

Original Article

Culturally Adapted Floor-to-Stand Exercises for COPD: A Quasi-Experimental Study

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ABSTRACT

OBJECTIVE: Conventional pulmonary rehabilitation remains difficult to access in many low-resource settings because of practical, geographic, and sociocultural barriers. Accordingly, floor-to-stand exercises (FSE) were developed as an equipment-free program centered on repeated floor-to-stand transitions that are commonly performed in daily life in North Africa. The main objective of the present study was to estimate program completion rates, identify predictors of non-completion, and describe clinical, functional, and peripheral muscle outcomes in chronic obstructive pulmonary disease (COPD) outpatients with documented difficulty rising from the floor.

MATERIAL AND METHODS: In this prospective, quasi-experimental pilot study, COPD outpatients participated in the 9-week progressive FSE program. Completion was defined as ≥ 22 floor-to-stand transitions/day during weeks 7-9. Assessments were performed at baseline and at day 63, and outcomes were compared between completers and non-completers.

RESULTS: Fifteen COPD outpatients were included; the completion rate was 46.7% (7/15). Completers had lower baseline Borg CR10 scores (6.0 vs. 7.5; $P = 0.047$) and higher 6-minute walk distance (330 vs. 261 m; $P = 0.037$). On day 63, completers improved on the modified Medical Research Council Dyspnea Scale (-2.0 ; $P = 0.015$), Borg CR10 (-3.0 ; $P = 0.011$), and COPD assessment test (-8.0 ; $P = 0.008$), whereas non-completers improved only on the Borg CR10 (-2.0 ; $P = 0.020$). Functional tests and peripheral muscle outcomes showed no consistent changes overall.

CONCLUSION: The FSE was feasible and safe in this study, with improvements primarily in symptoms and disease impact. Larger controlled studies are needed to confirm the effectiveness and optimize adherence. Trial registration: ClinicalTrials.gov NCT07277855.

KEYWORDS: COPD, exercise training, pulmonary rehabilitation and chronic care, cultural characteristics, pulmonary diseases

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INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is characterized by systemic manifestations, notably skeletal muscle dysfunction, which contribute to a self-perpetuating cycle of dyspnea, inactivity, deconditioning, and progressive functional decline.^{1,2} Pulmonary rehabilitation (PR) is the cornerstone intervention recommended by the Global Initiative for Chronic Obstructive Lung Disease (GOLD), aiming to improve symptoms, functional capacity, and quality of life while reducing healthcare costs.^{3,4}

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Conventional PR programs, such as treadmill or track walking, cycling and resistance training, are well established and endorsed by major societies (American College of Sports Medicine, American Thoracic Society, European Respiratory Society).^{5,6} However, their accessibility remains critically limited, with only 1.2% of eligible symptomatic COPD patients participating worldwide,⁷ mainly due to socioeconomic, infrastructural, and cultural barriers.^{8,9} These limitations have prompted the development of culturally adapted PR approaches, such as yoga in India, tai chi in China, and dance-based programs in specific countries, all showing promising results.¹⁰⁻¹² Culturally contextualized strategies may therefore be relevant not only in settings where PR access is limited, but also as complementary options for populations with habitual daily movement patterns.

In North Africa, culturally tailored PR strategies are scarcely evaluated. Daily life commonly includes floor sitting¹³ and repeated floor-to-stand movements. Moreover, a widely practiced daily religious routine in this predominantly Muslim region involves repeated transitions between floor-level and standing postures. Considering the 17 obligatory prayer units together with five commonly practiced additional units, a pragmatic target of 22 daily floor-to-stand transitions was selected.¹⁴⁻¹⁶ This context suggests that a structured rehabilitation model based on familiar floor-rising movements, performed either within daily routines or as a stand-alone exercise, may improve acceptability and adherence.

A floor-to-stand exercise (FSE) program was developed, centered on repeated floor-to-stand transitions commonly performed in daily life across North African communities. The FSE is proposed as a progressive, equipment-free program requiring minimal space and limited assistance, delivered over nine weeks in three phases. The program culminated in a target of 22 daily floor-to-stand transitions, distributed in clusters

throughout the 24-hour period. Completion was defined as achieving the target of 22 floor-to-stand transitions/day during weeks 7 to 9.

The main objective of the present study was to estimate program completion, identify predictors of non-completion, and describe clinical, functional, and peripheral muscle outcomes¹⁷⁻¹⁹ in COPD outpatients with documented difficulty rising from the floor.

MATERIAL AND METHODS

Study Design and Setting

This prospective, quasi-experimental study used a single-arm interventional design. The intervention and study assessments were conducted at the coordinating study site in Laghouat; four specialized respiratory care centers served to identify potentially eligible patients, as described below. Week 9 (day 63) outcomes, including clinical, functional, and muscle performance measures, were compared between completers and non-completers, and the prespecified completion endpoints were reported.

