Frailty and Pulmonary Rehabilitation in Chronic Respiratory Disease

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Pulmonary Rehabilitation Research Group Symposium | 2026

Presentation Outline

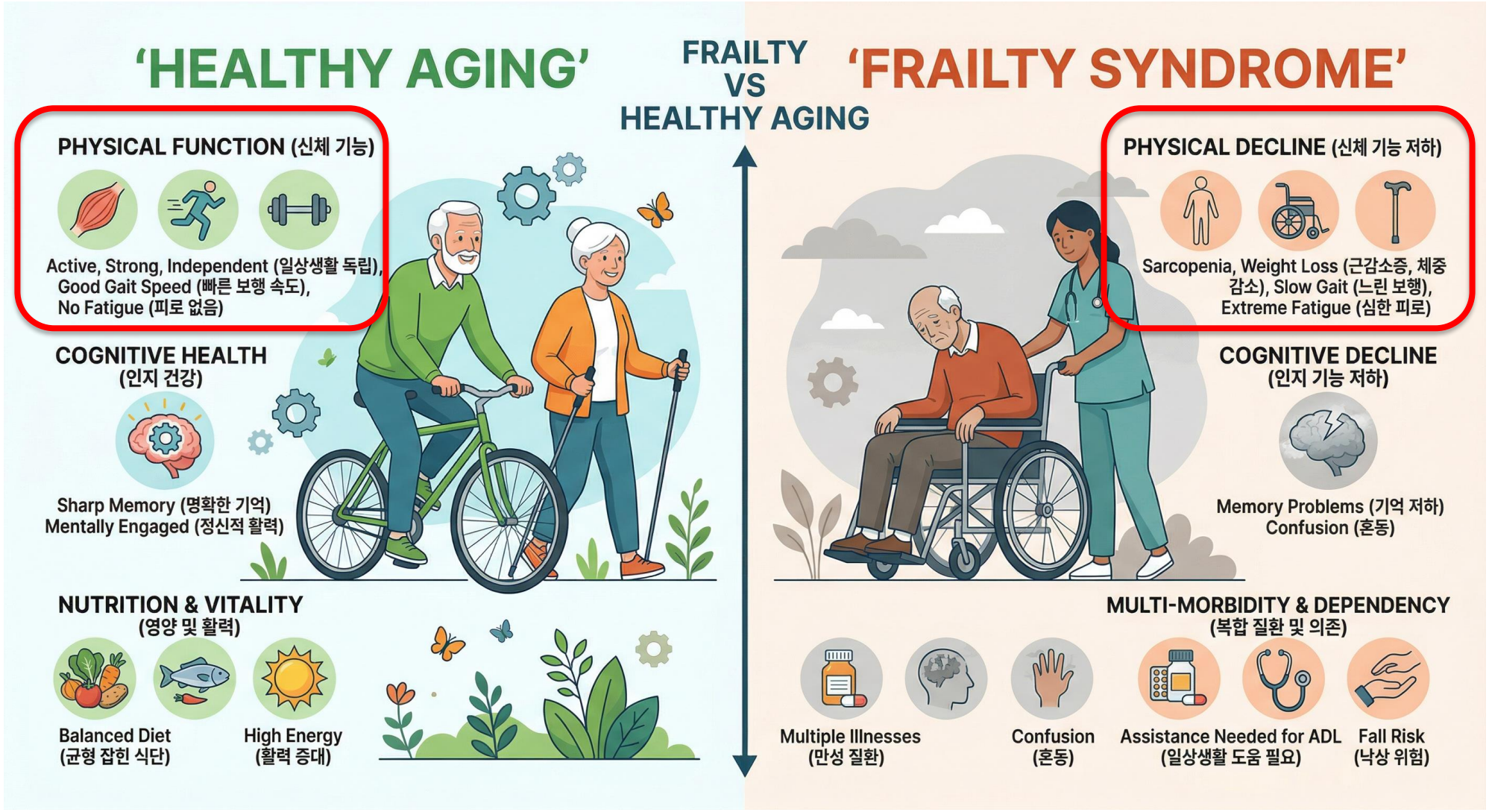
Introduction – Frailty

COPD and Other Respiratory Diseases

What we have to do?

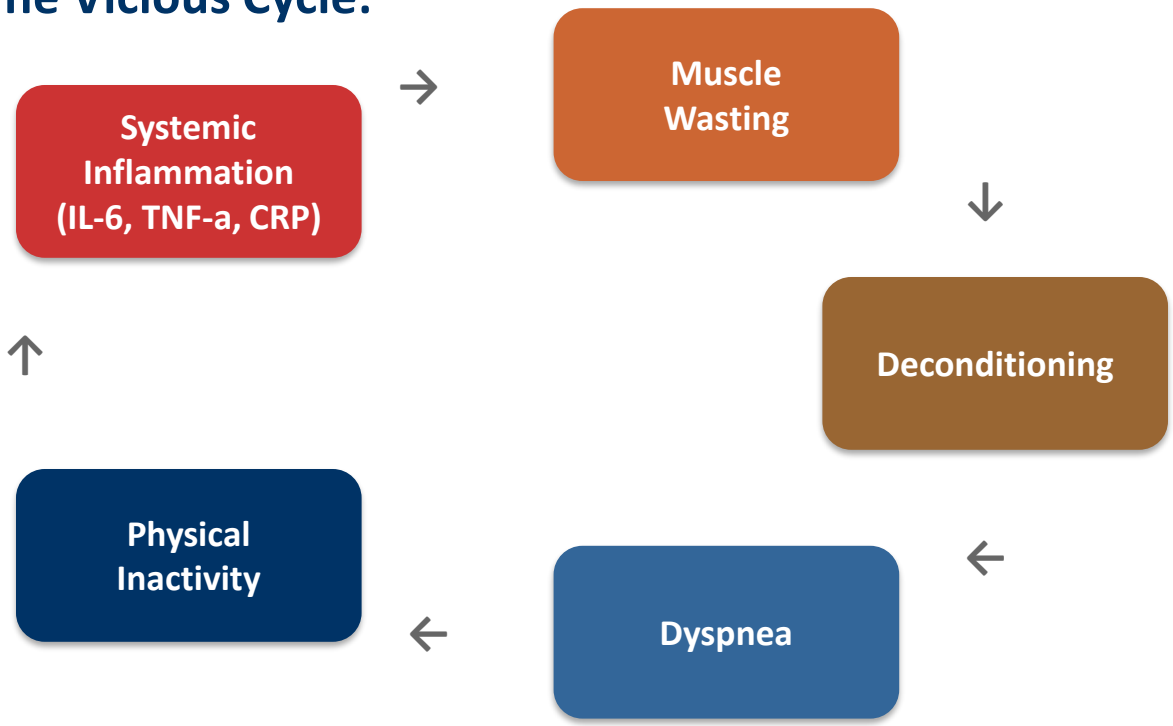
Introduction - Frailty

Frailty


'HEALTHY AGING'
FRAILTY VS HEALTHY AGING
'FRAILTY SYNDROME'
PHYSICAL FUNCTION (신체 기능)
Active, Strong, Independent (일상생활 독립),
Good Gait Speed (빠른 보행 속도),
No Fatigue (피로 없음)
PHYSICAL DECLINE (신체 기능 저하)
Sarcopenia, Weight Loss (근감소증, 체중 감소), Slow Gait (느린 보행),
Extreme Fatigue (심한 피로)
COGNITIVE HEALTH
(인지 건강)
Sharp Memory (명확한 기억)
Mentally Engaged (정신적 활력)
COGNITIVE DECLINE
(인지 기능 저하)
Memory Problems (기억 저하)
Confusion (혼동)
NUTRITION & VITALITY
(영양 및 활력)
Balanced Diet
(균형 잡힌 식단)
High Energy
(활력 증대)
MULTI-MORBIDITY & DEPENDENCY
(복합 질환 및 의존)
Multiple Illnesses
(만성 질환)
Confusion
(혼동)
Assistance Needed for ADL
(일상생활 도움 필요)
Fall Risk
(낙상 위험)

Pathophysiology of Frailty in Respiratory Disease

The Vicious Cycle:



Shared Mechanisms:

- Inflammaging and immunosenescence
- HPA axis dysregulation
- Oxidative stress & mitochondrial dysfunction
- Skeletal muscle proteolysis
- Reduced anabolic hormones (IGF-1, testosterone)
- Chronic hypoxemia accelerates all pathways

Angulo, Physical activity and exercise for frailty, Redox Biol 2020; Maltais, Vastus lateralis fiber shift in COPD, Am J Respir Crit Care Med 2014

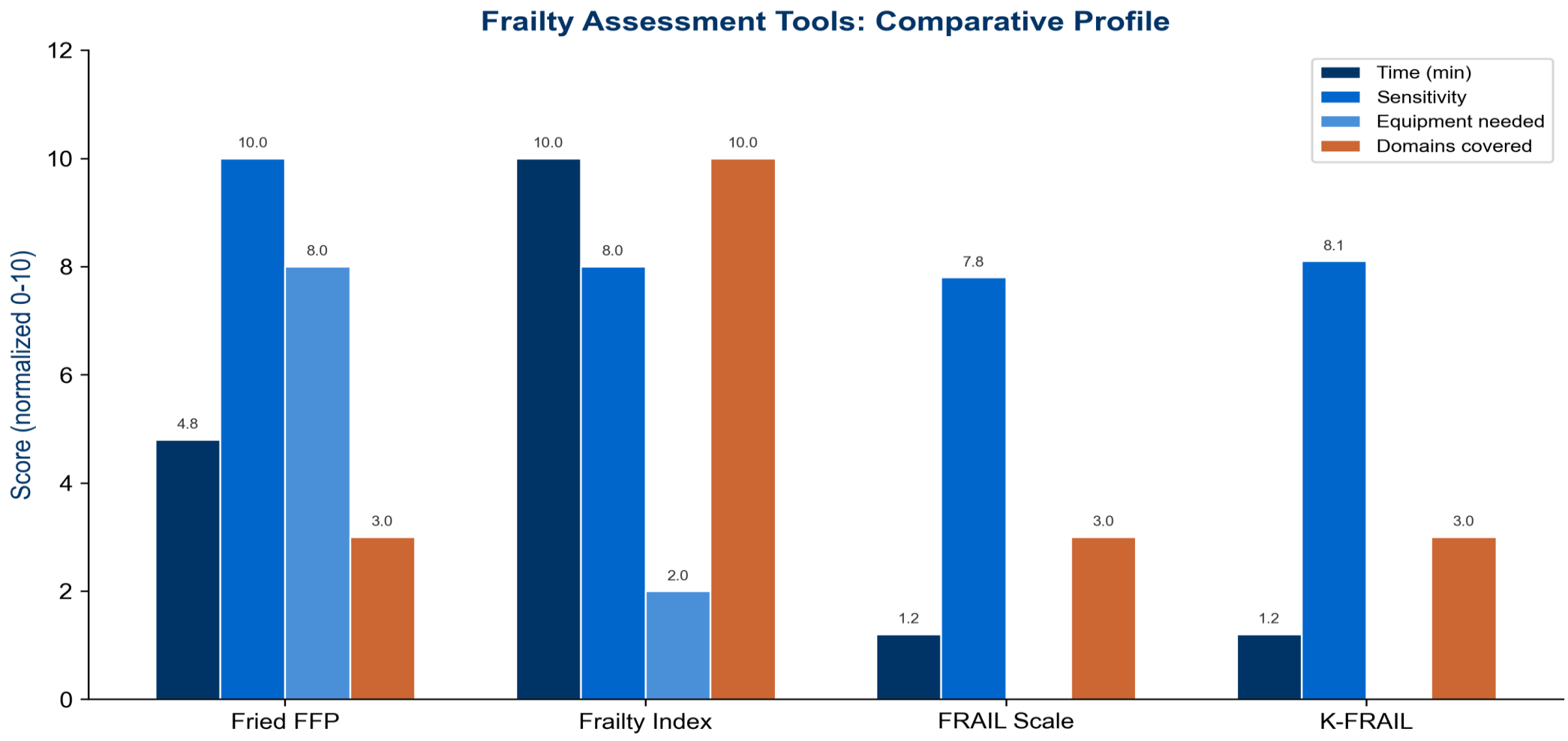
Frailty Assessment Tools

Feature	Fried FFP (GOLD)	Frailty Index (FI)	FRAIL Scale	K-FRAIL
Model	Phenotype (5 criteria)	Cumulative deficit (30-70+)	Screening (5 questions)	Korean FRAIL adaptation
Domains	Physical only	Multi-domain (medical, cognitive, social)	Physical + illness burden	Physical + illness burden
Time	10-15 min	15-30 min	<5 min (self-report)	<5 min (self-report)
Equipment	Dynamometer, stopwatch	None (chart review)	None	None
Cutoff (frail)	≥3 of 5	>0.21-0.25	≥3 of 5	≥3 of 5
Sensitivity vs FFP	Reference	High (AUC 0.76-0.84)	0.73-0.83	0.813 (Jung 2016)
Specificity vs FFP	Reference	0.65-0.75	0.75-0.85	0.776 (Jung 2016)

An TJ et al. (CHEST 2024): aOR for breathlessness — FI 9.29, FRAIL 5.21, FFP 3.09 (N=780)

Fried, J Gerontol 2001; Rockwood, J Gerontol 2007; Morley, J Nutr Health Aging 2012; Jung, Korean J Intern Med 2016; An, CHEST 2024 (PMID 39209061)

Frailty Tools: Comparative Profile



Fried, J Gerontol 2001; Rockwood, J Gerontol 2007; Morley, J Nutr Health Aging 2012; Jung, Korean J Intern Med 2016; An, CHEST 2024 (PMID 39209061)

Defining Frailty in Respiratory Disease: Fried Frailty Phenotype

Fried Frailty Phenotype (3 of 5 criteria)

Unintentional weight loss (> 4.5 kg/year)

Self-reported exhaustion

Low physical activity

Slow gait speed

Weak grip strength

Unintended Weight Loss	Exhaustion	Weakness	Slowness	Low Physical Activity
4.5 kg or more than 5% of body weight within a year	Self-Report (2 questions from the CES-D)	Jamar Handgrip dynamometer	Gait speed in meters/second (over 4 meters)	Short version of Minnesota Leisure Time Activity-Kcal/Kg
				

Robust: 0 criteria; Pre-Frail: 1-2 criteria; Frail: 3 or more criterion

Fried LP et al. Frailty in older adults: evidence for a phenotype. *J Gerontol A Biol Sci Med Sci* 2001; **56:** M146–56.

Defining Frailty in Respiratory Disease: K-FRAIL

표 11.1. The Korean version of the fatigue, resistance, ambulation, illness and loss of weight (K-FRAIL) scale.

질문	문항	점수
1. Fatigue (피로) 지난 한 달 동안 피곤하다고 느낀 적이 있습니까?	항상 그렇다	1점
	거의 대부분 그렇다	1점
	종종 그렇다	0점
	가끔씩 그렇다	0점
	전혀 그렇지 않다	0점
2. Resistance (저항) 도움이 없이 혼자서 쉬지 않고 10개의 계단을 오르는데 힘이 듭니까?	예	1점
	아니오	0점
3. Ambulation (이동) 도움이 없이 300 미터를 혼자서 이동하는데 힘이 듭니까?	예	1점
	아니오	0점
4. Illness (지병) 의사에게 다음 질병이 있다고 들은 적이 있습니까? (고혈압, 당뇨병, 암, 만성폐질환, 심근경색, 심부전, 협심증, 천식, 관절염, 뇌경색, 신장질환)	0~4개	0점
	5~11개	1점
5. Loss of weight (체중감소) 현재와 1년 전의 체중은 몇 kg이었습니까?	년 간 5% 이상 감소한 경우	1점
	1년 간 5% 미만 감소한 경우	0점
총점 판정	**3점 이상 = 노쇠** **1-2점 = 노쇠 전단계** **0점 = 정상**	

출처: Jung et al. Korean J Intern Med. 2016;31:594-600.

