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Rehabilitation for People with Respiratory Disease and Frailty
An Official American Thoracic Society Workshop Report

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Abstract

People with respiratory disease have increased risk of developing frailty, which is associated with worse health outcomes. There is growing evidence of the role of rehabilitation in managing frailty in people with respiratory disease. However, several challenges remain regarding optimal methods of identifying frailty and delivering rehabilitation for this population. The aims of this American Thoracic Society workshop were to outline key definitions and concepts around rehabilitation for people with respiratory disease and frailty, synthesize available evidence, and explore how programs may be adapted to align to the needs and experiences of this population. Across two half-day virtual workshops, 20 professionals from diverse disciplines, professions, and countries discussed key developments and identified opportunities for future research, with additional input via online correspondence. Participants highlighted a "frailty rehabilitation paradox" whereby pulmonary rehabilitation can effectively reduce frailty, but programs are challenging for some individuals with frailty to complete. Frailty should not limit access to rehabilitation; instead, the identification of frailty should prompt comprehensive assessment and tailored support, including onward referral for additional specialist input. Exercise prescriptions that explicitly consider symptom burden and comorbidities, integration of additional geriatric or palliative care expertise, and/or preemptive planning for disruptions to participation may support engagement and outcomes. To identify and measure frailty in people with respiratory disease, tools should be selected on the basis of sensitivity, specificity, responsiveness, and feasibility for their intended purpose. Research is required to expand understanding beyond the physical dimensions of frailty and to explore the merits and limitations of telerehabilitation or home-based pulmonary rehabilitation for people with chronic respiratory disease and frailty.

Keywords: pulmonary rehabilitation; respiratory disease; frailty; transplantation

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Overview

In October 2021, a group of international experts in frailty and rehabilitation in respiratory disease representing a diverse range of disciplines (e.g., pulmonology, geriatrics, palliative care, critical care, psychology, epidemiology) and professions (e.g., medicine, nursing, physical therapy) participated in two half-day online American Thoracic Society (ATS) workshops. These were initiated by the ATS Assembly on Pulmonary Rehabilitation on the basis of gaps identified in the literature, to help identify which frailty outcomes to use and how to design rehabilitation services for people with frailty. The goals of these workshops and report were to *1*) outline the definitions and underlying concepts of frailty, and instruments used to assess frailty in the context of rehabilitation; *2*) synthesize evidence for the effect of rehabilitation on frailty status and domains, and how frailty moderates effects of rehabilitation (e.g., on symptoms, function, and quality of life); *3*) explore the rehabilitation experiences of people living with respiratory disease and frailty (e.g., access, engagement); and *4*) consider the implications of frailty on the content, structure, and delivery of rehabilitation programs.

Key conclusions from the evidence synthesis and workshop include the following:

- Pulmonary rehabilitation models address the symptoms of, and factors contributing to, physical frailty in people with respiratory disease. However, some individuals with frailty can face challenges in completing outpatient center–based programs.
- Frailty should not limit access to rehabilitation services. The identification of frailty in individuals with respiratory disease should act as a prompt for comprehensive multidimensional assessment and tailored support.
- Strategies to improve engagement with, and outcomes of, rehabilitation could include exercise prescriptions that consider symptom burden and comorbidities, integration of additional geriatric or palliative care expertise, and preemptive planning for disruptions to participation.
- Frailty screening tools and measures should be selected on the basis of their intended purpose in rehabilitation settings, considering sensitivity, specificity, responsiveness, and feasibility.
- Research is required to further understand the cognitive, psychological, and social dimensions of frailty in chronic respiratory disease.
- The merits and limitations of telerehabilitation or home-based pulmonary rehabilitation for this population warrant further investigation.

Introduction

Frailty is a multidimensional state characterized by decreased reserves and diminished resistance to stressors. Its physical dimensions are most widely recognized, and physical frailty has been defined as "a medical syndrome with multiple causes and contributors that is characterized by diminished strength, endurance, and reduced physiological function that increases an individual's vulnerability for developing increased dependence and/or death" (1). Frailty is a modifiable factor that is relevant across diagnoses and settings. It is associated with aging (2) but not synonymous with old age. Similarly, although there are overlaps with disability and multimorbidity, these concepts are distinct from frailty (3).

Compared with adults without chronic lung disease, the risk of developing frailty is increased in those with chronic lung disease. Approximately one in five people with chronic obstructive pulmonary disease (COPD) are estimated to be living with frailty (4). Many factors contribute to the increased risk of frailty in this population, including comorbid conditions, smoking, low physical activity, repeated exacerbations, hospitalizations, poor nutrition, and polypharmacy (5–7). Frailty is not limited to those with older age (8, 9) and can be present in the context of mild airflow limitation (10).

Frailty is important to detect in people with chronic lung disease, as it independently predicts many health-related adverse outcomes, including hospital readmission, longer length of hospital stay, and mortality (11–14). Frailty is also associated with increased exacerbations, higher physical and psychological symptom burden, and dependence in activities of daily living (15–17). Frailty is a dynamic process, and a transition between states of frailty may be triggered by changes in health status, such as during hospital episodes (18). Frailty has been identified as an important "treatable trait" for clinicians to detect in the modern era of personalized medicine (19).

