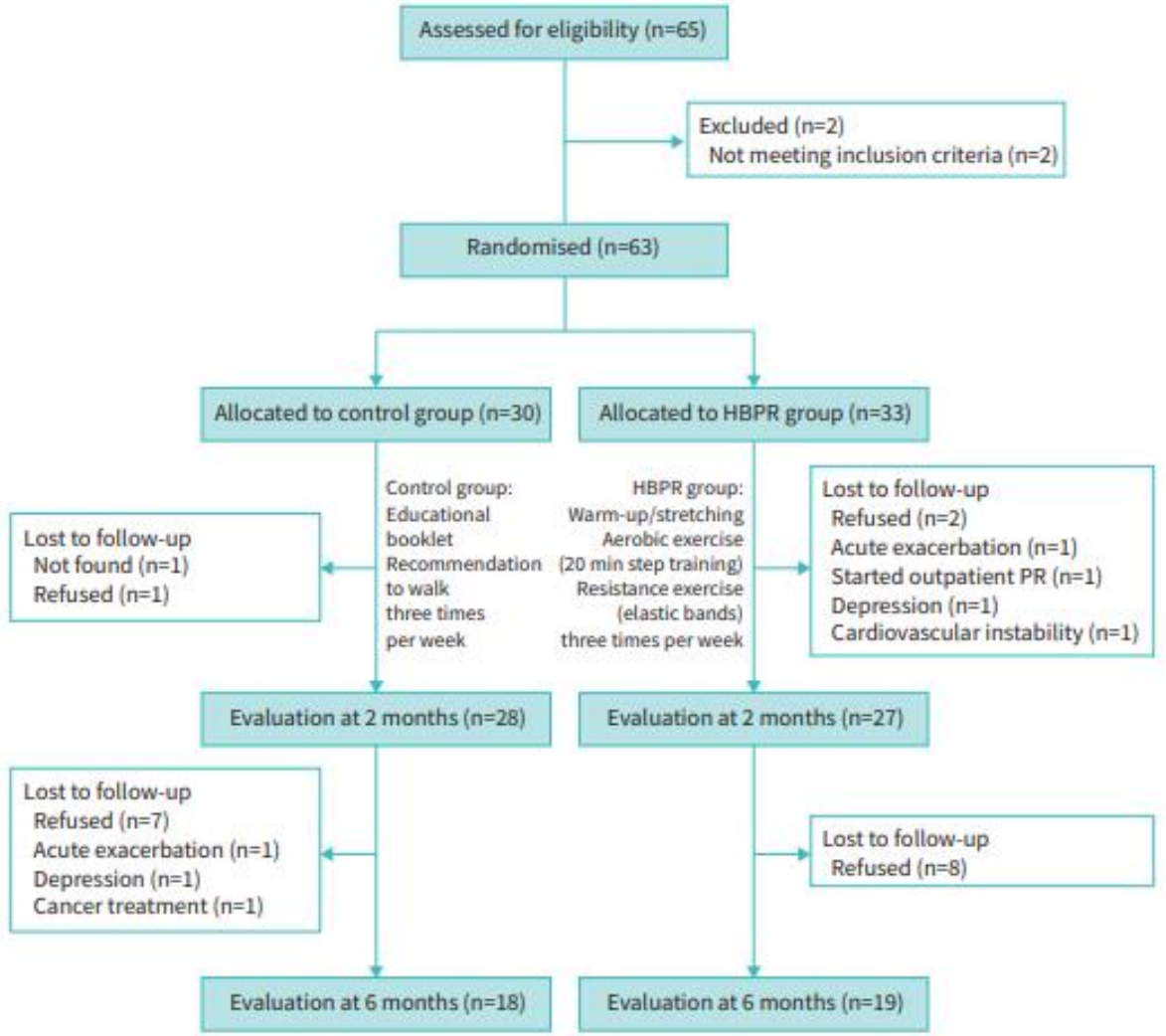

FIGURE 1 Consolidated standards of reporting trials participant disposition. HBPR: home-based pulmonary rehabilitation; PR: pulmonary rehabilitation.