Why it matters in respiratory disease:

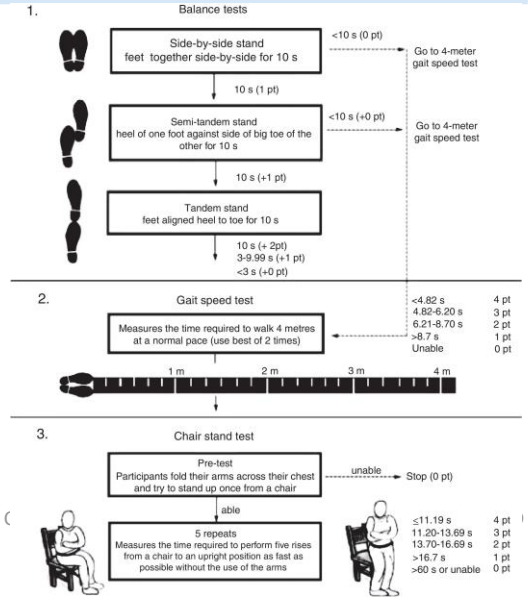
Shared pathophysiology: systemic inflammation, muscle wasting, deconditioning

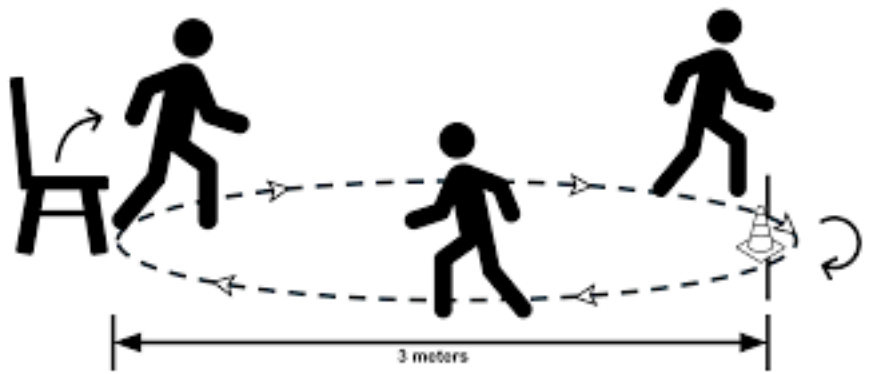
Accelerated trajectory: COPD exacerbations drive frailty progression

Bidirectional relationship: frailty worsens dyspnea; dyspnea promotes inactivity

Other Frailty Assessment Tools in Respiratory Disease

Tool	Components	Time	Strengths	Limitations
Fried (FFP)	5 physical criteria	10 min	Gold standard, validated	Equipment needed
SPPB-sarcopenia	Balance, gait, sit-stand	5 min	Objective, simple	Floor/ceiling effects
CFS	Clinical judgment 1-9	1 min	Quick, widely used	Subjective
TUG	Timed Up & Go	2 min	Single test	Limited domains



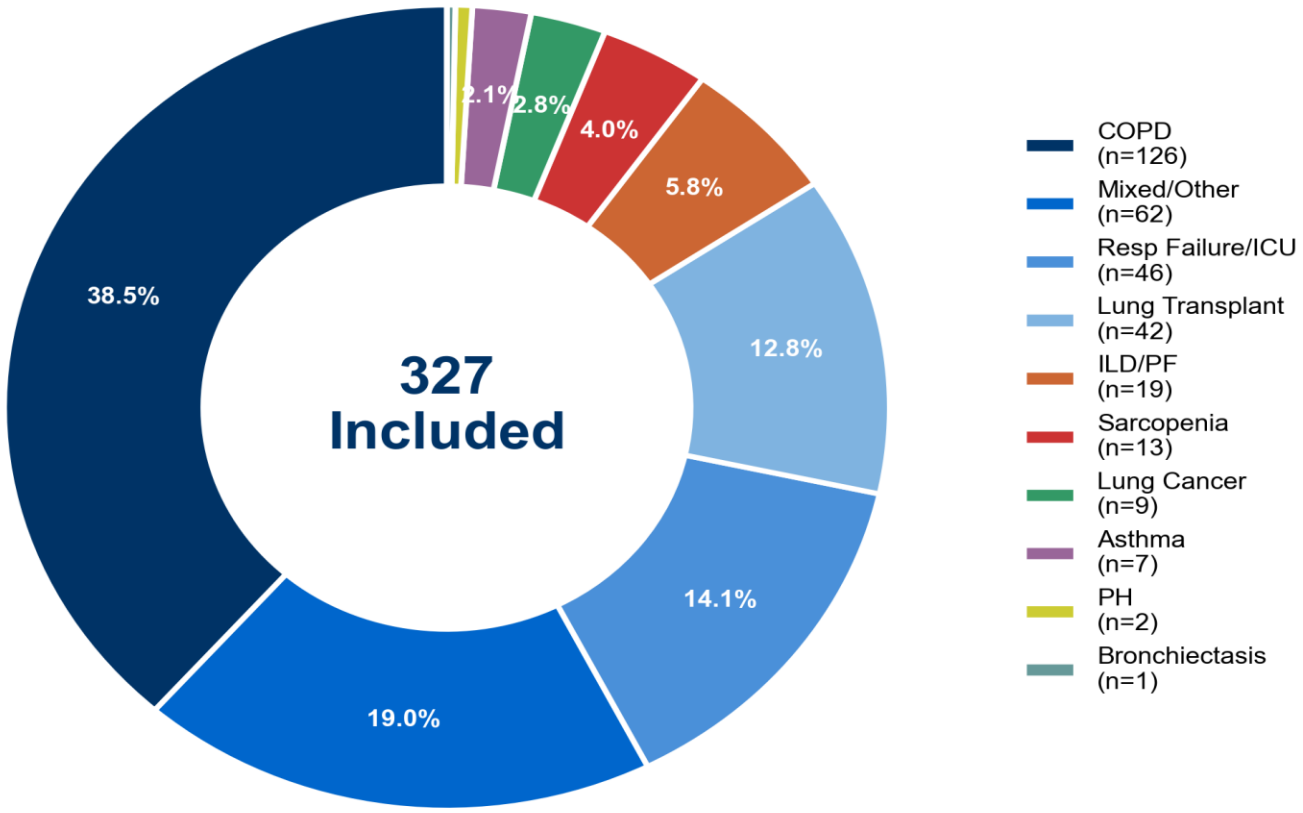


Pulmonary Rehab (PR) & Frailty

PubMed systematic search, 13 queries; 472 identified, 145 excluded (non-respiratory/no frailty content), 327 included

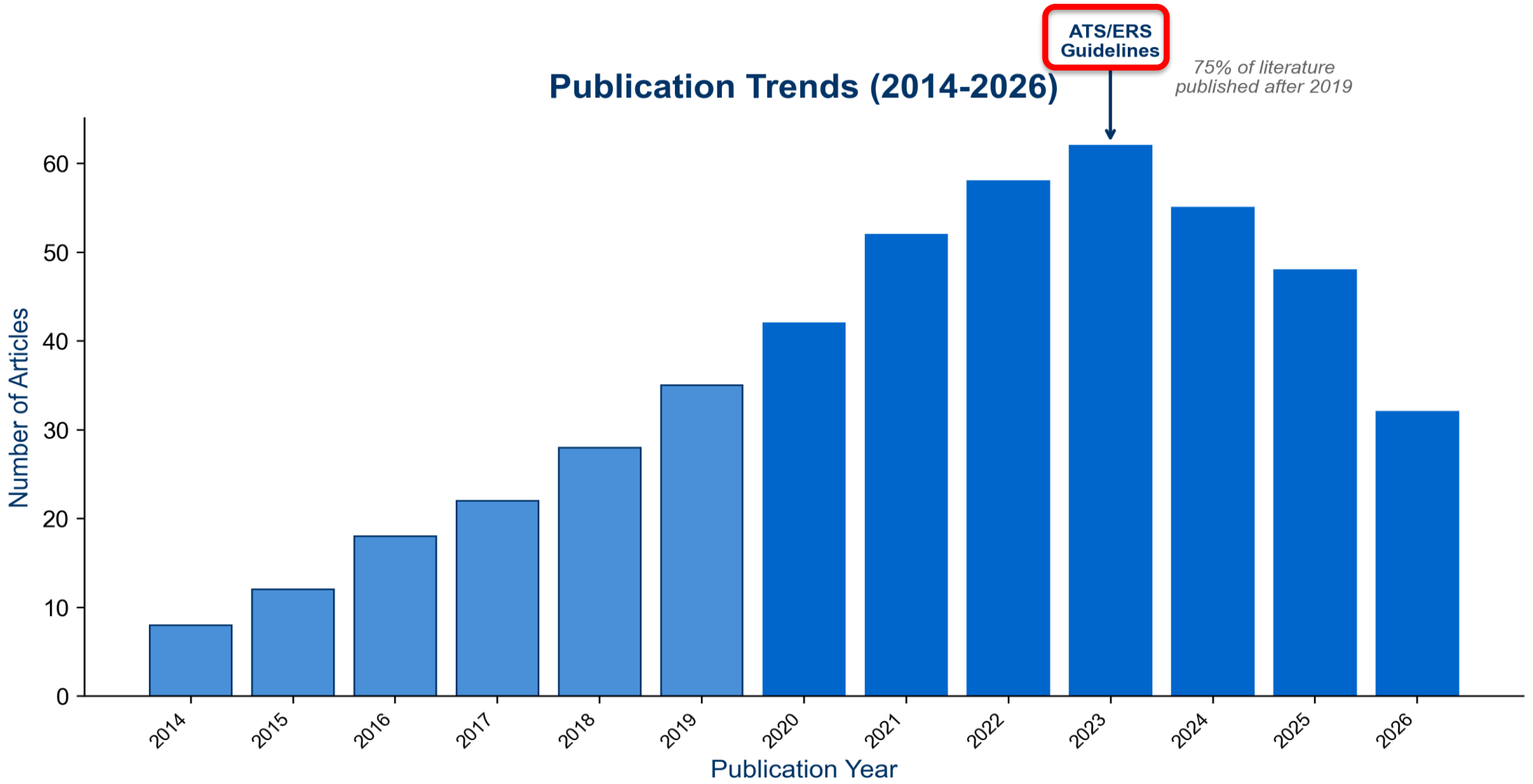
Literature Landscape: PR and Respiratory Disease with Frailty

Disease Group Distribution (327 included from 472 screened)



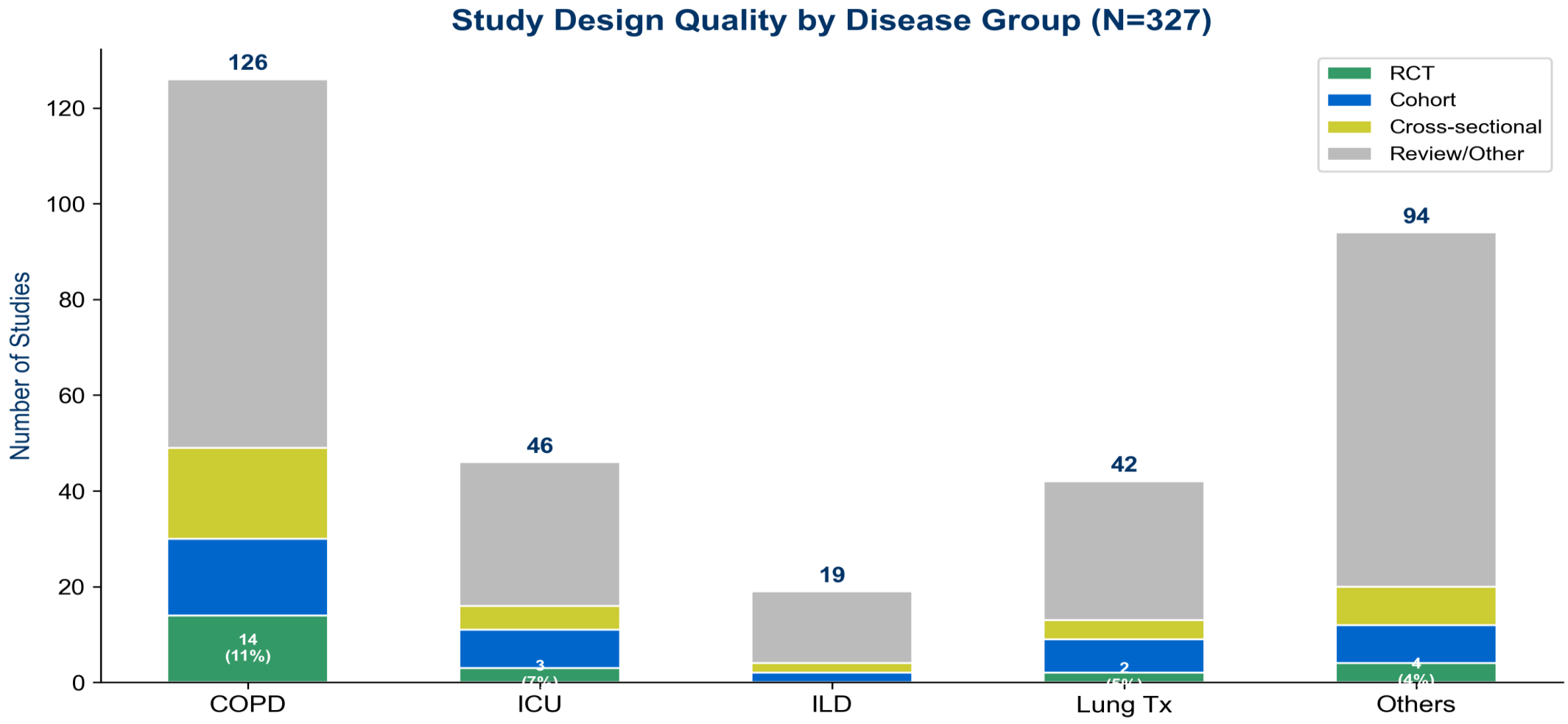
PubMed systematic search, 13 queries; 472 identified, 145 excluded (non-respiratory/no frailty content), 327 included

PR Publication Trends (2014-2026)



Search log v2; articles post-2019 highlighted; ATS/ERS PR guidelines published 2023

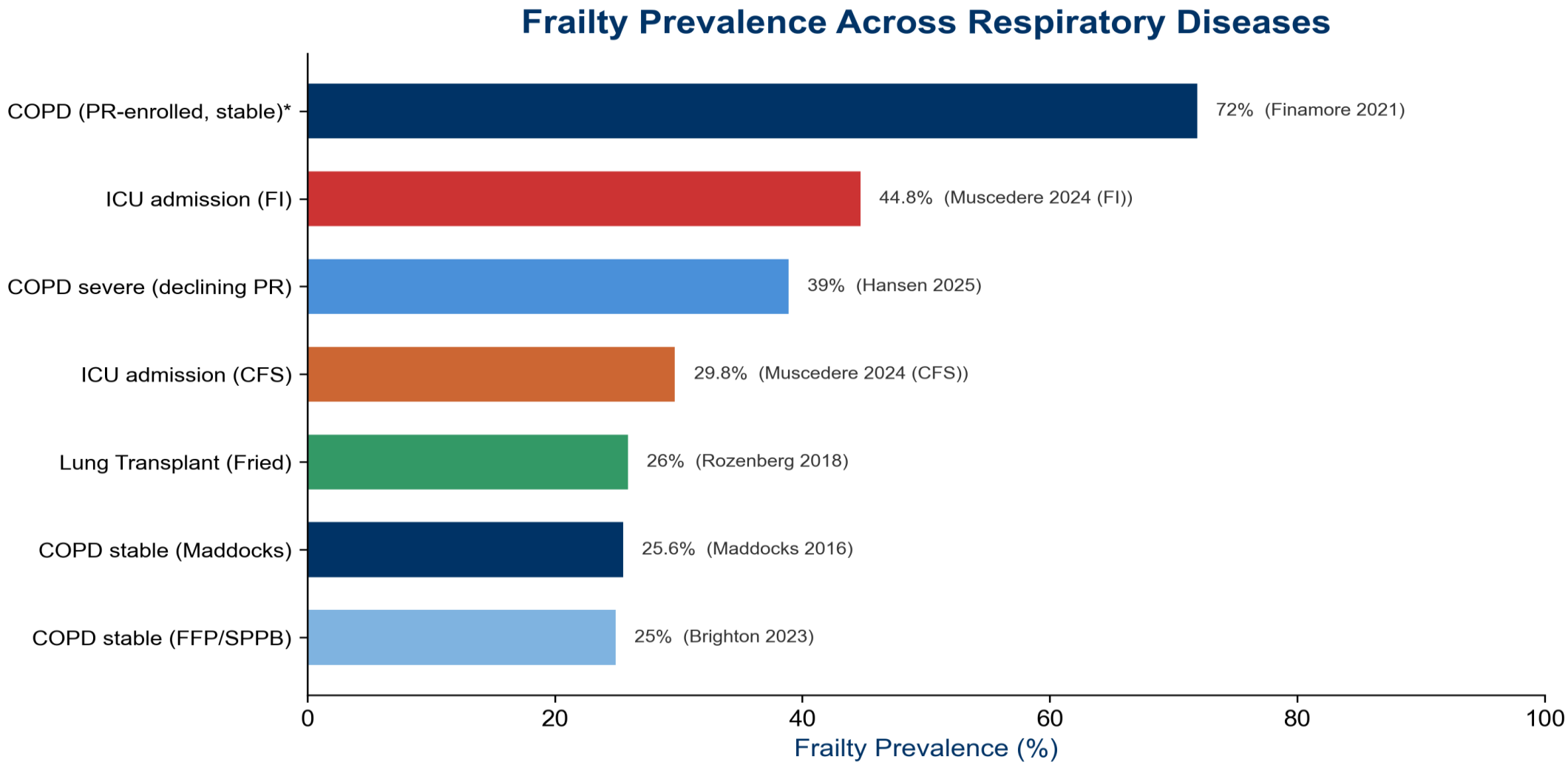
Study Design Quality Assessment by Disease Group



High-quality evidence (RCTs) concentrated in COPD; other diseases rely on observational data

Systematic review of 327 included articles (from 472 screened), PubMed 2026

Frailty Prevalence Across Respiratory Diseases



Maddocks, Physical frailty and PR in COPD, Thorax 2016; Brighton, Frailty tools and prognosis in COPD, Int J COPD 2023; Finamore, Frailty impact during and after PR, COPD 2021