Treatments for physical frailty include physical activity, exercise, and nutritional support as indicated (1, 20). In chronic respiratory disease, these are delivered via pulmonary rehabilitation (21) or other rehabilitation services, for example, those offered around critical illness. The well-established benefits of these programs on symptom burden, functional performance, health status, and health service use suggest that they can help manage frailty in these populations. However, data specific to people with respiratory disease and frailty are limited, and this group may encounter challenges undertaking rehabilitation programs challenges undertaking rehabilitation programs (e.g., due to high symptom burden). Understanding the benefits and challenges of rehabilitation for people with respiratory disease and frailty can help optimize service delivery for this large and important population.

Methodology

Because of ongoing travel disruptions relating to the coronavirus disease (COVID-19) pandemic, this ATS-funded workshop took place in two virtual live sessions in October 2021, each lasting 2 hours and 30 minutes. The 20 workshop speakers and participants represented diverse disciplines (pulmonology, geriatrics, palliative care, critical care, psychology, and epidemiology), professions (medicine, nursing, pharmacy, and physical therapy), and countries (Australia, Belgium, Canada, Italy, the Netherlands, the United Kingdom, the United States, and Peru). Potential conflicts of interest were disclosed and managed in accordance with the policies and procedures of the ATS.

Within each workshop, the first 60 minutes comprised presentations covering key concepts and evidence, to prime and stimulate the group discussion. Presentation topics, aligned with the workshop goals, included current definitions and concepts of frailty; assessment of frailty in chronic respiratory disease; frailty and pulmonary rehabilitation, including impacts and experiences of patients; and frailty in the context of lung transplantation, critical illness, and COVID-19 rehabilitation. The subsequent 90 minutes were dedicated to whole-group discussion. We encouraged participants to bring in best-practice examples, clinical challenges, and research priorities.

Detailed notes were taken, and workshop sessions were recorded and shared with participants to ensure transparency. The content of the notes and recordings were then synthesized to generate this workshop report, with input from all participants. Alongside the workshop activities, participants worked with four service user representatives to codevelop an accompanying public-facing fact sheet on frailty in respiratory disease.

The initial draft of the workshop report was authored by the co-chairs and speakers. The other participants reviewed and edited the draft report. The workshop report underwent external peer review and revision, followed by review and approval by the ATS Board of Directors.

Effects of Rehabilitation on Frailty in Chronic Respiratory Disease

A small but growing evidence base, particularly in people with COPD and candidates for lung transplantation, suggests that pulmonary rehabilitation delivered via various models can reduce frailty in people with respiratory disease (15, 22–27) (Table 1). These reductions in frailty are driven by direct effects of rehabilitation on components such as gait speed and sit-to-stand performance, potentially reflecting the positive impact on lower limb muscle function (27, 28). The evidence also suggests that broader health outcomes are improved in people with frailty after pulmonary rehabilitation, including symptom burden and quality of life (15, 23, 24, 29). The magnitude of benefit in some studies is more than that seen in robust or nonfrail participants (15, 24). Studies specific to frailty have tended to be limited to cohort designs rather than randomized trials. However, the consistency of improvements (despite diverse populations, settings, programs, and frailty measures) suggests a role for pulmonary rehabilitation interventions in reducing frailty in people with respiratory disease.

Importantly, findings relating to the impact of pulmonary rehabilitation on frailty reflect those who have completed interventions. Attrition of participants with frailty from pulmonary rehabilitation programs and loss to follow-up continue to be challenging. When controlling for age, sex, exercise capacity, and symptom burden, people with frailty have double the odds of not starting or not completing outpatient pulmonary rehabilitation (adjusted odds ratio, 2.20 [95% confidence interval, 1.39–3.46]; $P = 0.001$), and frailty represents a strong independent predictor of nonparticipation (15). This suggests a "frailty rehabilitation paradox" whereby individuals with frailty are less likely to take up and complete rehabilitation, yet those who complete rehabilitation show the biggest magnitude of change.

Experiences of Rehabilitation in People with Respiratory Disease and Frailty

Qualitative exploration of the experiences of people with COPD and frailty referred for pulmonary rehabilitation highlights unpredictable disruptions (e.g., exacerbations of lung disease, flare-ups of comorbid conditions) and conflicting priorities (e.g., other appointments, caregiving responsibilities) as commonly interfering with attendance (30). Although many of these challenges are not unique to individuals living with frailty, they may be particularly frequent and impactful to this group because of their clinical state of vulnerability.

An evidence synthesis focused on exercise-based interventions for people with COPD and frailty (31) illustrates how this combination of conditions can provide a challenging context for rehabilitation interventions. For example, those with COPD and frailty may hold more negative perceptions of themselves and exercise-based services, present with heterogeneous symptoms and comorbidities, or be experiencing decreasing reserve and losses across multiple domains (e.g., function, confidence, social connection). These conditions may be further compounded by fluctuating health that causes unpredictable disruptions to attendance. Approaches that foster trusting relationships and shared priorities, that are flexible in their content and delivery of rehabilitation, and that can address multidimensional concerns and build functional self-efficacy are therefore likely to be of most value. Examples seeking to address these principles include van Dam van Isselt and colleagues (32) and Brighton and colleagues (33), each proposing integrating specialist geriatric expertise and comprehensive assessment alongside usual rehabilitation models to address multidimensional concerns. Others, such as Singer and colleagues (26) and Diamond and colleagues (23), have used an app-based approach to facilitate an individualized home-based approach to rehabilitation, providing additional flexibility in terms of delivery mode and overcoming barriers relating to travel to increase flexibility. Although optimal rehabilitation models for respiratory disease and frailty are still unknown, attempts to provide flexible rehabilitation delivery to better meet the