Changes in Exercise Capacity and Muscle Strength

TABLE 2 Change in clinical differences from baseline to 2 months and follow-up (6 months)

	Within-group differences from baseline (95% CI)				Between-group differences	
	HBPR (n=33)		Control (n=30)		HBPR minus control	
	End rehabilitation minus baseline (n=27)	6 months minus end rehabilitation (n=19)	End rehabilitation minus baseline (n=28)	6 months minus end rehabilitation (n=18)	End rehabilitation minus baseline	6 months minus end rehabilitation
ISWT m	60.94±119.79 (21.84–100.04)*	−32.39±50.63 (−80.08–10.49)	−26.97±80.15 (−65.37–11.42)	31.55±131.74 (−13.67–78.85)	87.91 (32.98–142.85)#	−63.94 (−129.87–1.99)
ESWT min	4.62±5.43 (2.88–6.35)*	−0.14±3.82 (−2.88–2.60)	0.26±3.34 (−1.44–1.96)	0.43±7.47 (−2.38–3.25)	4.36 (1.93–6.79)#	−0.57 (−4.50–3.35)
MIST total steps	66.11±87.86 (38.80–93.42)*	−32.73±54.08 (−54.30– −11.16)¶	−15.24±40.47 (−42.02–11.54)	−3.99±28.46 (−28.45–20.47)	81.35 (43.10–119.60)#	−28.74 (−61.35–3.88)
Daily steps	735.76±3114.20 (−275.40–1746.61)	−815.90±4359.73 (−2501.33–869.54)	−592.70±2032.41 (−1585.63–400.24)	−834.05±2614.79 (−2565.67–897.57)	1328.45 (−88.72–2745.61)	−18.15 (−2398.30–2434.59)
Quadriceps strength kg-force	4.90±7.63 (2.24–7.56)*	−3.06±8.67 (−6.78–0.66)	−0.82±6.09 (−3.43–1.79)	−0.24±7.19 (−4.07–3.58)	5.72 (1.99–9.45)#	−2.82 (−8.15–2.51)

Data are presented as mean±SD (95% CI). HBPR: home-based pulmonary rehabilitation; ISWT: incremental shuttle walk test; ESWT: endurance shuttle walk test; MIST: modified incremental step test. *: $p<0.05$ *versus* baseline; #: $p<0.05$ between groups; ¶: $p<0.05$ *versus* end rehabilitation.

Changes in Quality of Life

TABLE 3 Change in quality of life differences from baseline to 2 months and follow-up (6 months)