Participants

Eligible participants were adult outpatients diagnosed with COPD according to GOLD criteria⁴ [post-bronchodilator forced expiratory volume in one second (FEV1)/forced vital capacity <0.7 and compatible clinical symptoms such as dyspnea or chronic cough] and reporting muscle dysfunction that limited their ability to rise from a kneeling position. Exclusion criteria were ischemic heart disease, stroke, or COPD exacerbation requiring systemic corticosteroids, each occurring within the preceding two months. Early termination criteria consisted of predefined serious adverse events occurring after protocol initiation, including major cardiovascular, respiratory, or neurological complications that compromise safe participation; acute intercurrent illness; clinically significant cognitive decline impairing adherence; and withdrawal of consent.

Potentially eligible patients presenting for routine COPD consultation at the four specialized respiratory care centers in Laghouat, Algeria, between 01 December 2024 and 28 February 2025 were identified by the consulting respiratory physicians and referred to the coordinating study site for eligibility assessment. Sixteen individuals were initially recorded administratively. One did not proceed to the study baseline evaluation after a very early cardiological assessment identified clinically significant heart failure with recurrent pulmonary edema, making participation in the exercise program unsafe. The clinical study cohort therefore comprised 15 participants. All participants included in the clinical study cohort received guidance on the structured FSE rehabilitation program and provided written informed consent before study procedures.

Data Collection and Measurement Tools

Assessments were conducted in person at baseline (day 0) and post-intervention (day 63). Mid-intervention monitoring on days 21 and 42 was performed via structured telephone calls focusing on adherence and adverse events. An adverse event

Main Points

- Floor-to-stand exercises represent an equipment-free, culturally grounded, predominantly home-based pulmonary rehabilitation strategy based on repeated floor-to-stand transitions and designed for resource-limited settings.
- In this 9-week study, 46.7% of chronic obstructive pulmonary disease (COPD) outpatients with floor-rising difficulty achieved the predefined completion target (≥22 floor-to-stand transitions/day during weeks 7–9).
- Lower baseline perceived exertion (Borg CR10) and higher baseline exercise capacity [6-minute walk distance (6MWD)] were associated with completion, suggesting identifiable profiles for targeted support.
- Completers showed statistically significant and clinically relevant improvements in dyspnea (mMRC) and health status (CAT), while objective functional tests [6MWD, 1-minute sit-to-stand (STS), timed up and go (TUG), fingertip-to-floor distance (FFD)] did not significantly change in this small sample.
- Peripheral muscle performance assessed by force-sensor dynamometry with belt-stabilized testing showed no consistent improvement over the 9-week study period.

was defined as any untoward medical occurrence temporally associated with study participation, whether or not it was considered related to the intervention. A serious adverse event was defined as any adverse event that results in death, is life-threatening, requires inpatient hospitalization or prolongs existing hospitalization, results in persistent or significant disability or incapacity, or constitutes an important medical event requiring intervention to prevent such outcomes. Event seriousness and relationship to the intervention were assessed separately by the investigators.

To minimize measurement variability, clinical questionnaires, functional tests, and standardized peripheral muscle tests were administered in a fixed sequence at each in-person visit. The fixed sequence was as follows: symptom- and health-status questionnaires [modified Medical Research Council Dyspnea Scale (mMRC), perceived exertion Borg CR10, and health status COPD assessment test (CAT)]; functional tests [6-minute walking distance (6MWD), 1-minute sit-to-stand (STS), timed up and go (TUG), and fingertip-to-floor distance (FFD)]; and peripheral muscle testing. Standardized rest intervals were planned; additional recovery time was allowed, when clinically required, to safely complete symptom-limited testing.

Socio-demographic and medical history data were collected at baseline. COPD diagnosis was confirmed by post-bronchodilator spirometry, with disease stage categorized according to GOLD ABE classification.⁴

Clinical assessment included dyspnea, measured using the mMRC (0–4; 0= dyspnea only with strenuous exercise; 4= too dyspneic to leave the house), and perceived exertion/dyspnea during FSE, measured using the modified Borg CR10 scale (0–10; 0= no dyspnea; 10= maximal dyspnea). Disease impact was evaluated with CAT (0–40; higher scores indicate greater disease impact). Functional evaluation focused on mobility (TUG, in seconds); flexibility (FFD, in cm); and exercise capacity (6MWD, in meters, and 1-min STS, number of repetitions). Prognosis was assessed using the body mass index (BMI), airflow obstruction, dyspnea, and exercise index (BMI, predicted post-bronchodilator FEV1 %, mMRC, and 6MWD).

Peripheral muscle performance was assessed on the right side using a portable force-sensor dynamometer with standardized positioning and belt-stabilized testing, consistent with published recommendations and reliability data in COPD.^{17–19} Testing followed a fixed sequence. Lower-limb tests were performed first and included seated knee flexion and knee extension, with the ankle strap positioned above the malleoli. Upper-limb tests were then performed; they included standing shoulder flexion and seated pectoral press, with the pectoral press performed last. For each task, the assessment followed a standardized progression from maximal isometric strength to isometric endurance and, when applicable, to isotonic endurance, each at 50% of maximal force. Outcomes were maximal isometric strength (kg), isometric endurance at 50% of maximal force (hold time maintaining $\geq 50\%$ of maximal force, s), and isotonic endurance at 50% of maximal force (repetitions completed in 1 minute).