Table 1. Effects of rehabilitation on frailty in people with chronic respiratory disease

Study (Country)	Design	Participants	Intervention	Impacts on Frailty	Other Relevant Findings
Community					
Gephine *et al.* (24) 2021 (France)	Prospective cohort study	47 people with COPD and chronic respiratory failure referred for home-based pulmonary rehabilitation	Eight-week home-based pulmonary rehabilitation comprising one supervised 90-min session and at least four unsupervised exercise sessions per week, plus educational, motivational, and self-management plans.	Shift from physical frailty (measured using the physical frailty phenotype) toward more robust state: of 18 completers initially frail, 4 (22%) remained frail, 11 (61%) became prefrail, and 3 (17%) became robust.	Health-related quality of life, fatigue, and anxiety and depressive symptoms of individuals who were physically frail before the program were improved by pulmonary rehabilitation, whereas these significant benefits were not seen in their nonfrail counterparts.
Maddocks *et al.* (15) 2016 (United Kingdom)	Prospective cohort study	816 people with COPD referred for pulmonary rehabilitation	Eight-week outpatient pulmonary rehabilitation comprising two supervised sessions (2 h exercise, 45 min multidisciplinary education) plus at least one additional unsupervised home-based exercise session per week.	Shift from physical frailty (measured using the physical frailty phenotype) toward more robust state: of 115 completers initially frail, 44 (38%) remained frail, 64 (56%) became prefrail, and 7 (6%) became robust. A small number of completers (13 of 390 [3.3%]) moved from prefrail to frail.	Adjusting for age and sex, a gradient of treatment response in favor of participants who were frail was evident for MRC score, handgrip strength, ISWT, CRQ fatigue, emotional and mastery domains, CAT score, and HADS scores. However, being frail was associated with double the odds of noncompletion (adjusted OR, 2.20 [95% CI, 1.39% to 3.46]).
Mesquita *et al.* (83) 2016 (the Netherlands)	Prospective cohort study	378 people with stable COPD completing pulmonary rehabilitation	Eight-week inpatient or 14-week outpatient pulmonary rehabilitation comprising 40 sessions. Participants were supervised by an interdisciplinary team and undertook exercise training and (if indicated) nutritional support, occupational therapy, psychological counseling, and education.	Mean Timed Up and Go time improved significantly from 10.2 ± 2.7 to 9.7 ± 2.3 s after pulmonary rehabilitation (mean change, −0.5 s [95% CI, −0.6 to −0.3 s]; $P < 0.0001$).	After stratifying for normal vs. abnormal (>11 s) baseline Timed Up and Go time, only the latter group showed significant improvements after rehabilitation: −1.5 (95% CI, −1.9 to −1.0) vs. 0.01 (95% CI, −0.2 to 0.2) seconds ($P < 0.001$).
Mittal *et al.* (25) 2015 (United States)	Prospective cohort study	41 people with chronic lung disease (77% with COPD) referred for pulmonary rehabilitation	Six- to 12-wk outpatient pulmonary rehabilitation comprising supervised exercise (40 to 50 min machine time plus light upper body exercise with weights) and education, two or three times per week. Each session ran 60 to 90 min.	The number of people with frailty (physical frailty phenotype) decreased in those completing 6 wk (from five to two) and in those completing 12 wk (from three to one) of rehabilitation. Five people had deterioration in their frailty status (four from robust to prefrail, one from prefrail to frail).	At Week 6, mean (SD) gait speed increased from 52.9 (15.4) to 61 (12.9) m/min after rehabilitation ($n = 37$); no additional increase was seen at 12 wk ($n = 22$).
Stoffels *et al.* (46) 2021 (the Netherlands)	Retrospective cohort study	632 people with COPD completing pulmonary rehabilitation	Eight-week inpatient or 14-wk outpatient pulmonary rehabilitation comprising 40 sessions. Participants were supervised by an interdisciplinary team and undertook exercise training and (if indicated) nutritional support, occupational therapy, psychological counseling, and education.	SPPB scores significantly improved from median 9 (IQR 8 to 10) to 10 (9 to 11) points after rehabilitation. When performance was categorized as low (0 to 6 points), medium (7 to 9 points), and high (10 to 12 points), proportions in each group were significantly different after rehabilitation (low, 11% to 8%; medium, 47% to 35%; high, 42% to 57%).	Participants with low baseline performance on the SPPB (0 to 6 points) showed significant improvements in balance, gait speed, and sit-to-stand, participants with medium baseline SPPB scores (7 to 9 points) showed significant improvements in gait speed and sit-to-stand, and participants with high baseline SPPB scores (10 to 12 points) showed significant improvements only in sit-to-stand.