	Within-group differences from baseline (95% CI)				Between-group differences	
	HBPR (n=33)		Control (n=30)		HBPR minus control	
	End rehabilitation (n=27)	6 months (n=19)	End rehabilitation (n=28)	6 months (n=18)	End rehabilitation	6 months
QoL-B (physical)	10.30±18.05 (2.79–17.80)*	−10.11±18.78 (−18.26– −1.95)#	−1.15±20.73 (−8.66–6.36)	−1.76±15.94 (−10.39–6.86)	11.44 (0.83–22.06)¶	−8.34 (−20.21–3.53)
QoL-B (role)	11.30±12.85 (4.84–17.76)*	−5.58±12.74 (−11.09– −0.07)#	−0.22±19.87 (−6.69–6.24)	−1.24±10.67 (−7.06–4.59)	11.52 (2.38–20.66)¶	−4.34 (−12.36–3.67)
QoL-B (vitality)	0.37±15.90 (−5.85–6.59)	−11.79±16.74 (−19.18– −4.40)#	−1.00±16.29 (−7.22–5.22)	−2.24±14.81 (−10.05–5.58)	1.37 (−7.42–10.16)	−9.55 (−20.31–1.21)
QoL-B (emotional)	3.52±12.34 (−1.08–8.12)	−0.89±12.98 (−5.83–7.62)	−3.63±11.46 (−8.23–0.97)	−4.41±15.90 (−11.52–2.70)	7.15 (0.65–13.65)¶	5.31 (−4.48–15.10)
QoL-B (social)	1.26±26.41 (−7.83–10.35)	1.68±17.82 (−7.24–10.61)	−3.41±20.28 (−12.50–5.68)	−0.06±20.53 (−9.49–9.38)	4.67 (−8.19–17.52)	1.74 (−11.24–14.73)
QoL-B (treatment burden)	−5.30±25.15 (−15.10–4.51)	5.68±19.69 (−4.92–16.29)	−0.07±25.63 (−9.88–9.73)	−2.71±25.76 (−13.92–8.51)	−5.22 (−19.09–8.64)	8.39 (−7.04–23.82)
QoL-B (health)	−2.63±17.71 (−9.05–3.79)	9.84±18.64 (1.73–17.96)#	−1.15±15.44 (−7.57–5.26)	8.65±15.91 (0.07–17.23)#	−1.48 (−10.56–7.59)	1.20 (−10.62–13.01)
QoL-B (respiratory)	3.04±11.31 (−1.93–8.00)	−4.68±11.33 (−10.26–0.89)	−0.56±14.23 (−5.52–4.41)	−7.88±2.62 (−13.78– −1.99)#	3.59 (−3.43–10.61)	3.20 (−4.91–11.31)

Data are presented as mean±SD (95% CI). HBPR: home-based pulmonary rehabilitation; QoL-B: Quality of Life Questionnaire Bronchiectasis.
*: p<0.05 *versus* baseline; #: p<0.05 *versus* end rehabilitation; ¶: p<0.05 between groups.

Contents

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Role of home-based pulmonary rehabilitation programs for disease progression and quality of life in patients with stable bronchiectasis: a single-center RCT

Siwen Min[1†], Hongting Liu[1†], Yajuan Zhang[2], Jingyi Wang[3], Li Wang[4], Yifan Jiang[5*] and Suxia Shi[1*]

Intervention

- Total n = 80 (40 per group)
- 12 months (1, 3, 6, 12 months)
- Home-based pulmonary rehabilitation (HBPR)
- WeChat based health education
  - Aerobic exercise (30–60 min/day)
  - Inspiratory muscle training
  - Airway clearance techniques (ACBT, postural drainage)
  - Health education (e-health platform)
  - Weekly remote monitoring and feedback

Control

- Usual care
  - Education materials
  - Routine follow-up

Treatment Effects

TABLE 2 Comparison of cough conditions, pulmonary function indicators and the number of acute exacerbations of the two groups of patients at different time points [($\bar{x} \pm s$), number of cases (%)].

		Intervention group (n = 40)	Control group (n = 40)	t/Z	P
Leicester Cough Questionnaire (LCQ) scores	Before intervention	8.91 (5.93, 12.10)	9.50 (6.60, 12.04)	−0.457	0.648
				−0.803	
	Six months after intervention	16.10 (15.58, 16.69)	12.24 (11.33, 13.00)	−2.834	<0.001
				−7.38	
	Twelve months after intervention	18.30 (17.81, 18.67)	13.43 (13.00, 14.01)	−7.698	<0.001
The number of acute exacerbations	Before intervention	2 (1, 3)	2 (1, 2)	−0.333	0.739
	One month after intervention	2 (2, 3)	2 (1, 2)	−0.521	0.603
				−2.956	
	Six months after intervention	1 (0, 1)	1 (1, 2)	−2.981	0.003
				−3.025	
	Twelve months after intervention	0.5 (0, 1)	1 (0, 2)	0.232	0.002
FEV1 (L)				0.817	
	One month after intervention	2.04 ± 0.39	2.05 ± 0.41	0.112	0.911
				2.163	
	Six months after intervention	2.38 ± 0.36	2.14 ± 0.43	2.707	0.008
				3.425	
	Twelve months after intervention	2.56 ± 0.48	2.20 ± 0.46		0.001