Program adherence and adverse events were assessed during structured telephone calls on days 21 and 42, and on day 63

clinical, functional, and muscle assessments were repeated, and program completion was documented.

Intervention: The Floor-to-Stand Exercise

All participants were invited to undertake the FSE, a progressive 9-week training structured into three phases with daily targets accumulated across brief, distributed sessions. The program was equipment-free, required minimal space, and combined home practice with brief supervised sessions during the initial phase. Each floor-to-stand transition begins in standing, transitions to a floor position, and ends in standing; daily targets refer to completed floor-to-stand cycles. Participants could integrate the practice into their daily routine, including during their religious prayers, or perform it in separate exercise sessions; in both cases, repetitions corresponded to completed cycles, as defined above.

Assistance during FSE was categorized as human assistance (a caregiver or family member), environmental support (chair or wall), or independent execution (Figure 1). Assistance was adapted to individual needs and progressively reduced when safe and feasible, rather than being rigidly linked to a specific phase.

The goal of the initial phase (weeks 1–3) was to achieve 7–15 floor-to-stand transitions per day and to restore the ability to rise from the floor. The training combined home practice with biweekly supervised sessions at the study hospital. Assistance was provided at the hospital with a chair, the wall, a family member, or a caregiver to ensure safety until basic ability was regained. Once patients reached this stage, hospital sessions were discontinued, and training continued at home. During supervised sessions, staff provided hands-on support as needed to help participants safely manage body weight during the transition and adjusted the level of support according to the participants' dyspnea, balance, and tolerance.

Family members/caregivers who would assist at home were also trained to provide safe support (positioning, grip, and timing of assistance) to enable home practice and progressively reduce assistance when possible.

In the intermediate phase (weeks 4–6), the goal was increased to 15–22 floor-to-stand transitions/day, to be performed at home. At this stage, patients were encouraged to practice partially independently, using support only when needed (chair, wall, or family assistance), providing stability and reassurance while progressively reducing reliance on help. Progression was symptom-guided: participants increased repetitions gradually within the prescribed range and assistance was reduced only when the cycle could be completed safely without pain or undue dyspnea.

The consolidation phase (weeks 7–9) aimed to maintain 22 floor-to-stand transitions per day, performed independently, without assistance, and exclusively at home.

For the analysis, completion was defined as the consistent achievement of 22 floor-to-stand transitions per day during the consolidation phase, as reported by the patient and corroborated whenever possible through interim phone calls.

This target was chosen because it reflects the 22 daily prayer units described above in Muslims' daily religious prayers (salat), thereby providing a culturally familiar and attainable benchmark for use within or outside a spiritual routine.

To ensure safety, patients were instructed to discontinue the exercise in case of acute pain, dizziness, syncope, falls, or respiratory deterioration and to promptly contact the clinical team. Participants were advised to "listen to their body", to progress gradually, to "push their limits but never through pain", and to adjust the number of sessions and the level of assistance according to day-to-day symptom tolerance.

For participants with severe dyspnea, balance impairment, or musculoskeletal limitations, the protocol allowed slower progression and the continued use of chair or wall support, with or without caregiver supervision, until the movement could be performed safely.

Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki. The protocol was approved by the Ethics Committee of the Faculty of Medicine, Laghouat University (protocol no.: 12/2024; decision date: 20 November 2024). Confidentiality was ensured through anonymization and secure data handling.

The intervention was delivered in a culturally sensitive manner

and designed to be compatible with participants' personal beliefs and practices, without promoting or discouraging religious or spiritual views.

Trial registration: ClinicalTrials.gov NCT07277855. The trial registration record was first publicly posted after completion of the nine-week assessment period.

Statistical Analysis

Analyses were performed using R software version 4.5.1 (R Foundation for Statistical Computing, Vienna, Austria). Statistical significance was set at $P < 0.05$. Qualitative variables were summarized as frequencies and percentages, and quantitative variables as medians with interquartile ranges. Group comparisons were made using chi-square test or Fisher's exact test for categorical variables and the Mann-Whitney U test for continuous variables.

The analysis addressed program completion rate, predictors of non-completion, and post-intervention changes. Predictors were explored by comparing baseline socio-demographic, medical, clinical, and functional characteristics between completers and non-completers. Within-group changes from baseline were assessed using the Wilcoxon signed-rank test (one-sided, according to the expected direction of improvement: higher scores for 6MWD and 1-min STS repetitions, and lower scores for mMRC score, Borg CR10 scale, CAT total score, TUG test,