(*Continued*)

Table 1. (*Continued*)

Study (Country)	Design	Participants	Intervention	Impacts on Frailty	Other Relevant Findings
McClellan *et al.* (28) 2014 (United States)	Retrospective cohort study	119 people who completed pulmonary rehabilitation (80% COPD/ asthma)	Pulmonary rehabilitation comprising supervised exercise and education sessions; mean duration was 19.3 (SD, 7.4) weeks (setting and frequency not specified).	Improvements in gait speed (>60 m/min in $n = 10$ at baseline vs. $n = 29$ after rehabilitation; $P < 0.001$) suggest that participants were less likely to be classified as frail after rehabilitation.	Participants with the lowest initial gait speeds had the largest increases after rehabilitation. Although most participants had gait speeds <60 m/min after rehabilitation, 62% had increases in walk distance of 30 m or more (considered a minimal clinically important distance in relation to survival in COPD [84]).
Transplantation					
Diamond *et al.* (23) 2021 (United States)	Prospective cohort study (pilot)	17 lung transplant recipients deemed frail/prefrail at discharge (SPPB score ⩽ 9)	Digital app to deliver home-based rehabilitation over 8 wk alongside standard rehabilitation. Incorporates daily exercise prescriptions, exercise videos with descriptions, exercise completion documentation, and healthcare provider messaging. The provider can view real-time feedback and adjust prescriptions accordingly.	Participants showed improvements in physical frailty phenotype scores (median change, −1 [IQR −3 to 0]) and SPPB scores (median change, 5 [IQR 4 to 7]) after intervention. By SPPB definitions, nine were no longer frail and four were prefrail after the intervention.	Participants also showed improvements on the Duke Activity Status Index (median change, 17.58 [IQR, 8.60 to 21.88]) and the Lung Transplant Valued Life Activities scale (median change, −1.09 [IQR, −1.71 to −0.40]). Participants reported positive experiences of the app.
Courtwright *et al.* (22) 2019 (United States)	Prospective cohort study	83 lung transplant recipients who completed postdischarge outpatient pulmonary rehabilitation	Outpatient pulmonary rehabilitation starting within 3 d of discharge, attending three sessions per week for 4 to 6 wk. Tailored supervised sessions of 60 to 75 min incorporate progressive programs of aerobic exercise, muscle strengthening, balance, postural retraining, education, and chest expansion exercises.	Among 35 participants who were frail at discharge (median SPPB score, 6 [IQR, 4 to 6] points), 85.7% were not frail at completion. Median improvement in SPPB score was 6 points (IQR, 5 to 7), resulting in a postrehabilitation median SPPB score of 12 points (IQR, 11 to 12 points).	Median 6-minute walk distance at the start of the program was 808 ft (IQR, 577 to 1,015 ft) compared with 1,429 ft (IQR, 1,179 to 1,600 ft) at completion ($P < 0.001$).
Singer *et al.* (26) 2018 (United States)	Prospective cohort study	15 lung transplantation candidates with frailty (SPPB score ⩽ 11)	Digital app to deliver home-based rehabilitation over 8 wk comprising daily exercise prescriptions, exercise videos with descriptions, exercise completion documentation and healthcare provider messaging. The provider could view real-time feedback and adjust prescriptions accordingly. Participants also received activity trackers, resistance bands, and a nutrition counseling session.	Among 13 participants completing rehabilitation, SPPB frailty improved in seven (54%) participants; mean change within participants was 1.0 (SD, 1.9). Physical frailty phenotype scores improved in eight (62%) participants; mean change across participants was −0.6 (SD, 1.0). Of six participants deemed frail by the physical frailty phenotype at baseline, four were no longer frail after the intervention.	Participants did not show significant improvements in 6MWD, grip strength, Lung Transplant Valued Life Activities scale score, or Duke Activity Status Index score, although the study was not powered for these outcomes. Participants reported that the app was engaging and easy to use.

(*Continued*)

Table 1. (*Continued*)

Study (Country)	Design	Participants	Intervention	Impacts on Frailty	Other Relevant Findings
Wickerson *et al.* (27) 2020 (Canada)	Retrospective cohort study	62 lung transplantation candidates accepted for transplantation who underwent rehabilitation	Six-week pretransplantation rehabilitation ($n = 62$) comprising three 90-min sessions per week. Sessions include stretching, functional exercises, resistance training, and aerobic exercise.	At baseline, 13 were frail/prefrail (SPPB score ⩽ 9), with a median SPPB score of 9 (IQR, 7 to 9) points. Of these, three remained frail/prefrail after rehabilitation; median SPPB score increased to 11.5 (IQR, 10 to 12 points). Improvements most often occurred in the sit-to-stand domain. Of 49 not frail at baseline, 4 became frail/prefrail after rehabilitation, with no change in median SPPB score from 12 (IQR, 11 to 12) points.	There was no change in postrehabilitation mean (SD) 6MWD (362 ± 86 vs. 356 ± 101 m).

Definition of abbreviations: 6MWD = 6-minute-walk distance; CAT = COPD Assessment Test; CI = confidence interval; COPD = chronic obstructive pulmonary disease; CRQ = Chronic Respiratory Questionnaire; HADS = Hospital Anxiety and Depression Scale; IQR = interquartile range; ISWT = Incremental Shuttle Walk Test; MRC = Medical Research Council; OR = odds ratio; SD = standard deviation; SPPB = Short Physical Performance Battery.

needs of this population without compromising on quality are promising.