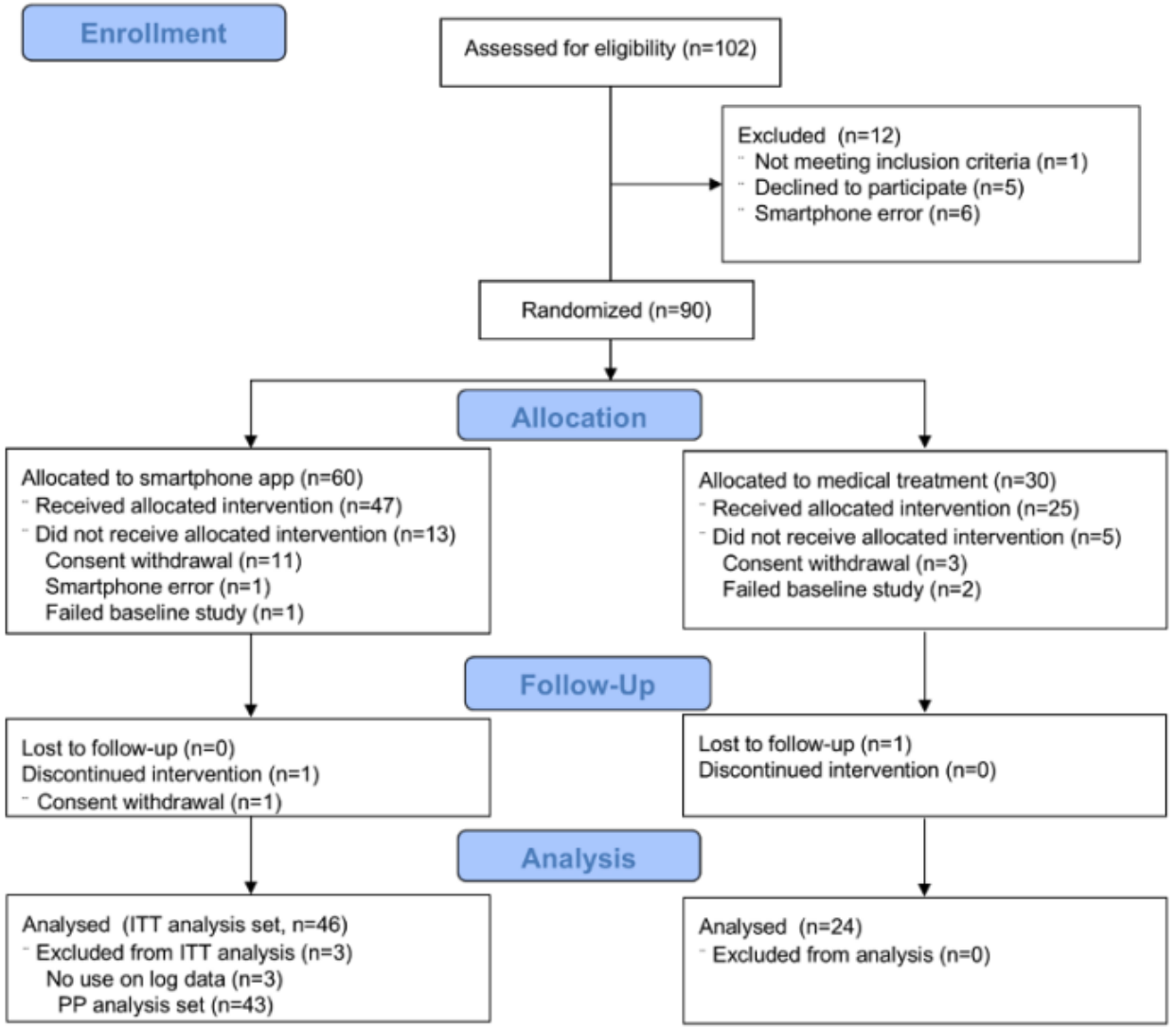
Original Paper

Clinical Efficacy of Smartphone App–Based Pulmonary Rehabilitation in Chronic Respiratory Diseases: Randomized Controlled and Feasibility Trials