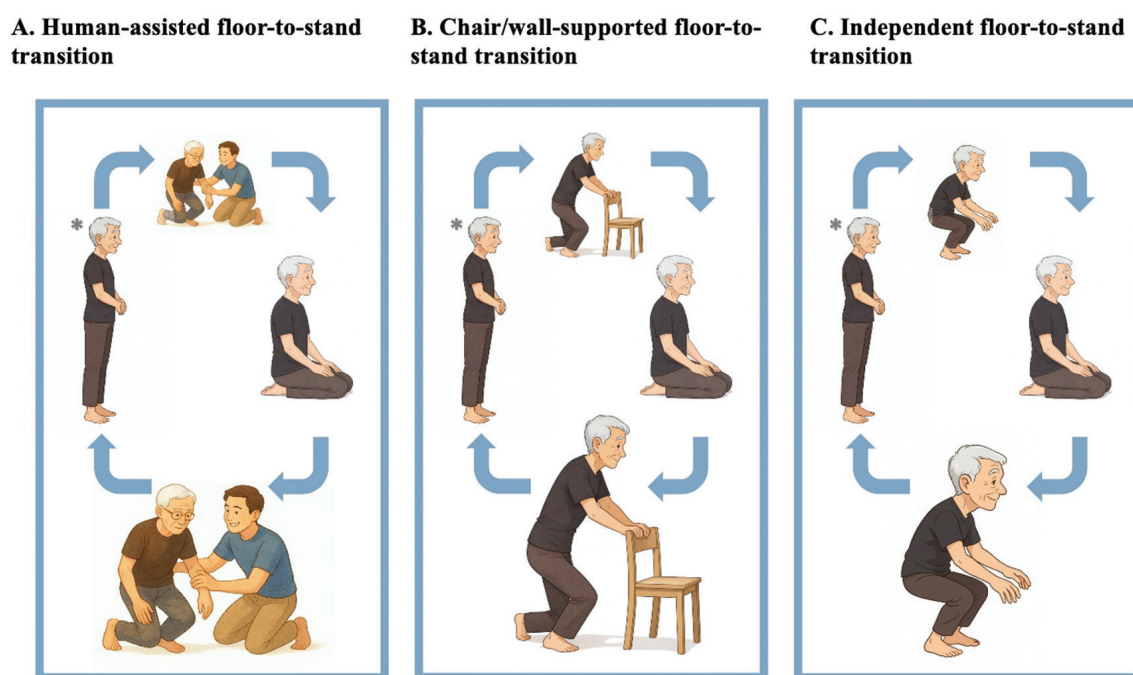


Figure 1. Categorized assistance modalities for floor-to-stand transitions

*Starting and finishing position of a complete floor-to-stand transition

Each panel depicts one complete floor-to-stand cycle, from standing to a floor position and back to standing. Panel A shows a transition performed with caregiver or family-member assistance. Panel B shows a transition performed with chair or wall support. Panel C shows an independent floor-to-stand transition without external assistance. These assistance modalities were used pragmatically according to patient capacity, symptom tolerance, and safety considerations, rather than being rigidly assigned to a specific phase of the program. The intervention followed a 9-week progressive schedule, with daily targets increasing from 7–15 to 15–22 and then 22 floor-to-stand transitions/day, accumulated in distributed daily sessions. Exercise was discontinued in case of acute pain, dizziness, syncope, falls, or respiratory worsening. The final target was selected as a culturally familiar benchmark; repetitions could be performed as separate exercise clusters or, if the participant wished, integrated into daily routines, including salat-related floor-to-stand transitions

and FFD). Between-group differences in median change scores were tested with the Mann–Whitney U test. Median changes in completers were further interpreted relative to minimal clinically important difference thresholds to evaluate clinical relevance, as follows: ≥ 1 -grade reduction for mMRC,²⁰ ≥ 2 -point reduction for CAT,²¹ ≥ 1 -point reduction for Borg CR10,²² ≥ 30 m for 6MWD,²³ ≥ 3 repetitions for 1-min STS,²⁴ and ≥ 0.9 – 1.4 s for TUG.²⁵

Muscle outcomes were analyzed using the same non-parametric framework (within-group Wilcoxon signed-rank tests and between-group comparisons of change scores), with one-sided tests applied in the prespecified direction of improvement (higher maximal strength and endurance).

RESULTS

Fifteen outpatients with difficulty rising from the floor were included. Most participants had symptomatic COPD at baseline: 9/15 (60.0%) were classified as GOLD group B and 5/15 (33.3%) as group E. No participant was receiving long-term oxygen therapy or non-invasive ventilation. Cardiometabolic comorbidities (hypertension and type 2 diabetes) were common, whereas musculoskeletal disorders were present in a minority of participants; one participant had inflammatory myopathy (Table 1; Supplementary Table S1). Overall, 7/15 participants (46.7%) met the completion criterion, consistently achieving the target of 22 floor-to-stand transitions per day during weeks 7–9. Among non-completers (8/15, 53.3%), four had 0–6 transitions/day, two had 7–14/day, and two had 15–21/day.

Predictors of Non-completion

Baseline socio-demographic, respiratory, and clinical characteristics were broadly comparable between completers and non-completers (Table 2). Baseline peripheral muscle performance is presented in Supplementary Table S2. In addition to lower perceived exertion and higher exercise capacity (Borg CR10 and 6MWD), completers showed higher baseline lower-limb muscle performance as measured by selected dynamometry measures. Functional and clinical profiles were otherwise generally similar. Musculoskeletal disorders were observed only among non-completers, without reaching statistical significance ($P = 0.244$).