Identification and Assessment of Frailty

Although a consensus definition of frailty already exists, there are multiple approaches regarding its operationalization and measurement. Two main overarching approaches to operationalizing frailty are the so-called physical frailty phenotype and the model based on estimation of the accumulation of health deficits. The first, proposed by Fried and colleagues, defines frailty in terms of the presence of three or more of the following characteristics: unintentional weight loss, weakness, exhaustion, slowness, and low physical activity (34). The second expresses frailty as the proportion of health deficits (i.e., symptoms, signs, clinical conditions, functional impairments, and laboratory abnormalities) presented by an individual at the end of a comprehensive assessment (35). From these two models stem a variety of instruments to quantify or measure frailty. A systematic review published in 2016 (36) identified more than 67 different tools. Agreement among the different frailty instruments tends to be modest (37), suggesting that each captures a distinct group of people expressing an increased vulnerability and risk condition. Although the gold-standard approach to managing frailty is based on a comprehensive geriatric assessment, abbreviated standardized tools can be helpful in approaching frailty to identify unmet needs. The measurement of frailty is also important to serve as an outcome for clinical care and research.

The Role of Validated Frailty Instruments

Frailty is a multidimensional construct that may manifest differently among individuals. Although it might seem intuitive to understand, frailty cannot be accurately identified via clinical judgment alone. As outlined in a frailty measurement training course by Haddad and colleagues (38), many types of bias can influence our assessments of frailty, from halo effects (relying on an overall impression, despite specific information suggesting the contrary) to leniency effects (preferring to score people more “favorably” when considering a construct perceived as negative). As it is difficult to standardize clinical judgment alone to assess frailty, tools that have demonstrated validity (accurate measurement of the intended concept) and reliability (stability of measurement within and across individuals) are required. In addition, it can be important to select measures that can identify a continuum of frailty within a population, avoiding “floor effects” (where there is a limit to poor scores) or “ceiling effects” (where there is a limit to high scores). In other words, the choice of the instrument to screen or measure frailty is strongly related to the final purpose for which the condition is assessed.

A growing evidence base confirms the predictive validity of some frailty measures in the context of respiratory disease, including the physical frailty phenotype (11, 39), the Short Physical Performance Battery (SPPB) (40), the Timed Up and Go test (41), gait speed (42), the Clinical Frailty Scale (43), and the frailty index (43) (Table 2). As such, these may be particularly suitable candidate measures, if they align with the purpose of measurement. Beyond these, a selection of measures validated in general older populations may suffice until further evidence becomes available. Considering the plethora of tools available, validation of existing tools is likely to be more efficient than the creation of new measures.

One challenge with frailty measurement is that although these measurements are designed to be applicable across many diagnoses, it is unclear whether respiratory conditions and symptoms may influence the measurement properties. It is possible that, where specific aspects of living with respiratory disease are found to affect the prognostic abilities of these measures, work to understand which respiratory-specific parameters need to be considered alongside frailty could be helpful. For example, combining respiratory-specific parameters (e.g., exacerbation history, oxygen requirements, dyspnea) with measurement of frailty can improve prognostic value in relation to mortality (10, 43) and disability in activities of daily living (10). It is also

Table 2. Examples of instruments with predictive validity in the context of respiratory disease

Measure	Administration Type	Resources	Description	Scoring	Properties in Respiratory Disease
Clinical Frailty Scale (68, 85)	Clinician assessed	∼3–5 min	Comprises clinical descriptions to guide scoring of frailty. Scores are allocated on the basis of clinical judgment, considering physical fitness, active disease symptoms, dependency, and cognitive status.	1 (very fit) to 9 (terminally ill), with scores of ⩾5 indicating frailty	Predictive of hospitalization and mortality in people with COPD (46).
Frailty index (46)	Chart review	∼3–5 min	Chart review of ⩾30 items on the basis of presence of comorbidities, symptoms, disabilities, or deficiency in health. The number of items present is expressed as a proportion.	A cut point ⩾0.25 is generally used to define frailty	Predictive of hospitalization (46) and mortality in people with COPD (46, 86) and ILD (87).
4-m gait speed	Single physical task	∼5 min Stopwatch Measured course	Speed of walking over a flat, unobstructed 4-m course, expressed in meters per second.	<0.8 m/s is commonly used to indicate frailty in community-dwelling older adults (44)	Reliable, valid, and predictive of hospitalization and mortality in people with COPD (88–90) and ILD (91, 92). Responsive to change after pulmonary rehabilitation in people with COPD (93) and ILD (94).
Timed Up and Go test	Single physical task	∼5 min Stopwatch Chair Measured course	Measures the time taken in seconds for a participant to stand from seated, walk to a marker 3 m away, turn, walk back to the chair, and then sit down again.	A threshold of >10 s is commonly used for community-dwelling older people (44); >8 s is suggested for people with COPD (41)	Valid and reliable in people with COPD (95) and ILD (96). Responsive to change after pulmonary rehabilitation (83) and can distinguish between people with COPD with and without frailty (41).
Short Physical Performance Battery (97)	Multiple physical tasks	∼8–10 min Stopwatch Chair Measured course	Comprises three physical tests: static balance, 4-m gait speed, and 5 sit-to-stands. Each is scored 0–4 and totaled, for a maximum score of 12.	Although thresholds vary, commonly, scores ⩽7 indicate frailty and 8 or 9 indicate prefrailty	Responsive to change after rehabilitation in people with COPD (98) and ILD (27, 99). Predictive of mortality in people with COPD (40, 43).
Physical frailty phenotype (34)	Multiple physical tasks and self-report	∼10–15 min Stopwatch Chair Measured course Handheld dynamometer Participant questionnaire	Measures the five phenotype components through self-report questions about weight loss, exhaustion, and physical activity and physical measurement of weakness (grip strength) and slowness (4-m gait speed).	Total scores range from 0 to 5; scores of ⩾3 indicate frailty, and scores of 1 and 2 indicate prefrailty	Responsive to change after pulmonary rehabilitation (15) and predictive of adverse events (39, 43) in people with COPD. Predictive of mortality in people with COPD (11, 43, 100) and ILD (101, 102).