Chiwook Chung[1,2], MD, PhD; Ah-Ram Kim[3], MD, PhD; Do-Yoon Kang[3], MD, PhD; Sunmok Kim[4], MD; Jinyoung Oh[5], MD, PhD; Hui Jung Kim[6], MD, PhD; Byongjo Park[7], MD; Seong Ho Lee[1], MPT; Dongbum Kim[8], MS; Hee Kwon[8], BS; Min-Woo Jo[9], MD, PhD; Sei Won Lee[1], MD, PhD

Study Design

- Single-center, single-blind randomized controlled trial
- 90 patients with chronic respiratory diseases
  - Obstructive (COPD/asthma): 76%
  - Bronchiectasis: 20%
  - Restrictive (ILD): 4%
- 2:1 randomization (app-based PR vs. usual care)
- 12-week smartphone app–based rehabilitation
- Outcomes assessed at baseline and 12 weeks



Study Protocol

Intervention (n=60)
SENIORS App (Android ≥8.0)

Aerobic	30 min outdoor walking · auto-tracked by phone sensor
Muscle	20–30 min limb & trunk · progressive weekly intensity
Education	Disease-specific modules · inhaler guidance · medication
Adherence	Daily pop-up · exercise-based incentives · social ranking
Monitoring	Clinician web dashboard · adherence & performance tracking
Nutrition	Protein supplement 10 g/day

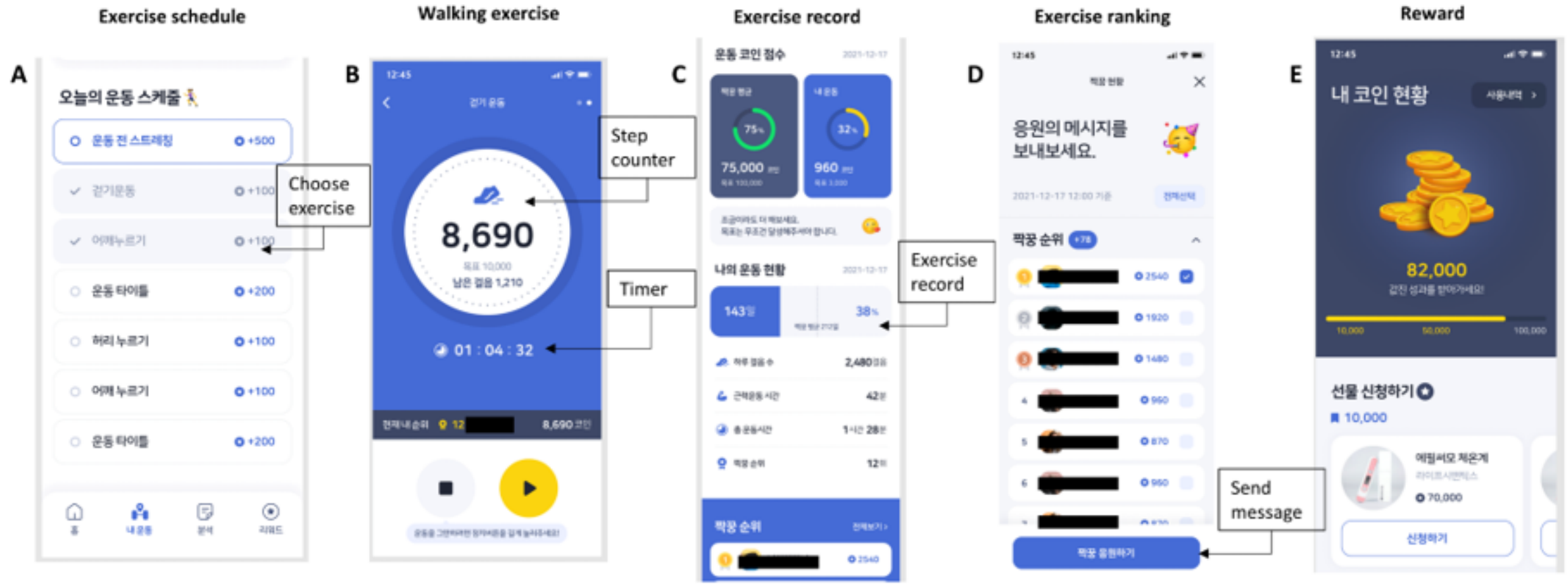
→ **Fully self-directed at home · no center visit required**