Post-intervention Outcomes (Clinical, Functional, and Muscle Performance)

By day 63, completers showed statistically significant improvements in mMRC, Borg CR10, and CAT, with changes meeting clinically important thresholds. Non-completers showed a statistically significant improvement only in Borg CR10. No significant changes were observed in functional tests (6MWD, 1-min STS, TUG, and FFD) in either group (Table 3). Peripheral muscle performance outcomes did not show systematic changes over the study period; only pectoral press isometric endurance increased in non-completers (Table 4). During in-person assessments, some participants required recovery periods longer than the standardized rest intervals to complete symptom-limited testing safely, particularly during the final upper-limb muscle tasks.

Table 1. Baseline clinical, respiratory, and functional characteristics of the study population (n = 15)

Variable	Value
Demographics	
Age (years)	67.0 [62.5, 74.5]
Male sex, n (%)	13 (86.7)
Weight, kg	68.0 [50.2, 88.5]
BMI, kg/m ²	22.5 [18.6, 30.9]
Socio-economic and access to care	
Distance home–hospital, km	2.3 [1.9, 3.6]
Transportation barrier, n (%)	10 (66.7)
Lack of social support, n (%)	6 (40.0)
Socioeconomic status, n (%)	
Low	2 (13.3)
Middle	11 (73.3)
High	2 (13.3)
Smoking history	
Current smoker, n (%)	2 (13.3)
Former smoker, n (%)	11 (73.3)
Pack-years index	40.0 [24.0, 55.0]
Smoking cessation, years	4.0 [2.0, 6.0]
COPD severity and symptoms	
Post-bronchodilator FEV1, % predicted	33.0 [26.5, 55.0]
mMRC score	3.0 [2.0, 4.0]
Borg CR10 scale	6.0 [6.0, 7.5]
CAT total score	21.0 [17.0, 24.5]
GOLD ABE classification, n (%)	
Group A	1 (6.7)
Group B	9 (60.0)
Group E	5 (33.3)
Comorbidities	
Cardiovascular disorders, n (%)	6 (40.0)
Metabolic disorders, n (%)	3 (20.0)
Musculoskeletal disorders, n (%)	3 (20.0)
Other disorders, n (%)	1 (6.7)
Functional tests and prognosis	
6MWD, m	300.0 [236.0, 332.5]
1-min STS repetitions	11.0 [10.0, 14.0]
TUG test, s	12.5 [12.0, 16.1]
FFD, cm	1.0 [0.0, 10.1]
BODE index	4.0 [3.0, 7.0]

Values are expressed as median [interquartile range] or n (%), as appropriate. Pack-years index was calculated as packs/day $\times$ years smoked. Other disorders included one case of dermatomyositis

BMI: body mass index, FEV1: forced expiratory volume in one second, mMRC: modified Medical Research Council, Borg CR10: borg category-ratio scale, CAT: COPD assessment test, GOLD: Global Initiative for Chronic Obstructive Lung Disease, 6MWD: 6-minute walk distance, STS: sit-to-stand, TUG: timed up and go, FFD: fingertip-to-floor distance, BODE: body mass index, airflow obstruction, dyspnea, and exercise capacity index, kg: kilogram, m: meter, min: minute, cm: centimeter, s: seconds

Table 2. Baseline clinical, respiratory, and functional characteristics and their univariate differences between FSE completers and non-completers

Variable	Completers (n = 7)	Non-completers (n = 8)	P
Demographics			
Age (years)	67.0 [62.0, 71.0]	68.0 [64.8, 76.8]	0.562
Male sex, n (%)	7 (100.0)	6 (75.0)	0.509
Weight, kg	70.0 [59.5, 92.7]	65.0 [48.0, 88.0]	0.487
BMI, kg/m ²	23.6 [21.5, 30.0]	21.9 [16.3, 28.0]	0.643
Socio-economic and access to care			
Distance home–hospital, km	3.2 [2.2, 3.9]	2.1 [1.7, 3.4]	0.417
Transportation barrier, n (%)	5 (71.4)	5 (62.5)	1.000
Lack of social support, n (%)	2 (28.6)	4 (50.0)	0.751
Socioeconomic status			0.988
Low, n (%)	1 (14.3)	1 (12.5)	
Middle, n (%)	5 (71.4)	6 (75.0)	
High, n (%)	1 (14.3)	1 (12.5)	
Medical history and comorbidities			
Cardiovascular disorders, n (%)	4 (57.1)	2 (25.0)	0.460
Musculoskeletal disorders, n (%)	0 (0.0)	3 (37.5)	0.244
Metabolic disorders, n (%)	2 (28.6)	1 (12.5)	0.897
Other disorders, n (%)	0 (0.0)	1 (12.5)	1.000
Smoking history			
Current smoker, n (%)	1 (14.3)	1 (12.5)	1.000
Former smoker, n (%)	6 (85.7)	5 (62.5)	0.668
Pack-years index	45.0 [32.0, 57.5]	27.5 [21.2, 40.5]	0.391
Smoking cessation, years	2.0 [1.2, 12.0]	4.5 [2.5, 5.8]	0.773
COPD severity and baseline symptoms			
Post-bronchodilator FEV1, % predicted	41.0 [26.5, 46.0]	33.0 [27.2, 62.2]	0.817
mMRC score	3.0 [2.0, 3.0]	3.5 [2.5, 4.0]	0.334
Borg CR10 scale	6.0 [5.5, 6.5]	7.5 [6.0, 8.2]	0.047
CAT total score	19.0 [15.0, 23.0]	23.0 [18.8, 24.8]	0.324
GOLD ABE classification			0.535
Group A, n (%)	1 (14.3)	0 (0.0)	
Group B, n (%)	4 (57.1)	5 (62.5)	
Group E, n (%)	2 (28.6)	3 (37.5)	
Functional tests and prognosis			
6MWD, m	330.0 [317.5, 357.5]	261.0 [172.5, 288.8]	0.037
1-min STS repetitions	12.0 [11.0, 16.5]	10.5 [8.8, 12.0]	0.114
TUG test, s	12.0 [10.5, 13.8]	14.5 [12.0, 17.4]	0.199
FFD, cm	8.0 [0.0, 9.6]	0.5 [0.0, 12.0]	1.000
BODE index	4.0 [3.0, 6.0]	5.0 [3.5, 7.5]	0.521