Definition of abbreviations: COPD = chronic obstructive pulmonary disease; ILD = interstitial lung disease.
Content was not derived from a systematic review.

important to understand whether existing scoring thresholds to identify frailty are still applicable in the context of respiratory disease. Ultimately, if a clinical decision might be influenced by a measure of frailty, practitioners need to be confident in its psychometric properties.

Considerations When Selecting a Frailty Instrument

Workshop participants discussed how the choice of a particular frailty tool depends on the purpose of measurement and how the results obtained will influence patient management. Practical consideration should be given to the feasibility of each tool in relation to the time and resource requirements, especially for brief clinical encounters. Attention should also be paid to instrument sensitivity (i.e., the ability to identify those with frailty) and specificity (i.e., the ability to identify those without frailty). A tool to screen for frailty and prompt further assessment should be highly sensitive to ensure that cases of frailty are detected. Meanwhile, the use of an instrument for rapid clinical decision making should be highly specific to limit the number of false-positive results.

As an additional example, in populations of community-dwelling older adults, measures such as slow gait speed and Timed Up and Go have high sensitivity (99% and 93%, respectively) but low specificity (64% and 62%) for identifying frailty (reference measure: physical frailty phenotype [44]). Meanwhile, measures such as the physical frailty phenotype and the frailty index show high specificity (93% and 85%, respectively) but low sensitivity (21% and 34%) for predicting 3-year mortality among community-dwelling older adults (45). As such, the use of any one of these screening instruments as a single diagnostic assessment is not suggested. Similarly, it is important to remember that the predictive value of frailty measures has been established at the population level rather than at the individual level. For this reason, it is more appropriate to use frailty measures as part of a comprehensive assessment to direct patient care.

In the context of rehabilitation, one reason to measure frailty might be to assess it as an additional outcome. Here, the responsiveness of a tool (i.e., its ability to pick up on clinically important changes) is important. Rehabilitation interventions are known to have multidimensional impacts on health but are particularly effective at improving objective physical outcomes through a substantial exercise training component. It is not surprising that rehabilitation studies measuring frailty as an outcome have selected tools that have substantial physical components (e.g., the physical frailty phenotype, the SPPB, gait speed; *see* Table 2). These measures are well aligned to the intended impact of this intervention and show good responsiveness (1, 46).

Another purpose for measuring frailty within rehabilitation may be to identify unmet needs and then individualize the program accordingly. In this instance, a more multidimensional tool that goes beyond the physical aspects of frailty might be required. Although well aligned to the outcomes of rehabilitation, measures such as the physical frailty phenotype and the SPPB are limited in their dimensionality and omit critical dimensions of frailty such as cognition or psychosocial challenges. For example, individuals with high SPPB scores can still have impaired exercise performance and symptoms of depression or anxiety (47). Given evidence of different manifestations of frailty in respiratory disease, multidimensional measures (e.g., the Clinical Frailty Scale [48], the Tilburg Frailty Indicator [49], the Edmonton Frail Scale [50]) are required for a more sensitive assessment. For those identified as potentially living with frailty, this screening process should act as a prompt for comprehensive multidimensional assessment, and a tailored management plan.

In both clinical and research contexts, the practicalities of using different measurement tools were discussed as an essential consideration. Although reasonably quick to complete, some physical components of frailty measures (e.g., handgrip dynamometry) may require equipment that is not always available. Meanwhile, some of the more comprehensive measures will take longer to complete, which might make them challenging to integrate alongside other standard pulmonary rehabilitation assessment measures without overlap or repetition. In addition, measures most suitable for assessment in a clinical setting before inpatient or outpatient rehabilitation may not always work across diverse delivery models. As such, the measurement purpose and psychometric properties of frailty tools must be balanced with practical considerations. Alongside this, ensuring adequate staff training to support robust measurement is essential. Increased availability of online training materials to support the use of some measures (e.g., the Clinical Frailty Scale [38]) may be helpful.

Implications of Frailty on Rehabilitation Program Content

In terms of program content, workshop participants agreed that exercise training should be routinely offered to people with respiratory disease and frailty. Fundamental principles for exercise prescription are no different for this population (i.e., providing a personalized prescription of sufficient intensity, duration, and frequency to produce physiological training effects). However, careful consideration of individuals' symptom burden and comorbidities will be particularly relevant for people with frailty (51), as they will often present with more severe symptom burden (15) and greater numbers of comorbidities (52). Many people with respiratory disease and frailty can find it challenging to exercise continuously because of limiting symptoms such as breathlessness and fatigue, and difficulties with balance (dynamic and static). Reinforcing techniques to help individuals manage exertional breathlessness and fatigue (e.g., breathing control and pacing) may be helpful. Different training modalities can allow people with high symptom burden to train at higher intensities, for longer, or more consistently. These include interval training (53), partitioned training (e.g., single-leg raises or cycling [54]), use of noninvasive ventilation (55, 56), and neuromuscular electrical stimulation (57, 58), which reduce the load on the respiratory system and improve exercise tolerance (59). Given the fluctuations in symptom burden and function experienced in the context of frailty (30), regular assessment of exercise tolerance and progression as individuals continue through their programs remains important. Skilled use of modalities and adaptations to optimize the dose of exercise training may be pertinent to people with frailty, given their more significant experiences of symptom burden and multidimensional loss (15, 17, 30).