Control (n=30)
Standard Outpatient Care Only

- Routine medications
- Physician visits as usual
- No exercise program
- No app
- No education modules
- No supplement

SENIORS application

Figure S1. Screenshots of the "SENIORS" application (A) Exercise schedule (B) Walking exercise (C) Exercise record (D) Exercise ranking (E) Reward



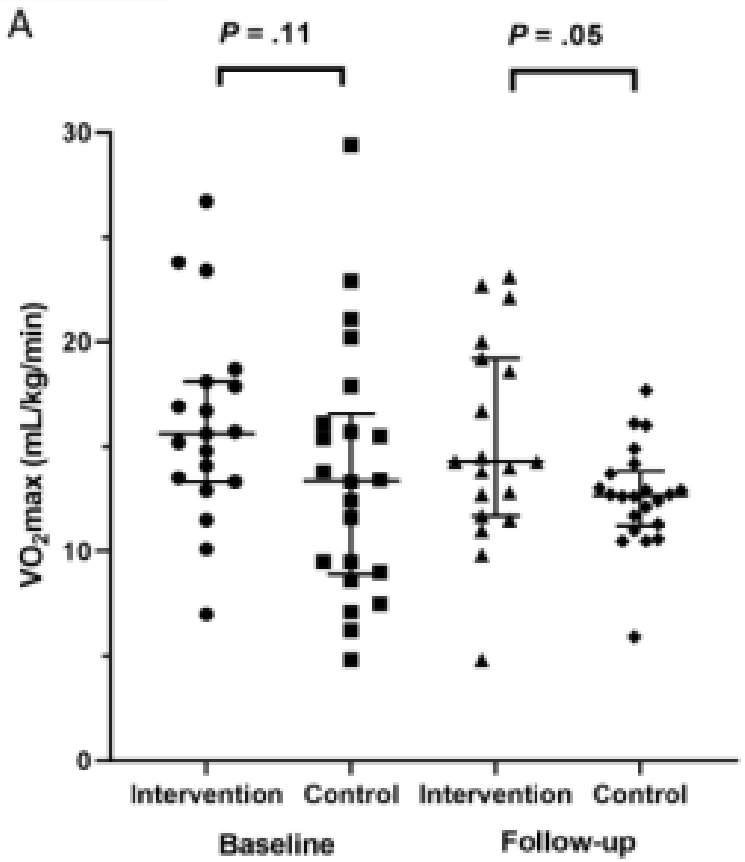
Treatment Effects

Table 3. Comparison of clinical outcomes of participants between the baseline and follow-up (per protocol analysis) in a randomized controlled trial investigating the clinical efficacy of smartphone-based rehabilitation in individuals with chronic respiratory disease, conducted at Asan Medical Center, Seoul, Republic of Korea, 2023.