Values are expressed as median [interquartile range] or n (%), as appropriate. Between-group comparisons were performed using Fisher's exact test or chi-square test for categorical variables and the Mann–Whitney U test for continuous variables. Pack-years index was calculated as packs/day × years smoked. Other disorders included one case of dermatomyositis

FSE: Floor-to-stand exercises, BMI: body mass index, FEV1: forced expiratory volume in one second, mMRC: modified Medical Research Council, Borg CR10: borg category-ratio scale, CAT: COPD assessment test, GOLD: Global Initiative for Chronic Obstructive Lung Disease, 6MWD: 6-minute walk distance, STS: sit-to-stand, TUG: timed up and go, FFD: fingertip-to-floor distance, BODE: body mass index, airflow obstruction, dyspnea, and exercise capacity index, kg: kilogram, m: meter, min: minute, cm: centimeter, s: seconds

Table 3. Baseline-to-post-intervention changes in clinical and functional outcomes: completers vs. non-completers

Outcome	Completers Δ (n = 7)	P within	Non-completers Δ (n = 8)	P within	P between
mMRC score	-2.0 [-2.0, -1.0]	0.015	-1.0 [-1.3, 0.0]	0.197	0.178
Borg CR10 scale	-3.0 [-3.0, -2.0]	0.011	-2.0 [-3.0, -0.8]	0.020	0.227
CAT total score	-8.0 [-11.5, -5.0]	0.008	-4.0 [-8.5, 0.8]	0.075	0.147
6MWD, m	-10.0 [-72.5, 19.5]	0.711	-16.0 [-43.8, 40.6]	0.663	0.728
1-min STS repetitions	0.0 [-1.5, 3.0]	0.262	-0.5 [-1.5, 3.0]	0.534	0.769
TUG test, s	-0.9 [-2.1, 2.7]	0.751	0.6 [-0.5, 1.4]	0.824	0.728
FFD, cm	0.0 [-4.6, 0.0]	0.181	0.0 [-1.5, 0.0]	0.292	0.714

Values are expressed as median change from baseline to day 63 [interquartile range]. Within-group changes were assessed using one-sided Wilcoxon signed-rank tests in the prespecified direction of improvement. Between-group comparisons of change scores were assessed using the Mann-Whitney U tests

Δ : change from baseline to day 63, mMRC: modified Medical Research Council, Borg CR10: modified borg category-ratio scale, CAT: COPD assessment test, 6MWD: 6-minute walk distance, STS: sit-to-stand, TUG: timed up and go, FFD: fingertip-to-floor distance, m: meters, s: seconds, cm: centimeters, IQR: interquartile range, min: minute

Table 4. Baseline-to-post-intervention changes in peripheral muscle performance: completers vs. non-completers

Variable	Completers Δ (n = 7)	P within	Non-completers Δ (n = 8)	P within	P between
Knee flexion					
Max isometric strength, kg	-1.2 [-14.3, 1.5]	0.864	-2.8 [-3.6, -1.1]	0.971	0.685
Isometric endurance at 50% max force, s	5.3 [-10.9, 15.0]	0.534	11.6 [4.5, 21.0]	0.054	0.385
Knee extension					
Max isometric strength, kg	-4.3 [-9.4, 3.2]	0.777	-2.8 [-4.5, -1.4]	0.962	0.862
Isometric endurance at 50% max force, s	-7.7 [-29.2, -4.7]	0.925	13.8 [-10.8, 31.2]	0.147	0.224
Isotonic endurance at 50% max force, reps/1 min	-8.0 [-18.0, 8.0]	0.866	2.0 [-5.0, 7.0]	0.336	0.296
Shoulder flexion					
Max isometric strength, kg	3.0 [-2.3, 6.7]	0.136	0.5 [-0.2, 2.1]	0.181	0.325
Isometric endurance at 50% max force, s	1.5 [-11.0, 14.0]	0.336	-4.8 [-11.0, 6.1]	0.824	0.728
Isotonic endurance at 50% max force, reps/1 min	-2.0 [-5.0, 1.0]	0.800	-2.5 [-6.0, 4.0]	0.802	0.954
Pectoral press					
Max isometric strength, kg	-1.8 [-5.1, 5.8]	0.664	-3.1 [-4.5, 1.7]	0.819	0.908
Isometric endurance at 50% max force, s	-7.6 [-13.9, 9.7]	0.777	16.5 [8.4, 23.3]	0.015	0.024