Multidimensional Frailty Burden in PR

Malnutrition + frailty coexist in **40%**

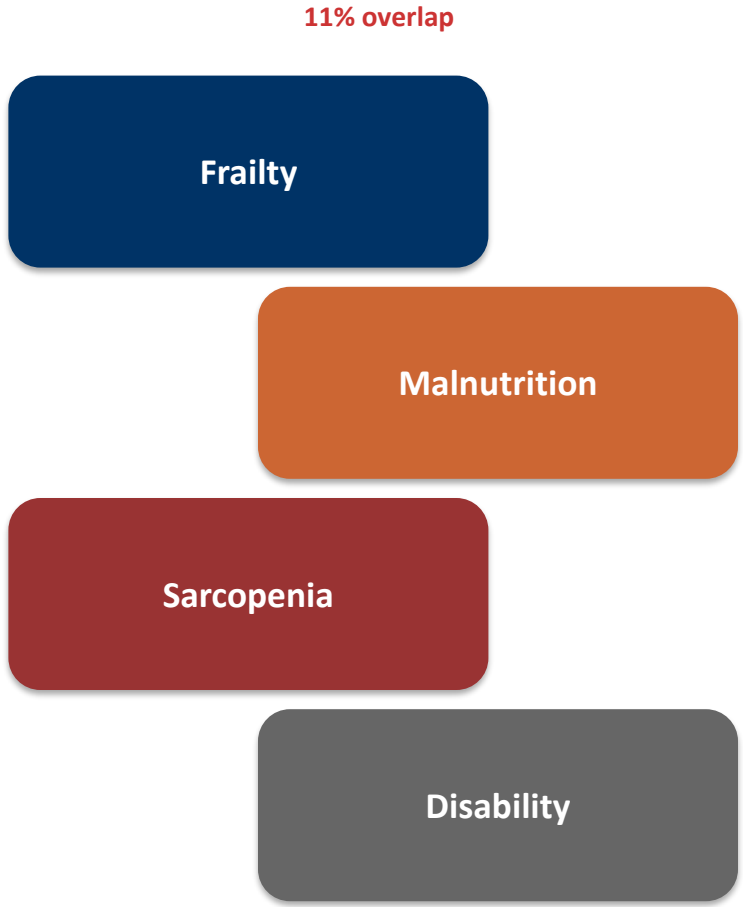
All 4 conditions overlap in **11%**

- **malnutrition, frailty, sarcopenia, disability**

Frail COPD comorbidities:

Worse ADL, exercise capacity, cognition, balance

Depression/anxiety prevalence elevated in frail COPD



Ter Beek, Malnutrition and frailty coexistence in COPD, Clin Nutr 2020; Kagiali, ADL cognition balance in COPD with frailty, Ir J Med Sci 2022

AWGS 2025: From Sarcopenia to Muscle Health

Table 1 | The AWGS Consensus: evolution of criteria through 2019 and 2025 updates to the 2014 criteria

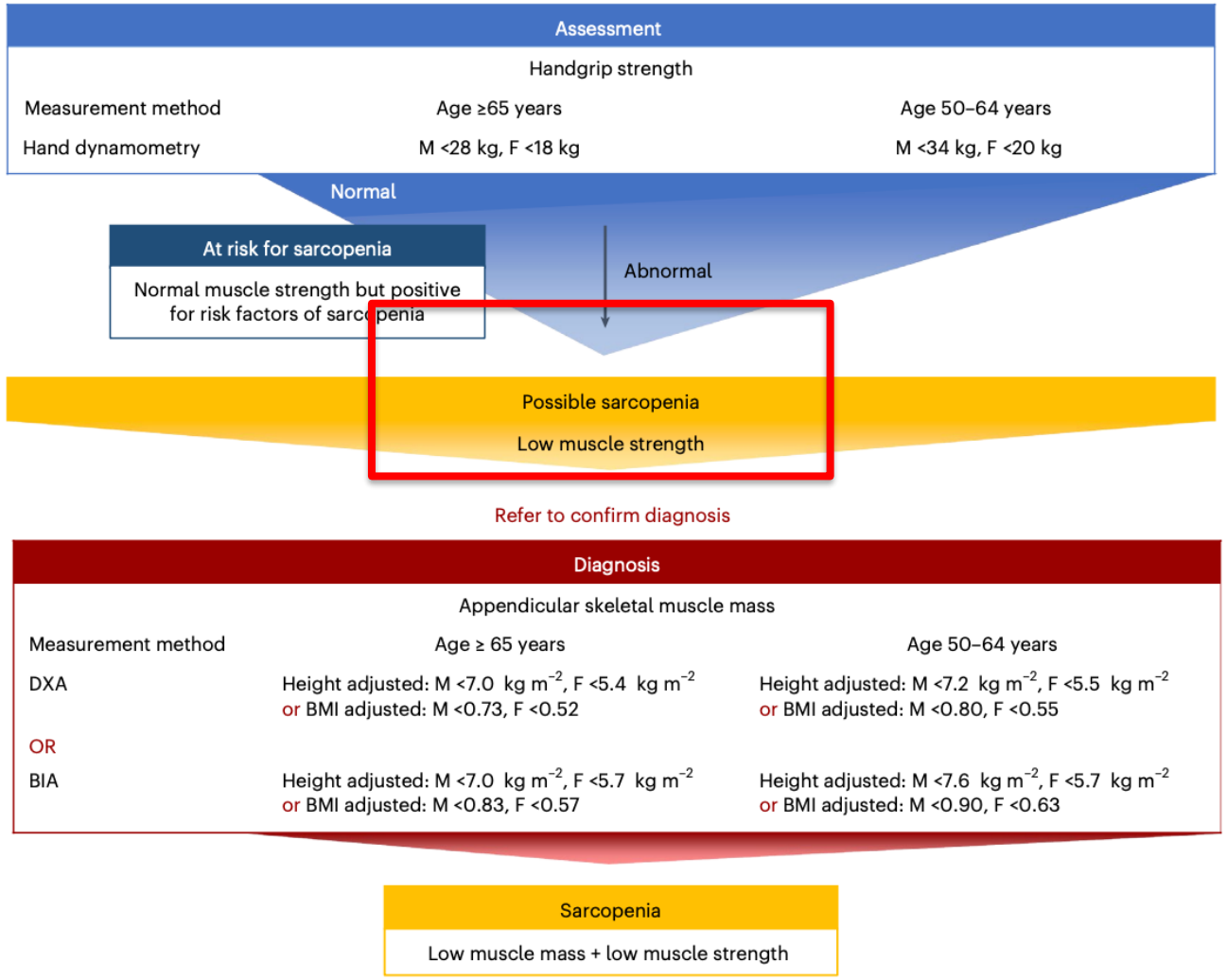
	AWGS 2014	AWGS 2019	AWGS 2025
Definition of sarcopenia	Age-related loss of skeletal muscle mass PLUS low muscle strength AND/OR low physical performance	No change from original 2014 definition	Age-related loss of skeletal muscle mass PLUS low muscle strength
Age cutoff	60 or 65 years (country-dependent)	60 or 65 years (country-dependent)	60 or 65 years for sarcopenia diagnosis, but introduces specific criteria for middle-aged adults (50–64 years)
Diagnostic algorithm	Linear algorithm: assess muscle mass and muscle function (grip strength, physical performance)	• Two separate algorithms: 1) Community settings 2) Hospital or research settings • Introduced 'possible sarcopenia' for primary care	• Enhanced two-track algorithm: 1) Community settings 2) Hospital or research settings • Emphasizes early identification and intervention
Case-finding	Not specifically addressed	1. Calf circumference: M <34 cm, F <33 cm 2. SARC-F: ≥4 3. SARC-CalF: ≥11	Add Yubi-wakka (finger-ring) test

Nature Aging. https://doi.org/10.1038/s43587-025-01004-y

AWGS 2025: No Severe Sarcopenia. Just Sarcopenia

[한국형 근감소증 선별 질문지] * 4점 이상이면 근감소증 의심할 수 있음

항목	질문	점수
근력	무게 4.5kg (9개들이 배 한 박스)를 들어서 나르는 것이 얼마나 어려운가요?	전혀 어렵지 않다=0 조금 어렵다=1 매우 어렵다/할 수 없다=2
보행 보조	방안 한 쪽 끝에서 다른 쪽 끝까지 걷는 것이 얼마나 어려운가요?	전혀 어렵지 않다=0 좀 어렵다=1 매우 어렵다/보조기(지팡이 등)를 사용해야 가능/할 수 없다=2
의자에서 일어서기	의자(휠체어)에서 일어나 침대로, 혹은 침대에서 일어나 의자(휠체어)로 옮기는 것이 얼마나 어려운가요?	전혀 어렵지 않다=0 좀 어렵다=1 매우 어렵다/도움 없이는 할 수 없다=2
계단 오르기	10개의 계단을 쉬지 않고 오르는 것이 얼마나 어려운가요?	전혀 어렵지 않다=0 좀 어렵다=1 매우 어렵다/할 수 없다=2
낙상	지난 1년 동안 몇 번이나 넘어지셨나요?	전혀 없다=0 1~3회 =1 4회 이상 =2



Nature Aging. https://doi.org/10.1038/s43587-025-01004-y

MEDLAB Research Institute by TJ.An

AWGS 2025: Physical Performance as Outcomes

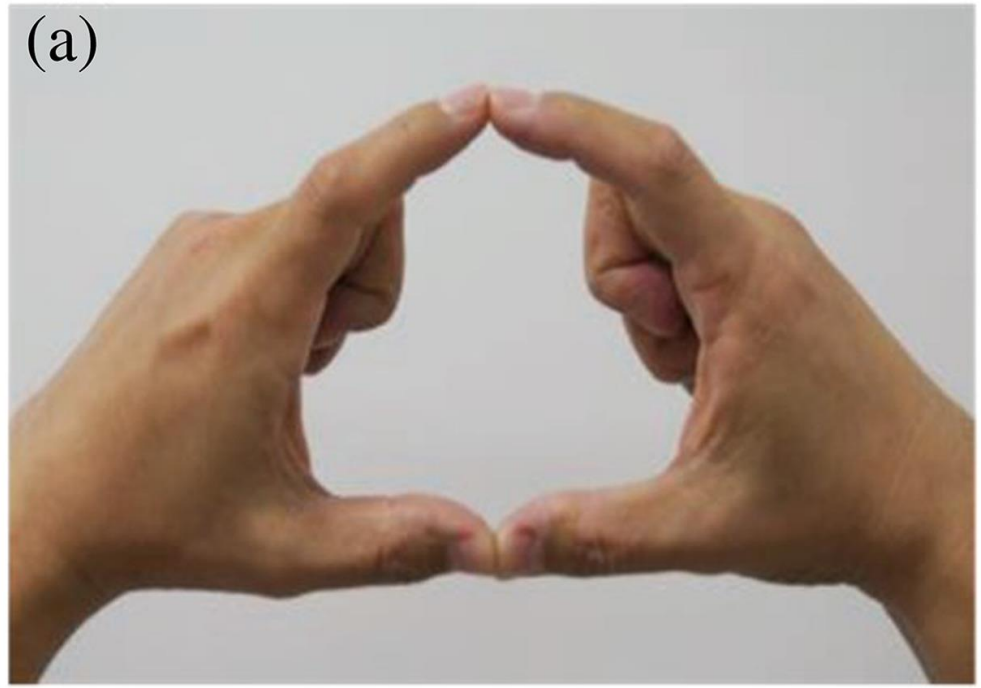
Table 2 | Measurements of muscle strength, muscle mass and physical performance in the AWGS 2025 consensus

Measurement	Adjustment	Cutoff values			
		Age 50–64 years		Age ≥ 65 years	
		Men	Women	Men	Women
Muscle strength					
Handgrip (kg)		<34.0	<20.0	<28.0	<18.0
Muscle mass					
DXA	ASM/height^2	<7.2	<5.5	<7.0	<5.4
BIA	ASM/height^2	<7.6	<5.7	<7.0	<5.7
DXA	ASM/BMI	<0.80	<0.55	<0.73	<0.52
BIA	ASM/BMI	<0.90	<0.63	<0.83	<0.57
Physical performance (outcomes)					
Five-times chair stand test (seconds)		≥10.0	≥10.0	≥12.0	≥12.0
Gait speed, 6-m walk test (m s^{-1})		<1.2	<1.2	<1.0	<1.0

ASM, appendicular skeletal muscle.

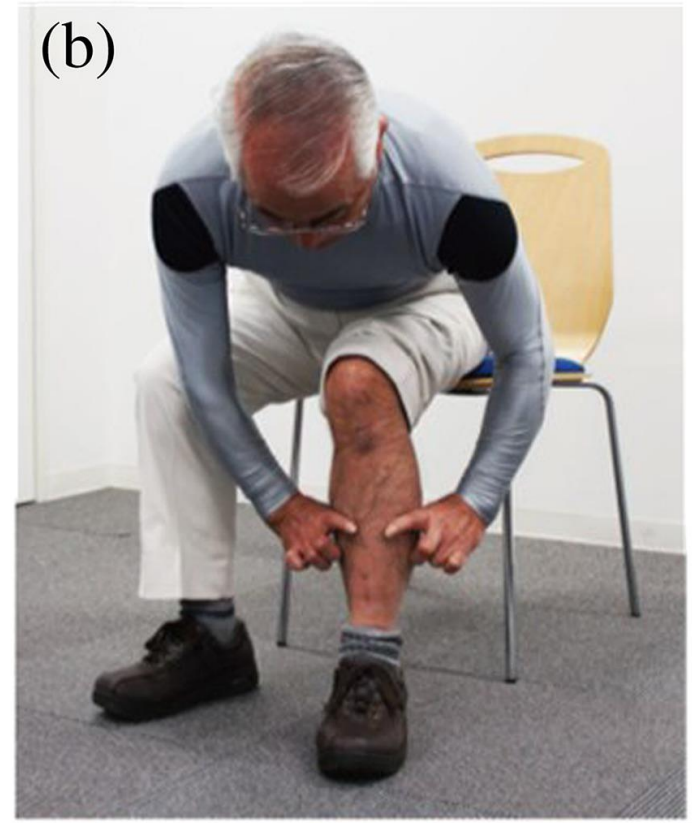
Nature Aging. https://doi.org/10.1038/s43587-025-01004-y

(a)



“Yubi-wakka” (finger-ring)

(b)



(c)

Bigger

Just-fit

Smaller

Nutrition Assessment and Intervention

Mini Nutritional Assessment MNA®

Nestlé Nutrition Institute

이름: 성별: 나이: 키: cm 체중: kg 일자:

※ 해당 사항에 체크하시고, 오른쪽 빈 칸에 점수를 적으십시오.

Screening

A 지난 3개월 동안 밥맛이 없거나, 소화가 잘 안되거나, 씹고 삼키는 것이 어려워서 식사량이 줄었습니까?
- 0= 많이 줄었다
- 1= 조금 줄었다
- 2= 변화 없다

B 지난 3개월 동안 몸무게가 줄었습니까?
- 0= 3kg 이상 감소
- 1= 모르겠다
- 2= 1kg~3kg 감소
- 3= 변화 없다

C 거동 능력
- 0= 외출 불가, 침대나 의자에서만 생활 가능
- 1= 외출 불가, 집에서만 활동 가능
- 2= 외출 가능, 활동 제약 없음

D 지난 3개월 동안 정신적 스트레스를 경험했거나 급성 질환을 앓았던 적이 있습니까?
- 0= 예
- 2= 아니오

E 신경 정신과적 문제
- 0= 중증 치매나 우울증
- 1= 경증 치매
- 2= 없음

F1 체질량 지수 = kg 체중 / (m 높이)^2
- 0 = BMI < 19
- 1 = 19 ≤ BMI < 21
- 2= 21 ≤ BMI < 23
- 3= BMI ≥ 23

체질량지수를 모를 경우 F2 로 가십시오.
F1 응답을 하신 분은 F2 를 하실 필요가 없습니다.

F2 종아리둘레 (Calf circumference, cm)
- 0 = CC < 31
- 3 = CC ≥ 31

Screening score (총 14점)

12-14 점	☐	정상
8-11 점	☐	영양불량 위험 있음
0-7 점	☐	영양불량

Chen, AWGS 2025, Nat Aging (PMID 41188603); Cruz-Jentoft, EWGSOP2, Age Ageing 2019; Dent, ICFSR 2019; An, ERJ Open Res 2025

Nutrition Assessment and Intervention

Malnutrition: 40% coexistence with frailty (Ter Beek 2020)

Screening

- MNA-SF (6 items, <5 min)

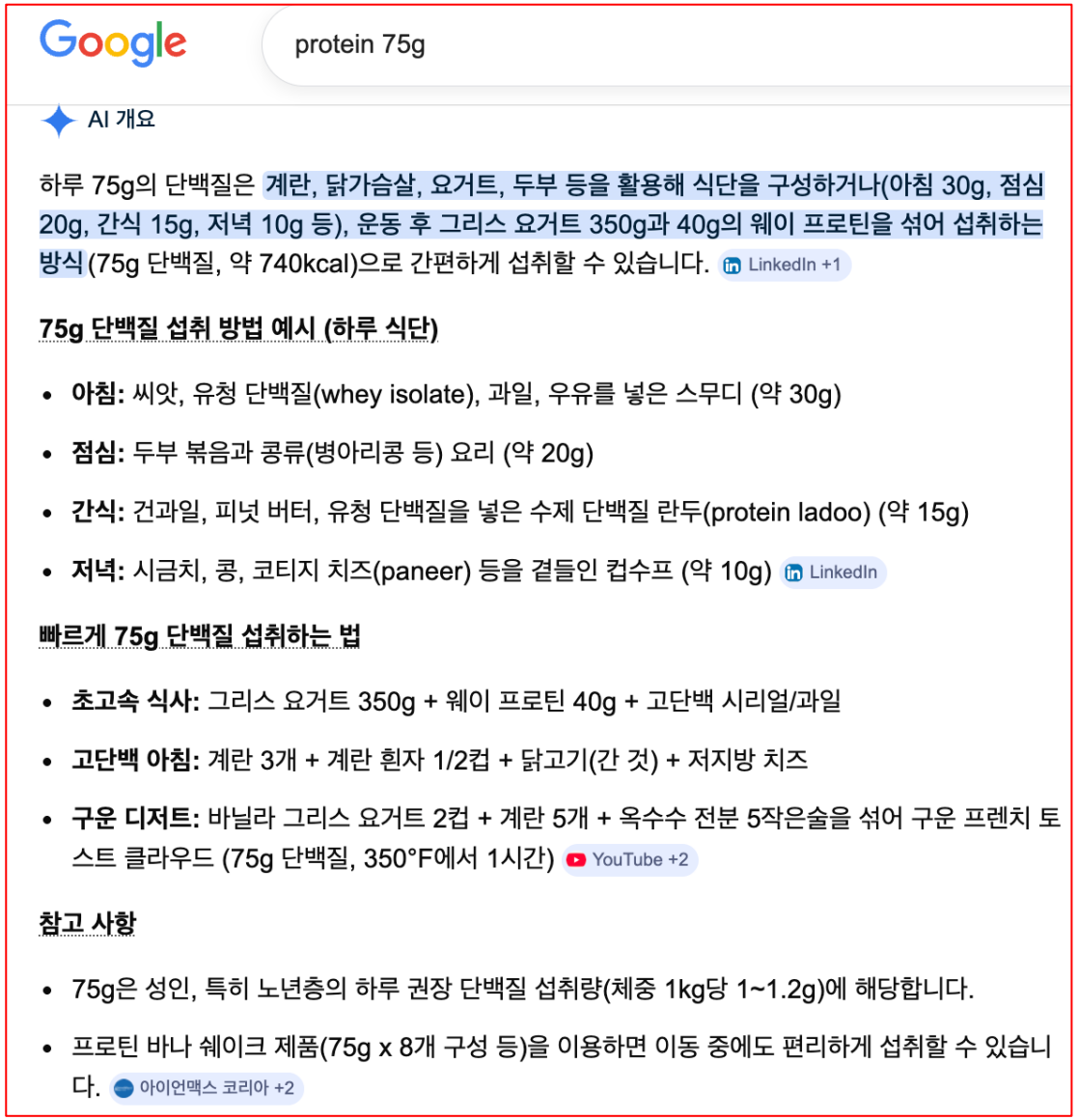
  (≥12 = normal | 8-11 = at risk | ≤7 = malnourished)