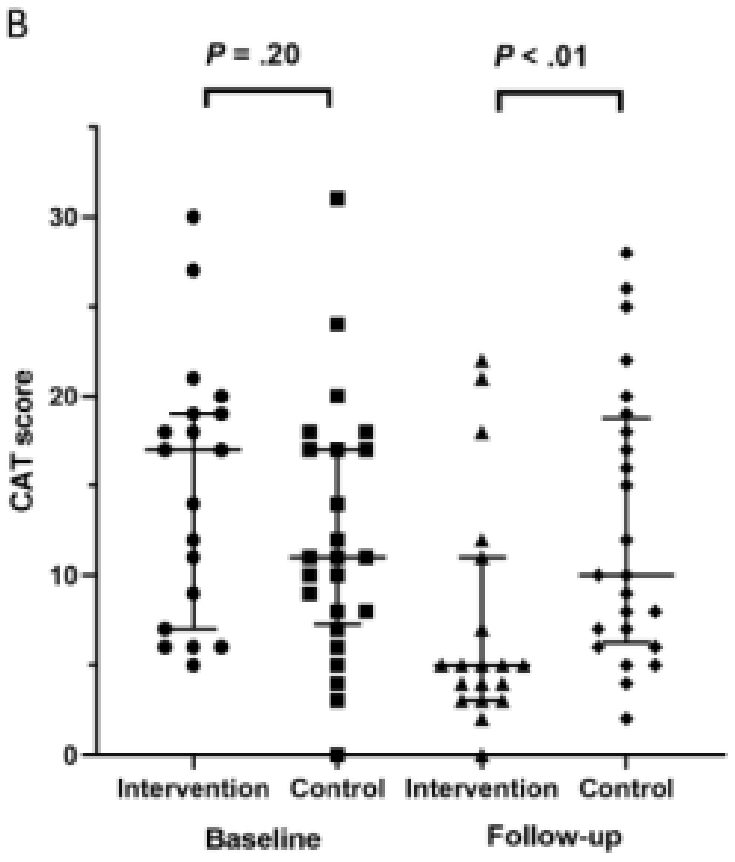
	Baseline, median (IQR)	Follow-up, median (IQR)	*P* value
Intervention (n=43)			
VO_2 max[a] (mL/kg/min)	15.7 (12.7-19.2)	14.0 (10.6-18.4)	.04
CAT[b] score	16.0 (9.5-20.0)	7.0 (4.0-15.0)	<.001
IPAQ[c] (n=41)	792.0 (23.1-1649.3)	1488.0 (1250.3-3027.8)	<.001
mMRC[d] dyspnea scale	1.0 (1.0-2.0)	1.0 (1.0-1.8)	.006
EQ-5D-5L index	0.816 (0.743-0.861)	0.871 (0.814-1.000)	<.001
HINT-8[e] index	0.792 (0.735-0.859)	0.828 (0.767-0.891)	<.001
FEV_1[f] (%predicted)	57.0 (44.3-66.8)	58.0 (43.5-69.0)	.27
FVC[g] (%predicted)	75.0 (66.3-87.5)	77.0 (69.3-87.5)	.04
DL_{CO}[h] (%predicted)	61.0 (53.5-67.0)	62.0 (51.0-71.8)	.08
Hand grip strength (kg)	33.7 (28.0-41.0)	33.3 (27.7-41.7)	.74
Limb muscle mass (kg)			
Upper limb	5.0 (3.9-6.0)	4.8 (3.8-6.1)	.47
Lower limb	15.6 (13.1-17.0)	15.4 (13.0-16.9)	.56

Treatment Effects

VO2 max



CAT score



Summary

- Airway clearance technique는 객담 배출을 증가시키고 호흡곤란과 삶의 질을 개선하며 악화 감소에도 기여할 수 있어, 환자의 증상과 상태에 맞춘 개별화된 적용이 중요하다.

- 호흡재활치료는 운동능력(6MWT, ISWT), 신체활동량, 호흡곤란, 삶의 질(SGRQ)을 유의하게 개선하여 환자의 전반적인 기능 상태와 일상생활 수행능력을 향상시킵니다.

- 스마트폰 기반 앱을 활용한 재택 호흡재활은 운동, 교육, 순응도 관리, 원격 모니터링을 통합적으로 제공할 수 있고 이러한 디지털 재활은 접근성을 높이고 환자의 참여도와 지속성을 향상시키는 데 기여할 수 있다.

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Thank you for your attention