Values are expressed as median change from baseline to day 63, with interquartile range [IQR] shown below the median. Positive values indicate increased muscle performance, whereas negative values indicate decreased performance. P within refers to the within-group change assessed using a one-sided Wilcoxon signed-rank test in the prespecified direction of improvement. P between refers to the between-group comparison of change scores assessed using the Mann-Whitney U test. Peripheral muscle performance outcomes were maximal isometric strength, isometric endurance at 50% of maximal force, and isotonic endurance at 50% of maximal force

Δ : change from baseline to day 63; IQR: interquartile range, Reps: repetitions, min: minute, s: seconds, kg: kilogram, Max: maximum

Safety Profile and Motivational Barriers

Telephone follow-up at days 21 and 42 was completed for 14 of 15 participants (7/7 completers and 7/8 non-completers). A small amount of additional item-level information was missing, so available-case denominators were 13 or 14 depending on the variable; percentages at these interim assessments were calculated using the number of participants with available data for each item. Day-63 assessments were available for all 15 participants. Effort-related musculoskeletal complaints were infrequent on day 21 (14.3% vs. 28.6%, $P = 1.000$) and on day 42 (one case in each group, $P = 1.000$). By day 63, no completer reported symptoms, whereas 50.0% of non-completers did (P

$= 0.110$). Four COPD exacerbations occurred during follow-up; one required hospitalization and was therefore classified as a serious adverse event. In the investigators' judgment, these exacerbations were related to the underlying course of COPD and not to the intervention. No comorbidity decompensation was reported on days 21 or 42; one inflammatory myopathy flare occurred on day 63. Mental fatigue was common but consistently less frequent among completers, although these differences were not statistically significant (day 21: 28.6% vs. 71.4%, $P = 0.285$; day 42: 42.9% vs. 57.1%, $P = 1.000$; day 63: 28.6% vs. 75.0%, $P = 0.201$).

DISCUSSION

In this 9-week, equipment-free FSE program, 46.7% of participants achieved the predefined completion target (22 floor-to-stand transitions/day). Completers had a better baseline functional status and showed clinically meaningful improvements in dyspnea and health status, whereas functional performance and peripheral muscle outcomes changed minimally.

Determinants of Program Completion and Adherence

Nearly half of participants achieved program completion, defined as performing 22 daily floor-to-stand repetitions. Although modest, this rate supports the feasibility of the protocol in a setting with limited rehabilitation infrastructure. Importantly, even non-completers demonstrated substantial engagement, with half achieving over seven daily repetitions, indicating overall acceptability.

Completion was associated with better baseline functional status, as completers exhibited lower Borg CR10 scores and higher 6MWD. This contrasts with findings by Boutou et al.²⁶, who reported higher completion among patients with lower baseline performance, likely reflecting differences in program structure and completion definitions. Socio-demographic characteristics and smoking status were not associated with adherence, suggesting that commonly reported barriers such as cost, distance, and transportation²⁷⁻²⁹ were effectively mitigated by the program's design.

Social support appeared influential, with a higher prevalence among completers, consistent with evidence highlighting the facilitating role of caregivers in rehabilitation participation.^{8,30} Conversely, musculoskeletal pain and psychological factors, including fatigue and low motivation, may have limited adherence, in line with previous reports identifying these as under-recognized barriers in COPD rehabilitation.³¹⁻³³ These findings emphasize that adherence reflects an interplay of physical, psychological, and social determinants rather than physiological capacity alone.

Interpretation of Post-intervention Changes

Completers showed clinically meaningful improvements in dyspnea, exertional effort, and disease impact, whereas the only statistically significant change among non-completers was in perceived exertion. This pattern suggests that the main short-term benefit of sustained FSE practice was symptomatic rather than physiological. The improvement in CAT among completers is particularly relevant, because CAT is known to be responsive to rehabilitation-related change and is widely used to capture patient-perceived benefit in COPD.²¹

These results should be interpreted in the context of conventional center-based PR, which remains the reference intervention when accessible. Conventional PR is usually delivered as a supervised, multidisciplinary program combining endurance training (such as cycle ergometry) with resistance training, often including lower-limb strengthening. In randomized controlled trials, such programs have produced clinically meaningful improvements in exercise tolerance, dyspnea, and health-related quality of life compared with usual care.^{34,35} In

this respect, the direction of change observed with the FSE is consistent with the rehabilitation literature regarding symptom burden and health status, but the magnitude and breadth of benefit appear to be narrower than typically expected from conventional PR.

This difference is also helpful for interpreting the functional outcomes. In conventional PR, improvements in exercise tolerance are commonly reflected by gains in 6MWD and related endurance outcomes.^{34,35} In the present study, the absence of consistent signals for 6MWD and 1-min STS suggests that FSE did not provide sufficient aerobic or endurance stimuli to induce broader physiological adaptations over 9 weeks. Rather, the intervention seems to have primarily affected confidence in movement, symptom perception, and task-specific functional tolerance. The numerically favorable change in TUG among completers may still be of interest because repeated floor-to-stand transitions plausibly train balance, transitional mobility, and lower-limb control; however, this signal remains modest and should be interpreted cautiously given the small pilot sample.