Prediction: nutritional risk predicts outcomes in respiratory disease

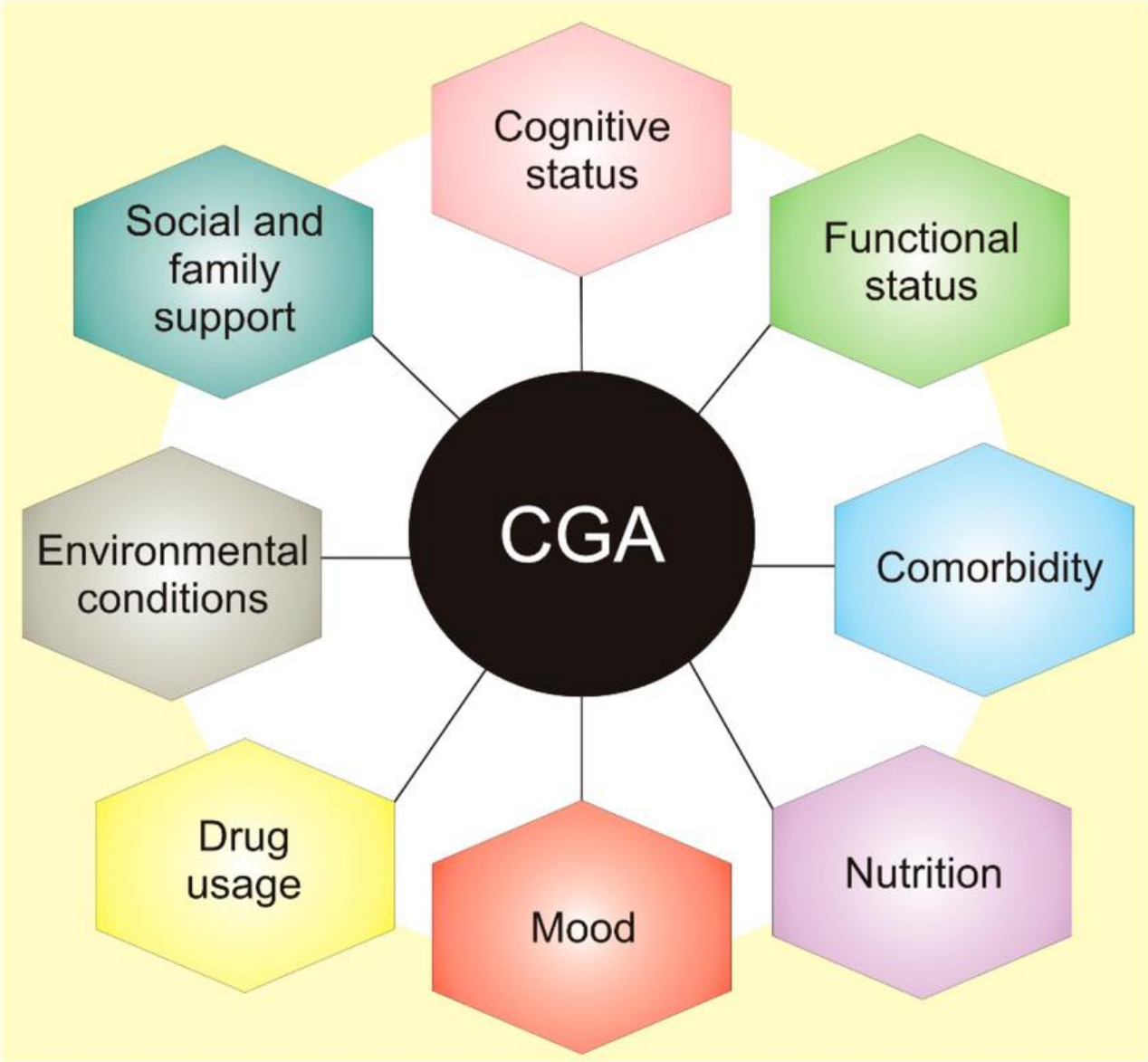
Protein targets (ICFSR 2019): 1.0-1.2 g/kg/day (general elderly) | 1.2-1.5 g/kg/day (if sarcopenic)

Combined exercise + nutrition!

Chen, AWGS 2025, Nat Aging (PMID 41188603); Cruz-Jentoft, EWGSOP2, Age Ageing 2019; Dent, ICFSR 2019; An, ERJ Open Res 2025



CGA? Comprehensive Geriatric Assessment



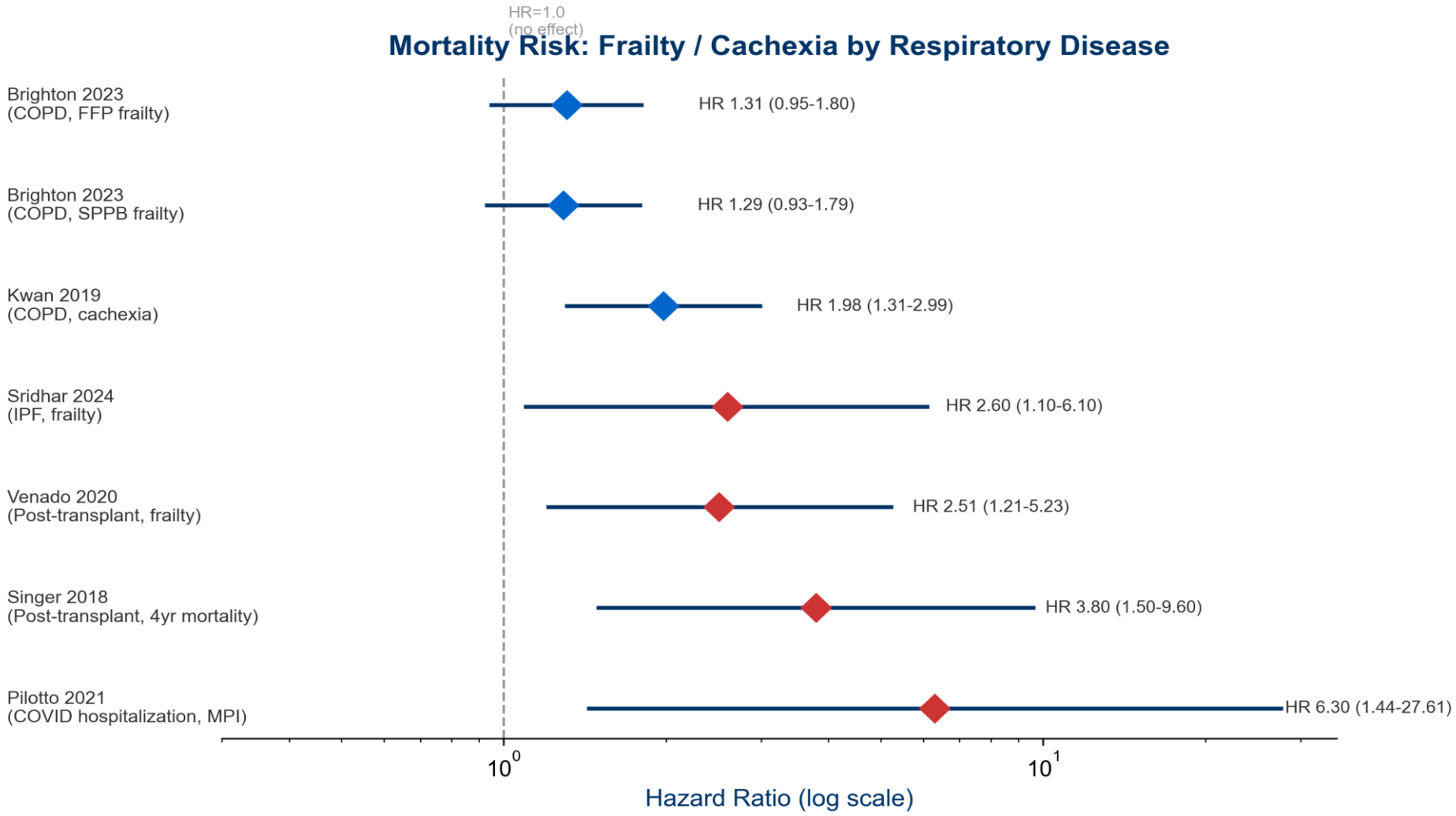
Implications for rehabilitation:

Multimodal assessment essential (not just physical frailty)

CGA captures full burden better than single-domain tools

); Sridhar, Frailty and mortality in IPF, Respir

Mortality Impact of Frailty by Disease



Brighton, Frailty tools and prognosis in COPD, Int J COPD 2023; Kwan, Weight loss in COPD-related cachexia, J Cachexia Sarcopenia Muscle 2019; Sridhar, Frailty and mortality in IPF, Respir Res 2024

Hospitalization and Healthcare Utilization

- **Frailty and readmission:**
  - **PR participation reduces 30-day readmission: HR 0.47 (95% CI 0.33-0.68)**
  - **Frailty screening at admission predicts 30-day readmission**
- **Healthcare utilization burden: Frailty independently predicts longer hospital stay**
- **Exacerbation-driven hospitalization:**
  - **Primary reason for PR non-completion in frail patients**
  - **Post-exacerbation frailty worsening accelerates decline trajectory**

--> Frailty screening as potentially cost-effective intervention / Early identification

Myers, PR and readmission in COPD exacerbation, Chronic Obstr Pulm Dis 2021; Maddocks, Physical frailty and PR in COPD, Thorax 2016; Ushida, Hospital Frailty Risk Score in COPD, Arch Gerontol Geriatr 2022

COPD and Other Respiratory Diseases

Frailty in COPD — Deep Dive

Prevalence: 25.6% (95% CI 22.7-28.7%) in stable COPD

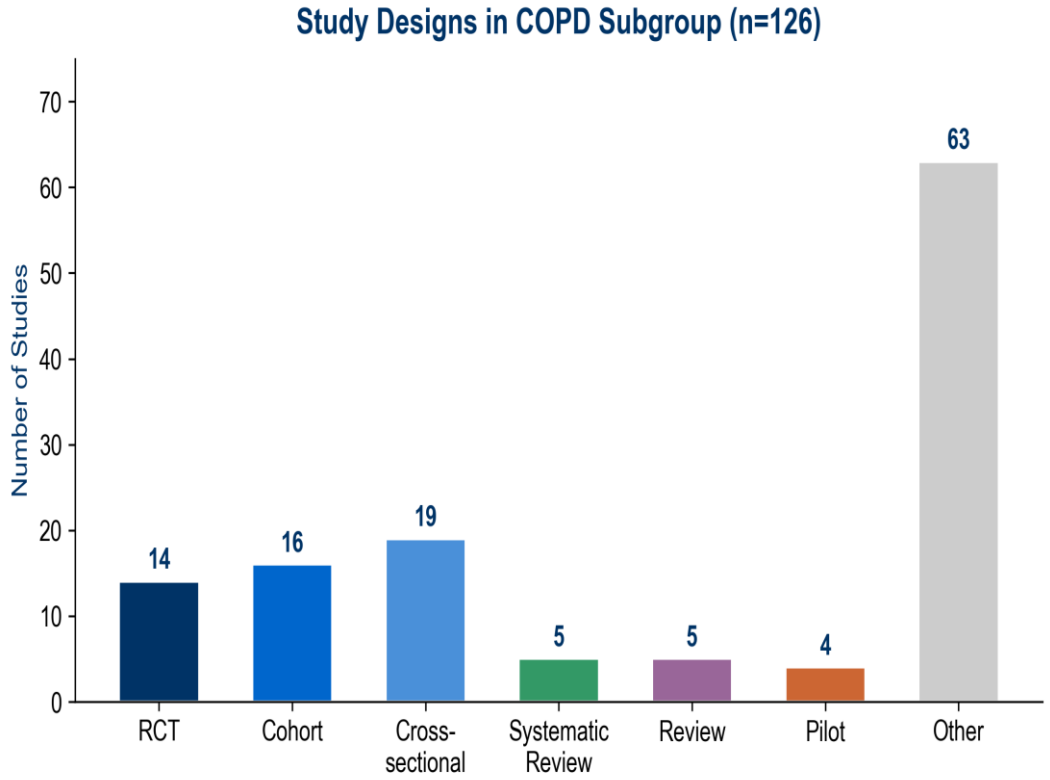
- Severe COPD declining PR: 39%
- COPD (stable, PR-enrolled): 72% (Finamore 2021)*

Key predictors:

- Higher GOLD stage, MRC dyspnea score
- Multimorbidity burden

Sarcopenia-frailty overlap:

- Sarcopenia prevalence: 20-40% (Khan 2025); 46% in PR
- Malnutrition + frailty coexist in 40%
- Cachexia in COPD: HR 1.98 for mortality (Kwan 2019)



Maddocks, Physical frailty and PR in COPD, Thorax 2016; Kwan, Weight loss in COPD-related cachexia, J Cachexia Sarcopenia Muscle 2019; Khan, Sarcopenia in COPD, 2025

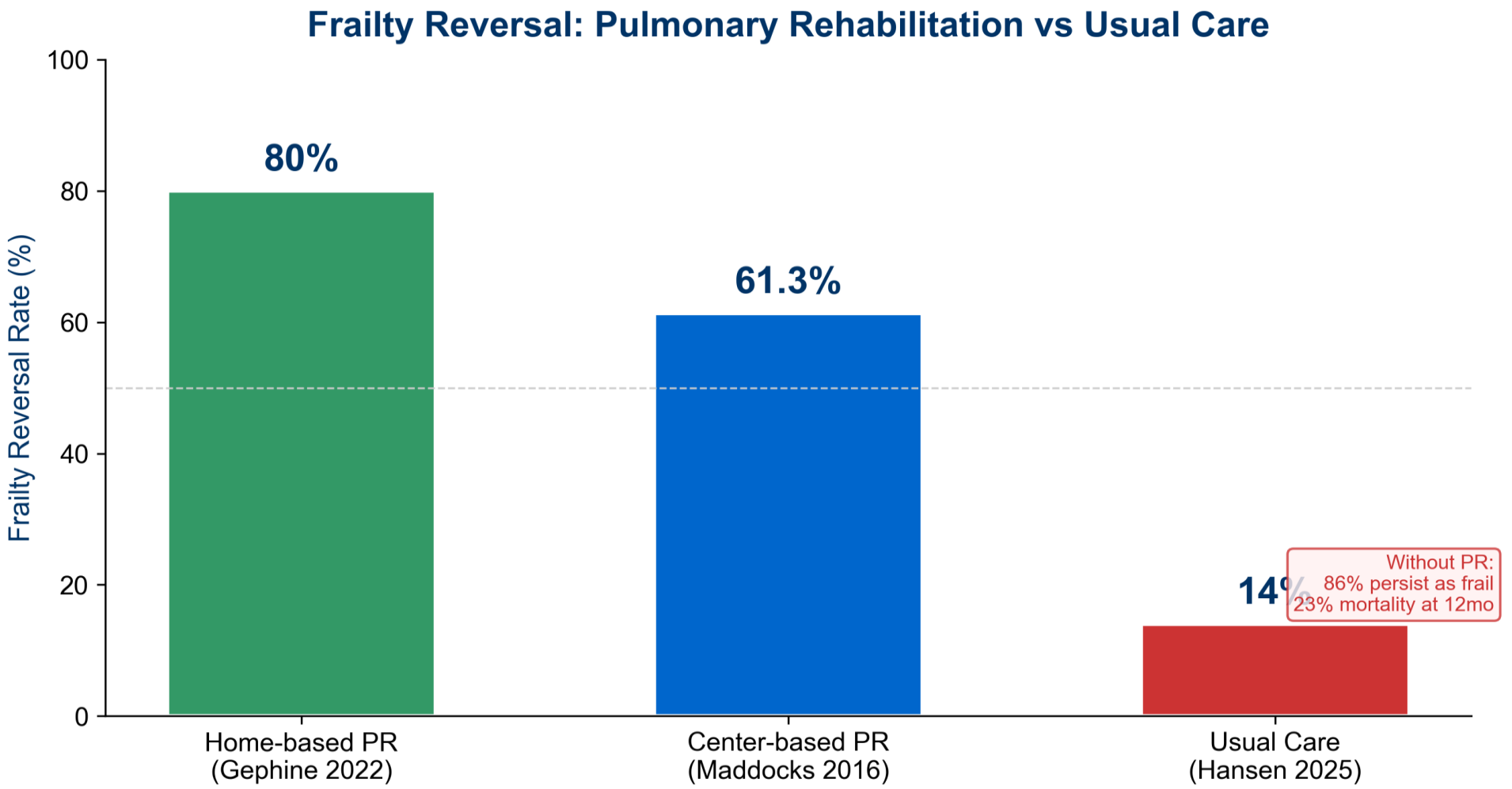
Key RCTs in Frailty and Pulmonary Rehabilitation