Balance impairment and gait disturbance were highlighted as components of frailty and risk factors for falls. Growing evidence confirms balance deficit, gait disturbances, and increased risk of falling among people with COPD (60, 61). Several contributing factors that link balance impairment and frailty risk have been proposed, including decreased physical activity, muscular weakness, and comorbidities (60). Psychosocial factors such as heightened anxiety, feelings of disorientation, and housing quality, are also likely to be important. Falling is a predictor of morbidity and mortality (62) and can have a profound psychosocial impact, including feelings of powerlessness (63) and subsequent social withdrawal from activities (64). An increased focus on balance training within rehabilitation could improve balance and reduce risk of falls (65, 66), relevant to people with COPD and frailty. Malnutrition is another important contributor to frailty, and weight loss is a crucial mortality driver (67, 68). Nutritional supplementation, if indicated after an individual assessment, could help promote weight gain and support the energy requirements of new exercise behaviors (69).

Implications of Frailty on Rehabilitation Program Structure and Delivery

Frailty highlights the need for a responsive, adaptive, and flexible approach to rehabilitation delivery. People with frailty may be more likely to deteriorate between the time of initial assessment and enrollment into a program, so a "fast track" to reduce wait times could be justified, as is sometimes offered to people after hospitalization. Many pulmonary rehabilitation programs promote strong multiprofessional working and input from different professionals on the basis of a participant's presentation and needs (21, 70). Personalizing care on the basis of a frailty assessment might encourage interdisciplinary work across different specialties, such as geriatrics, palliative care, and primary care. Integrated models of respiratory care are well aligned with what is known about the multidimensional losses experienced by people living with respiratory disease and frailty (30). Planning of service delivery around frailty may provide a stimulus to integrate pulmonary rehabilitation with, for example, geriatrics or palliative care to achieve a more personalized approach. For example, van Dam van Isselt and colleagues (71) described adapting individuals' rehabilitation programs to incorporate greater nutritional input, psychosocial support, and advance care planning, to align with the participant's main concerns.

At the service level, issues around who, when, and how care coordination could be achieved were recognized as highly relevant. Practical ways to integrate disciplines include knowledge exchange among professions, bringing in educational content on frailty and geriatrics syndromes within rehabilitation programs, and training rehabilitation teams on nutritional and balance assessment. Frailty itself and the multidimensional loss associated with it can serve as useful referral criteria or triggers to link with additional services (e.g., palliative care [72]), especially as people's recognition of their own deterioration can prompt thoughts about death and dying (73). Palliative care involvement could benefit people with frailty accessing pulmonary rehabilitation via management of chronic breathlessness, advance care planning, and psychosocial support.

Workshop participants also raised the issue of higher attrition from pulmonary rehabilitation programs among people with COPD and frailty (15). In a cohort study, people with frailty had more unplanned hospital admissions and deteriorations in health that led to disruptions to planned rehabilitation sessions. The reasons for the disruptions are very heterogeneous, so a comprehensive assessment and personalization of care were considered most effective. The need for more active follow-up after an exacerbation, was highlighted. People experiencing exacerbations or health deterioration may not be able to answer and respond to phone calls. In some centers, this leads to "loss to follow-up" and less opportunity to rejoin a program. A plan for continuing, adapting, and then returning to a program was considered a better fit for many people with frailty. For example, some programs offered once-weekly supervised training or additional catch-up sessions. These would need to be aligned to changes in service contracts and payments. At the service level, workshop participants believed that there was a need to carefully consider any unintended consequences of associating frailty with low completion rates. For example, if noncompletion rates are used as a service evaluation metric, people with frailty could be discriminated against by providers.

Emerging delivery models of telerehabilitation and home-based pulmonary rehabilitation may help improve access and uptake for people with respiratory disease and frailty (74), who can experience difficulty completing center-based programs (15). People with frailty have described the burden of getting to hospital-based programs and linked this to a belief that they are not a good "fit" with the center-based model (30). Avoiding travel to a center may reduce the demands on participants and allow them to engage regularly in rehabilitation sessions. A recent ATS workshop highlighted 13 essential components of pulmonary rehabilitation that must be part of any model (74). These include personalization of content and delivery, guided by a comprehensive assessment, and robust quality assurance processes. Best practice would include conducting a multidimensional, center-based comprehensive assessment, then directing individuals to the preferred program option (74). This might include exploring technological capabilities, considering some evidence of lower technology use in people with versus without frailty (75), and low acceptability for some people with respiratory disease (76). They found insufficient data to determine the characteristics of people most likely to succeed in different models of pulmonary rehabilitation and suggested that clinical judgment should be used to identify individuals who remain best served by a center-based approach (74). Patient choice and preference will also influence the delivery model.