The muscle results follow the same logic. Peripheral muscle outcomes remained largely unchanged over 9 weeks, suggesting that the FSE program did not provide a sufficiently strong resistance stimulus to produce consistent gains in dynamometric testing. This contrasts with COPD training studies showing that resistance-containing rehabilitation programs can improve peripheral muscle force, including lower-limb strength, and that combined endurance-plus-strength approaches may produce greater gains in quadriceps strength than endurance training alone.^{36,37} The discrepancy is plausible: FSE is a pragmatic, low-resource, functional-transition program, whereas conventional PR and structured resistance training use more controlled loading, progression, and repetition schemes. Furthermore, in the present study, the muscle assessments relied on isolated, standardized measures, whereas FSE is likely to have a greater influence on task-specific movement efficiency and confidence than on maximal force generation.

Finally, the present findings remain coherent with the literature on culturally adapted rehabilitation modalities such as Tai Chi and yoga, which often show stronger effects on symptoms, health status, and functional confidence than on isolated physiological or muscle endpoints.^{10,12,38-40} Overall, FSE should not be viewed as equivalent to conventional PR. Rather, it appears to be a pragmatic, culturally contextualized strategy that may provide meaningful symptomatic benefit when conventional PR is unavailable or difficult to access.

Cultural Relevance and External Validity

A major strength of the FSE program is its alignment with local cultural practices and daily routines. Exercises could be performed safely at home with minimal supervision, thereby reducing travel and cost burdens that participants frequently reported. The floor-based movements reflect functional activities embedded in North African daily life,¹³ potentially enhancing familiarity and adherence. Program flexibility further allowed adaptation to personal and religious schedules without imposing cultural constraints.

These features suggest that FSE could be transferable across North Africa, where shared lifestyle patterns and familial structures provide a common framework.¹⁴ However, heterogeneity in healthcare infrastructure and patient education across urban and rural areas warrants cautious extrapolation.⁴¹ Broader validation will require multicenter studies in diverse settings.

Limitations and Implications for Future Research

The absence of randomization limits causal inference, although it is ethically justified in this context. Sample size and attrition reduced statistical power, and self-reported home practice may have introduced information bias. COPD-related fatigue and psychological comorbidities further complicated sustained participation, underscoring the need for individualized rehabilitation strategies. In addition, the clinically necessary extension of recovery time beyond standardized rest intervals may have increased measurement variability in late-session measures of muscle strength and endurance. Future studies should plan more conservative rest windows and consider recording actual recovery times to support sensitivity analyses.

Despite these limitations, clinically meaningful improvements were observed in key outcomes, supporting further evaluation of the FSE in larger, randomized trials. Future research should assess long-term effects on falls, quality of life, and disease burden, as well as optimal integration within existing rehabilitation pathways.

CONCLUSIONS

In a resource-limited North African setting, a culturally adapted, equipment-free, floor-to-stand rehabilitation program proved feasible and safe, with nearly half of participants achieving full adherence. Completers consistently obtained statistically significant improvements in dyspnea, tolerance to exertion, and disease impact, whereas non-completers showed limited benefits. Peripheral muscle testing did not show systematic gains over 9 weeks. Musculoskeletal comorbidities, mental fatigue and limited social support emerged as potential barriers to adherence, underscoring the role of both physical and psychosocial determinants in rehabilitation success. The socio-cultural adaptability of the protocol further supports its relevance for similar populations across North Africa. These findings should not be interpreted as supporting equivalence between the FSE and conventional center-based PR, which remains the reference intervention when accessible. Rather, they support further controlled evaluation of the FSE as a pragmatic, low-resource, culturally acceptable option that may complement existing rehabilitation pathways or extend access to rehabilitation where conventional PR cannot be delivered.

Ethics

Ethics Committee Approval: The study protocol was approved by the Ethics Committee of the Faculty of Medicine, Laghouat University (protocol no.: 12/2024; decision date: 20 November 2024). All procedures were conducted in accordance with institutional and ethical standards and the Declaration of Helsinki.

Informed Consent: Informed written consent was obtained from all participants.

Footnotes

Authorship Contributions

Surgical and Medical Practices: R.S.A.B., H.M.F., A.Z., L.L., F.H., A.L., Concept: R.S.A.B., H.M.F., A.Z., L.L., M.S.B., F.H., A.L., M.O.S., Design: R.S.A.B., M.B., H.M.F., A.Z., L.L., M.S.B., F.H., M.O.S., Data Collection or Processing: M.B., H.M.F., A.Z., L.L., M.S.B., Analysis or Interpretation: R.S.A.B., H.M.F., A.Z., L.L., F.H., A.L., M.O.S., Literature Search: R.S.A.B., M.B., H.M.F., A.Z., L.L., M.S.B., Writing: R.S.A.B., M.B., H.M.F., A.Z., L.L., M.S.B., F.H., A.L., M.O.S.

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