Study	Year	N	Population	Intervention	Key Result
Brighton	2024	31	COPD + frailty	CGA + PR (feasibility)	87% retention rate
Barker	2020	200	Post-exacerbation	Supported PR referral	41% vs 34% uptake (NS)
Ohbayashi	2024	28	COPD + frailty/sarcopenia	Rehab + Ninjin'yoeito	Significant fatigue improvement

Only 3 RCTs directly address frailty in PR (max N=200) — large multicenter RCTs are urgently needed (AT

Brighton, CGA for COPD and frailty in PR, ERJ Open Res 2024; Barker, Video intervention for PR uptake, Am J Respir Crit Care Med 2020; Ohbayashi, Rehab + Ninjin'yoeito for COPD frailty, Int J COPD 2024

Frailty Reversal: Rehabilitation vs Usual Care



Maddocks, Physical frailty and PR in COPD, Thorax 2016; Gephine, Home-based PR in frail COPD, Chronic Obstr Pulm Dis 2022; Hansen, Frailty tools in severe COPD declining PR, J Clin Med 2025

PR Outcomes in Frail Patients — Exercise Capacity

6-Minute Walk Distance (6MWD) Outcomes

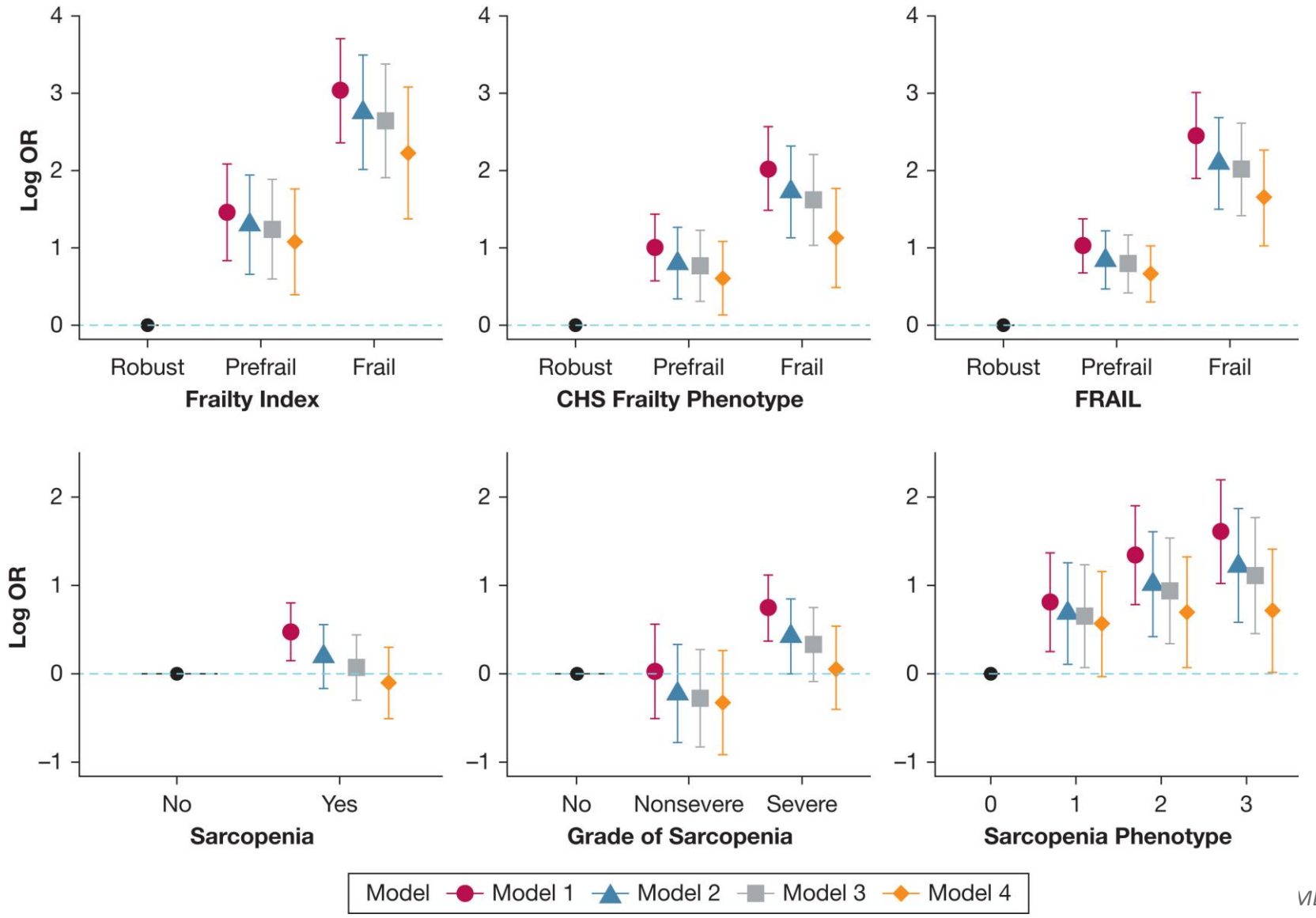
Population	6MWD Change	Comparison	Source
Frail vs non-frail COPD	+43.6 m (during PR)	Frail vs non-frail interaction beta +43.6, p=0.01	Finamore 2021
Frail vs non-frail COPD	-47 m (post-PR decline)	Frail vs non-frail interaction beta -47, p=0.02	Finamore 2021
COPD general (all patients)	+44-62 m	Clinically significant	Gloeckl 2018*
Lung Transplant prehab	+94 m	$p<0.05$	Rozenberg 2018
Post-ICU rehab (25-day)	253 m after program	vs baseline	Lemyze 2022

Key insight: Frail patients show paradoxically greater gains during PR, but are at risk of accelerated decline after PR completion.

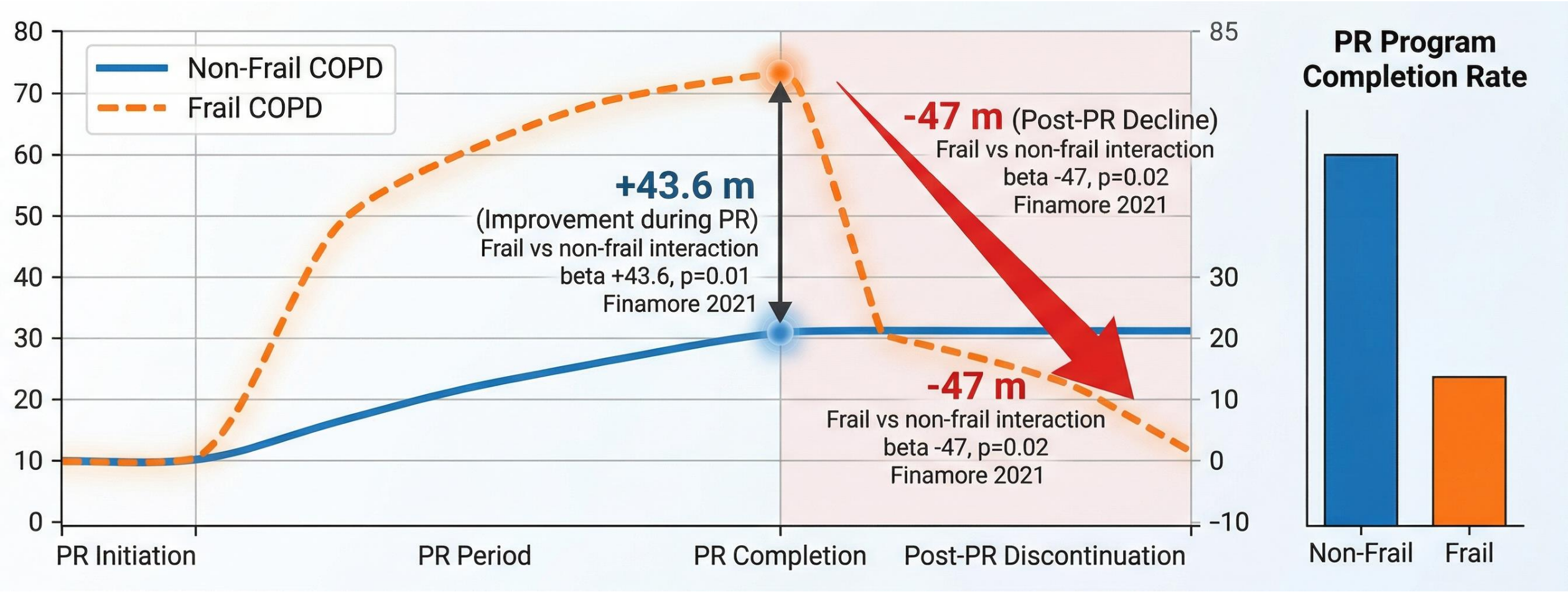
*Gloeckl 2018: general COPD PR data, not frailty-specific subgroup

Finamore, Frailty impact during and after PR, COPD 2021; Gloeckl, PR and exercise training in COPD, Dtsch Arztebl Int 2018; Rozenberg, Frailty and prehab in lung transplant, J Heart Lung Transplant 2018

Increased frailty can exacerbate dyspnea



PR in COPD: Frail vs. non-Frail



Finamore, Frailty impact during and after PR, COPD 2021; Gloeckl, PR and exercise training in COPD, Dtsch Arztebl Int 2018; Rozenberg, Frailty and prehab in lung transplant, J Heart Lung Transplant 2018

The Frailty-Rehabilitation Paradox

THE PROBLEM

- Frail patients 2.2x more likely to not complete PR (OR 2.20, 95% CI 1.39-3.46, p=0.001)
- Without PR: frailty persists in 86%
- 12-month mortality without PR: 23%
- Only 19% of PR programs routinely screen for frailty
- Higher dropout, lower adherence, transport barriers

THE OPPORTUNITY

- Frailty reversal in PR completers: 61.3% (Maddocks 2016)
- Home-based PR improvement rate: ~80% (Gephine 2022)
- Sustained improvement at 6 months post-intervention
- Frail patients show GREATER exercise capacity gains

Maddocks, Physical frailty and PR in COPD, Thorax 2016; Gephine, Home-based PR in frail COPD, Chronic Obstr Pulm Dis 2022; Liao, PR exercise package for elderly frail COPD, J Nurs Res 2025

Frailty in Respiratory Failure / ICU

Prevalence at ICU admission: 29.8% (CFS) to 44.8% (FI)

45.3% had WORSENED frailty at 6-month follow-up (GETTING WORSE!)

ICU-acquired weakness significantly overlaps with frailty phenotype

COVID hospitalization mortality: HR 6.30 (Pilotto 2021: COVID in-hospital mortality, not ICU-specific)

Rehabilitation challenges: Limited mobility during MV, Post-ICU syndrome overlap

→ Early mobilization protocols as frailty mitigation

→ Post-ICU rehab: +253m 6MWD after 25-day program (Lemyze 2022)

Muscedere, Frailty outcomes in critically ill (FORECAST), Intensive Care Med 2024; Pilotto, MPI prognostic stratification in COVID, Aging Clin Exp Res 2021

Frailty in ILD

ILD / Pulmonary Fibrosis (19 articles)

- Frailty prevalence: ~26%
- Progressive disease accelerates frailty
- IPF frailty mortality: HR 2.6 (1.1-6.1) (Sridhar 2024)
- Unique challenge: supplemental O2 dependency
- Limited PR evidence — emerging ILD frailty data

Rozenberg, Frailty and prehab in lung transplant, J Heart Lung Transplant 2018; Venado, Frailty and mortality after lung transplant, Thorax 2020; Sridhar, Frailty and mortality in IPF, Respir Res 2024

Lung Transplant — Prehabilitation Focus

Key findings on frailty and transplant outcomes:

- Pre-transplant frailty prevalence: 26% (Rozenberg 2018)
- Post-transplant frailty mortality: HR 2.51 (Venado 2020)
- Post-transplant frailty 4-yr mortality: HR 3.8 (Singer 2018)
- Post-transplant frailty CLAD risk: csHR 1.76 (1.05-2.92) (Singer 2023)

Prehabilitation evidence:

- 6MWD gain with prehabilitation: +94m (Rozenberg 2018)
- Kennedy 2019 (American Society of TPL consensus): frailty independently predicted worse outcomes
- Courtwright 2018: frailty measured at listing vs discharge (modifiability data)

Growing consensus: frailty is modifiable pre-transplant; prehabilitation should be standard of care

Singer 2018, Frailty phenotypes in lung transplant candidates, Am J Transplant 2018; Singer 2023, Frailty and CLAD after lung transplant, Transplantation 2023; Venado, Frailty and mortality after lung transplant, Thorax 2020

Frailty in PH, Asthma, and Bronchiectasis

Pulmonary Hypertension (2 studies):

- No PH-specific frailty mortality data available
- Right ventricular failure compounds frailty phenotype
- No PR + frailty intervention studies
- CRITICAL EVIDENCE GAP: PH frailty research needed

Asthma: Minimal frailty prevalence data, Older asthma patients may have overlapping COPD-frailty, No frailty RCT

Bronchiectasis (1 study only): Virtually no evidence on frailty assessment or intervention

MAJOR EVIDENCE GAPS IN NON-COPD DISEASES

Non-COPD diseases represent 61% of articles but have minimal frailty-PR intervention evidence

PubMed systematic search 2026; no validated PH-specific frailty data identified

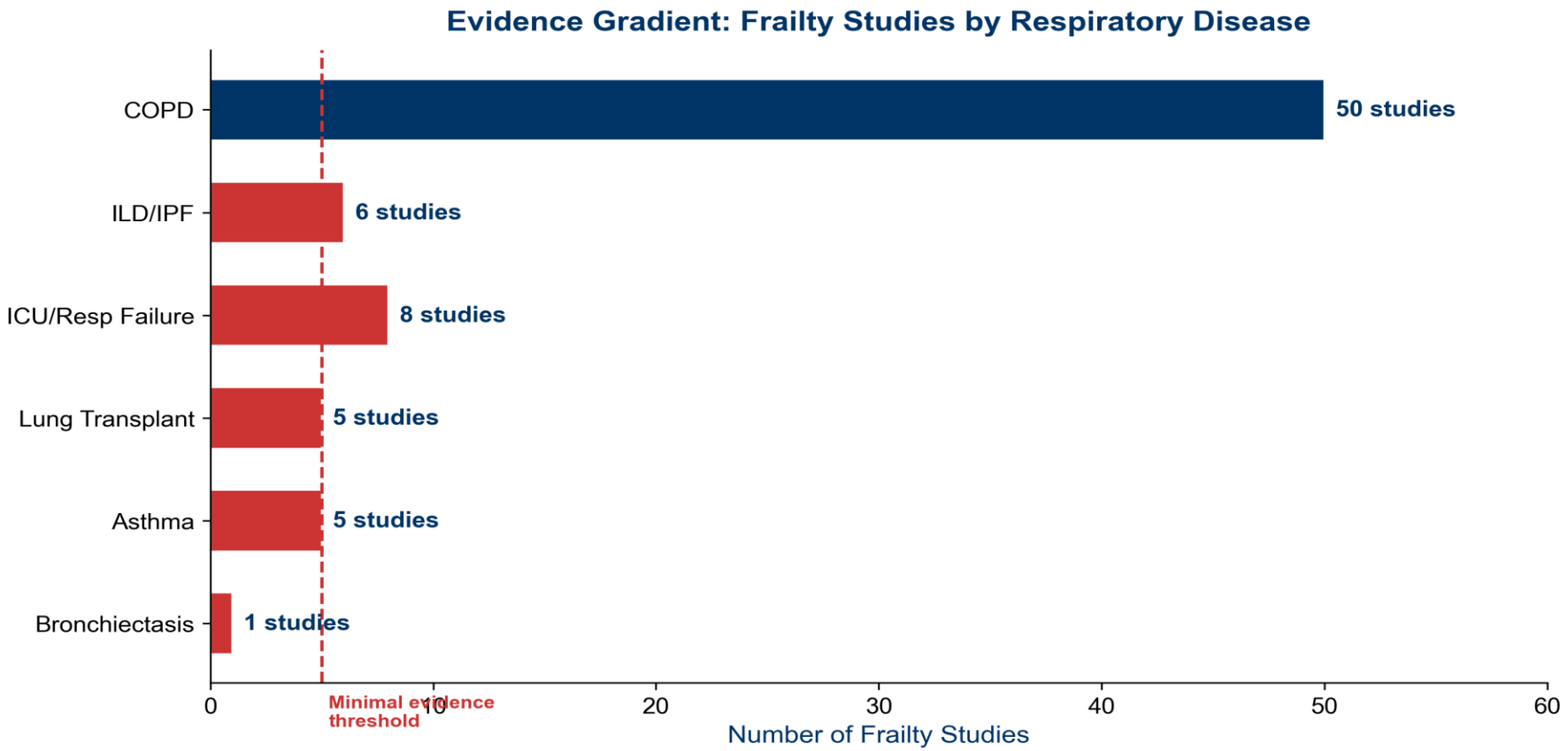
What We Have to do?