Practical considerations when comparing center-based with other models included the following: *1*) center-based programs may afford more opportunity for in-person contact with different professionals; *2*) telerehabilitation or home-based models do not always include or enable the same depth of assessment (e.g., tests of functional exercise capacity are missed out or replaced with tests of physical performance), so the addition of a frailty tool was considered potentially valuable to telerehabilitation or home-based models to prompt an in-depth assessment and personalized care; *3*) the frequency, degree, and nature of supervision are variable (phone calls, videoconferencing, home visits) for telerehabilitation or home-based models; and *4*) the home environment allows occupational assessment in an individual's habitual physical and social environment. Workshop participants reflected on changes to rehabilitation due to COVID-19. Face-to-face supervision of exercise and streamlined assessments were reduced and approaches rapidly "digitized." Participants believed that these changes may disproportionately affect people with frailty, including restrictions on family and friends who support attendance at center-based programs and the loss of social connections gained through group activities.

Frailty in the Context of Rehabilitation after COVID-19

Many survivors of COVID-19 have persistent symptoms beyond 12 weeks after severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection (post–COVID-19 condition/long COVID-19) with multisystem involvement, including pulmonary pathology (77). Alongside frailty as a risk factor for severe acute COVID-19, frailty has been observed several months into recovery in adults previously working (78, 79). The longer-term outcomes of frail survivors are not yet established, but frailty is a recognized complication in recovery from other causes of acute adult respiratory distress syndrome (80). The etiology of post–COVID-19 frailty is not yet established, but severe ongoing symptoms, including breathlessness, one year after discharge from the hospital are associated with reduced physical function (81), highlighting a need for recovery and rehabilitation targeting frailty.

Future Research

Key areas for future research were discussed and included *1*) identifying and measuring frailty in respiratory rehabilitation, *2*) testing optimal models of rehabilitation for frailty in respiratory disease, and *3*) broadening research into these areas across more diverse locations and systems.

Given the numerous existing frailty measures available, further research is needed to determine their performance in the context of respiratory disease, including responsiveness to rehabilitation interventions. Although this work has begun for physically focused measures, there are currently gaps with more multidimensional measures and those relying solely on self-report items. While generating evidence for frailty tools that could be used in pulmonary rehabilitation, identifying opportunities to increase the implementation of frailty assessment in this field may be helpful. People with frailty are at increased risk of not receiving disease-modifying treatments (8, 15), so measuring frailty to monitor for inequalities, as well as capture meaningful intervention impacts, may be helpful. The inclusion of frailty in future guidelines, audit, and accreditation programs relating to pulmonary rehabilitation could be considered to facilitate this.

Several critical evidence gaps remain regarding the optimization of engagement with, and benefit from, rehabilitation for people with respiratory disease and frailty. Exploring the role of alternative exercise prescriptions suited to some people with frailty (e.g., interval training, neuromuscular electrical stimulation), and the value of incorporating rehabilitation content that attends to balance, falls, and weight gain/loss, may be of particular interest for this population. This will likely include testing models of integrated care to meet often multidimensional unmet needs, as well as strategies to maximize participation (e.g., fast-track entry, proactive planning for how to return after a disruption). Work to assess the comparative merit and limitations of telerehabilitation/home-based versus center-based pulmonary rehabilitation for people with frailty, in terms of both engagement and outcomes, can help guide future decision making and monitor for potential inequalities in access and outcomes.

Broadening research into rehabilitation for people with respiratory disease and frailty across diverse geographical locations and health systems is also required. Most work has taken place across Europe and North America, and the extent to which learning from this work applies across contexts is unclear. In some countries, the word "frailty" may not have a direct translation to local languages or is not commonly used in everyday language. National guidelines for respiratory diseases do not always exist in low- and middle-income countries, and where they do, comorbidity management is not always included (82). In geographical locations with lower income or resources, there can also be additional challenges to frailty identification and rehabilitation delivery, including limits on space and equipment available, inconsistencies in existing practices, and fewer opportunities for multidisciplinary care. Each of these factors presents an opportunity for new research and practice, learning from evidence-based approaches from other regions and adapted by local professionals and service users to suit their specific contexts. In all cases, being explicit about the characteristics of regions involved (rather than relying on high-level economic categories or assuming that findings extrapolate across all regions within a country) will help understand the transferability of findings.

Conclusions

Pulmonary rehabilitation can address and reduce frailty in people with respiratory disease but is challenging for some individuals with frailty to complete. Frailty should not limit access to rehabilitation; instead, the identification of frailty should prompt comprehensive assessment and tailored support, including onward referral for additional specialist input, as applicable. Exercise prescriptions that consider symptom burden, as well as comorbidities, integration of additional geriatric or palliative care expertise, and preemptive planning for disruptions to participation may enhance patient engagement and outcomes. To identify and measure frailty in people with respiratory disease, tools should be selected on the basis of sensitivity, specificity, responsiveness, and feasibility for their intended purpose. Research should increase understanding beyond physical dimensions of frailty and explore the merits and limitations of telerehabilitation or home-based pulmonary rehabilitation for people living with chronic respiratory disease and frailty. ■

This official workshop report was prepared by an *ad hoc* subcommittee of the ATS Assembly on Pulmonary Rehabilitation.

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