Critical Evidence Gaps

1. Non-COPD frailty-PR evidence is near absent — ILD, PH, asthma, bronchiectasis
2. No standardized frailty screening protocol in PR programs worldwide
3. Frailty reversal as a primary outcome — only 3 studies (Maddocks, Gephine, Hansen)
4. Long-term sustainability: post-PR decline in frail patients poorly characterized
5. Sarcopenia-specific interventions in respiratory disease — no large RCTs
6. Implementation science: how to integrate frailty screening into routine PR workflow

Based on systematic review of 327 included articles (472 screened), PubMed 2014-2026

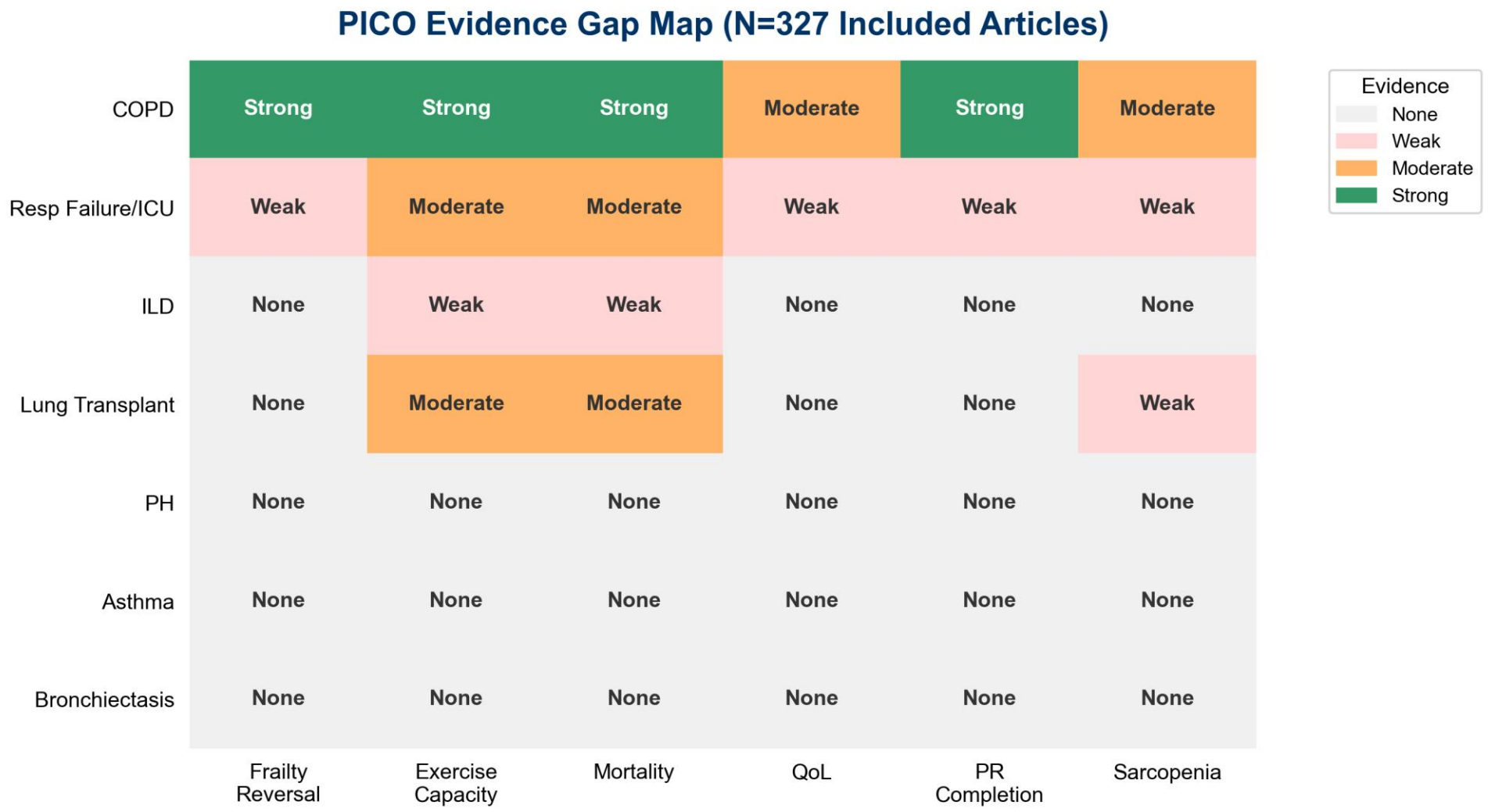
Unmet Need: Evidence Gradient by Respiratory Disease



Asthma: only 5 studies, prevalence 9.5-37% (Verduri 2023 SR). Bronchiectasis: 1 study (Fujita 2022, N=36, 22.2%). No rehabilitation trials in either disease.

Verduri, Geriatrics 2023 (PMID 37623275); Fujita, J Clin Med 2022 (PMID 36329435); Wang, BMJ Open Respir Res 2023 (PMID 37336621)

PICO Evidence Gap Map — Updated (N=327)



Based on systematic review of 327 included articles (472 screened), PubMed 2026. v4 corrections: ILD mortality None->Weak (Sridhar 2024 = IPF); PH mortality: no valid data (Sridhar was misattributed)

Clinical Practice Gap: Screening and Implementation

19%

of PR programs routinely screen for frailty

79%

of clinicians believe PR is appropriate for frail patients

94%

want more guidelines on frailty management

Knowledge-practice gap: Strong evidence for PR benefit in frailty,

but virtually no implementation studies or standardized protocols exist.

Alzubaidi, Frailty screening in PR: survey, Chron Respir Dis 2025

ATS/ERS Guideline Recommendations

ATS Workshop Report 2023

Defined 'frailty rehabilitation paradox'

Recommended CGA integration into PR

Called for flexible delivery models (home, tele)

Identified need for disease-specific clinical trials

Advocated for standardized frailty screening in PR

ERS Statement 2023

Frailty underrepresented in respiratory guidelines

Validated screening tools recommended

Personalized management pathways needed

Explicit call for RCTs in frailty + CRD

Multidisciplinary approach endorsed

Both societies agree: frailty is a treatable trait, not a contraindication to PR

Maddocks, ATS Workshop: Frailty and PR, Ann Am Thorac Soc 2023; Osadnik, ERS Statement: Frailty in chronic lung disease, Eur Respir J 2023

Optimizing Pulmonary Rehabilitation for Frail Patients

Home-based PR: ~80% frailty improvement, sustained at 6 months

- Removes transport barriers — key dropout factor for frail patients
- Gephine 2022: N=47, COPD, home-based PR program

Comprehensive Geriatric Assessment (CGA) integration:

- Average 3 recommendations per patient
- 65% of CGA recommendations implemented
- Brighton 2024: CGA embedded in PR pathway

Person-centered approaches:

- Individualized exercise prescription
- Addressing psychological barriers (fear of falling, breathlessness anxiety)
- Patient narratives: value of 'being seen as a whole person'
- Brighton 2020: qualitative study on patient experiences

Gephine, Home-based PR in frail COPD, Chronic Obstr Pulm Dis 2022; Brighton, CGA for COPD and frailty in PR, ERJ Open Res 2024; Brighton, Experiences of PR in COPD and frailty, Ann Am Thorac Soc 2020

Telerehabilitation and Digital Therapeutics

Current evidence: zero empirical telerehab studies for frail respiratory patients

Proposed models:

- Lippi 2022: technology-enhanced organizational model
- Home-based PR as proof of concept (Gephine 2022: 80% improvement)

Potential advantages for frail patients:

- Eliminates transport barriers (primary dropout factor)
- Real-time monitoring for exacerbation detection
- Flexible scheduling — accommodates 'unpredictable disruptions' (Brighton 2020)

CBT-based digital components:

- Breathlessness reappraisal and graded exposure
- Behavioral activation for deconditioning
- Regulatory considerations for DTx classification

Lippi, Telerehab organizational model, 2022; Gephine, Home-based PR in frail COPD, Chronic Obstr Pulm Dis 2022; Maddocks, ATS Workshop: Frailty and PR, Ann Am Thorac Soc 2023

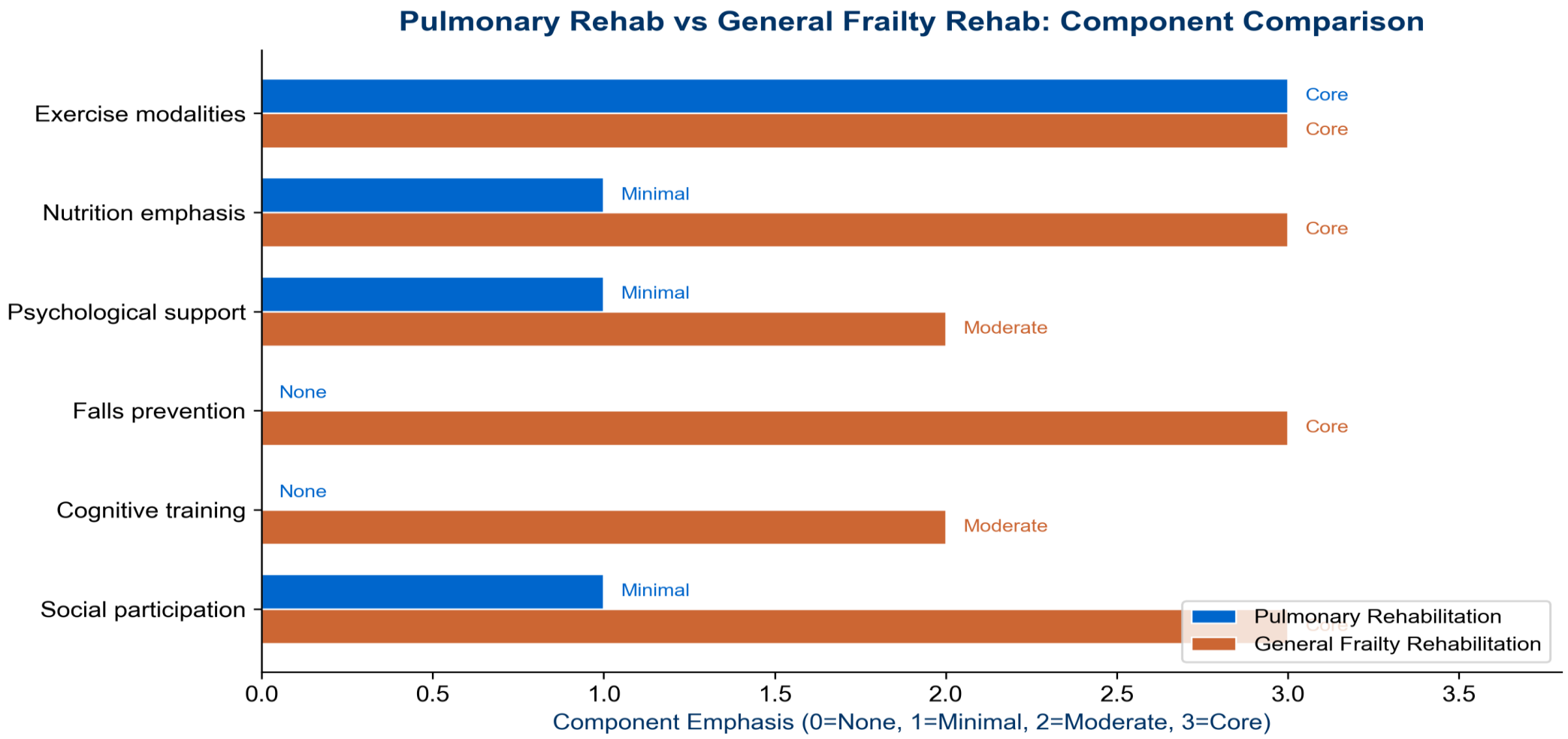
What We Have to do?
Clue 1: Let’s emulate previously validated one Comprehensive+Intensive PR

Pulmonary Rehab vs General Frailty Rehab

Dimension	Pulmonary Rehabilitation	General Frailty Rehab
Exercise Core	Endurance + Resistance	Resistance + Balance + Endurance + Flexibility
Unique Components	Breathing exercises, IMT, O_2 mgmt, Airway clearance	Falls prevention, Cognitive training, Polypharmacy review, CGA
Nutrition Role	Supportive (if underweight)	**Core** component (protein 1.2 g/kg/day target)
Program Duration	6–12 weeks	**12–24 weeks (6 months)**
Primary Outcome	6MWD, mMRC, CRQ/SGRQ	SPPB, Gait speed, Grip strength, Fried criteria
Frailty Reversal	61% in completers	42–83% depending on intensity

ATS/ERS PR Statement 2013 (PMID 24127811); ICFSR Guidelines 2019 (PMID 31641726); Maddocks ATS Workshop 2023 (PMID 37261787)

Component Comparison: PR vs Frailty Rehab



ATS/ERS PR Statement 2013 (PMID 24127811); ICFSR Guidelines 2019 (PMID 31641726); Maddocks ATS Workshop 2023 (PMID 37261787)

Multicomponent Interventions: Network Meta-Analysis

Network meta-analysis: 69 RCTs, N=5,765 (Sun et al. Age and Ageing 2023)

Intervention type ranking (pairwise vs control):

#1: Physical activity (PA): SMD 0.43 (95% CI 0.34–0.51)

#2: Multicomponent intervention: SMD 0.34 (95% CI 0.23–0.45)

#3: Nutrition intervention: SMD 0.21 (95% CI 0.06–0.35)

PA subtype ranking:

#1: Resistance training: SMD 0.58 (95% CI 0.33–0.83)

#2: Mind-body exercise: SMD 0.57 (95% CI 0.24–0.90)

#3: Mixed physical training: SMD 0.47 (95% CI 0.37–0.57)

#4: Aerobic training: SMD 0.36 (95% CI 0.09–0.62)

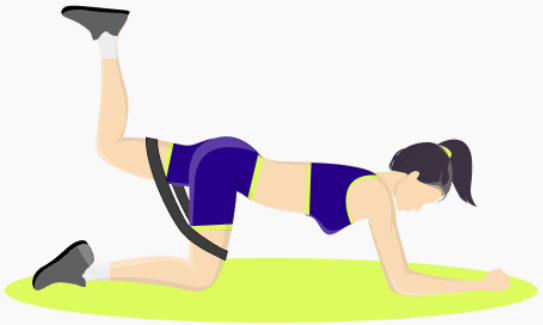
Optimal dose (Nagata 2023): 2–3 sessions/wk; ICFSR 2019: resistance is first-line

Resistance training is the single most effective component. Multicomponent > single-domain.

Sun X et al. Age Ageing 2023 (PMID 36746389); Nagata CA et al. Ageing Res Rev 2023 (PMID 37774931)

ULTIMATE NUTRITION

RESISTANCE BANDS vs. WEIGHTS



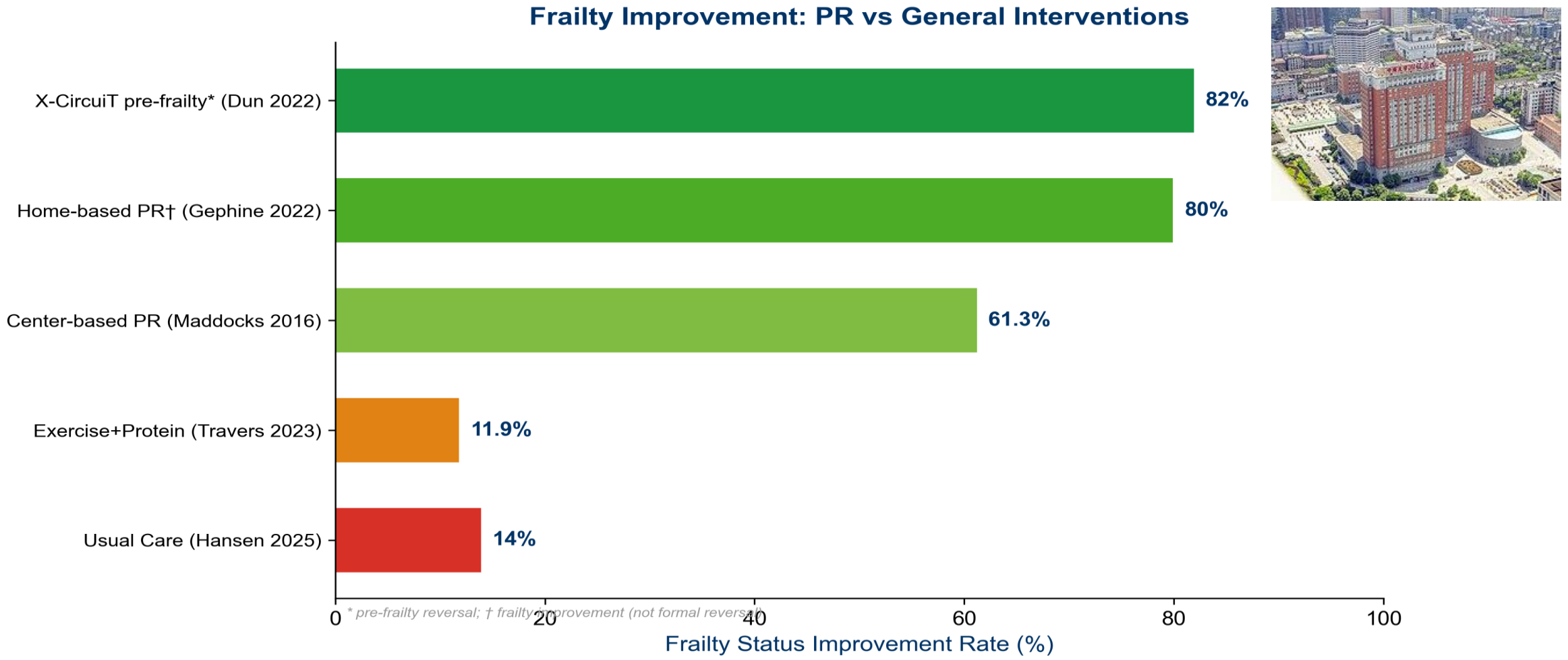
RESISTANCE BAND BENEFITS

1. **Portability:**
   Perfect for those who travel or have limited space.
2. **Joint-Friendly:**
   Ideal for those with joint issues or recovering from injuries.
3. **Versatility:**
   Excellent for full-body workouts and progressive resistance.

WEIGHT BENEFITS

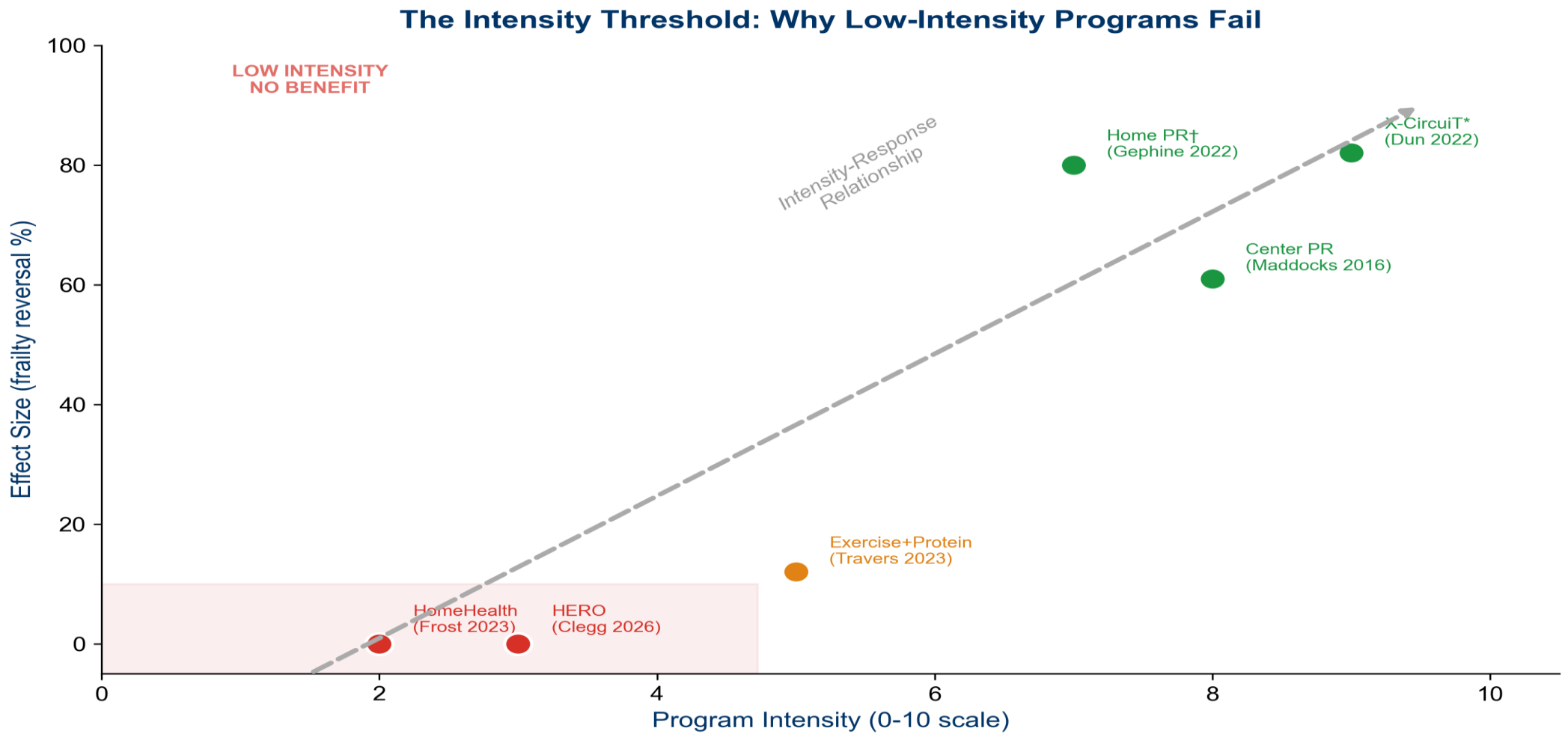
1. **Muscle Building:**
   Superior for hypertrophy and strength gains.
2. **Consistent Resistance:**
   Provides a constant load throughout the entire movement.
3. **Exercise Variety:**
   Allows for a wide range of exercises targeting every muscle group.

Frailty Improvement: PR vs General Interventions



Dun, Age Ageing 2022; Gephine, Chronic Obstr Pulm Dis 2022; Maddocks, Thorax 2016; Travers 2023; Ji, JAMA Netw Open 2025; Hansen, J Clin Med 2025

The Intensity Threshold



Frost, Lancet 2023; Clegg, Age Ageing 2026; Ji, JAMA Netw Open 2025; Travers 2023; Maddocks, Thorax 2016; Dun, Age Ageing 2022; Gephine, COPD 2022

Multicomponent Rehab: Prevent Long-term care costs in Frailty

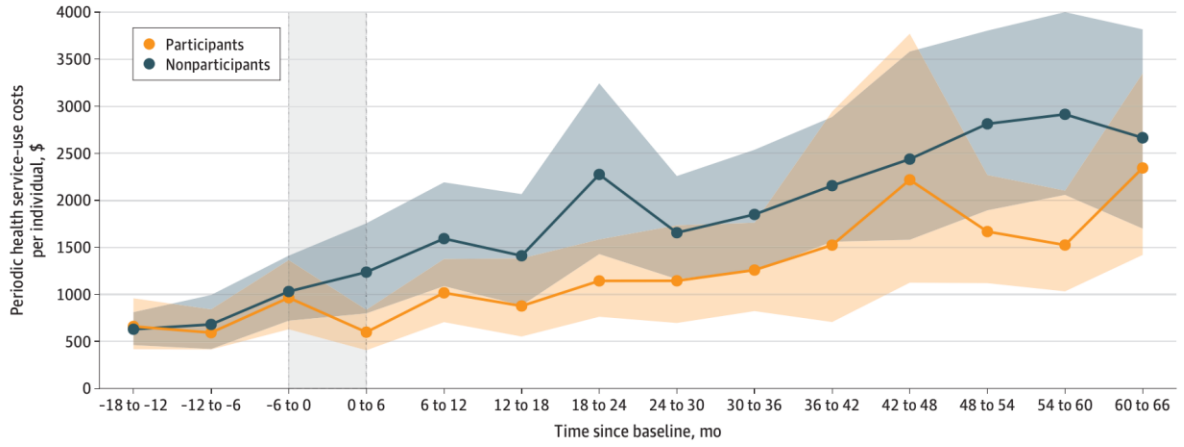
JAMA Network | Open

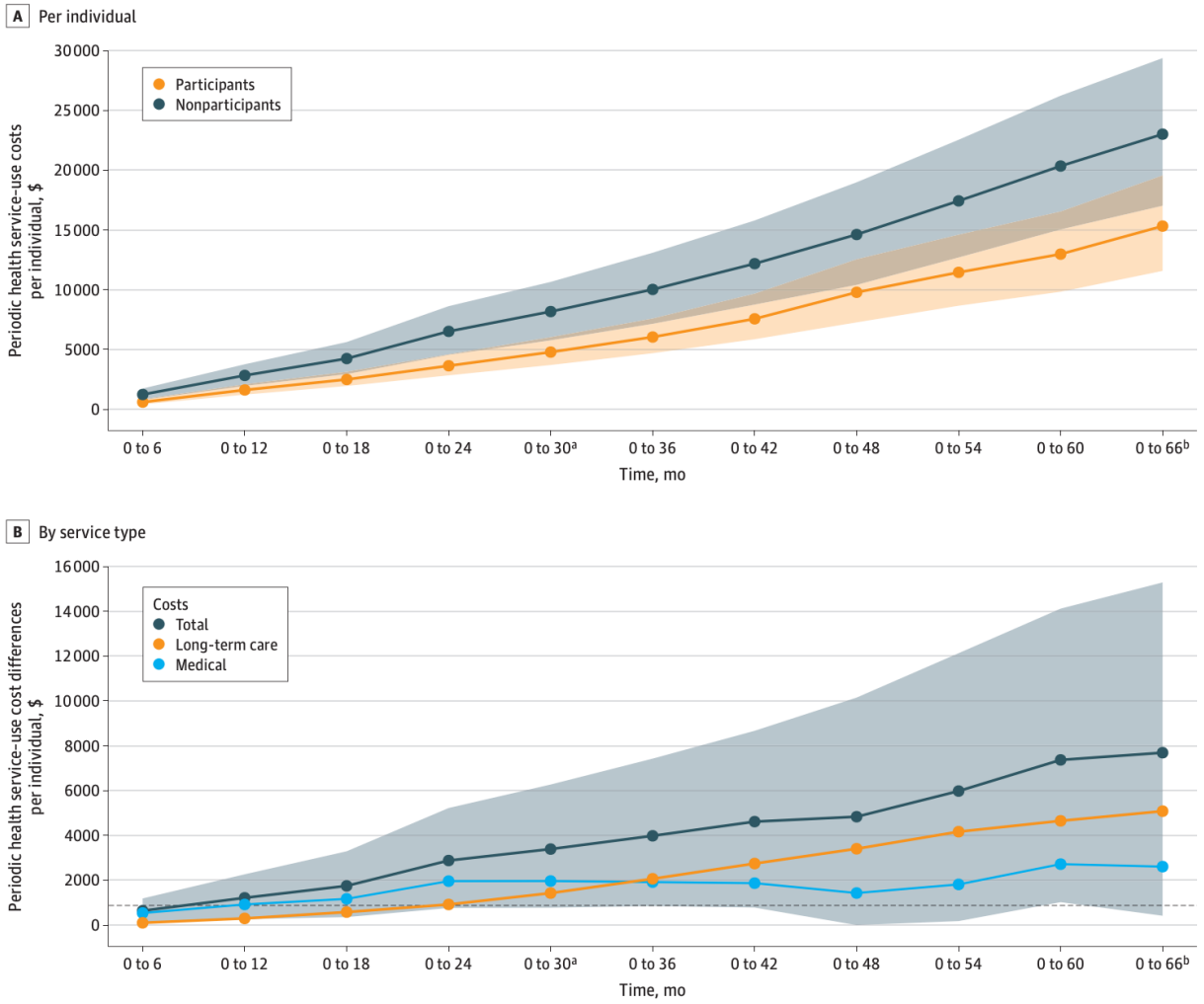
Original Investigation | Geriatrics

Long-Term Health and Cost Outcomes of a 24-Week Multicomponent Frailty Intervention in Older Adults

Sunghwan Ji, MD, MS; Jihye Lim, MD, PhD; Tai Joon An, MD, PhD; Geonyeong Jang, MD; Ji Yeon Baek, MD, PhD; Kunhee Park, MD, PhD; Ju Jin Jung, BS; Seon-Hee Cheon, RN; Jun-Pyo Myong, MD, PhD; Yun-Hee Lee, PhD; Juhee Cho, PhD; Jin Lee, PhD; Hojoon Sohn, MPH, PhD; Il-Young Jang, MD, PhD

Figure 2. Trends in Periodic Health Service–Use Costs Per Individual for Participants and Nonparticipants





Ji, JAMA Netw Open 2025 (PMID 41222933); Frost, HomeHealth RCT, Lancet 2023 (PMID 37997084); Clegg, HERO RCT, Age Ageing 2026 (PMID 41719425)

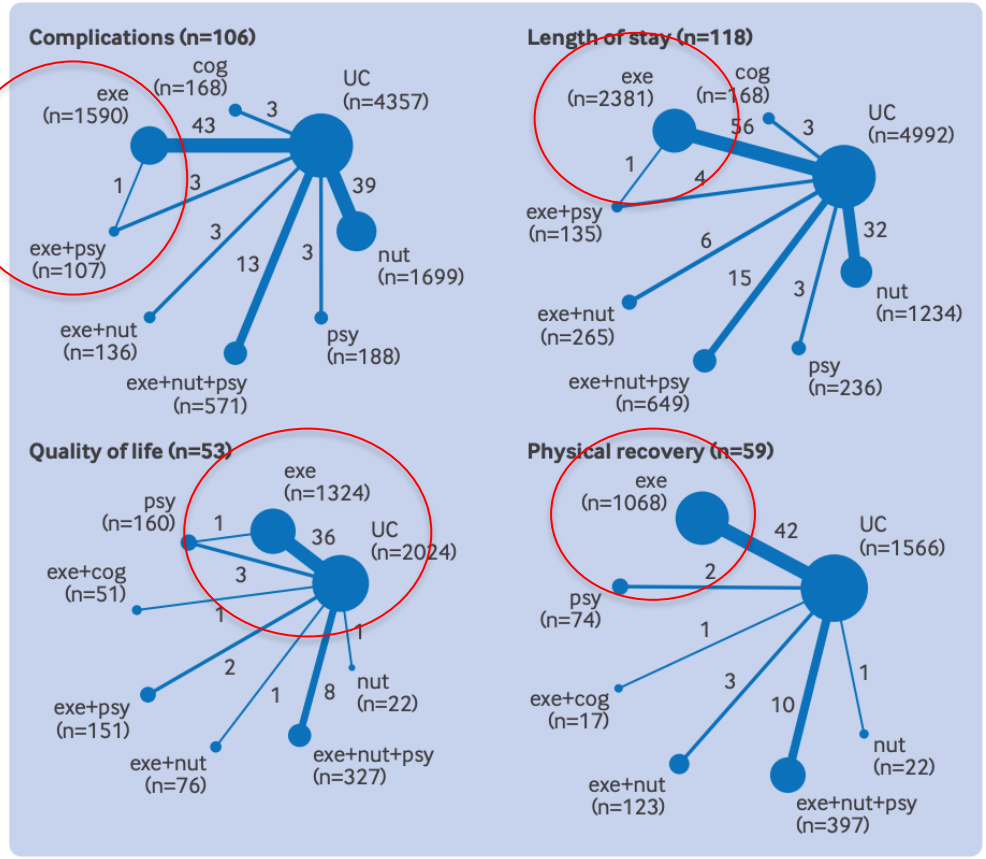
MEDLAB Research Institute by TJ.An

What We Have to do?
Clue 2: Let’s emulate previously validated one Prehabilitation

Prehabilitation in Post-OP care

Relative efficacy of prehabilitation interventions and their components: systematic review with network and component network meta-analyses of randomised controlled trials

Daniel I McIsaac,[1] Gurlavine Kidd,[2] Chelsia Gillis,[3] Karina Branje,[2] Mariam Al-Bayati,[2] Adir Baxi,[2] Alexa L Grudzinski,[4] Laura Boland,[5] Areti-Angeliki Veroniki,[6] Dianna Wolfe,[2] Brian Hutton[2]



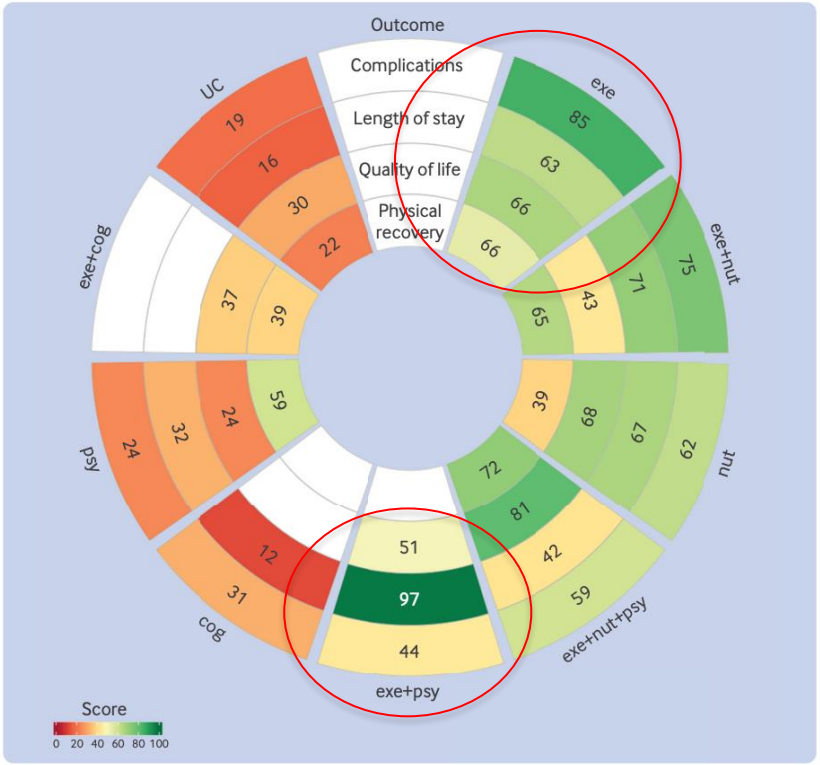


Fig 4 | Rank-heat plot obtained from treatment-level network meta-analysis. The rank heat plot presents a summary of P scores (range 0-100) for each intervention across outcomes, where darker shades of green represent more benefit and darker shades of red represent less benefit.cog=cognitive; exe=exercise; nut=nutrition; psy=psychosocial; UC=usual care

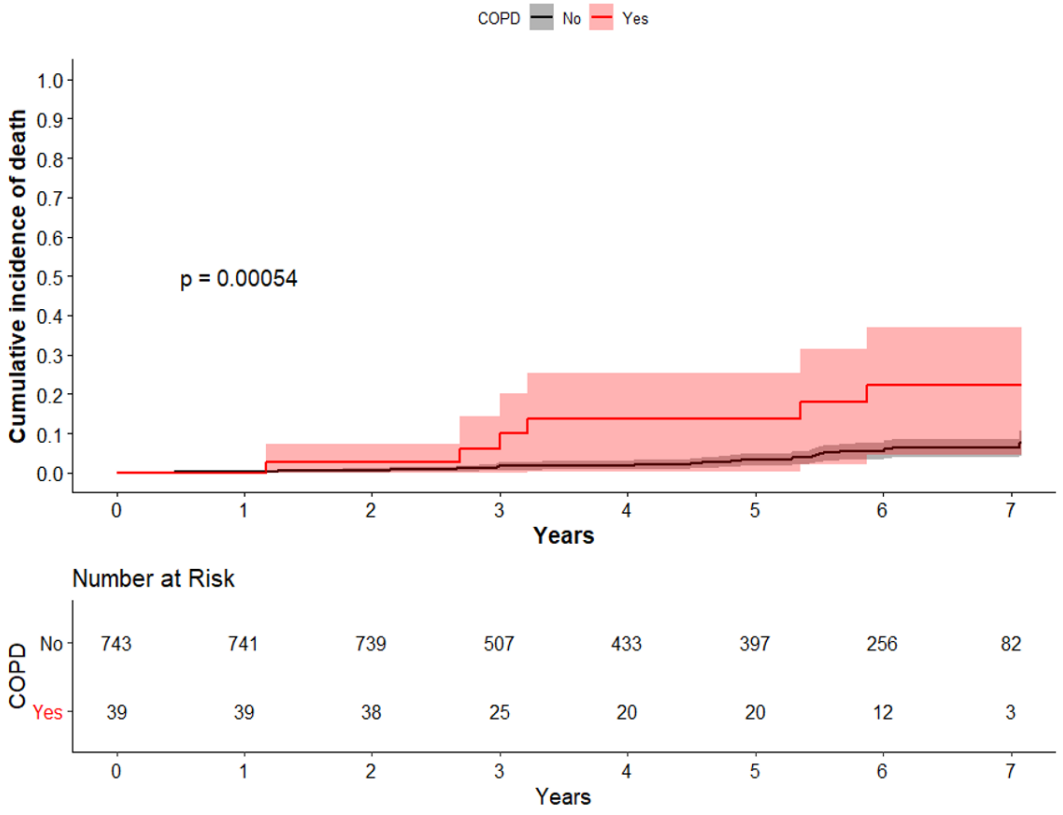
tute by TJ.An

What We Have to do?
Clue 3: Gait Speed and Frailty as Treatable Trait and Outcome

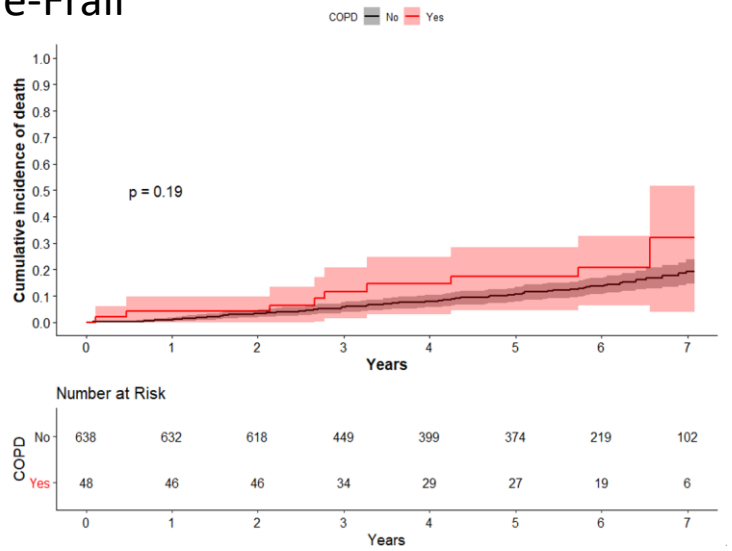
Frailty as Treatable Trait and Clinical Outcome!

KM graph according to COPD: ASPRA Study in Korea

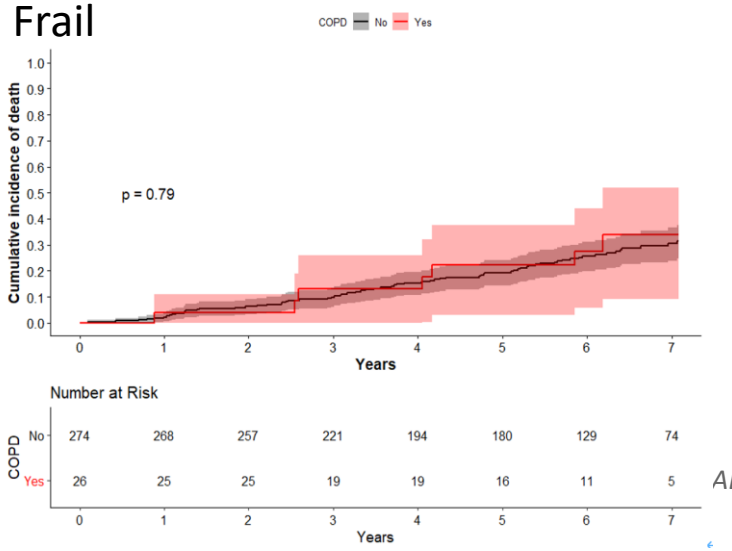
Robust



Pre-Frail



Frail



Maddocks, Physical frailty and PR in COPD, Thorax 2016; Kwan, Weight loss in COPD-related cachexia, J Cachexia Sarcopenia Muscle 2019; Khan, Sarcopen

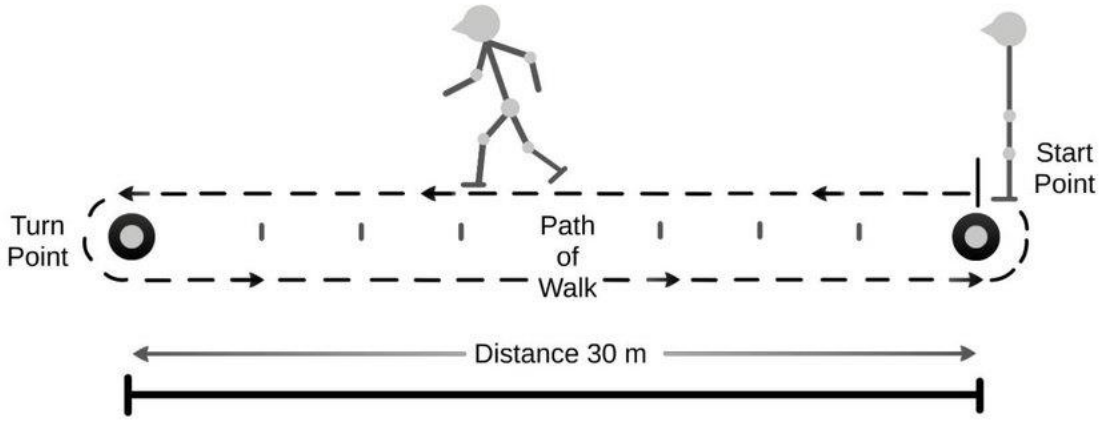
AB Research Institute by TJ.An

How about using gait speed (1m/s) as screening value and treatable target?

Table 2 | Measurements of muscle strength, muscle mass and physical performance in the AWGS 2025 consensus

Measurement	Adjustment	Cutoff values			
		Age 50–64 years		Age ≥ 65 years	
		Men	Women	Men	Women
Muscle strength					
Handgrip (kg)		<34.0	<20.0	<28.0	<18.0
Muscle mass					
DXA	ASM/height^2	<7.2	<5.5	<7.0	<5.4
BIA	ASM/height^2	<7.6	<5.7	<7.0	<5.7
DXA	ASM/BMI	<0.80	<0.55	<0.73	<0.52
BIA	ASM/BMI	<0.90	<0.63	<0.83	<0.57
Physical performance (outcomes)					
Five-times chair stand test (seconds)		≥10.0	≥10.0	≥12.0	≥12.0
Gait speed, 6-m walk test (m s^{-1})		<1.2	<1.2	<1.0	<1.0

ASM, appendicular skeletal muscle.



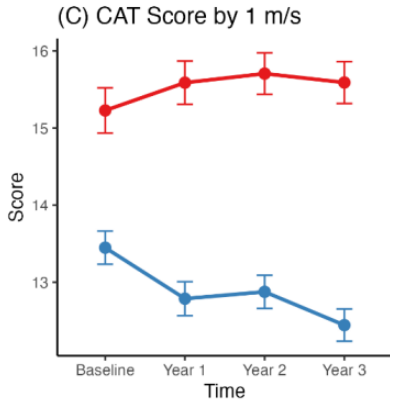
How about using gait speed (1m/s) as screening value and treatable target?

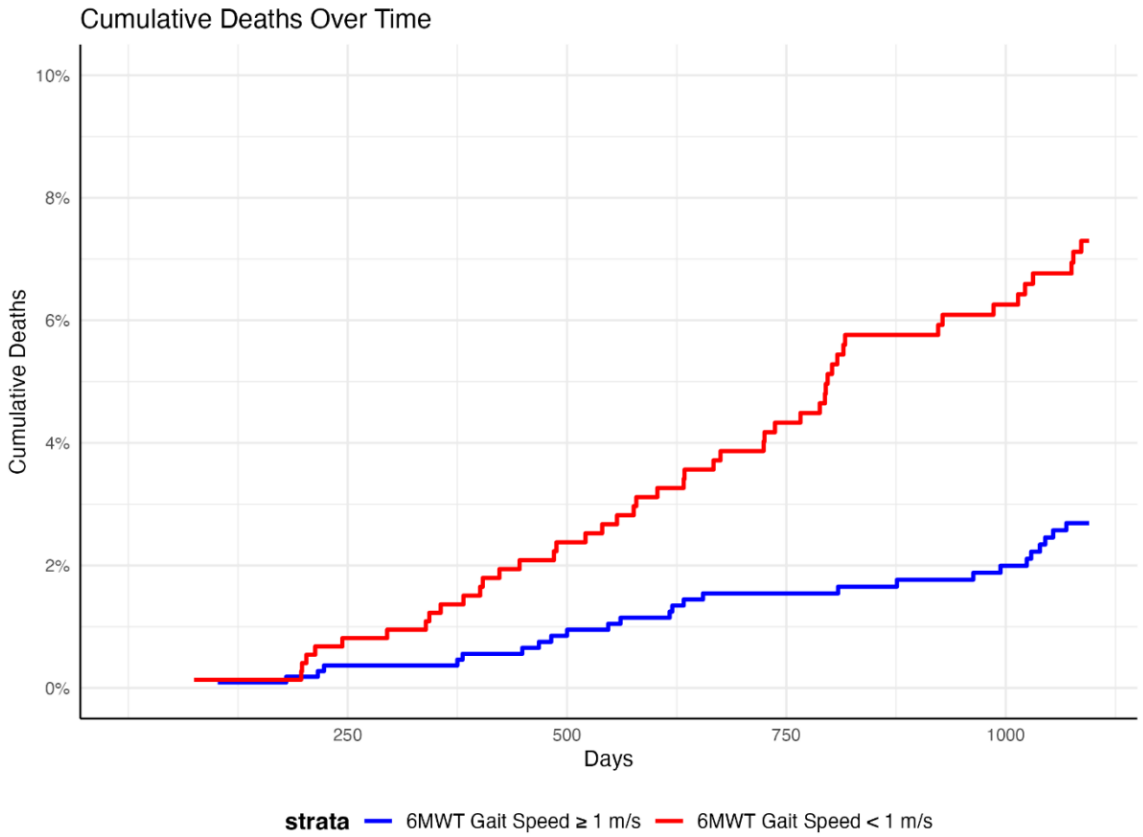
Original Research Article | Open access

Prognostic Value of Gait Speed for Exacerbations and Mortality in COPD

Moon Jin Kim | Seohyun Kim | Hyesoo Kim | Jae Ha Lee | Chin Kook Rhee | Seoung Ju Park | Yu-il Kim | Woo Jin Kim | Kwang Ha Yoo | Tai Joon An See Less

ERJ Open Research 2025 01155-2025; DOI: https://doi.org/10.1183/23120541.01155-2025





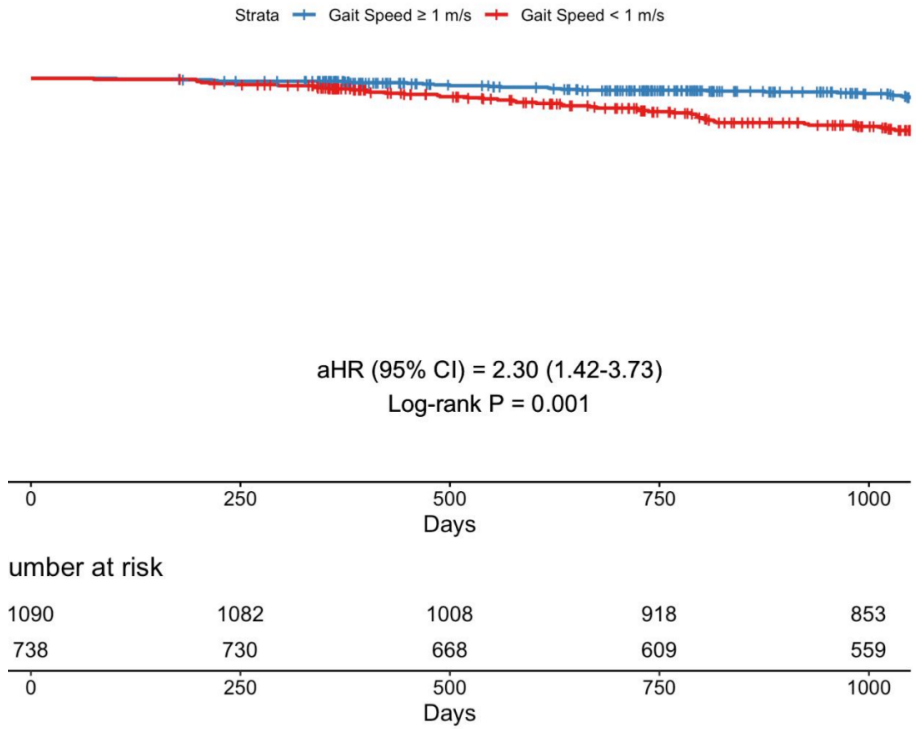
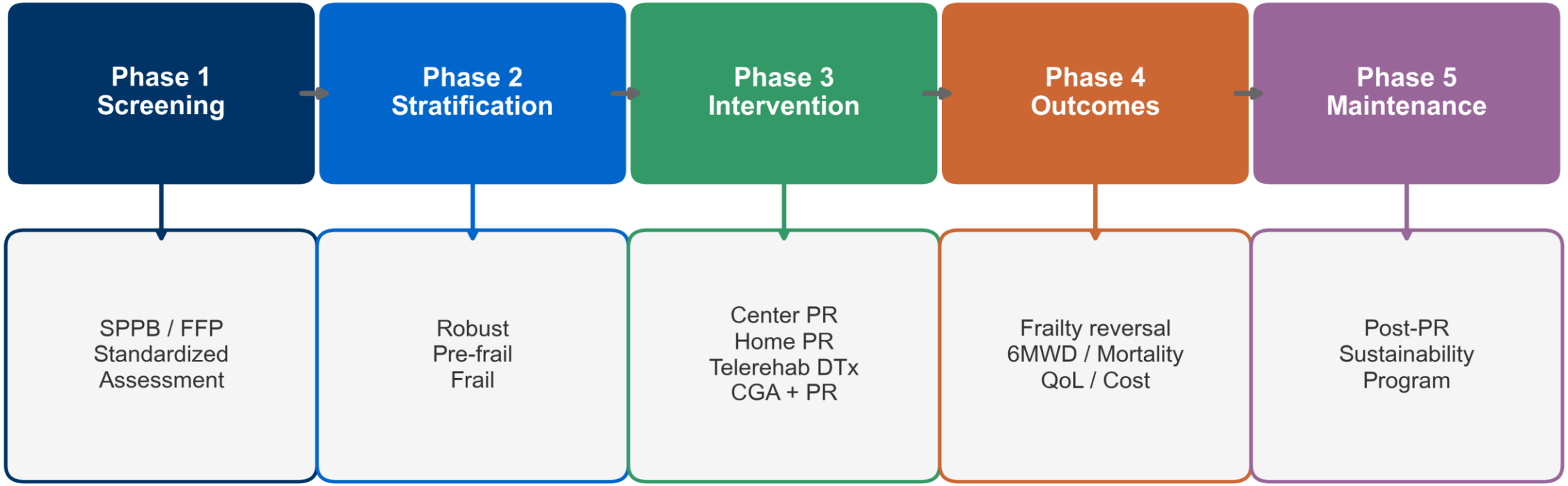


Figure 3a

Proposed Research Framework



From Screening to Sustained Outcomes: An Integrated Research Agenda

Maddocks, ATS Workshop: Frailty and PR, Ann Am Thorac Soc 2023; Osadnik, ERS Statement: Frailty in chronic lung disease, Eur Respir J 2023

Take Home Messages

Take-Home Messages

1. Frailty affects **25-72% of chronic respiratory disease patients**, escalating with disease severity

2. The Frailty-Rehabilitation Paradox: frail patients are **hardest to retain but benefit most** (61-80% improvement)

3. **Screening first! K-FRAIL or Fried FP score**

4. **Comprehensive (Nutrition, Sarcopenia, Family, Mood etc) and Intensive PR!**

5. **Resistance training** is the most effective component; **multicomponent** > single-domain

6. **Prehabilitation, Telerehab**

Systematic review of 327 included articles (472 screened), PubMed 2014-2026

Thank You